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A Systematic Review of Dual-Sensory Impairment in Older Adults

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A capstone research project submitted to the Graduate Faculty in Audiology in partial fulfillment of the requirements for the degree of Doctor of Audiology, The City University of New York

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This manuscript has been read and accepted for the Graduate Faculty in Audiology in satisfaction of the capstone project requirement for the degree of Au.D.

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Abstract

A SYSTEMATIC REVIEW OF DUAL-SENSORY IMPAIRMENT IN OLDER ADULTS

by

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The elderly population (ages 65 years and older) in the United States is estimated to double between 2000 and 2030 to approximately 72 million people. Among this population, sensory impairment is a chronic disability. The combination of both hearing and vision impairment, referred to as dual-sensory impairment (DSI) is a chronic condition on the rise. The prevalence of DSI ranges from a low of 1.6% to as high as 22.5% depending on the population (Appollonio et al., 1995). Higher prevalence rates tend to emerge in populations receiving rehabilitative and hospital care. DSI impacts independent physical function and verbal communication, along with social and emotion well being (Schneider, Gopinath, McMahon, Leeder, Mitchell, & Wang, 2011). Persons with DSI have difficulty independently performing activities of daily living and are at increased risk for cognitive decline, depression, social disengagement, falls, comorbid chronic conditions, and mortality.

This systematic review focuses on the literature examining mental and physical risks of hearing loss, visual acuity loss, and dual-sensory deficits. The literature supports the hypothesis that persons with DSI are at greater risk for cognitive and physical decline, as well as for increased difficulty participating in social and functional activities. The greater the severity of the loss, especially vision, the faster the rate of decline and/or appearance of symptoms. The literature also supports potential benefit of identifying and

rehabilitating older adults with DSI utilizing self-report measures, such as the MOS 36-Item Short-Form Health Survey, the Hearing Handicap Inventory for the Elderly, and the Dizziness Handicap Inventory. These questionnaires will help clinical audiologists provide long-term patient-centered aural rehabilitation for disabilities emanating from DSI.

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Abbreviations

DSI=Dual Sensory Impairment

SSI=Single Sensory Impairment

HI=Hearing Impairment

VI=Vision Impairment

dB HL=Decibels Hearing Level

ADLs=Self-care personal activities of daily living

IADLs=Instrumental activities of daily living

MMSE=Mini Mental State Examination

SF-36= MOS 36-Item Short-Form Health Survey

HHIE=Hearing Handicap Inventory for the Elderly

DHI=Dizziness Handicap Inventory

HRQoL=Health-Related Quality of Life

PROMs=Patient Reported Outcome Measures

PTA=Pure-tone average

FoF=Fear of Falling

NHIS=National Health Interview Study

CVD=Cardiovascular Disease

OR=Odds Ratio

INTRODUCTION

The elderly population, ages 65 years and older, in the United States is set to double between 2000 and 2030 from 35 to 72 million (Schneider, Gopinath, McMahon, Leeder, Mitchell, & Wang, 2011). This is a trend reported globally. Developed countries support a greater number of older adults, however, the growth rate for this population is faster in less developed countries; 51% projected growth rate in developed countries versus a whopping 140% in less developed countries. In year 2030, the elderly population will comprise 13% of the world's total population. To put that into perspective, the older adult population will supersede that of children aged 5 years and under. In 2006, the United States elderly population was the second largest in the world after China, totaling approximately 38,690,169 million people (Weinstein, 2013).

As the former population grows and life expectancy increases, the risk of developing chronic disabilities goes up. An example of a chronic disability is sensory impairment.

The two types of sensory impairments that will be addressed in this systematic review are uncorrected hearing and vision impairment. The combination of both disabilities will be hereby referred to as Dual-Sensory Impairment (DSI). Single-sensory impairment (SSI) is either hearing or vision loss, and no impairment would be classified as persons without physical/functional limitations. Appollonio et al. (1995) found the prevalence of DSI to be as low as 1.6% and as high as 22.5% in varying populations. Higher prevalence rates were reported among urban populations for persons receiving hospital, rehabilitation, and care services (Schneider et al., 2011).

What populations of older adults are at risk for dual-sensory impairment?

The DSI population is important to consider due to the impact these sensory deficits have on quality of life, physical abilities, social and activity engagement, cognitive function, mortality, depression, and fear of falling. Corrective lenses, surgical interventions, and hearing aids are either not applicable to the majority of persons or an insufficient method of rehabilitation when not accompanied by ongoing counseling and assessment. Dual-sensory impairment not only impacts independent physical function and dexterity, but emotional sensitivity and social communication abilities as well. Crews and Campbell (2004) conducted a quantitative study of 9,447 individuals ages 70 years and older, and found that persons with DSI were less likely than those with no or single sensory impairments to be involved with social activities, such as going to the movies, eating at restaurants, and attending religious services. These older adults reported increased functional effects, fatigue, anxiety, and lack of engagement. It should be noted that in this study, persons with sole visual impairment participated less actively than those with hearing impairment only (Schneider et al., 2011).

Dual-sensory impairment impacts both mental and physical health. Poorer mental health increases the likelihood of negative self-perceptions of both hearing and vision sensory abilities. Other variables that impact self-perception are socio-demographics, education, lifestyle, age, functional disability, social engagement, isolation, and comorbid chronic medical conditions (Kiely, Anstey, & Luszcz, 2013). It is important to keep these potentially confounding variables in mind when reviewing data based on self-report survey distribution/collection. Kiely et al. (2013) found that older adults reported poorer mental health only when there was DSI. DSI prevalence minimized social engagement, which was found to be associated with higher rates of depression. These researchers illuminated a need for services, care facilities, and rehabilitation programs to be available for and specifically geared towards individuals with DSI.

Hearing Impairment (HI)

Hearing impairment, as referenced throughout the reviewed studies, can be defined by degree of severity and type of loss. The type of age-related hearing loss in these studies is sensorineural, caused by a decreased number of functioning hair cell receptors in the organ of Corti. Genetic predisposition, noise exposure, and ototoxicity can play a role in this type of hearing loss (Weinstein, 2013). Lin et al. (2013) illustrated that participants with hearing loss at baseline had a 24% greater risk of cognitive impairment than normal hearing individuals did. In addition, the greater the severity of hearing loss, the faster the annual rate of cognitive decline, which included executive function and psychomotor processing speed. In age-related sensorineural hearing loss, hair cell degeneration typically begins at the basal end of the cochlea, tonotopically responsible for high frequency sounds. In terms of speech, vowel information resides in the low frequencies, whereas consonant information is obtained in the mid-to-high frequency range. As an individual's access to speech signals decrease, the need for repetition and contextual information becomes more critical. Atrophy of the auditory organs, nerve, and central auditory processing occurs at different rates in individuals (Weinstein, 2013). The longitudinally designed studies are engineered to administer assessments over a span of years in attempt to adequately capture deterioration of the brain's integrity and its effect on both physical and mental function.

Reliable clinical hearing assessments were performed on all study participants by licensed audiologists in soundproof booths. Calibration standards for equipment complied with the International Standards Organization protocol 389 (1991). The calibrated audiometer used in most studies was the Madsen OB822 audiometer. Air-conduction thresholds were obtained from 250-8000Hz in both ears, and bone conduction thresholds were tested from 250-4000Hz, including octave and inter-octave frequencies (.25, 0.5, 1, 2, 3, 4, 6, 8k Hz). Bilateral hearing impairment was calculated by the pure-tone averages (PTA) of hearing thresholds at 500, 1000, 2000, and 4000Hz in each ear. The Blue Mountains Hearing Study (BMHS), conducted from 1997 to 2004, defined hearing loss as a PTA > 25dB HL, with a moderate-to-severe hearing loss as a PTA > 40dB HL (Schneider, Gopinath, McMahon, Teber, Leeder, Wang, & Mitchell, 2012). Some studies recognized a high-frequency PTA of hearing thresholds at 1000, 2000, and 4000Hz due to its stronger correlation with speech understanding in background noise (Smith, Bennett, & Wilson, 2008).

Hearing impairment can negatively impact ones health in multiple ways. Age-related changes in the cochlea and auditory portions of the central auditory system impair auditory perceptions of sounds and speech communication abilities. It was generally noted via self-report if a participant wore hearing aids, however, testing was always performed without aids. Auditory deficits require increased listening effort and use of cognitive resources for speech understanding regardless of hearing aid usage (Weinstein, 2013). A few risk factors for developing concurrent vision and hearing impairment in older adults include cigarette smoking and type 2 diabetes. Smokers are 50% more likely to have hearing loss than non-smokers are, and smoking is also a risk factor for the development of macular degeneration and cataract. Type 2 diabetes increases both degeneration of hair cells in the cochlea and the risk of developing diabetic retinopathy and/or cataract due to the microvascular complications associated with diabetes (Schneider et al., 2012).

Vision Impairment (VI)

The World Health Organization (WHO) defines blindness as "profound vision impairment with best-corrected visual acuity worse than 20/400, low vision (or moderate-severe vision impairment) as visual acuity between 20/70 and 20/400, and normal to near-normal vision as 20/60 or better in the better eye," (Smith et al., 2008, p. 601).

Vision impairment can be defined across the studies reviewed as less than 20/40 uncorrected visual acuity in the better eye (Schneider et al., 2011). Elderly patients may present with vision loss due to four common causes: age-related macular degeneration (AMD), glaucoma, cataract, and diabetic retinopathy. AMD is the most common cause of vision loss in this population, and there are two types: nonexudative "dry" AMD and exudative "wet" AMD. 90% of the population with AMD has the nonexudative category of the disease. While less common, exudative AMD causes more severe vision loss (Quillen, 1999).

In general, AMD patients present with blurred vision, distortion of images/writing, and central scotoma. Common forms of nonexudative AMD include drusen and geotrophic atrophy. Drusen are deposits of extracellular material on the macula, which generally occurs in both eyes. Some patients with drusen deposits can be asymptomatic, while it can result in blurred or distorted vision for others. Geographic atrophy presents as rounded patches of atrophy on the retina, retinal pigment epithelium, and choroid. This can occur in one or both eyes. These patches of atrophy can grow larger and cause blurred or distorted vision, a need for increased lighting for reading or driving-type performance tasks, and a loss of visual acuity. Exudative AMD, occurring in ten-percent of the population, is a growth of fluid/blood vessels from the choroidal circulation to the subretinal area, which leak into the macular and cause blurred or distorted central vision (Quillen, 1999).

Glaucoma is caused by glaucomatous optic nerve damage and visual field loss. Glaucoma is a leading cause of blindness, causing vision loss in an estimated 1 million Americans over the age of 65 and is the cause of legal blindness in 75% of this population. The most common form of glaucoma is primary open-angle glaucoma, which is a chronic, progressive disorder that becomes symptomatic after significant visual field loss. Aside from visual field loss, it can also cause uncomfortable intraocular pressure. Family history, age, myopia, hypertension, and diabetes are all risk factors for both men and women developing primary open-angle glaucoma. Glaucoma can cause systemic side effects, such as hypotension, headache, arrhythmia, fatigue, depression, back pain, and weakness (Quillen, 1999).

Cataract becomes more prevalent with age (from 5% to 50% of persons 75 years of age and older), and is the leading cause of blindness worldwide and the most common cause of vision impairment in the elderly population. It is characterized by lens opacities that blur vision, glare, and monocular diplopia. However, unlike the other causes of vision loss, cataract can be safely removed with surgery. Cataract surgery, covered by Medicare, is performed in over 1 million persons per year. If no comorbidities exist, cataract surgery can be successful in helping to restore both vision and quality of life for the sufferer (Quillen, 1999).

Lastly, Diabetic Retinopathy is caused by poor retinal circulation, which can be characterized by intra-retinal hemorrhages, microvascular abnormalities, and retinal edemas and exudates. This is the most common cause of blindness for middle-aged Americans, and its prevalence increases with worsening of diabetes symptoms. The most common form of diabetic retinopathy is the non-proliferative macular edema. Some patients with this can by asymptomatic, while others will experience retinal thickening and distorted central vision. A proliferative diabetic retinopathy can be caused by proliferations of new blood vessels from the optic disc, retina, or retinal ischemia. This type of proliferation can cause hemorrhages and/or retinal detachment. Early detection and treatment, such as glucose monitoring or diabetic laser therapy can help reduce the risk of vision loss (Quillen, 1999).

Dual-Sensory Impairment (DSI)

Brennan et al. (2005) utilized data from the Longitudinal Study on Aging (which included 5,151 people ages 70 years and older) to conclude that for persons with DSI, visual impairment had more of an impact than hearing impairment on limiting activities of daily living (Schneider et al., 2011). Activities of daily living (ADLs) can be defined as solo functional tasks, such as grooming, eating, dressing, bathing, toileting, walking, getting outside, and getting in/out of a bed or chair (Kiely et al., 2013; Brennan, Horowitz, & Su, 2005). According to Kiely et al. (2013) instrumental activities of daily living (IADLs) should also be included when assessing a person's function. These activities include the following: laundry, housework, home maintenance, cooking, using the telephone, managing finances, navigating public transport, shopping, and writing. For many of the studies reviewed, the Short Form Health Survey (SF-36) was distributed to participants to self-assess functional capabilities.

The SF-36 is a standardized, validated survey comprised of 36-items designed to assess eight mental and physical health concepts (See Appendix A). These concepts include the following: health-related limitations on physical activities, physical or emotion-related limitations on social activities, physical health-related limitations on usual role activities (work or daily activities), emotional stability-based limitations on usual role activities, physical body pain, overall state of mental health, vitality, and general health and well being perceptions. The SF-36 questionnaire can be administered via post-mail or by trained professionals in clinic. This multi-item questionnaire was adapted from the original 20-item Medical Outcomes Study (MOS) short form, and it is scored using the Likert method of summated ratings. To adjust for ceiling and floor effects, items can be eliminated depending on the population under assessment. The SF-36 was utilized in the majority of reviewed studies for recording the mental and physical functions of the DSI population (Ware & Sherbourne, 1992).

Daily living activities are more challenging for the DSI population due to the many areas impacted by sensory deficit on top of a decline in biologic functions due to the natural human aging process. Cultural, environmental, education, and genetic factors all affect the aging process, as well as intellectual functioning in later years

(Lindenberger & Baltes, 1994). The elderly U.S. population of over 10 million residents lives with four or more chronic health conditions (Weinstein, 2013).

Lin et al. (2004) noted the DSI population is at greater risk of experiencing cognitive decline, as measured by the Mini Mental State Examination (MMSE), when compared to those with no sensory impairment or single sensory impairment (Schneider et al., 2011). With aging, cortical plasticity is reduced and persons with DSI have less access to sensory stimuli needed for active cognitive training of the brain. Sensory loss, while generally peripheral in its effects, indicates central nervous system deterioration that may negatively impact both metabolic and intellectual functioning of the brain. The Lindenberger & Baltes (1994) concluded that sensory impairment had a significant impact on intellectual changes accompanying increased age, and that age had a more significant impact on visual acuity than it did on auditory capability over time. These intellectual changes, both crystal and fluid, were further categorized into the following five cognitive abilities: speed, reasoning, memory, knowledge, and fluency. In addition to vision and hearing, balance-gait predicted a similar decline in intellectual function in older age. Aside from physiological deterioration in the brain, sensory deprivation is thought to play some role in decreased intellectual functioning due to a reduced likelihood that the individuals will have "cognitively stimulating interactions with their environment," (Lindenberger & Baltes, 1994, p. 352).

It is critical for clinicians to understand the potential effects of dual-sensory impairment on an individual's mental and physical function for adequate assessment and patient-centered rehabilitative care. The SF-36 survey, Hearing Handicap Inventory for the Elderly, and Dizziness Handicap Inventory are just a few standardized and validated ways to obtain ongoing self-report assessment of function and quality of life information on patients. Gilligan & Weinstein (2014) pointed out that aside from comorbid health conditions that become more common with aging, older adults with sensory loss may have health literacy difficulties, cultural/linguistic barriers, low education levels, and lack of internal motivation to follow through with rehabilitation recommendations. Health professionals such as audiologists, ophthalmologists, physicians, physical therapists, psychologists, and social workers have to work together to provide the best comprehensive care for these individuals (Weinstein, 2013).

HYPOTHESIS

The main hypotheses for this literature review are as follows: there is a direct relationship between dual-sensory impairment and poorer health-related quality of life, increased mortality rates, and limitations on activities of daily living. Physical and cognitive functioning is negatively impacted in the older adult population with dual-sensory impairment as compared to persons with single sensory or no impairments. Outcome measure questionnaires can be used as part of a rehabilitative battery to identify mental handicaps, such as depression and fear of falling, and to assist with patient-centered care interventions.

Impacts: Cognitive function, physical activity, fear or falling, quality of life, activities of daily living, mortality and depression

RESEARCH QUESTIONS

The purpose of this investigation is to conduct a systematic review designed to answer the following questions:

What populations of older adults are at risk for dual-sensory impairment?

What are the effects of dual-sensory impairment on quality of life, cognitive function, physical capabilities, mortality, and depression in older adults?

How can clinical audiologists utilize rehabilitative tools to identify older adults with DSI and facilitate patient-centered care?

METHODS

Search Strategy

A database search was conducted for peer-reviewed studies published from 1979 to present, and a total of 42 quantitative articles in English were reviewed. The following databases were accessed: googlescholar.com, CINAHL, NHANES, and PubMed. Of the articles included in this systematic review, four represented cross-sectional data collected from older adult population samples, and nine represented longitudinal studies. These studies were conducted in three different countries, including: United States, Australia, and Iceland. Studies were eliminated if vision loss data was based on corrected impairments, the poorer eye, or was not assessed through visual acuity measures as defined below. For longitudinal studies, it was important to have a large sample, since mortality rates in an elderly population can limit comparison data collection after baseline measures. In addition, other co-morbidities and incidental health ailments may occur more frequently, which can limit eligibility for follow-up data analysis.

Keywords included prevalence, incidence, dual sensory impairment, hearing loss, hearing impairment, vision loss, tinnitus, dual sensory loss, sensory, corrected vision, visual acuity, blue mountains eye study, beaver dam eye study, elderly, mortality, rehabilitation, tinnitus survey, dizziness survey, depression survey, hearing handicap inventory for adults/elderly, glaucoma, cataract, macular degeneration, diabetic retinopathy, noise-induced hearing loss, age related hearing loss, presbyopia, and diabetes. In addition to articles, one textbook was used from a well-respected professional in her field.

Participants

The study selection criteria for inclusion into the systematic review in terms of participants included both male and female adults ages 49 years and older, with the exception of one longitudinal study on mortality that looked at participants ages 18 and older. Variables controlled for at baseline included age, education, history of smoking or alcohol drinking, visual acuity, hearing ability, cardiovascular disease, hypertension, cholesterol, blood pressure, and diabetes. Physical function, general health, cognitive status, depressive symptoms, and community involvement were also significant variables accounted for in selecting participants. Both urban and suburban populations were surveyed.

In terms of sensory impairment; for hearing loss, it was noted whether or not a participant wore hearing aids (unilateral or binaural), and impairment level was assessed without aids. Vision loss was measured on participants without use of corrective lenses or surgical intervention. This eliminated participants who pursued cataract surgery.

Clinical Assessment for Hearing Impairment

In the accepted studies, a professional tested hearing with calibrated equipment in a soundproof booth. Calibration of the equipment was performed on a regular basis in compliance with the International Standards Organization protocol 389. Hearing thresholds were obtained at octave frequencies from 500Hz to 8000Hz (0.5, 1, 2, 4, and 8k Hz). Normal hearing was defined as hearing levels better than 25 decibels hearing level (dB HL) at all frequencies. Hearing impairment was defined as a pure-tone average of greater than 25dB HL for air-conduction thresholds at frequencies 500Hz, 1k Hz and 2k Hz. Unilateral hearing impairment was defined as hearing impairment in one ear with no impairment of the other ear. Bilateral hearing impairment was defined as hearing impairment in both ears. The level of impairment was stated according to the poorer ear with unilateral impairment, and to the better ear in cases of bilateral impairment. Degree of hearing impairment was classified via a three-frequency pure tone average as follows: mild hearing loss from > 25 to ≤ 45dB HL, moderate hearing loss from > 45 to ≤ 65dB HL, and severe hearing loss as > 65dB HL (Chia, Wang, Rochtchina, Cumming, Newall, & Mitchell, 2007).

Clinical Assessment for Vision Impairment

Vision impairment is classified in multiple ways. The studies chosen for this systematic review quantify impairment by measuring for visual acuity, as opposed to contrast sensitivity or visual field. In The Blue Mountains Eye Study, participants had detailed eye examinations, which generally included subjective refraction, a screening visual field test, applanation tonometry, and stereo optic disc photography. Visual fields were measured with a 76-point 30-degree suprathreshold screening visual field test of the Humphrey Visual Field Analyser. Test reliability eliminated participants with fixation losses greater than 20%. Visual acuity was analyzed by quartile, and those who wore glasses kept them on during analysis. Visual impairment was the same as that defined by the Beaver Dam Eye Study: no impairment is vision better than 20/40 (41-70 letters), mild is 20/40 to 20/60 (26-40 letters), moderate is 20/80 to 20/160 (6-25 letters), and severe is 20/200 or worse (less than 4 letters). Data from the better eye was used in the studies reviewed (Boptom, Cumming, Mitchell, & Attebo, 1998).

RESULTS

What are the effects of dual-sensory impairment on quality of life, cognitive function, physical function, mortality, and depression in older adults?

Quality of Life

Three studies were identified and met inclusion criteria for effects of DSI on quality of life in older adults. Table 1 provides snapshots of included studies. All of the studies had large sample sizes with participants ages 55 and older. One of the studies was cross-sectional in design, while the other two were longitudinal. The studies concluded that hearing and vision impairment alone, as well as DSI adversely impact both physical and mental function in older adults. Self-report questionnaires and the SF-36 survey were used to assess the impact of sensory impairment on quality of life and activities of daily living (ADLs and IADLs) for study participants.

Chia, Mitchell, Rochtchina, Foran, Golding, & Wang (2006) investigated the relationship between age-related vision and hearing impairments, as well as the impact of DSI on quality of life, as measured by the SF-36. Both visual and hearing acuity were clinically assessed for the 2334 participants ages 55 to 98 years old. Approximately 75% of these participants had previously been a part of the Blue Mountains Eye Study conducted in Australia. Cataract and AMD were the predominant causes of vision loss. In the current study, 116 participants (65.2%) presented with dual-sensory impairment. Data indicated that participants with hearing impairment were more likely to present with concurrent vision loss than those without hearing loss (odds ratio=1.5). Additionally, older participants were more likely to present with sensory impairment, likely due to physiologic atrophy. Results of the SF-36 indicated that vision loss affects ability to actively engage with physical and spatial surroundings, while hearing loss impacts daily communication and social participation (Chia et al., 2006).

Chia, Wang, Rochtchina, Cumming, Newall, & Mitchell (2007) focused on the relationship between hearing impairment and quality of life in older adults, assessed via the SF-36. Health-related quality of life includes the physical, emotional, and social aspects of being in good health. For example, self-sufficient care, positive mood, personal relationships, and community involvement are all elements of well-being. Data were collected on 2431 participants ages 49 and older. Clinical hearing assessments revealed 1347 participants (55.4%) without hearing loss, 324 participants (13.3%) with unilateral hearing loss, and 760 (31.3%) participants with bilateral hearing loss. Based on self-report of hearing loss, 1187 participants (51%) reported hearing impairment and lower health-related quality of life (Chia et al., 2007).

After controlling for sociodemographic factors and comorbid chronic health conditions, results of the study indicated a significant relationship between bilateral hearing impairment and poor health-related quality of life scores on the SF-36 for both physical and mental function. Cases of severe bilateral hearing loss scored the poorest on the SF-36. However, even though not statistically significant, cases of mild bilateral hearing impairment resulted in lower SF-36 scores as compared with no impairment. SF-36 scores were similar for participants with unilateral hearing loss or no impairment.

Hearing aid users (approximately 25-30% of the bilaterally-impaired participants) had slightly higher SF-36 scores than non-users who were bilaterally hearing impaired, but not to a significant degree (Chia et al., 2007).

Brennan, Horowitz, & Su (2005) examined the impact of both single and dual-sensory impairment in older adults on competent performance of ADLs and IADLs. Sensory impairment and chronic health conditions can impede cognitive and physical ability, making everyday tasks and independent function challenging for older adults. Data on 5151 participants ages 70 and older were obtained from the Longitudinal Study on Aging. Self-assessment was used to measure socio-demographics, physical health, cognitive ability, sensory impairment (hearing and vision), and functional tasks. Based on self-report, 21% of participants had dual-sensory impairment, 15% had only vision impairment, 22% had only hearing impairment, and 43% had no sensory impairment (Brennan et al., 2005).

Results of the impact of DSI on functional tasks were broken down into ADL and IADL categories. The following ADL tasks presented with significantly more risk for mild to moderate dually-impaired participants than for those with no impairments: bathing, dressing, getting outside, and preparing meals (when vision loss was severe). The IADLs tasks of shopping, managing money, using the telephone, and light housework only presented with significantly more risk than for unimpaired individuals when DSI was severe. Most ADL and IADL task measures revealed that risk of difficulty did not significantly increase when going from a SSI to a DSI. Additionally, in most cases DSI increased risk of performance difficulty over hearing impairment and no impairment, but not over vision loss only participants (Brennan et al., 2005).

Table 1. Overview of Studies on Effects of DSI on Quality of Life and Activities of Daily Living in Older Adults

Authors	Sample Size	Age (in yrs) of participants	Study Design	Assessment Tools	Results
Chia, Mitchell, Rochtchina, Foran, Golding, & Wang (2006)	2334	55 to 98 yrs old	Longitudinal	Clinical hearing and vision assessments. SF-36.	Both hearing and vision impairment effect physical and mental function. Participants with hearing loss were more likely to present with visual impairment.
Chia, Wang, Rochtchina, Cumming, Newall, & Mitchell (2007)	2431	Mean = 67 yrs of age	Cross-sectional	Clinical hearing assessment. SF-36.	Bilateral HI was associated with poorer SF-36 scores (mental & physical). The more severe the impairment, the poorer the HRQOL scores.
Brennan, Horowitz, & Su (2005)	5151	70 and older	Longitudinal	Patient report of physical and cognitive health status. Patient report of sensory impairment and functional tasks.	DSI associated with greater difficulty on IADL and ADL tasks than SSI. Cognitive status was a significant variable for ADL and IADL task difficulties.

Cognitive Function

Two studies were identified and met inclusion criteria for effects of DSI on cognitive function in older adults (ages 69 and older). Table 2 provides snapshots of included studies. One of the studies was cross-sectional in design, while the other was longitudinal with a larger sample size. As the brain ages physiological integrity can decline, which has the potential to affect auditory processing speed, speech understanding, listening effort, and information retention. One commonly used and standardized method of assessing cognitive decline is the Mini-Mental State Examination (MMSE).

Lin et al. (2004) conducted a study on older adult women to probe into any association between vision and hearing impairment, as well as their combined effect on cognitive and functional decline. The participants were originally a part of a Study of Osteoporotic Fractures that took place between 1992 and 1994, with the sample drawn from four metropolitan cities. A total of 6,112 women were eligible to participate in the study; both hearing and vision abilities were clinically assessed at baseline, and the MMSE was utilized to measure cognitive ability at both baseline and follow-up. Examinations indicated that 18.2% of participants had vision impairment and 19.9% had hearing impairment. Participants were excluded if they had prior hip fractures or bilateral replacement. Every two years throughout the study's duration clinical examinations and self-report interviews were conducted for updated overall health, lifestyle and dietary risk factors for falls, daily activities, comorbid health conditions, and sociodemographic information (Lin et al., 2004).

Both hearing and vision impairment had significant relationships with increased cognitive and functional decline. A few elements of functional decline included handgrip strength, arthritis, and walking speed. In the multivariate models, the odds ratio (OR) was significant for vision impairment contributing to both cognitive and functional decline (OR=1.78 and OR=1.79, respectively), but not for hearing impairment and functional decline (OR=1.10). However, hearing impairment (with or without hearing aid use) showed a non-significant trend towards an increased decline in cognitive ability (OR=1.38). Participants with DSI had significant odds for both cognitive and functional decline over time (OR=2.19 and OR=1.87, respectively). This study illustrated a significant relationship between hearing loss and cognitive decline, as well as the impact DSI can have on both cognitive and functional abilities in older adults (Lin et al., 2013).

Lastly, Lindenberger & Baltes (1994) utilized a cross-sectional design (N=156) to assess the relationship between hearing, visual acuity, and cognitive function to aging. Balance-gait, overall health, and education were elements considered when predicting intellectual capabilities, of which it was found that balance-gait is the most accurate predictor of both hearing and vision impairment in older age. Data were utilized from an ongoing project on aging sponsored in Berlin, called BASE. This database was composed of a stratified sample of men ages 70-103 years old. Both hearing and visual acuity were clinically assessed; it is important to note that visual acuity was based on corrected vision in this study. Cognitive ability was recorded with 14 tests measuring the following 5 intellectual capabilities: speed, reasoning, knowledge, memory, and fluency.

No significant differences emerged between the independent effects of either visual loss or hearing loss on cognitive function. Additionally, aging was seen to have a greater negative impact on visual acuity, than on hearing. DSI accounted for approximately 52% of variance in intellectual function, while vision alone accounted for only 41.3% and hearing for 34.5%. A significant relationship emerged between vision impairment and poorer scores on cognitive speed-related tasks. It was hypothesized that vision and hearing might be helpful predictors of age effects on cognitive function due to sensory deprivation; especially since individual differences and outside variables need to be accounted for.

Table 2. Overview of Studies on Effects of DSI on Cognitive Function in Older Adults

Authors	Sample Size	Age (in yrs) of participants	Study Design	Assessment Tools	Results
Lin, Gutierrez, Stone, Yaffe, Ensrud, Fink, Sarkisian, Coleman, & Mangione (2004)	6112	Ages 69 and older	Longitudinal	Clinical hearing and vision assessments, MMSE.	Vision impairment at baseline was associated with cognitive and functional decline, while hearing impairment was not. DSI was associated with the greatest likelihood for cognitive and functional decline (in women).
Lindenberger & Baltes (1994)	156	Mean age = 84.9 yrs	Cross-sectional	14 cognitive assessments, including: Digit Letter Test, DSS, Identical Pictures, Figural Analogies, Letter Series, Practical Problems, Practical Knowledge, Spot-a-Word, Vocabulary, Activity Recall, Memory for Text, Paired Associates, Animals, and Letter *S*	Sensory abilities/limitations are strong predictors of late-life intellectual functioning. Vision and hearing acuity may indicate physiological integrity of the brain as it ages.

Physical Function

Two studies were identified and met inclusion criteria for effects of DSI on physical function and fear of falling in older adults. As is evident from Table 3, the studies were cross-sectional in design with participants ranging in age from 49 and older. Approximately one-third of older adults experience one or more falls per year (Boptom et al., 1998). Not only falls, but fear of falling, leads to decreased physical activity and participation in daily activities.

Boptom et al. (1998) conducted a cross-sectional survey of falls in participants with vision impairment. A total of 3299 adults ages 49 and older responded to the health survey and underwent clinical eye examinations to assess visual acuity, contrast sensitivity, and visual field. In response to the survey, 2478 (75.1%) of persons reported no falls, 532 (16.1%) persons reported one fall, 143 (4.3%) persons reported two falls, and 146 (4.4%) persons reported three or more falls within the past 12-months. Participants ages 65 and older composed 29.6% of the reported total number of falls. Boptom et al. (1998) found that poor visual acuity, reduced contrast sensitivity, and decreased visual field were all significant factors for participants reporting two or more falls within a 12-month time span. Late acquired AMD was associated with a 70% increased risk of falling two or more times per year, however, this result was not statistically significant likely due to the small sample size. Cataract, glaucoma and diabetic retinopathy also showed non-significant increased risk of falls in older adults (Boptom et al. 1998).

Nguyen, Arora, Swenor, Friedman, & Ramulu (2015) focused their study on the correlation between visual acuity loss and physical activity. 200 persons with either glaucoma, AMD, or no visual acuity loss between ages 60 and 80 years old participated. Omnidirectional waistband accelerometers were used to measure level and frequency of physical activity for one week’s time, and participants were asked to complete the

Chicago Fear of Falling Questionnaire. Visual field and contrast sensitivity losses were found to be statistically significant predictors of decreased physical activity in visually impaired subjects. In glaucoma patients, a correlation was found between decreased physical activity and increased fear of falling, suggesting that fear of falling mediates the relationship between vision loss and limitation of physical activities.

Table 3. Overview of Studies on Effects of DSI on Physical Function and Fear of Falling in Older Adults

Authors	Sample Size	Age (in yrs) of participants	Study Design	Assessment Tools	Results
Boptom, Cumming, Mitchell, & Attebo (1998)	3654	Ages 49 and older	Cross-sectional	Clinical vision assessment. PROMs. Blue Mountains Eye Study survey.	Vision impairment (poor visual acuity) is correlated with two or more annual falls in older adults.
Nguyen, Arora, Swenor, Friedman, & Ramulu (2015)	200	Ages 60-80 yrs	Longitudinal	Clinical assessment, waistband omnidirectional accelerometer, Chicago Fear of Falling Measure, Salisbury Eye Evaluation Driving Study adapted questionnaire, Early Treatment of Diabetic Retinopathy Study chart, and MMSE.	Increases in FoF are associated with decreased physical activity, and FoF mediates the relationship between vision field loss and physical activity restrictions.

Mortality

Three studies were identified and met inclusion criteria for effects of DSI on mortality in older adults. Table 4 summarizes the studies. Two of these studies were longitudinal in design with large sample sizes of participants ages 65 and older. The third study utilized data from participants ages 18 and older. Overall, it was found that DSI is significantly associated with increased age and greater risk of mortality. When other health-related comorbidities were controlled for in the sample populations, the relationship between sensory impairment and mortality weakened.

Freeman, Egleston, West, Bandeen-Roche, & Rubin (2005) conducted a longitudinal study of the effect of visual acuity change on mortality, not of hearing loss. Persons ages 65 to 84 years old participated. Inclusion criteria included: (1) score greater than 17 on the MMSE, (2) living independently, (3) the ability to communicate. Baseline measures were taken and assessments were performed two years later. All participants in the study received annual follow-up telephone calls throughout the duration of the study.

Participants whose visual acuity was worse at baseline had significant risk of increased mortality. Of the 481 deaths recorded throughout the study, those participants were (on average) older African-American men with worse baseline visual acuity and other comorbid health conditions, such as hypertension or diabetes. After controlling for demographic information, a moderate two-year loss in visual acuity was positively associated with increased mortality risk, especially for participants with worse visual acuity at baseline (Freeman et al., 2005).

Fisher et al. (2014) conducted a study to assess the impact of both hearing and vision impairment on mortality in older adults ages 67 and up. The data were collected from a 1967 population-based study conducted by the Icelandic Heart Association. Clinical hearing and vision assessments were performed on the 4,944 eligible persons between years 2002 and 2006. Of these, 343 persons (7%) presented with DSI, 455 (9.2%) with vision loss only, and 1,250 (25.4%) with hearing loss only. Among the group with sensory impairment, mean age was slightly higher than the control group, and women were significantly more likely than men to have vision impairment (10.5% vs. 7.6%) and vice versa (51.3% vs. 39.8%) for hearing impairment.

Other characteristics of the sensory impaired group included lower education, cognitive impairment, less education, poorer self-reported health, increased depressive symptoms, less functional ability, and higher rates of comorbid health conditions. The follow up period for the study was approximately 3-7 years after baseline measures, and 846 participants passed away in that time; cause of death for 42.6% of persons were attributed to cardiovascular disease and natural aging. Male participants with hearing loss were at a significantly higher risk for cardiovascular disease related-mortality, whereas those with DSI were at greater risk for death by any cause. Additionally, men, smokers, and those with comorbid chronic health conditions were at a greater risk for mortality. Interestingly, Fisher et al. (2014) found that both men and women wearing hearing aids had decreased risk of mortality compared to same-aged peers with severe sensorineural hearing loss who did not wear hearing aids. It was theorized that perhaps less social isolation due to hearing aid use contributed to this decreased risk (Fisher et al., 2014).

Lee et al. (2007) analyzed data from the 1986-1994 National Health Interview Survey on 116,796 persons ages 18 and older. Data was collected annually by either self-report or family report from households in all 50 states of the United States. Researchers hypothesized that concurrent DSI may prevent lifestyle adaptations that could have been achieved if only SSI or none were present. For example, without visual cues, speech processing is more difficult for those with hearing loss. DSI generally reduces physical and social activity engagement and promotes functional and cognitive decline, as well as faster mortality rates. Lee et al. (2007) concluded that moderate-to-severe vision and hearing impairment in women is significantly associated with increased mortality risk, even when other health conditions were controlled for; the findings were less consistent for men.

Table 4. Overview of Studies on Effects of DSI on Mortality in Older Adults

Authors	Sample Size	Age (in yrs) of participants	Design	Assessment Tools	Results
Freeman, Egleston, West, Bandeen-Roche, & Rubin (2005)	1991	Ages 65 to 84 years	Longitudinal	MMSE. Salisbury Eye Evaluation. General health questionnaire.	Worse baseline acuity positively associated with higher mortality rate. Women who gained 2 or more lines of visual acuity over 2 years lowered their risk of dying.
Fisher, Li, Chiu, Themann, Petersen, Jónasson, Sverrisdottir, Garcia, Harris, Launer, Eiriksdottir, Gudnason, Hoffman, & Cotch, (2014)	4926	Ages 67 yrs and older	Longitudinal	Clinical vision and hearing assessments. Geriatric Depression Scale. Patient report of health status.	Male participants with hearing impairment were at higher risk of CVD-related mortality (as compared to no impairment), and those with DSI were at a greater risk of mortality from any health-related cause. Men were impaired at greater severities than women. Male hearing aid users

					had lower risk of any health-related mortality.
Lee, Gomez-Marin, Lam, Zheng, Arheart, Christ, & Caban (2007)	116,796	Ages 18 and older	Cross-sectional	1986-1994 National Health Interview Survey.	As number and severity of impairments increased, so did the relationship between sensory loss and mortality. Associations were stronger for women than men. When controlling for other health conditions, associations between sensory loss and mortality decreased.

Depression

Three studies were identified and met inclusion criteria for effects of DSI on depression and social engagement in older adults. Table 5 summarizes these studies. All of the studies were longitudinal in design with large sample sizes of participants ages 55 and older. Common depressive symptoms included sadness, hopelessness, fatigue, worthlessness, nervousness, and restlessness (Capella-McDonnall, 2005). In general, studies have shown that vision loss alone has a greater impact than hearing loss does on depression.

Capella-McDonnall (2005) reviewed the 2001 National Health Interview Survey (NHIS) data of 9832 persons (representing approximately 54.6 million people) ages 55 and older from the United States to determine whether or not DSI has an effect on depressive symptoms. Of this sample, 6,089 (approximately 33.4 million people) were used in the controlled analysis. Data were collected via self-report of hearing and vision abilities, overall health, socioeconomic status, education, income, functional capabilities (ADLs and IADLs), social engagement, social support, and depressive symptoms. The

NHIS was composed of questions identifying the depressive symptoms listed above, prevalence within the past 30 days, and impact on social engagement and ADLs. While the dependent variable of the study was depressive symptoms, the independent variable was sensory loss, assessed through self-report questionnaires. Of the controlled sample of 6,089 persons, 447 (7.3%) identified with DSI, 541 (8.9%) identified with vision loss only, 1,515 (24.9%) identified with hearing loss only, and 3,586 (58.9%) identified with no sensory impairment. After controlling for independent variables, such as age and poverty, a statistically significant relationship was found for participants presenting with sensory loss and experiencing depression. However, persons with DSI were not more likely than those with vision loss only to experience those symptoms. Dual-sensory impaired participants were more likely than those with no sensory impairments to report depressive symptoms, but this result was not statistically significant ($p=0.079$).

Capella-McDonnall (2009) analyzed the development rate of depressive symptoms in a population with DSI, as well as the potential impact of preexisting SSI on the development of depression over time. The investigator reported that clinical research on the effects of acquired DSI on depression, as well as the effects of developing DSI after previously adjusting to a single impairment is needed. Combined data for this study were obtained from the Health and Retirement Study (HRS) and the Aging and Health Dynamics Study (AHEAD). Data were combined for both studies in 1998, and continued being collected every two years until 2006. The sample size of 2,689 persons with 13,460 observations consisted of two types of participants: people who developed DSI during the duration of the study (total of 1,380 persons), and people who did not report sensory loss during the study (total of 1,309 persons). Stratified random sampling (age and gender controlled) was used to assemble the latter control group. Persons were eliminated from the study if depression data could not be collected from them due to death or absence (Capella-McDonnall, 2009).

Based on the sample size, women and minorities had higher initial scores of depression than men (especially Caucasian). It was also statistically significant that depression occurred at a faster rate with aging for those who developed DSI during the study, than for those who did not. The significant rate of increase was initially large (0.39), then gradually decreased over time. In the Caucasian sample, increase peaked approximately 5.3 years after developing DSI, and at 4.7 years for the minority sample. Persons with vision loss at baseline scored ~0.34 higher on the depression scale than those with hearing loss only or no sensory impairment at baseline; however, the VI baseline sample did not experience a significant change in depression scores over the duration of the study. For men, depressive symptoms increased at first report of DSI, followed by a slower growth rate for the next 5 years. Growth patterns were similar for both men and women, however, women reported DSI later on than the men, and experienced higher initial depression scores (Capella-McDonnall, 2009).

Kiely, Anstey, & Luszcz (2013) clinically assessed hearing and vision loss for 1,611 participants ages 65 to 103 years old. Depressive symptoms were recorded through the Centre for Epidemiological Studies Depression (CES-D) survey, the MMSE was used to assess cognitive function, and physical activities were noted through ADL and IADLs. Corrected visual acuity and hearing loss results sifted participants into four categories: no sensory loss (21.1% of participants), vision loss only (6.5%), hearing loss only (47.2%), and DSI (25.2%). Data were collected approximately 5 times from the Australian sample via. personal interview and clinical assessments over a 16-year period (Kiely et al., 2013).

Participants with DSI had significantly more depressive symptoms on average than those with no sensory impairment. Those with DSI had higher levels of depressive symptoms than those with hearing loss only, and there was no difference in report of symptoms for vision loss only participants versus those with no loss. Researchers summarized that participants were found to be in poorer mental health with increased risk of depressive symptoms only when vision loss was combined with hearing loss (i.e. DSI). Self-report of impairments as well as participation in daily activities were reliable indicators for how individuals were coping with sensory loss, which is important for clinicians engaging in aural rehabilitation for dually impaired patients (Kiely et al., 2013).

Table 5. Overview of Studies on Effects of DSI on Depression and Social Engagement in Older Adults

Authors	Sample Size	Age (in yrs) of participants	Study Design	Assessment Tools	Results
Capella-McDonnall (2005)	9832	Ages 55 and older	Longitudinal	Data obtained from 2001 National Health Interview Survey. Patient report data from NHIS of depressive symptoms. PROMs.	DSI had a significant effect on depressive symptoms. Vision loss alone, not hearing, increased risk of depressive symptoms in similar fashion to DSI.
Capella-McDonnall (2009)	2689	Ages 75 and older	Longitudinal	Shortened CES-D. PROMs.	Significant increase in depression and faster rate of development associated with DSI. Higher depression scores

					for those with DSI than no sensory impairment.
Kiely, Anstey, & Luszcz (2013)	1611	Ages 65-103 yrs old	Longitudinal (16 yrs)	Centre for Epidemiological Studies Depression scale (CES-D) via personal interview, and clinical assessment.	Depression symptoms associated with hearing loss and DSI, not vision loss. Difficulty with ADLs and social engagement illuminate depressive symptoms and sensory impairments.

DISCUSSION

How can clinical audiologists utilize rehabilitative tools to identify older adults with DSI and facilitate patient-centered care?

This systematic review was designed to explore dual-sensory impairment's effects on quality of life, cognitive function, mortality, and depression in older adults, as compared to single or no sensory impairment. These effects are not always outwardly observable, so it is important for audiologists to utilize self-report questionnaires on a consistent and repetitive basis throughout care to identify and monitor how ways patients are affected by DSI. Identification of difficulties and symptoms is key in facilitating discussion between clinician and patient, and in choosing an effective method of aural rehabilitation to address each patient's specific and unique needs.

As illuminated from the results of this review, older adults with chronic sensory impairments tend to have more difficulty interacting with their communities, and healthcare professionals can identify these patients with both quantitative and qualitative measures for more effective patient-centered rehabilitation. Examples of qualitative, patient reported outcome measures (PROMs) that can be utilized in a hospital, ENT, or private practice setting include the Hearing Handicap Inventory for the Elderly (HHIE), the Dizziness Handicap Inventory (DHI), and the MOS 36-Item Short-Form Health Survey (SF-36).

Chia et al. (2007) had participants complete the Hearing Handicap Inventory for the Elderly along with clinical assessment of hearing loss (see Appendix B). Only half of the participants in the study who reported self-perceived hearing loss had measurable hearing loss, however, there were no significant differences in SF-36 scores between participants who had quantifiable hearing loss and those that only perceived loss. This speaks to the value of self-report data, despite its lack of objectiveness and variability in nature (Brennan et al., 2005). Often times, self-perceived hearing loss can change faster and more dramatically than measurable hearing, or a person with mild hearing loss may report great difficulty hearing in noisy environments. Some audiologists will provide amplification set to prescriptive hearing loss, while others will alter gain settings based on patient feedback.

The HHIE allows the audiologist to discover what situations are most bothersome and difficult for patients, as well as the emotional toll of hearing loss. It brings the audiogram to life and aids in understanding how hearing loss has altered both behavior and mood. The three goals of the HHIE are to identify situational and emotional problems associated with hearing loss, determine the need for rehabilitation, and assist in planning aural rehabilitation. The questionnaire is proven to have high internal consistency and high split-half reliability (Weinstein, Spitzer, & Ventry, 1986).

Another benefit of the HHIE is that it can be administered throughout follow-up care. Newman & Weinstein (1988) administered the HHIE both at the hearing aid evaluation and at the one-year follow-up appointment. A significant reduction in self-perceived emotional and social effects was recorded after hearing aid use. These results support the theory that hearing aids can be useful tools in helping older adults achieve more autonomy and independent function, especially when more than one deficit is occurring. As noted in the results section, patients with DSI, or moderate to severe vision impairment along with mild hearing loss are the most likely to be negatively affected in their daily lives.

The Dizziness Handicap Inventory has high test-retest reliability and was developed with the goal of qualifying the impact dizziness, vertigo, and imbalance have on everyday life (see Appendix C). The 25-item survey categorizes self-perceived handicap into three subcategories: functional, emotional, and physical. In small, rural clinics that cannot afford balance-testing equipment, the DHI can be not only a valuable tool for rehabilitation, but for identification of symptoms and difficulties as well. Some patients may appear physically competent in the clinic, yet present with fear of falling due to experiencing even one vertiginous episode. This fear may go unrecognized without discussing or administering the DHI as a part of patient-centered aural rehabilitation protocol. Utilizing this questionnaire, Jacobson & Newman (1990) found that patients with frequent dizziness attacks and imbalance scored lower than those presenting with constant dizziness. Patients with DSI are likely to modify daily activities and behavior, especially when dizziness is present, and the DHI is another way to help identify and rehabilitate these patients in clinic.

The MOS 36-Item Short-Form Health Survey also has high test-retest reliability and internal consistency, as demonstrated by both Brazier et al. (1992) and McHorney, Ware, & Raczek (1994). The SF-36 touches on eight health concepts regarding limitations in mental, social, and functional health (see Appendix A). This survey is a reliable method of obtaining a picture of one's general health, as well as a way to spark conversation regarding impacts of sensory impairment and potential rehabilitative paths. Those with DSI scored lower on the SF-36 throughout the studies reviewed; as severity of impairments increased, so did self-imposed limits on ADLs. Clinicians need to utilize all applicable standardized and validated measures to gather health information on the patient at hand (Ware & Sherbourne, 1992).

Audiologists providing aural rehabilitation to patients with DSI should adapt their counseling to accommodate for both loss of vision and hearing. This is relevant not only to the style of hearing aids chosen, but also in the types of decision aids utilized, communication mode chosen (aural versus manual), and any physical rehabilitation suggested to address fear of falling and activity limitations. For example, a clinician may encourage a patient who has admittedly restricted physical output to participate in activities that will contribute to social engagement. Social engagement helps increase activity levels and overall well being, which in turn reduces fear of falling and isolation. Gallant (2003), among many researchers, identified that self-management of chronic illness can help minimize the negative psychological and physical impacts of the disability. Individuals who maintain engagement in their communities and social networks, and who practice ADLs and IADLs have higher self-efficacy and more intact coping mechanisms for combating effects of DSI. Social support network involvement was found to be directly and positively correlated with promotion of self-management behaviors (Gallant, 2003).

Capella-McDonnall (2005) emphasized the importance of training health care professionals to recognize depressive symptoms to provide targeted rehabilitation and referrals to reinforce high self-efficacy. This training should apply even more broadly to recognizing difficulties with cognitive and physical function, as well as signs of social isolation, fear of falling and self-imposed activity restrictions. In fact, the 2016 Physician Quality Reporting System (PQRS), financed through the Centers for Medicare and Medicaid, requires audiologists to utilize clinical depression and follow-up screeners while evaluating tinnitus complaints. A couple examples of available depression screening tools include the Patient Health Questionnaire (PHQ-9) and the Center for Epidemiological Studies Depression Scale (CES-D). The audiologist reports performance of a screener through ICD-10 CPT codes ("Reporting Audiology Quality Measures," 2016). Re-assessment over time is crucial since new symptoms may appear as illnesses develop or degree of loss increases.

An audiologist focused on delivering patient-centered care will recommend further medical testing if there is a report of dizziness/imbalance. A patient with bothersome tinnitus should be informed about cognitive-behavioral therapy, in addition to hearing aids and noise generators. A patient expressing depressive symptoms should be encouraged to join advocacy support groups, such as the Hearing Loss Association of American ("Hearing Loss Association of America," 2016). It is critical for professionals to inform patients in clinic about community resources, as research shows time and again that older adults on Medicare have a low likelihood of seeking and utilizing medical care services, resulting in poorer health outcomes. Areas of poverty with limited numbers of health professionals have the most at risk populations for lack of preventative medical testing, care, and follow-up rehabilitation and outreach (Asch, 2000).

Limitations of the Research on Dual-Sensory Impairment

Systematic review of the literature identified numerous articles supporting the hypotheses that DSI leads to: (1) a poorer quality of life, which includes decreased social and emotional engagement; (2) cognitive decline; (3) limited physical activities and increased falls per year; (4) greater risk of mortality; and (5) depressive symptoms. As severity of sensory loss increases, especially for visual acuity, so does the significance of negative impact on overall functioning. Hence the impact is dose related. Many of the studies included in the review had methodological flaws, which jeopardized their internal and external validity. Most studies did not control for comorbid health conditions nor did they control for individual's demographic differences. Methodological limitations included mortality, cross-sectional design, and independent variable classification.

Data collection was limited due to the mortality effect, especially since studies focused on the older adult population. Many subjects with severe cases of DSI or/and comorbid health conditions did not complete data collection either due to functional limitations or mortality. Most studies were longitudinal with repeated measurements and reports gathered annually throughout the study's duration. Statistical analysis could only be performed for data collected from each participant at all rounds of assessment. Another limitation was cross-sectional study design, since severity of impairment and symptoms tend to develop and worsen over time for DSI sufferers; cross-sectional studies are not able to capture later health developments. In addition, it was difficult to find researchers who only measured the independent variable "vision impairment" based solely on uncorrected, clinically assessed visual acuity, and who controlled for both demographic and comorbid health conditions that might impact patient's report of difficulties.

CONCLUSION

Based on the systematic review, moderate to severe levels of impairment as well as bilateral hearing and vision loss resulted in poorer quality of life reports and the appearance of depressive symptoms. Unilateral hearing loss or absence of sensory impairment did not impact ADLs or social engagement, but vision loss alone lowered scores. Persons with hearing loss were more likely to present with concurrent visual impairment. Vision and hearing loss were proven to be indicators of late-life cognitive decline. Baseline vision impairment was found to be significantly associated with both cognitive and functional decline, but hearing impairment was not. Fear of falling due to loss of visual acuity resulted in decreased physical activity and increased number of falls per year. Greater and faster mortality rates were associated with vision loss and DSI, however, hearing aid use lowered the risk of health-related mortality. Severity of sensory impairments had a direct relationship with mortality risk, especially when comorbid health problems were present.

Recommendations for dually impaired persons should be patient-centered, and the future of aural rehabilitation can be more effective with a standardized battery of questionnaires used in the office to identify subjective difficulties. There is a need for future research on the efficacy of counseling DSI patients with use of appropriate visual aids versus without, or with caregivers present at appointments versus not. Further research should include comparing and contrasting use of the questionnaires listed above to identify patients with DSI-based handicaps, as well as measuring their value as tools to monitor progress or regression throughout rehabilitation.

Appendix A

SF-36 Items
(Ware & Sherbourne, 1992)

1. In general, would you say your health is:
2. *Compared to one year ago,* how would you rate your health in general *now*?
3. The following items are about activities you might do during a typical day. Does *your health now* limit you in these activities? If so, how much?
   a. *Vigorous activities*, such as running, lifting heavy objects, participating in strenuous sports
   b. *Moderate activities*, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf
   c. Lifting or carrying groceries
   d. Climbing *several* flights of stairs
   e. Climbing *one* flight of stairs
   f. Bending, kneeling, or stooping
   g. Walking *more than a mile*
   h. Walking *several blocks*
   i. Walking *one block*
   j. Bathing or dressing yourself
4. During the *past 4 weeks*, have you had any of the following problems with your work or other regular daily activities *as a result of your physical health?*
   a. Cut down the *amount of time* you spent on work or other activities.
   b. *Accomplished less* than you would like
   c. Were limited in the *kind* of work or other activities
   d. Had *difficulty* performing the work or other activities (for example, it took extra effort)
5. During the *past 4 weeks*, have you had any of the following problems with your work or other regular daily activities *as a result of any emotional problems* (such as feeling depressed or anxious)?
   a. Cut down the *amount of time* you spend on work or other activities
   b. *Accomplish less* than you would like
   c. Didn't do work or other activities as *carefully* as usual
6. During the *past 4 weeks*, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
7. How much *bodily* pain have you had during the *past 4 weeks*?
8. During the *past 4 weeks*, how much did *pain* interfere with your normal work (including both work outside the home and housework)?
9. These questions are about how you feel and how things have been with you *during the past 4 weeks*. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the *past 4 weeks*
   a. Did you feel full of pep?

   b. Have you been a very nervous person?
   c. Have you felt so down in the dumps that nothing could cheer you up?
   d. Have you felt calm and peaceful?
   e. Did you have a lot of energy?
   f. Have you felt downhearted and blue?
   g. Did you feel worn out?
   h. Have you been a happy person?
   i. Did you feel tired?
10. During the *past 4 weeks*, how much of the time has your *physical health or emotional problems* interfered with your social activities (like visiting with friends, relatives, etc.)?
11. How TRUE or FALSE is *each* of the following statements for you?
   a. I seem to get sick a little easier than other people
   b. I am as health as anybody I know
   c. I expect my health to get worse
   d. My health is excellent

SF-36 Response Choices

1. Excellent, Very Good, Good, Fair, Poor
2. Much better now than one year ago, Somewhat better now than one year ago, About the same as one year ago, Somewhat worse now than one year ago, Much worse than one year ago
3. Yes, Limited a Lot; Yes, Limited a little; No, Not limited at all

4a-d. Yes, No
5a-c. Yes, No
6. Not at all, Slightly, Moderately, Quite a bit, Extremely
7. None, Very mild, Mild, Moderate, Severe, Very Severe
8. Not at all, A little bit, Moderately, Quite a bit, Extremely
9. All of the time, Most of the time, A good bit of the time, Some of the time, A little of the time, None of the time
10. All of the time, Most of the time, Some of the time, A little of the time, None of the time
11. Definitely true, Mostly true, Don’t know, Mostly false, Definitely false

Appendix B

Hearing Handicap Inventory for the Elderly (HHIE)
(Ventry & Weinstein, 1982)

Instruction: The purpose of this scale is to identify the problems your hearing loss may be causing you. Answer **Yes**, **Sometimes**, or **No** for each question.

S-1. Does a hearing problem cause you to use the phone less often than you would like?
E-2. Does a hearing problem cause you to feel embarrassed when meeting new people?
S-3. Does a hearing problem cause you to avoid groups of people?
E-4. Does a hearing problem make you irritable?
E-5. Does a hearing problem cause you to feel frustrated when talking to members of your family?
S-6. Does a hearing problem cause you difficulty when attending a party?
E-7. Does a hearing problem cause you to feel "stupid" or "dumb"?
S-8. Do you have difficulty hearing when someone speaks in a whisper?
E-9. Do you feel handicapped by a hearing problem?
S-10. Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?
S-11. Does a hearing problem cause you to attend religious services less often than you would like?
E-12. Does a hearing problem cause you to be nervous?
S-13. Does a hearing problem cause you to visit friends, relatives, or neighbors less often than you would like?
E-14. Does a hearing problem cause you to have arguments with family members?
S-15. Does a hearing problem cause you difficulty when listening to TV or radio?
S-16. Does a hearing problem cause you to go shopping less often than you would like?
E-17. Does any problem or difficulty with your hearing upset you at all?
E-18. Does a hearing problem cause you to want to be by yourself?
S-19. Does a hearing problem cause you to talk to family members less often than you would like?
E-20. Do you feel that any difficulty with hearing limits or hampers your personal or social life?
S-21. Does a hearing problem cause you difficulty when in a restaurant with relative or friends?
E-22. Does a hearing problem cause you to feel depressed?
S-23. Does a hearing problem cause you to listen to TV or radio less often than you would like?
E-24. Does a hearing problem cause you to feel uncomfortable when talking to friends?
E. 25. Does a hearing problem cause you to feel left out when you are with a group of people?

Total Score: ____
Subtotal E: ____
Subtotal S: ____

Determine presence of perceived emotional and situational hearing handicaps based on E and S scores.

0-16: No Handicap
17-42: Mild to Moderate Handicap
≥43: Significant Handicap

Appendix C

Dizziness Handicap Inventory (DHI)
(Jacobson & Newman, 1990)

Instructions: The purpose of this scale is to identify difficulties that you may be experiencing because of your dizziness or unsteadiness. Please answer "yes," "no," or "sometimes" to each question. ***Answer each question as it pertains to your dizziness or unsteadiness problem only.***

P1. Does looking up increase your problem?

E2. Because of your problem do you feel frustrated?

F3. Because of your problem do you restrict your travel for business or recreation?

F5. Because of your problem do you have difficulty getting into or out of bed?

F6. Does your problem significantly restrict your participation in social activities such as going out to dinner, movies, dancing, or parties?

F7. Because of your problem do you have difficulty reading?

P8. Does performing more ambitious activities like sports, dancing, and household chores such as sweeping or putting dishes away increase your problem?

E9. Because of your problem are you afraid to leave your home without having someone accompany you?

E10. Because of your problem have you been embarrassed in front of others?

P11. Do quick movements of your head increase your problem?

F12. Because of your problem do you avoid heights?

F13. Does turning over in bed increase your problem?

F14. Because of your problem is it difficult for you to do strenuous housework or yard work?

E15. Because of your problem are you afraid people may think you are intoxicated?

E16. Because of your problem is it difficult for you to go for a walk by yourself?

P17. Does walking down a sidewalk increase your problem?

E18. Because of your problem is it difficulty for you to concentrate?

F19. Because of your problem is it difficult for you to walk around your house in the dark?

E20. Because of your problem are you afraid to stay home alone?

E21. Because of your problem do you feel handicapped?

E22. Has your problem placed stress on your relationships with members of your family or friends?

E23. Because of your problem are you depressed?

F24. Does your problem interfere with your job or household responsibilities?

P25. Does bending over increase your problem?

A “yes” response is scored 4 points. A “sometimes” response is scored 2 points. A “no” response is scored O points. “F” represents an item contained on the functional subscale. “E” represents an item contained on the emotional subscale and “P” represents an item contained on the physical subscale.

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