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Hearing loss and psychiatric disorders: a review

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Invited Review

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Abstract

Hearing loss is one of the most common yet unrecognized impairments experienced by adults, especially as they age. Mental health investigators and practitioners require better understanding of hearing loss, its association with psychiatric disorders, and the treatment of these disorders in the presence of hearing loss as well as the treatment of hearing loss itself. In this review, the authors briefly explore the global burden of hearing loss. Next we provide an overview of the extant literature on hearing loss associated with cognitive impairment, depression, anxiety disorders, psychoses, and quality of life with attention focused on the strength of the association, possible mechanisms explaining the association, data on treatment options specific to these disorders, and future research opportunities for these disorders. Current approaches to the treatment of hearing loss are presented, including hearing aids, rehabilitation including psychotherapies, surgical procedures (specifically cochlear implants), and induction loops connected to telecoils. Finally, cutting edge research into the pathophysiology and potential biological treatments of hearing loss is described.

Introduction

Hearing loss is one of the most frequent impairments experienced by adults, and prevalence increases with age. In this review, we focus upon the association of adult-onset mild-to-severe hearing loss and psychiatric disorders. Though of great public health importance, we do not discuss deafness (profound hearing loss) or childhood hearing loss. Despite the fact that mental health professionals encounter patients with hearing loss on an almost daily basis, the interaction between that loss and psychiatric disorders is not discussed frequently in the literature and often not recognized, though the number of published empirical studies has increased in the past 2–3 years (Wilson *et al.*, 2017). In addition, the current treatments for hearing loss beyond hearing aids are largely unknown or ignored by health care professionals including mental health professionals.

Reasons for this lack of understanding include at least two factors. First, the relative quietness of a clinician's office frequently makes it difficult for the clinician to estimate the degree of impairment experienced by the patient. In addition, there are no known pharmacological interventions specifically for hearing-related psychiatric disorders, though pharmacotherapy may be beneficial for a psychiatric disorder associated with hearing loss. Many therapies are available for hearing loss and mental health care providers should be acquainted with those interventions and their limitations. For example, psychotherapy may be beneficial, yet communication barriers must be overcome.

In this paper, we have prepared a review based on a search of PubMed for all articles that included one or more of the four psychiatric disorders listed below as well as quality of life and 'hearing'. The review begins with a brief overview of the epidemiology of hearing loss. We next present a narrative review of the extant literature on the association of hearing loss with the following conditions: neurocognitive disorders, depression, anxiety, psychoses, and quality of life. In this review, we provide an estimate of the strength of the association between hearing loss and the psychiatric disorder discussed. For each diagnosis, we explore the current yet very limited data on possible mechanism which may explain the association. We next explore the limited data on empirical-based interventions for the disorders reviewed. We make recommendations for areas where future research will be valuable in expanding and deepening our knowledge of hearing loss and psychiatric disorders. Finally we review current general interventions for hearing loss, a topic about which many mental health workers are not aware. The term 'hearing loss' refers to sensory neural hearing loss unless otherwise specified.

The evaluation of hearing loss

The definition of hearing loss beyond self-report depends upon the measurement of sound intensity required before an individual is just barely able to hear a sound presented at a range of frequencies that are important for hearing speech (typically 250–8000 Hz).

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Thresholds are measured in decibels (dB), which is a logarithmic scale that reflects the intensity of a sound. Adults with normal hearing can hear in the range of 0–20 dB, the equivalent of hearing sounds as faint as a human breathing. Those with mild hearing loss have hearing thresholds in the range of 21–40 dB and would have difficulty hearing a whisper. Those with moderate loss have thresholds in the range from 41 to 55 dB and struggle to hear speech at a normal level. Those with moderately severe loss have thresholds in the range from 56 to 70 have difficulty hearing speech in the presence of background noise. Those with severe hearing loss have thresholds in the range from 71 to 90 dB have difficulty hearing a lawnmower, and those with profound hearing loss (above 90 dB) often experience pain with loud noise (NASEM, 2016). In many epidemiologic studies, however, only self-reported hearing loss serves as a proxy.

The epidemiology of hearing loss

The global burden of hearing loss is estimated to be 6.8% of the world's population, is more frequent in men, and increases with age (Cruickshanks *et al.*, 2003; Cheng *et al.*, 2009; Wilson *et al.*, 2017). Prevalence among Mexican Americans is similar to that among whites yet lower among African Americans in the USA (Cheng *et al.*, 2009). Among adults under 70 years of age, hearing loss is decreasing in the USA, perhaps in part because workers are protected from more from extreme sounds, such as the noise reducing ear coverings used on the tarmac by airplane personnel (Hoffman *et al.*, 2017).

Risk factors for hearing loss include lower socioeconomic status, current smoking, possibly higher systolic blood pressure, obesity or increase in waist circumference, highly elevated glycosylated hemoglobin, atherosclerosis, and ototoxic medications such antibiotics, chemotherapeutic agents, aspirin, NSAIDS, and acetaminophen (NASEM, 2016, pp. 50–55). The strength of association is significantly greater for each of these factors in cross-sectional studies than longitudinal studies with the exception of ototoxic medications. The Center for Disease Control has recently targeted exposure to loud noises, such as attending rock concerts or working in occupations with high noise exposure as a significant risk that should be more publicized (CDC, 2017).

Hearing loss and psychiatric disorders

Psychiatric disorders of all varieties are associated with hearing loss, easily determined by asking key questions especially of family members. For example, persons with hearing loss have difficulty following a conversation if there is background noise, such as found in a restaurant. They become frustrated with their inability to follow a conversation when talking with their families. Though they can hear speech, that speech may be indistinct, particularly in the presence of background noise, and therefore hear only portions of the conversation. Hearing loss is partially compensated if the hearing impaired can see the person with whom they are conversing and read lips and other visual cues. Therefore, none of these problems may emerge in a quiet examination room or office and therefore may be easily missed. Embarrassment or other factors can prevent the patient from revealing the impairment.

Neurocognitive disorders

A substantial literature has emerged confirming the association of hearing loss with neurocognitive disorders. Those who do not have access to or use a hearing aid find conversation difficult if they have a moderate or more severe hearing loss. This in turn can lead to isolation and may increase or precipitate cognitive decline (Shankar *et al.*, 2013). In one cross-sectional study based on a chart review for adults 50+ years of age, hearing loss was highly prevalent among those who were cognitively impaired. Those with a medical history of diabetes in addition experienced more hearing loss. As would be expected, the cognitively impaired with the greatest hearing loss were the most likely to use hearing aids (Nirmalasari *et al.*, 2017). In the Health ABC Study, a cohort of 3075 men and women, aged 70–79 at baseline, and oversamples for African Americans was recruited for longitudinal follow-up. Investigators found that moderate age-related hearing decline was associated with accelerated cognitive decline among older adults (Lin *et al.*, 2013). Among over 1000 subjects with baseline hearing loss (pure-tone average >25 dB), annual rates of decline on a cognitive screen and the Digit Symbol Substitution test were 41% and 32% greater, respectively, than those with normal hearing. In the English Longitudinal Study on Aeging of 7865 subjects, for those with self-reported hearing loss, the hazard over 10 years of developing dementia was 1.4 times as high in individuals who reported moderate hearing and 1.6 times as high in those who reported more severe hearing loss compared with those with no hearing loss (Davies *et al.*, 2016). One group of investigators performed a meta-analysis of 40 studies worldwide. Among cross-sectional studies, a significant association was found for cognitive impairment [odds ratio (OR) 2.00] and dementia (OR 2.42) (Loughrey *et al.*, 2018). Among prospective cohort studies, a significant association was found for cognitive impairment (OR 1.22) and dementia (OR 1.28) but not for Alzheimer disease (though the trend toward significance was found). Vascular dysfunction and impaired verbal communication were hypothesized as contributors to the association between hearing loss and cognitive decline. Overall, the evidence is strong in both cross-sectional and longitudinal studies for an association between hearing loss and cognitive decline.

Possible mechanisms have been explored which contribute to more steep declines in cognitive function among the hearing impaired. Four possible mechanisms have been suggested: cognitive decline causes sensory decline (little evidence to support this mechanism); sensory decline causes cognitive decline (intuitive in that sensory deficits increase cognitive efforts and then decrease cognitive performance, yet the evidence is minimal); information degradation (impoverished perceptual input contributes to cognitive decline); and the presence of an intervening variable such as cerebrovascular disease (Wayne and Johnsrude, 2015).

One group sought to determine possible neuropathological associations in mice with neural hearing loss. The mice with neural hearing loss showed elevated auditory brainstem response thresholds and poorer performances in spatial working and recognition memories than the controls. They exhibited more p-τ and lipofuscin in the hippocampus. The cognitive impact of hearing loss varied with the types of memory loss. Working memory impairment was reversible, whereas recognition memory impairment was permanent (Park *et al.*, 2018). Another team of investigators suggested that at a neural level, chronic hearing loss leads to reduced activation in central auditory pathways, resulting in compensatory increased activation in the cognitive control network, dysfunctional auditory–limbic connectivity, and deafferentation-induced atrophy in frontal brain regions – mechanisms which increase the risk of both cognitive decline (Rutherford *et al.*, 2018). The changes reduce cognitive reserve and increase executive

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dysfunction. These explorations into mechanisms are promising, yet remain in the early stages. Clearly more studies of mechanisms are required.

Do hearing aids slow the progress of cognitive decline in the cognitively impaired? Emerging evidence suggests this may be the case. One group found use of hearing aids were associated in a cross-sectional study of 100 subjects between ages 80 and 99 with improved cognition (Qian *et al*., 2016). Another group compared subjects who were first-time hearing aid users (n = 18) with a hearing-matched control group (n = 14) over a period of 6 months (Karawani *et al*., 2018). The use of hearing aids enhanced working memory performance and increased cortical response amplitudes. Neurophysiologic changes correlated with working memory changes, suggesting a mechanism for decreased cognitive function with hearing loss. These results suggest a neural mechanism for the sensory-cognitive connection as described above.

Findings of improved cognitive function with hearing aid use may lead to increased adoption of hearing loss remedies. A group from Great Britain tested whether use of hearing aids was associated with better cognitive performance, and if this relationship was mediated via social isolation and/or depression using the UK Biobank data set with over 160 000 subjects. They found that hearing aid use was associated with better cognition independent of social isolation and depression (Dawes *et al*., 2015). Not all studies, however, reveal a positive outcome with the use of hearing aids. In a controlled randomized trial of 51 subjects, investigators found no positive benefit of hearing aid use after 6 months follow-up among subjects 68 years of age and older (Nguyen *et al*., 2017). The evidence for improving cognition via the use of hearing aids is promising but sparse at present. A large-scale trial (The ACHIEVE study) is underway to further explore the potential for intervention using hearing aids (Deal *et al*., 2017). To date there is no evidence from empirical, well-controlled studies suggesting other modes of intervention to be of benefit among persons with hearing loss for improving or retarding decline in cognition.

Depression

Hearing loss has long been associated with depression. Investigators in one early study identified a fourfold increase in symptoms of anxiety and depression in those with hearing loss when compared with the general population (Thomas, 1984). In a community sample of 5832 subjects from Korea, self-reported hearing loss was associated with significantly higher rates of depression and this association was magnified among those with dual hearing and visual impairment (Han *et al*., 2018). Results of the Health ABC study (described above) determined that subjects reporting impaired/worsening hearing had a trajectory compared with controls for increased depressive symptoms when they were followed for 5 years (Brewster *et al*., 2018). At year 5, individuals with increased depressive symptoms had greater hearing loss measured by audiometric threshold for low-frequency and mid-frequency sounds compared with those with lower levels of depressive symptoms. In a study of NHANES data, both speech-frequency hearing loss and high-frequency hearing loss were associated with increased frequency of depression using the PHQ-9 (Scinicariello *et al*., 2018).

In a recent review, however, investigators suggest that the longitudinal data supporting a causal relationship between hearing loss and depression are mixed though suggestive (Rutherford *et al*., 2018). The authors speculate further that behavioral mechanisms could explain in part these associations, such as older adults withdrawing from situations in which they have difficulty hearing and communicating. This in turn may contribute to social isolation, loneliness, and consequent cognitive decline and depression as described above. Overall, however, the evidence is positive for an association between hearing loss and depression. Nevertheless, the direction of the relationship is not always clear.

Rutherford *et al*. (2018) suggest the following possible neurobiological mechanism for this association. Chronic hearing loss may lead to a reduced activation in central auditory pathways. This in turn may result in an increased activation of the cognitive control network, interruption of auditory–limbic connectivity, and atrophy in frontal brain regions secondary to deafferentiation. The result is increase depression risk results because cognitive reserve and executive dysfunction are compromised and therefore contribute to emotional dysregulation. Yet empirical evidence supporting specific mechanisms are limited and we are only at the frontier of understanding these mechanisms.

Few data are available that demonstrate effective unique interventions for the depressed with hearing loss. Improving hearing through the available interventions such as hearing aids coupled with psychotherapy (when possible) and psychotropic medications is the obvious current best approach to treatment. Antidepressants are not generally considered ototoxic. Yet empirical evidence for particular interventions leading to lower frequency of depression remains to be demonstrated.

Anxiety disorders

A number of population-based studies demonstrate an association between anxiety disorders and hearing loss, most focusing upon generalized anxiety disorder. Investigators using data from the Health ABC study (described above) investigated the cross-sectional relationship between hearing loss and anxiety symptoms. Compared with individuals who reported no hearing loss, the odds of prevalent anxiety were higher among individuals with mild hearing loss (1.32) and the odds increased as the hearing loss worsened (1.59). Hearing aid use did not decrease the odds of anxiety (Contrera *et al*., 2016). In contrast, investigators in Norway found no relationship between self-reported hearing loss and anxiety in a longitudinal study (n = 2890 community-dwelling subject 60+ years of age) (Cosh *et al*., 2018). In a longitudinal population study of 10 566 adult Taiwanese, investigators exploring a reversed causal relationship, found an increased risk of sudden hearing loss among those with anxiety disorder (Chung *et al*., 2015). Overall, the evidence favors an association between anxiety and hearing loss with intriguing questions about the direction of causality. We know virtually nothing about mechanisms or we found no empirical studies suggesting that a particular intervention might reduce anxiety. Yet adults who have difficulty hearing would be suspected to be more anxious in social situations if they cannot follow conversations and subsequently feel more isolated and perhaps at risk of missing conversation that could be essential to their social functioning.

Psychoses

Among the oldest reports of an association between hearing loss and psychiatric disorders are those which have investigated the association of hearing loss and psychoses. Over 50 years ago, Kay and Roth attempted to determine if deafness, when

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accompanied by abnormalities of personality and loss of multiple relatives, led to greater social isolation in a paraphrenic population of older adults from Great Britain compared with older adults with a mood disorder. They found that impairment in hearing was present in 40% of the British paraphrenic patients, and in 15% the impairment was marked (Kay and Roth, 1961). Felix Post later reported, from a sample of 72 patients with paranoid disorder, that 25% experienced hearing loss compared with 11% of controls (Post, 1966). Based on these early publications, despite their methodologic limitations, a belief emerged among psychiatrists that hearing loss is associated with paranoid psychoses. More recent literature, however, does not demonstrate such a clear relationship though an association has persisted in most studies.

In a recent meta-analyses of epidemiologic studies, investigators identified hearing loss as a risk for all psychosis outcomes assessed, including hallucinations, delusions, other psychotic symptoms, and delirium though the ORs were relatively small. Early onset of hearing loss led to an increased risk for schizophrenia later in life. Potential mechanisms underlying this association included loneliness and disturbances of source monitoring (locating the source of sounds and interpreting these sounds) (Linszen *et al*., 2016). In another study, self-reported hearing loss was associated with increased frequency of psychotic symptoms among younger persons using a hearing aid, but not older adults (van der Werf *et al*., 2007). The evidence, though mixed, points toward an association.

A possible link between paranoid psychoses and hearing loss is the frequency of auditory hallucinations in persons with hearing loss. A group in Canada surveyed 125 older adults referred to an audiology department (Cole *et al*., 2002). In this sample, the prevalence of auditory hallucinations was 32.8% and the types of hallucination varied widely and included humming or buzzing (35.9%), shushing (12.8%), beating or tapping (10.6%), ringing individual sounds (15.4%), multiple sounds (12.6%), voices (2.5%), or music (2.5%). Many of these 'hallucinations' are not hallucinations that we associate with psychiatric disorders. In addition, even auditory hallucinations are not always a hallmark of psychotic disorders (Waters *et al*., 2018).

Investigators in a small study explored possible biological links between hearing loss and psychoses (Gevonden *et al*., 2014). D2/3 binding was compared in normal adults and the hearing impaired, searching for a possible mechanism by which hearing loss may contribute to psychotic symptoms. The participants with hearing loss were more likely to experience feelings of social defeat and loneliness than healthy controls, but they did not differ from healthy controls in baseline psychotic symptoms. There were no significant group differences in baseline D2/3 receptor binding. However, repeated-measures multivariate analysis of covariance with age and tobacco smoking as covariates found a greater amphetamine-induced striatal dopamine release among the participants with hearing loss than the healthy controls. After amphetamine administration, the participants reported more changes in affect than the healthy controls, but no greater increase in psychotic symptoms. Likewise, reports of social exclusion and an increase in psychotic symptoms were not associated with dopamine release.

Yet another theory regarding the association of hearing loss and psychotic symptoms involves the complexity of the social environment (van der Werf, 2010). To test this hypothesis, investigators explored whether increased vulnerability for psychosis could be found in individuals with hearing loss as a consequence of a decreased ability to form correct representations of the social world and attributions of intention of others, characteristics necessary in a more complex environment. Complexity was operationalized as living in an urban as opposed to a less dense population area among over 3000 subjects. The association between hearing loss and psychosis was conditional on population density. The investigators concluded that the level of complexity of the social world interacting with the individual's ability to correctly process this information via their ability to hear increased the risk for psychotic symptoms. Mechanisms therefore have been explored and though these explorations are preliminary, they are intriguing and call for further research.

Despite the lack of empirical studies of intervention, when appropriate, antipsychotic medications should be administered to persons with psychoses and hearing loss as there is no significant increase in ototoxicity with these medications. Improving the hearing capacity, perhaps with hearing aids or other interventions, should be introduced concurrently if not initially though empirical evidence of reducing psychoses by the use of hearing aids is not available.

Quality of life

In a recent literature review, investigators found general consensus that hearing loss reduced the generic quality of life (QoL) among those impaired, not an unexpected finding (Nordvik *et al*., 2018). Among 13 articles which met search criteria, the authors also found that the measures of QoL were highly associated with symptoms of depression and anxiety reviewed above. Data from one study included in the review derived from the Beaver Dam Study with over 2500 middle-aged and elderly subjects. Subjects were assessed for QoL by using measures of activities of daily living (ADLs), instrumental ADLs (IADLs), and the Short Form 36 Health Survey (SF-36) (Ware and Sherbourne, 1992; Dalton *et al*., 2003). Twenty-eight percent of subjects had a mild hearing loss and 24% moderate-to-severe hearing loss. Severity of hearing loss was significantly associated with having a perceived hearing handicap and with self-reported communication difficulties. Individuals with moderate-to-severe hearing loss were more likely than individuals without hearing loss to have impaired ADLs and IADLs. These problems significantly impaired quality of life as measured by the SF-36.

Treatment of psychiatric disorders associated with hearing loss

Virtually no evidenced-based psychotherapeutic treatments are currently available for persons with psychiatric disorders associated with hearing loss. In one preliminary trial, investigators found a trend supporting the use of cognitive behavioral therapy to treat the mental distress associated with hearing loss (Williams *et al*., 2015). Another study provides preliminary support for the use of psychotherapy to improve compliance in the use of hearing aids (though the evidence is weak) (Armitage *et al*., 2017). Despite the lack of a strong evidence base, psychotherapy should be employed when feasible to treat the hearing impaired who experience comorbid psychiatric problems. The challenges are obvious, namely that the hearing impaired may not fully understand the comments of the therapist (even instructions about the use of medications) or will have difficulty expressing the emotional pain secondary to dual challenge of experiencing this pain, yet also perceiving that the therapist is not speaking loud enough

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or clear enough to be understood by the patient. The therapist in turn may become frustrated that she cannot communicate effectively with the patient with hearing loss.

Given that none of the medications typically used to treat psychiatric disorders are known to cause major problems with ototoxicity, there is no reason not to use these medications judiciously. Some evidence suggests that drugs used to treat erectile dysfunction may lead to ototoxicity, however (FDA, 2007). Before prescribing a medication, the clinician should determine to what extent other forms of therapy, such as efforts to improve hearing and therapy to assist the patient in adjusting to the hearing loss, as noted above. The role of antidepressants and hearing loss has received sporadic attention by the hearing health care community. In recent years, interest has arisen in the potential effect of antidepressant medications to both prevent and/or improve hearing loss. In one study, doxepin mitigated neuronal damage in the primary auditory cortex of mice by correcting overactivation of acid sphingomyelinase which catalyzes the generation of ceramide. Increased levels of ceramide can lead to cell death in the inner ear (Su *et al*., 2017). In a small study, citalopram, however, did not improve central auditory processing disorder (Polanski *et al*., 2017). Yet another small study, however, did provide evidence of improvement in auditory processing disorder after 60 days including pure tone audiometry, speech discrimination, and identification of speech (Cruz *et al*., 2004). The evidence for the effectiveness of antidepressants to decrease hearing loss, however, is sparse yet an area for further exploration.

Mental health professionals should be aware of the current treatment approaches to hearing disorders. Given this knowledge, they should refer their patients to appropriate specialists. Otolaryngologists, audiologists, and hearing instrument specialists all provide services to adults with hearing loss. All three professions can prescribe hearing aids. Otolaryngologists often work in concert with audiologists to provide in-depth evaluation of the hearing loss. In the most severe cases, cochlear implants (described below) are an option available through the otolaryngologist. Treatment of hearing loss does not stop with technological assistance. Auditory rehabilitation is an evidence-based intervention (Chisom and Arnold, 2012). These programs are designed so that individuals learn to adapt to their hearing loss, become familiar with hearing assistive technologies, learn strategies for better listening and communication, and provide psychosocial support (NASEM, 2016, pp. 86–88). The programs can be group based or individualized. Audiologists as well as speech and language pathologists can administer these programs.

When evaluating a patient with hearing loss, the first step is to determine whether the hearing loss is one that may represent an emergency or which can be corrected easily. Every clinician should be aware of these emergent conditions, labeled 'red flag' conditions by the FDA (FDA, 2003). The most common is cerumen impaction (unilateral or bilateral) which can be treated by a primary care provider, audiologist, otolaryngologist, or even self-removal with ceruminolytics or irrigation. Other red flag conditions include active drainage from the ear; sudden onset or rapidly progressing hearing loss; acute or chronic dizziness; sudden or rapidly progressive hearing loss in one ear; and pain or discomfort in the ear. Each should lead to a referral to a physician who has experience treating hearing problems. Sudden unilateral hearing loss should trigger immediate referral to an otolaryngologist because it may be the primary symptom of an acoustic neuroma.

Hearing aids are the standard treatment for mild-to-severe hearing loss. They are expensive, costing around $4700 for a pair of medium-range aids in the USA in 2013, this cost including both the hearing aid itself as well as the services of the audiologist or hearing instrument specialist (Strom, 2014; Blazer, 2018). Most insurance carriers, including Medicare, do not cover the cost of hearing aids in the USA. Some (but not all) types of hearing aids are available free of charge by the Veterans Administration and by the National Health Service in Great Britain. The average life expectancy of a hearing aid is about 5 years. Therefore, cost can be a critical barrier to hearing aid use.

To complicate matters further, many who have purchased or provided free hearing aids do not use them following initial adjustments. Reasons for non-use include the perception that hearing aids are not effective, difficult to fit (adjustment of the hearing aid to the proper pitch and frequency), maintain (such as changing batteries), stigma, as well as ongoing costs of batteries, maintenance, and repair. Frustration with hearing aids may lead individuals to decide that they can manage without (McCormack and Fortnum, 2013). In a sample of the 50+ years of age from the National Health and Nutrition Examination Study, 3.8 million Americans wore hearing aids, yet only 14.2% with hearing loss used them (Chien and Lin, 2012). In a Cochrane review, slight evidence was found for increased use among persons who were able to better self-manage their hearing aids (Barker *et al*., 2016).

Bipartisan legislation was introduced recently by Senators Warren and Grassley to permit the sale of over the count hearing aids and the legislation passed congress with wide margins (Warren and Grassley, 2017). The FDA is in the process of drafting legislation to regulate these devices and that regulation would insure protection against problems such as sound intensity being set dangerously high. In the meantime, Personal Sound Amplification Products (PSAPs) are widely available and advertised frequently in the media. They cannot be recommended as a hearing aid substitute at present. Many persons do purchase them and some may meet the standards for a future over-the-counter hearing aid.

Additional hearing-assistive technologies are available. Cochlear implants (a device is placed in the inner ear to improve the perception of sound for persons who do not benefit from amplification) can be a very effective means of improving hearing for those with severe-to-profound hearing loss. The placement of the internal portion of the cochlear implant is a surgical procedure that lasts about 1.5–2 h and requires a general anesthetic. This procedure can be safely performed in most older adults.

One promising yet underutilized technology that can improve the benefit of hearing aid technologies is the installation and use of hearing induction loops and telecoils. This combination connects wirelessly the sound system in a room via a telecoil in the individual's hearing aid. The induction hearing loop can be installed with wiring around the perimeter of the room that connects to the room's sound system (ideal for group gatherings where speakers use microphones such as worship services). This connection reduces background noise and improves the clarity of sound (NASEM, 2016, pp. 162; 39). Telecoils and induction loops are almost universally available for hearing aids in Europe.

Other promising approaches to hearing loss are on the horizon. Therapies are being developed which target the regeneration of cochlear inner hair cells. At least three approaches are under investigation (Patel and McKinnon, 2018). Gene therapy, for example, has focused in part on the role of the Atoh1 transcription factor. Atoh 1 expression leads to the growth of hair cells as well as neurogenesis (Birmingham *et al*., 1999). Pharmacotherapy has also been explored to enhance key signaling pathways, such as

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the Wnt system (Shi *et al*., 2012). Stem cells may also hold some promise. For example, mesenchymal stem cells have been shown to enhance cochlear spiral ganglion neurons and restoration of some improved auditory brainstem response (Bas *et al*., 2014).

Conclusion

Mental health professionals must become more sensitive to those 'silent' disabilities which complicate the treatment of psychiatric disorders. The association between hearing loss and the disorders is well established and increasing evidence is emerging that suggest the sensory impairment contributes to if not precipitates the disorder. Psychiatrists, psychologists, and other trained specialists are in an ideal position to both identify these impairment as they relate to psychiatric disorders and to refer patients/clients to appropriate services. With adequate knowledge of the services, these professionals can facilitate the use of those services available, especially hearing aids. Just as with psychiatric treatments, the treatment of hearing loss has progressed markedly in recent years yet has much further to go.

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