

The Nexus of Sensory Loss, Cognitive Impairment, and Functional Decline in Older Adults: A  
Scoping Review

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### **Abstract**

**Background and Objectives:** The prevalence of cognitive impairment and sensory loss in hearing or vision increases with age. Cognitive impairment coupled with sensory loss may exacerbate disability in late life, yet this issue has not been systematically studied. The purpose of this scoping review was to examine the literature that studied the relationship between cognitive impairment, sensory loss, and activities of daily living in older adults.

**Research Design and Methods:** Two reviewers independently screened 1,410 studies identified from five electronic databases (Medline, EMBASE, PsycINFO, CINHALL, and the Web of Science). The search was completed in June 2020. A study was eligible if it included measurements of cognitive function, vision or hearing, and activities of daily living.

Additionally, the data analyses must address how cognitive impairment and sensory loss are related to the performance of activities of daily living.

**Results:** The final review included 15 studies. Findings show an additive effect of cognitive impairment and sensory loss on the activities of daily living. Cognitive impairment or vision loss independently relates to the decline in activities of daily living. Hearing loss relates to the decline only when the loss is severe, or if the daily task is hearing-specific.

**Discussion and Implications:** Older adults with coexisting sensory loss and cognitive impairment have the highest risk or prevalence of disability, comparing to cognitive impairment or sensory loss alone. This finding highlights the importance of developing interventions to reduce the risk of disability for older adults experiencing multiple impairments.

**Keywords:** Hearing Loss; Cognitive Dysfunction; Vision Disorders; Activities of Daily Living

### **Introduction**

One in six Americans aged 70 years and older have visual impairment, and one in four have hearing loss (Dillon et al., 2010). The prevalence of visual impairment or hearing loss increases with age. The prevalence rate is more than doubled in adults aged 80 years and older compared with those aged between 70 and 79 years. Eleven percent of adults aged 80 years and older have dual sensory impairment (Swenor et al., 2013). Associations between visual impairment and cognitive decline (Fischer et al., 2016; Hajek et al., 2016; Maharani et al., 2019; Zheng et al., 2018) or hearing impairment and cognitive decline (Fischer et al., 2016; Lin et al., 2013; Loughrey et al., 2018; Maharani et al., 2019) have been suggested. For example, older adults with visual impairment have more subjective cognitive complaints compared to those without visual impairment (Lee et al., 2019). Having more than one sensory impairment increases the odds of cognitive decline (Brenowitz et al., 2019; Fischer et al., 2016). Alternatively, the prevalence rate of sensory loss in people with cognitive deficits is higher than people without dementia (Deardorff et al., 2019). Accordingly, multiple impairments involving sensory and cognition are common in older adults, especially in those with advanced age.

Both visual impairment and hearing loss adversely affect older adults' independence in activities of daily living (ADL) and quality of life (Brown et al., 2014; Dalton et al., 2003; Gopinath et al., 2012; Gopinath et al., 2011; Solheim et al., 2011; Taylor et al., 2016). Visual impairment can negatively impact the ability to read, recognize faces, shop, and perform in-home activities (Brown et al., 2014; Taylor et al., 2016). Hearing loss can lead to verbal-related challenges, such as holding a conversation, or non-verbal related, such as hearing the telephone ringing or water boiling. Similarly, cognitive decline can potentially hamper ADL independence and deteriorate the quality of life (Cordier et al., 2019; Hill et al., 2017). About 12% of adults

aged 65 or older reported having a cognitive impairment, and near 39% of whom gave up day-to-day activities because of the impairment (Taylor et al., 2018). The caring cost for people with cognitive impairments who need ADL assistance can be as high as \$56,290 per person (Hurd et al., 2013). Sensory loss in people with cognitive deficits further increases the care cost. Healthcare costs are greater for older adults with dual sensory loss and cognitive impairments compared to those with dual sensory loss but without cognitive impairments (Deardorff et al., 2019).

The Information Processing Model (Atkinson & Shiffrin, 1968) could be helpful to explain how sensory loss coupled with cognitive impairment affect older adults' ADL performance. This model describes that sensory information from environmental stimuli is processed in the short-term memory or working memory before being encoded into the long-term memory, where the information can be stored or retrieved. Working memory is also where the incoming sensory information processes the retrieved information from the long-term memory before execution or producing behavioral output. Vision or hearing loss decreases older adults' ability to detect the signal information from the two senses, leading to poor execution of ADL. Cognitive impairment decreases older adults' capacity to process sensory information and retrieve information stored in the long-term memory, leading to poor execution of ADL as well. Sensory loss together with cognitive impairment may, therefore, aggravate older adults' ability to process information needed to execute ADL.

Given that the risk of cognitive decline and sensory impairment increase with age, research in multiple impairments and disability in late life is growing but has not yet been systematically reviewed. The purpose of this scoping review was to identify studies that examined sensory loss, cognitive impairment, and **ADL** status or quality of life in older adults.

This scoping review extends prior research through investigating the relationship between sensory impairment, cognitive decline, ADL, and quality of life in older adults. The scoping review question was: What is known from the existing literature about how sensory loss, specifically in vision and hearing, with cognitive impairment affect older adults' ADL and quality of life?

### **Methods**

The scoping review procedure was guided by Arksey and O'Malley's framework, which was a five-stage process (Arksey & O'Malley, 2005). Stage one was identifying the research question. Stage two was identifying relevant studies. Stage three was study selection. Stage four was charting the data. The final stage involved collating, summarizing, and reporting the results. The review protocol was not registered. The checklist of the PRISMA Extension for Scoping Reviews (Tricco et al., 2018) was presented in the appendix.

#### **Identifying Relevant Studies**

Relevant studies were identified from electronic databases search and backward reference searching. A librarian assisted in generating the search terms and strategies. The librarian conducted an initial search in Medline via Ovid. Potential articles retrieved from the initial search were analyzed for MeSH terms, keywords, and keyword synonyms. The final search terms were specific to cognition deficits, vision or hearing loss, the aging population, and the outcomes of ADL performance and quality of life. Search terms were modified to each database to include relevant thesauruses. Five electronic databases were searched for relevant literature: Medline via Ovid (1948 to November 6<sup>th</sup>, 2018), EMBASE via Emabse.com (1947 to November 6<sup>th</sup>, 2018), PsycINFO via EBSCO (1967 to October 30<sup>th</sup>, 2018), CINAHL via EBSCO (1937 to

November 6<sup>th</sup>, 2018) and Web of Science via Clarivate Analytics (1990 to November 6<sup>th</sup>, 2018).

The search was updated in July 2019 and again in June 2020. The publication language was limited to English. The publication type could be a case study, journal article, clinical trial, reviews, systematic reviews, and meta-analysis. Supplementary Table 1 shows the search terms, strategies, and limitations applied in each electronic database. References of eligible studies were also screened to identify additional qualified studies.

### **Study Selection**

Study selection involved screening the literature identified from the last stage. Screening criteria were based on the specifics of the scoping review question. A study was considered eligible if it included measurements of cognitive function, vision or hearing, and ADL or quality of life. The cognitive function was not limited to a specific cognitive function. The indicator of sensory function could include vision or hearing, or both. The degree of sensory loss could be assessed by self-reported or a device. The measurement of ADL could include basic self-care activities, such as dressing, or instrumental ADL (IADL), such as meal preparation. The mean age of study participants must be 60 years and older. Finally, the study must address how cognitive impairment and sensory loss contributed or related to the ADL performance and quality of life in the older adult population. For example, the study analysis could include ADL or quality of life as a dependent variable and cognitive function and sensory factors as independent variables in a regression model. A second example would be that the study participants were grouped into sensory loss, cognitive impairments, and sensory loss plus cognitive impairments.

A study was excluded if: 1) the text indicated that participants younger than 55 years old were recruited; 2) the article type was a letter, editorial, or commentary; and 3) the research design was an intervention study. Additionally, driving is a special skill, which is more complex than regular IADL. A study was excluded from further review if driving performance or status is the solely functional outcome.

The literature screening process consisted of two phases: the title and abstract screening and the full-text screening. During the title and abstract screening, each record was reviewed by two authors independently. Discord between the two authors was resolved by consulting with the other authors or requesting a full-text review. Records that passed the initial screening as well as records that needed more information to determine eligibility were moved onto the full-text screening. The full-text screening process was similar to the title and abstract screening. Reasons for exclusion at this phase were recorded.

### **Charting the Data**

Charting the data was a process of extracting information from each study to a standard form. A data charting form was first piloted among all reviewers by charting two studies independently. After piloting, each study was charted by two reviewers independently. The two reviewers then met to compare charted information and to resolve any discrepancies. The following information was charted: the first author's name and country, year of publication, aim(s) of the study, research design, study population, participant characteristics and sample size, measures of vision and hearing, cognitive function, ADL and/or quality of life, and findings relevant to the review question.

### **Collating, Summarizing, and Reporting the Results**

In this stage, extracted information was summarized by years of publications and study locations, study design and purpose, study population and participant characteristics, and measures. Key findings were collated, analyzed, and reported by the following information: whether it was a longitudinal study or a cross-sectional study and whether the study investigated the compound effect or individual effect of sensory loss and cognitive decline.

## Results

Figure 1 shows the flowchart of literature screening. In total, 1,410 studies were identified. After removing duplicates, 927 studies were screened for titles and abstracts. Forty-three studies underwent full-text screening. Twenty-eight studies were removed from further review because they did not include targeted key variables (14 studies), or the study analysis did not answer the scoping review question (13 studies). One study (Liu et al., 2016) was excluded because the study was an expansion of a study that has been included. Fifteen studies were included in the scoping review. Characteristics of these studies, participants, measurements, and relevant key findings were summarized in Supplementary Table 2.

Of these 15 studies, 14 were published after 2005. Most studies were conducted in North America (n=10), followed by Europe (n=3) and Asia (n=2). All studies included participants of both genders. Ethnicity information was reported only in the eight studies conducted in the United States. The mean age of participants ranged between 62 to 100 years and above. The mean age in eight studies was either in the 70s or close to the 70s. The level of education was not consistently reported. The general years of education in 12 studies that reported the education information was between 8 and 12.

## Measurements



### *Sensory Measures*

Self-reported sensory loss was the most common method used to evaluate vision or hearing. Four studies used questions to evaluate visual impairment only (Patel et al., 2020; Whitson et al., 2007; Whitson et al., 2014; Xu et al., 2019); eight used questions to evaluate visual impairment as well as hearing impairment (Griffith et al., 2010; Guthrie et al., 2018; Jagger et al., 2005; Kurichi et al., 2017; Laforge et al., 1992; Martin et al., 2018; Spiers et al., 2005; Tomioka et al., 2015). The number of self-reported questions tended to be small, one or two questions for each sensory function. The severity of sensory deficit was often subjective and not clearly defined. Whitson et al. (2007) considered participants having a visual impairment if they reported negatively to questions: When you wear glasses or contacts, “can you see well enough to recognize a friend across the street ?” or “can you see well enough to read ordinary newspaper print?” In a later study by the same lead author, participants were asked to rate their vision as “excellent,” “very good,” “good,” “fair,” or “poor” (Whitson et al., 2014). A rating of “fair” or “poor” was considered an impairment. Patel et al. (2020) classified self-reported visual impairment as the participant being blind or unable to see across the street and/or read newspaper print, even with glasses. Griffith et al. (2010) evaluated visual and hearing loss as chronic conditions. Jagger et al. (2005) rated sensory impairment on the three-point scale of “good,” “fair,” and “poor.” Similar to Whitson et al. (2014), ratings of “fair” and “poor” were combined in the analysis. Guthrie et al. (2018) rated vision function on a 5-point Likert scale and hearing function on a 4-point Likert scale by interviewing the participants. Kurichi et al. (2017) used self-reported severe hearing loss or being deaf, and self-reported severe vision impairment or no usable vision. Martin et al. (2018) dichotomized the vision or hearing problems as “yes” or “no.” Tomioka et al. (2015) used one single question, “Do you feel you have hearing loss?” to assess

hearing impairment. Spiers et al. (2005) used self-reported suffering from poor vision or hearing, or the interviewer observed sensory problems that interfered with the interview process. Laforge et al. (1992) used a four-point scale of “excellent,” “good,” “fair,” and “poor,” or blind/deaf. Only three studies applied objective vision and hearing tests. Heyl et al. (2012) combined objective tests of vision (near vision screening and distance visual acuity test) and hearing (audiometric assessment) along with self-reported vision capacity and hearing loss. Wood et al. (2005) used subjective tests of vision (far visual acuity, near visual acuity, and contrast sensitivity) and hearing (audiometer). Gill et al. (2020) used a Jaeger card to measure vision and an audiometric assessment for hearing.

### *Cognitive Measures or Indicators*

The Mini-Mental Status Exam (MMSE) or the modified MMSE, which measures global cognitive function, was used in eight studies (Gill et al., 2020; Griffith et al., 2010; Jagger et al., 2005; Martin et al., 2018; Spiers et al., 2005; Tomioka et al., 2015; Wood et al., 2005; Xu et al., 2019). Among those eight studies, Jagger et al. (2005) and Wood et al. (2005) used MMSE together with other cognitive tests. Jagger et al. (2005) included the information and orientation subtest of the Clifton Assessment Procedure for the Elderly. Wood et al. (2005) also used cognitive domain-specific tests of literacy, processing speed, attention switching, lexical decision, working memory, intellectual functions, and executive functioning. The second most used test was the Short Portable Mental State Assessment, which was used in three studies (Laforge et al., 1992; Whitson et al., 2007; Whitson et al., 2014). Regarding the five remaining reviewed studies, Heyl et al. (2012) used a battery of cognitive tests, including Counting Backwards, Animal Naming, Digit Span and Backwards, and Similarities. Guthrie et al. (2018) measured cognitive function using the Cognitive Performance Scale. In Kurichi et al.’s study

(2017), the cognitive status was indicated by self-reported Alzheimer's disease. Patel et al. (2020) determined dementia status as probable dementia, possible dementia, or no dementia based on the physician's diagnosis, proxy interview, and performance tests of memory, orientation, and executive function.

### ***Measures of ADL and Quality of Life***

The majority of ADL measures were self-reported functional status. Examples of these measures included Barthel Index (Martin et al., 2018; Xu et al., 2019), Katz ADL scale (Laforge et al., 1992; Whitson et al., 2007), ADL Self-performance Hierarchy Scale and IADL Involvement Scale (Guthrie et al., 2018), modified Townsend ADL Scale (Spiers et al., 2005), and the ADL items in the Older Americans Resources and Services (Griffith et al., 2010; Martin et al., 2018). All above are established ADL measures. Six studies did not specify the sources of ADL measures (Gill et al., 2020; Heyl & Wahl, 2012; Jagger et al., 2005; Kurichi et al., 2017; Patel et al., 2020; Whitson et al., 2014). These studies used ADL items or mixed ADL with IADL items. One study used the Timed IADL Test, which recorded time to complete selected IADL tasks (Wood et al., 2005). The same study also included measures of life-space, driving space, and driving exposure. The quality of life was not evaluated in any of the reviewed studies, so no related results were reported.

### **Study Design, Purpose, and Relevant Key Findings**

Table 1 summarized whether sensory loss and cognitive impairment independently or additively associated with a decline in ADL or IADL by study type, a longitudinal study or a cross-sectional study. The longitudinal studies examined how sensory function and cognitive function across time predict ADL or IADL disability. The cross-sectional studies examined associations among interested factors simultaneously.

***Longitudinal studies***

Seven studies used a longitudinal research design (Gill et al., 2020; Jagger et al., 2005; Kurichi et al., 2017; Laforge et al., 1992; Spiers et al., 2005; Tomioka et al., 2015; Whitson et al., 2007). These studies analyzed existing data from large datasets or local population registries. All studies included sensory measures of vision and hearing, except one which only included vision (Whitson et al., 2007). Gill et al. (2020) evaluated the potential risk factors and precipitants associated with severe disability over a 19-year period. Jagger et al. (2005) investigated the role of sensory and cognitive function on the onset of activity restriction over a 10-year period. Laforge et al. (1992) and Spiers et al. (2005) investigated similar topics to Jagger et al. (2005), but over a one-year or two-year period. Kurichi et al. (2017) developed a prediction model to identify risk factors and protective factors for ADL deterioration, institutionalization, or death in a cohort over a two-year period. Tomioka et al. (2015) examined the relationships between hearing loss and the level of change in ADL over a five-year period. Whitson et al. (2007) tried to determine the risk of disability in a cohort, particularly people with coexisting visual and cognitive impairments, over a six-year period.

The seven longitudinal studies were presented at the top of Table 1. Two longitudinal studies provided information on how sensory loss together with cognitive impairment affected ADL or IADL decline over time. Whitson et al. (2007) found that the risk of disability was greatest in people with coexisting visual and cognitive impairments, relative to people with visual impairment only or cognitive impairment only. Laforge et al. (1992) estimated that the risk of ADL decline among people with multiple impairments in vision, hearing, and cognition was more than six times higher than those without any of these impairments. They also found the

presence of cognitive impairment or sensory impairment (visual impairment or vision with hearing impairment) increases the risk of ADL decline.

Similar to Laforge et al., Jagger et al. (2005) identified that dual sensory loss increased the risk of activity restriction. However, vision loss or hearing loss alone did not increase the risk. Their findings on cognitive impairment and the onset of ADL disability were measurement dependent. The information or orientation subtest of the Clifton Assessment Procedure for the Elderly, not the MMSE, predicted the risk of activity restriction over a 10-year period.

The rest of the four studies found that vision loss and cognitive decline were independently related to poor ADL or IADL but results in hearing loss were inconsistent (Gill et al., 2020; Kurichi et al., 2017; Spiers et al., 2005; Tomioka et al., 2015). Gill et al. (2020) reported that cognitive impairment increases the risk of progressive disability and catastrophic disability. Hearing impairment increases the risk of progressive disability, while visual impairment increases the risk of catastrophic disability. Kurichi et al. (2017) found that the presence of Alzheimer's disease, vision impairment, and hearing impairment independently predicted ADL decline. Spiers et al. (2005) identified that cognitive impairment and eyesight problems were independently associated with the onset of disability but not hearing problems. Tomioka et al. (2015) divided the functional outcome into the subscales of IADL (e.g., transportation), intellectual activity (e.g., newspaper or book reading), and social role (e.g., initiating conversations). Visual impairment and cognitive impairment were individually related to the decline in all three subscales, while hearing impairment was related to the decline in the subscale of intellectual activity and social role.

### ***Cross-sectional Studies***

Eight studies utilized a cross-sectional research design (Griffith et al., 2010; Guthrie et al., 2018; Heyl & Wahl, 2012; Martin et al., 2018; Patel et al., 2020; Whitson et al., 2014; Wood et al., 2005; Xu et al., 2019). All studies analyzed existing data from large datasets or local population registries, except one recruited its own set of participants (Heyl & Wahl, 2012). Five studies included sensory measures of vision and hearing (Griffith et al., 2010; Guthrie et al., 2018; Heyl & Wahl, 2012; Martin et al., 2018; Wood et al., 2005), while the rest of the studies included measures of vision only. Guthrie et al. (2018) examined the compounded effects of sensory and cognitive impairments on health-related outcomes using assessment data from home care patients and long-term care residents. Heyl et al. (2012) evaluated the role of cognitive resources in everyday functioning in older adults with dual sensory impairment, single sensory impairment (vision or hearing), or no vision and hearing impairment. Patel et al. (2020) examined the relationship between dementia and visual impairment on daily functioning. Wood et al. (2005) examined speed and non-speed cognitive factors and sensory factors in functional abilities. Whitson et al. (2014) assessed the relationship between comorbid cognitive and vision impairment and disability. The other studies shared a similar research purpose, to identify factors associated with older adults' functional disability (Griffith et al., 2010; Martin et al., 2018; Xu et al., 2019).

The bottom of Table 1 summarized findings of these eight cross-sectional studies. Four studies provided information on how sensory loss together with cognitive impairment affected ADL or IADL decline. Griffith et al. (2010) found that, among all the chronic conditions they measured, the presence of cognitive impairment and vision problems together yielded the highest risk of disability. Cognitive impairment rendered a higher risk of disability in complex self-management tasks across all age groups. Guthrie et al. (2018) divided their participants into nine

groups by the type of sensory impairment (no impairment, vision impairment, hearing impairment, and dual sensory impairment) and its combination with cognitive impairment. Their data showed that groups with cognitive impairment have a higher percentage of disability rates than those groups with sensory deficits only. People with all three impairments (cognitive and dual sensory loss) were most likely to have reduced independence than people with cognitive impairment only. Patel et al. (2020) found an interaction effect between visual impairment and cognitive impairment. Namely that older adults with both visual impairment and cognitive impairment had a lower functional status on mobility activities, self-care activities, and household activities than each impairment alone. Whitson et al. (2014) identified that the risk of ADL disability and IADL disability was greatest in people with coexisting visual and cognitive impairment. They also identified an interaction between cognitive impairment and visual impairment on ADL disability.

The remaining four cross-sectional studies investigated the individual effect of sensory loss or cognitive impairment. Results from Martin et al.'s study (2018) were sample dependent. The Tokyo sample showed that both visual impairment and cognitive impairment significantly and independently predicted the ADL outcome, while the Georgia sample showed that only cognitive impairment significantly predicted the ADL outcome. Hearing impairment was not a significant factor in either sample. Wood et al. (2005) divided her cognitive measures into speed-related or non-speed-related. Both cognitive function and sensory factors significantly and independently predicted the Timed ADL test and mobility. Non-speed cognitive factors accounted for the most variance of the Timed IADL test. In contrast, speed cognitive factors accounted for the most variance in mobility, indicated by life-space, driving-space, and driving exposure. Xu et al. (2019) found that vision loss and cognitive impairment individually related to

a poor ADL outcome. Heyl et al. (2012) used structural equation modeling to investigate the role of cognitive resources in everyday functioning. They found that older adults with visual impairment and dual sensory impairment had more difficulty in ADL and IADL tasks that were performed outside the home than those without sensory deficits. Additionally, the correlations between cognitive function and ADL as well as IADL were significant in older adults with visual impairment and older adults with hearing impairment. This finding suggests that older adults tap into the cognitive function to assist in performing ADL and IADL tasks when their sensory function is compromised.

### **Discussion**

This scoping review aimed to examine how sensory loss and cognitive impairment affect ADL and quality of life in older adults. None of the reviewed studies assessed the quality of life. Of the 15 studies identified, six studies examined the compound effect of sensory loss and cognitive impairment (Griffith et al., 2010; Guthrie et al., 2018; Laforge et al., 1992; Patel et al., 2020; Whitson et al., 2007; Whitson et al., 2014). Findings of the review suggested that vision loss and cognitive impairment additively relate to ADL decline. Older adults with dual sensory loss and cognitive impairment have the highest risk or prevalence of disability. While vision loss and cognitive impairment independently relate to ADL decline or poor performance, the cognitive factor may play a more significant role in mediating the degree of disability. Dual sensory loss is associated with greater or equal ADL decline compared to vision loss only. Hearing loss, depending on the severity of hearing loss and the type of daily activity, seems to be a less significant factor for ADL decline.



The prevalence of sensory loss and cognitive impairments increases with age (Dillon et al., 2010; Swenor et al., 2013). However, studies investigated late-life disability have paid much less attention to sensory and cognitive functions than to neuromuscular and motor functions (Artaud et al., 2015; Duchowny et al., 2018; Fielding et al., 2017). Eight of the 15 studies identified in the scoping review were with a research purpose to evaluate the relationship between sensory loss, cognitive impairment, and ADL decline or disability (Guthrie et al., 2018; Heyl & Wahl, 2012; Jagger et al., 2005; Martin et al., 2018; Patel et al., 2020; Whitson et al., 2007; Whitson et al., 2014; Wood et al., 2005). The remaining studies were with a research purpose to identify risk factors associated with late-life disability. These studies suggested that sensory loss plays a significant role in ADL decline, specifically dual sensory loss or vision loss. Older adults with dual sensory loss may experience greater or equal loss in ADL compared to older adults with vision loss only (Heyl & Wahl, 2012; Jagger et al., 2005; Laforge et al., 1992). The activity complexity and the degree of sensory loss may determine the degree of disability in the two populations. Prior study has suggested that older adults with severe dual sensory loss experience more difficulties than older adults with vision loss in IADL tasks, such as meal preparations, shopping, and telephone use, but not in basic ADL tasks (Brennan et al., 2005). Sensory loss may not warrant ADL decline because some loss may be offset by increased dependent on other sensory systems. However, older adults with severe dual sensory loss have a limited sensory function to compensate.

The sense of vision, intuitively, plays a relatively prominent role in performing everyday tasks than hearing. Vision impairment is associated with more significant loss in ADL than hearing impairment (Heyl & Wahl, 2010; Heyl & Wahl, 2012; Rudberg et al., 1993). Findings of this scoping review suggest that hearing loss could interfere with daily functioning

when the impairment becomes severe or when the daily tasks require the sense of hearing to execute. Gill et al., (2020) found that hearing loss is a risk factor for progressive disability but not catastrophic disability. Kurichi et al. (2017) used a high threshold of hearing loss (severe hearing loss or deaf) and identified that hearing loss is a significant predictor of ADL status. Tomioka et al. (2015) found that hearing loss is a significant factor for social activities, for example, visiting a sick friend. In addition, hearing impairment has been positively associated with impaired postural balance (Agmon et al., 2017), which may underlie mobility limitation leading to difficulties in ADL and IADL. Therefore, the activity limitations experienced by older adults with hearing loss may not simply due to hearing impairment.

Cognitive impairment may be more associated with disability than sensory loss, especially in the advanced age population. One reviewed study showed that the proportion of older adults with cognitive impairment experience disability is relatively higher than those with sensory loss in home care and long-term care services (Guthrie et al., 2018). Older adults may draw cognitive resources to compensate for sensory loss to maximize ADL performance. For example, older adults with visual impairment may rely more on memory to locate familiar daily objects. Therefore, cognitive function becomes a significant factor contributing to ADL performance in older adults with vision impairment or hearing impairment (Heyl & Wahl, 2012). Older adults with sensory loss would experience greater ADL limitations if cognitive impairment occurs.

Based on the Information Processing Model (Atkinson & Shiffrin, 1968), older adults with coexisting conditions would experience degraded sensory signals and limited cognitive resources, which would then additively and adversely affect the execution of daily tasks, leading to care dependency. Although only 40% of the reviewed studies provided information about the

compound effect of sensory loss and cognitive impairment, findings of these studies are consistent with that the coexisting of the two conditions yields the greatest risk of ADL decline or disability than either condition alone. This result has strong clinical implications for planning best care for older adults with coexisting conditions of sensory loss and cognitive impairment. Intervention research in this area has slowly emerged (Dawes, Wolski, et al., 2019; Leroi et al., 2020; Whitson et al., 2013). The intervention has tried to address degraded sensory signals by using assistive devices, such as a closed-circuit television or hearing aids, or limited information processing capacity by using cognitive strategies, such as allowing more time, having repetitive sessions, and emphasizing a minimally distracting environment.

The ability to perform ADL independently is an important facet of quality of life to older adults (Molzahn et al., 2010). However, none of the reviewed studies included the measure of the quality of life. One reason could be that these studies were focused on identifying risk factors related to disability, so the quality of life was less relevant to their research questions. An increase in the severity of sensory loss or cognitive impairment is associated with a lower quality of life (Hill et al., 2017; Tseng et al., 2018). Future studies may further investigate the compound effect of sensory loss and cognitive impairment on older adults' quality of life.

One strength of this scoping review was the use of existing large datasets or population registries by most reviewed studies. The data were retrieved from large-scale longitudinal or survey studies with well-established sampling plans. The large and representative sample may support the rigor of the research methodology in these studies.

Nevertheless, the use of self-report measures might have weakened the research methodology of the reviewed studies. The estimation of sensory loss in vision or hearing could be questionable when the estimation was based on only one or two self-reported questions. The

degree of sensory loss might be over- or under-estimated without using objective measures of sensory loss. Particularly, age-related hearing loss can be stigmatized (Wallhagen, 2009), leading to under-estimating the severity. Along the same line, the research result might be biased if the ADL status is mainly based on self-reported measures. Some widely-used self-reported ADL measures have shown a lack of adequate psychometric properties or a ceiling effect to detect a subtle functional decline in the older adult population (Hopman-Rock et al., 2019; Nielsen et al., 2016). Self-reported and performance-based measures of ADL assess different aspects of functional ability in older adults. In sum, future studies may consider employing various types of measures to capture sensory loss and ADL change.

Another weakness in the research methodology is failing to address the potential impact of visual impairment or hearing impairment on the cognitive measures, given that visuospatial ability is a main component of cognitive function. Additionally, auditory and visual abilities are required to process and identify answers on cognitive test items. Hearing and vision impairments can result in overestimated cognitive impairment (Dupuis et al., 2015; Lim & Loo, 2018). Omitting hearing- or vision-dependent cognitive test items could be a crude solution but may alter the test specificity or sensitivity (Al-Yawer et al., 2019; Pye et al., 2017). New developments in cognitive tests for people with sensory loss are underway. Examples of these new developments include tactile-based cognitive tests for people with dual sensory loss, reading administration procedure for people with hearing loss, and oral administration procedure for people with vision loss (Bruhn & Dammeyer, 2018; Dawes, Pye, et al., 2019; Okano et al., 2020). Given the high prevalence of vision and hearing loss in older adults, future studies are encouraged to consider these new developments in cognitive tests.

### **Conclusion**

Older adults with coexisting sensory loss and cognitive impairment have the highest risk or prevalence of ADL disability, comparing to sensory loss or cognitive impairment alone. Developing interventions to reduce the risk of disability for older adults experiencing multiple impairments would be a logical next step. This scoping review were mostly based on studies analyzing existing large datasets or population registries with limited measures of sensory and cognitive functions. Future studies are encouraged to apply a prospective research design and include objective measures of vision and hearing as well as cognitive tests that accommodate sensory loss.

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Figure 1. The Flow Diagram of Literature Screening and Selection.

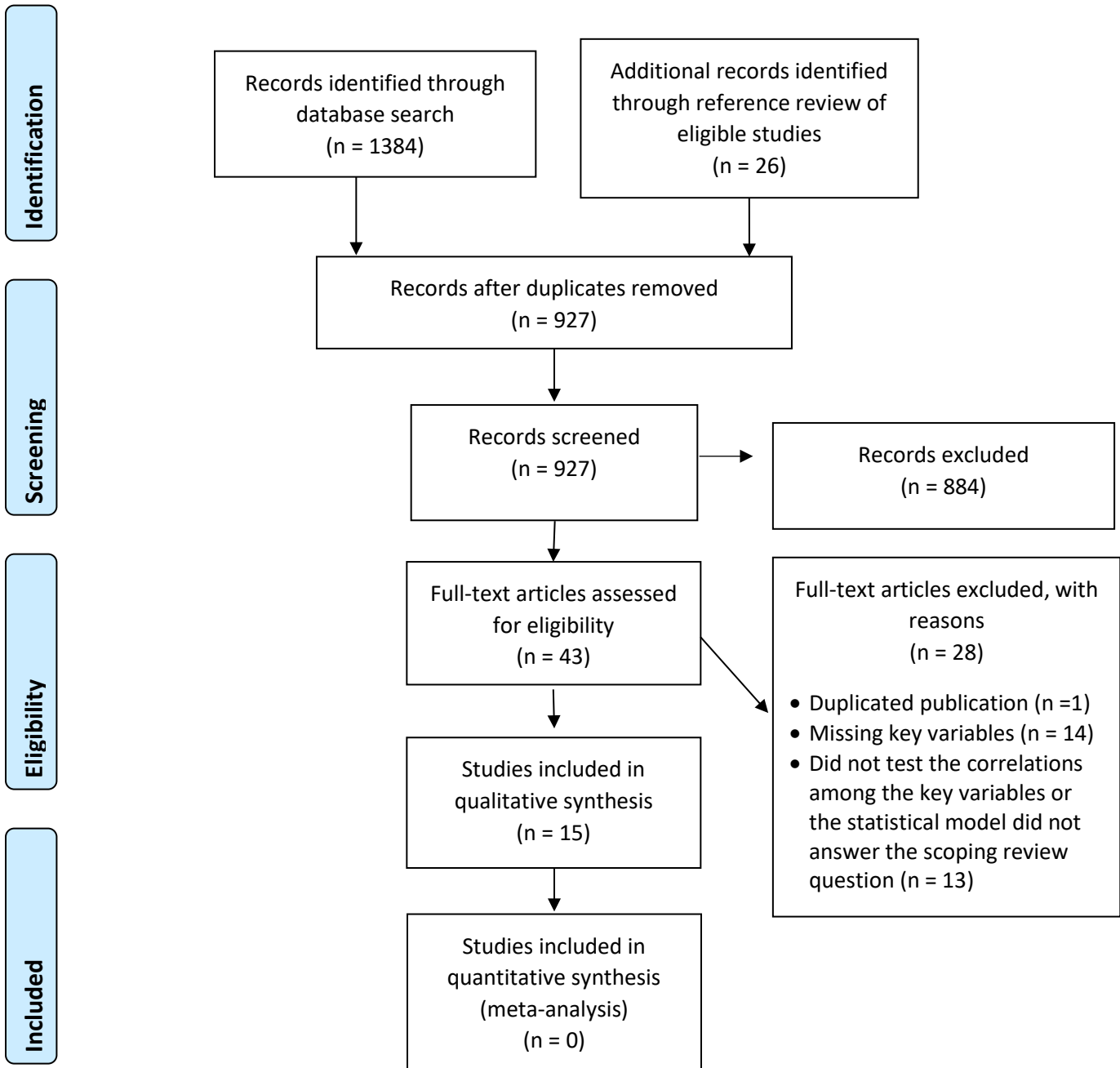


Table 1. Summary of Sensory and Cognitive Factors Associated with Disability by Study Type.

	Sensory loss			Cognitive impairment	Vision plus cognitive impairments	Hearing plus cognitive impairments	Dual sensory plus cognitive impairments
	Vision	Hearing	Dual sensory				
<b>Longitudinal studies</b>							
Gill 2020	+	+	.	+	.	.	.
Jagger 2005	-	-	+	+ <sup>-a</sup>	.	.	.
Kurichi 2017	+	+	.	+	.	.	.
Laforge 1992	+	-	+	+	.	.	+
Spiers 2005	+	-	.	+	.	.	.
Tomioka 2015	+	+	.	+	.	.	.
Whitson 2007	+	.	.	+	+	.	.
<b>Cross-sectional studies</b>							
Griffith 2010	+	-	.	+	+	.	.
Guthrie 2018	-	-	-	+	+	+	+
Heyl 2012	+	-	+	.	+ <sup>b</sup>	+ <sup>b</sup>	-
Martin 2018	+	-	.	+	.	.	.
Patel 2020	+	.	.	+	+	.	.
Whitson 2014	+	.	.	+	+	.	.
Wood 2005	+	+	.	+	.	.	.
Xu 2019	+	.	.	+	.	.	.

“+” indicates a relatively significant factor in the reviewed study. “-“ indicates a relatively non-significant factor in the reviewed study. “.” indicates a factor was not assessed in the study. a. The result was assessment dependent. b. Cognition becomes a critical factor for everyday functioning in people with vision impairment or hearing impairment.

Supplementary Table 1. Search Terms and Strategies used for the Literature Search in the Electronic Databases.

<b>Medline OVID</b>
<p>((exp Cognition Disorders/ OR Cognitive Dysfunction/ OR exp Dementia/ OR (cognitive* adj3 (disorder* OR dysfunction* OR impair* OR decline* OR loss OR defect*)) OR (neurocognitive adj3 disorder*)) OR (mental adj3 deterioration*))  AND  (((sensory OR sensorimotor OR vision OR hearing) adj3 (dysfunction* OR impair* OR decline* OR loss OR defect*)) OR sensation disorders/ or hearing disorders/ OR vision disorders/ OR Hearing Loss/ OR (dual-sensory adj3 (impairment or loss)))  AND  (exp Aged/ or senior\$.ti,ab. or elderly.ti,ab. or ((old\$ or elder\$) adj3 (adult\$1 or person\$1 or people\$1 or individual\$1)).ti,ab.)  AND  (Activities of Daily Living/OR Self Care/ OR Social Support/ OR Independent Living/ OR "Quality of Life"/ OR (activit* adj3 daily living) OR ADL OR IADL OR self-care))  not (letter OR editorial or news or comment).pt.  Database limits: English</p>
<b>EMBASE</b>
<p>('cognitive defect'/exp OR (cognitive* NEAR/3 (disorder* OR dysfunction* OR impair* OR decline* OR loss OR defect*)) OR (neurocognitive NEAR/3 disorder*)) OR (mental NEAR/3 deterioration*))  AND  ('sensory dysfunction'/de OR 'hearing disorder'/de OR 'hearing impairment'/exp OR 'visual disorder'/de OR 'visual impairment'/exp OR ((sensory OR sensorimotor OR vision OR hearing) NEAR/3 (dysfunction* OR impair* OR decline* OR loss OR defect*)) OR ('dual sensory' NEAR/3 (impairment OR loss)))  AND  ('aged'/exp OR senior*:ab,ti OR (((old* OR elder*) NEAR/3 (adult* OR person* OR people* OR individual*)):ab,ti))  AND  ('daily life activity'/exp OR 'self care'/de OR 'social support'/exp OR 'independent living'/exp OR 'quality of life'/exp OR (activit* NEAR/3 'daily living') OR adl OR iadl OR 'self care')  Database limits: English, Articles, Articles in press, Reviews</p>
<b>PsycINFO</b>
<p>(DE "Cognitive Impairment" OR DE "Dementia" OR DE "Dementia with Lewy Bodies" OR DE "Presenile Dementia" OR DE "Semantic Dementia" OR DE "Senile Dementia" OR DE "Vascular Dementia" OR DE "Alzheimer's Disease" OR (cognitive* N2 (disorder* OR dysfunction* OR impair* OR decline* OR loss OR defect*)) OR (neurocognitive N2 disorder*) OR (mental N2 deterioration*))  AND</p>



<p>(DE "Sensory System Disorders" OR (DE "Hearing Disorders" OR DE "Deaf") OR (DE "Vision Disorders" OR DE "Balint's Syndrome" OR DE "Blind" OR DE "Eye Disorders" OR DE "Hemianopia") OR ((sensory OR sensorimotor OR vision OR hearing) N2 (dysfunction* OR impair* OR decline* OR loss OR defect*)) OR ('dual sensory' N2 (impairment OR loss))) AND  (DE "Activities of Daily Living" OR DE "Self-Care Skills" OR DE "Social Support" OR DE "Quality of Life" OR (activit* N2 'daily living') OR ADL OR IADL OR "self care")  Limits: English, Age limits – aged, very old; journals</p>
<b>CINAHL</b>
<p>(MH "Cognition Disorders+" OR MH "Dementia+" OR ((cognitive* N2 (disorder* OR dysfunction* OR impair* OR decline* OR loss OR defect*)) OR (neurocognitive N2 disorder*)) OR (mental N2 deterioration*)) AND  (MH "Sensation Disorders" OR MH "Hearing Disorders+" OR MH "Vision Disorders+" OR ((sensory OR sensorimotor OR vision OR hearing) N2 (dysfunction* OR impair* OR decline* OR loss OR defect*)) OR ('dual sensory' N2 (impairment OR loss))) AND  ((MH "Aged+") OR ((old* OR elder*) N2 (adult* OR person* OR people* OR individual*))) AND  (MH "Activities of Daily Living+" OR MH "Self Care" OR MH "Support, Psychosocial" OR MH "Community Living" OR MH "Quality of Life" OR (activit* N2 'daily living') OR ADL OR IADL OR "self care")  Limits: English; Publication types: case study, clinical trial, journal article, meta analysis, randomized controlled trial, research, review, systematic review</p>
<b>Web of Science</b>
<p>TS=(((cognitive* NEAR/2 (disorder* OR dysfunction* OR impair* OR decline* OR loss OR defect*)) OR (neurocognitive NEAR/2 disorder*)) OR (mental NEAR/2 deterioration*)) OR dementia) AND (((sensory OR sensorimotor OR vision OR hearing) NEAR/2 (dysfunction* OR impair* OR decline* OR loss OR defect*)) OR ("dual sensory" NEAR/3 (impairment OR loss))) AND (((old* OR elder*) NEAR/2 (adult* OR person* OR people* OR individual*))) AND ((activit* NEAR/3 'daily living') OR adl OR iadl OR "self care" OR "quality of life"))  Database limits: English, Article, review</p>

Supplementary Table 2. Summary of Studies Included in the Scoping Review.

Study ID Country	Study Purpose Research Design	Study Participants	Setting or Data Source	Measures	Relevant Main Findings
Gill 2020 USA	<p>To evaluate the potential risk factors and precipitants associated with severe disability that develops progressively (during ≥2 months) versus catastrophically (from 1 month to the next).</p> <p><b>Longitudinal</b> study (19 years).</p>	<p>n = 754 (Female = 64.6%). Non-Hispanic White = 90.5%. Mean age = 78.4±5.3 years. Years of education, about 1/3 of participants had less than 12 years of education.</p>	<p>Data from the Precipitating Events Project, a longitudinal study of 754 community-living persons aged 70 years or older who were initially without ADL disability.</p>	<p><b>Sensory</b></p> <ul style="list-style-type: none"> <li>- Vision: Jaeger card.</li> <li>- Hearing: Audiometer.</li> </ul> <p><b>Cognition</b></p> <ul style="list-style-type: none"> <li>- MMSE.</li> </ul> <p><b>Functional outcome</b></p> <ul style="list-style-type: none"> <li>- Self-report of needing help from another person in bathing, dressing, walking, and transferring.</li> </ul> <p><b>Quality of Life</b></p> <ul style="list-style-type: none"> <li>- None.</li> </ul>	<ul style="list-style-type: none"> <li>• Hearing impairment (Hazard ratio = 1.7) and cognitive impairment (Hazard ratio = 2.0) are risk factors for progressive disability.</li> <li>• Visual impairment (Hazard ratio = 1.4) and hearing impairment (Hazard ratio = 1.3) are risk factors of catastrophic disability.</li> </ul>

<p>Griffith 2010 Canada</p>	<p>To identify a set of chronic conditions that are independently associated with overall functional disability and to investigate the impact of chronic conditions on total burden of functional disability.</p> <p>Cross-sectional study.</p>	<p>n = 8,858 (Female = 59.5%). Ethnicity/race was not reported. Mean age = 75.7±7.1 years. Years of education, mean = 10.1±3.9 years.</p>	<p>Data from the community-dwelling sample of the first wave of the Canadian Study of Health and Aging.</p>	<p><b>Sensory</b> - Self-reported vision problems and hearing problems as chronic conditions.</p> <p><b>Cognition</b> - Modified MMSE (Score &lt; 77 was used to define cognitive impairment).</p> <p><b>Functional outcome</b> - ADL items and IADL items in the OARS. - Alternative scoring of OARS in basic self-care, intermediate self-care and complex self-management.</p> <p><b>Quality of Life</b> - None.</p>	<p><b>Single chronic conditions</b></p> <ul style="list-style-type: none"> <li>• Cognitive impairment, vision impairment, and other three chronic conditions individually contributed the most to population attributable risks for ADL-related disability. Cognitive impairment had the highest population attributable risks in participants aged 85 and older.</li> <li>• Cognitive impairment was associated with higher population attributable risks for IADL-related disability in the older age groups.</li> <li>• The presence of cognitive impairment yielded the highest population attributable risk in disability related to complex self-management, across all age groups.</li> </ul> <p><b>Multiple chronic conditions</b></p> <ul style="list-style-type: none"> <li>• The presence of cognitive impairment, vision problems, and other three chronic conditions contributed to the most to population attributable risks for ADL and IADL related disability.</li> <li>• The presence of cognitive impairment and vision problems yielded the highest population attributable risk in disability related to complex self-management for most age groups.</li> </ul>
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<p>Guthrie 2018  Canada</p>	<p>To understand the potentially compounded effects of sensory and cognitive impairments on a series of health-related outcomes in two cohorts of older adults in Ontario receiving ongoing health care either in the community or in a residential setting.</p> <p>Cross-sectional study.</p>	<p>Cohort of home care clients: n = 291,824 (Female = 61.1%). Ethnicity/race was not reported. Mean Age = 82.8±7.9 years. Years of education, 63 to 79% have some high school, high school, or above high school education.</p> <p>Cohort of long term care residents: N = 110,578 (Female = 69.5%). Ethnicity/race was not reported. Mean Age = 86.9±7.5 years. Years of education, 63 to 71% have some high school, high school, or above high school education.</p>	<p>Data were from the Resident Assessment Instrument for Home Care and the Minimum Data Set 2.0 for Long Term Care collected between 2009 to 2014 in Ontario, Canada.</p>	<p><b>Sensory</b></p> <ul style="list-style-type: none"> <li>- Hearing function. Rated by a trained health care professional on a 4-point Likert scale by interviewing the individual.</li> <li>- Vision function. Rated by a trained health care professional on a 5-point Likert scale by interviewing the individual.</li> </ul> <p><b>Cognition</b></p> <ul style="list-style-type: none"> <li>- Cognitive Performance Scale.</li> </ul> <p><b>Functional Outcome</b></p> <ul style="list-style-type: none"> <li>- The ADL Self-performance Hierarchy Scale. The scale includes 4 activities: eating, locomotion, toileting, and personal hygiene.</li> <li>- The IADL Involvement Scale. The scale includes 7 activities: the activities of meal preparation, ordinary housework, managing finances, managing medications, phone use, shopping, and transportation.</li> </ul> <p><b>Quality of Life</b></p> <ul style="list-style-type: none"> <li>- None.</li> </ul>	<ul style="list-style-type: none"> <li>• Individuals with all three impairments (cognitive and dual sensory impairments) were the most likely to experience reduced independence in their ADLs and IADLs compared to those with cognitive impairment alone.</li> <li>• <b>Home Care Cohort:</b> The cognitive impairment and dual sensory impairment group experienced the highest rates of ADL impairment (57.5%) and IADL impairment (82.0%).</li> <li>• <b>Long-term Care Cohort:</b> Nearly all residents with cognitive and dual sensory impairments had impaired ADLs (97.3%).</li> </ul>
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<p>Heyl 2012 Germany</p>	<p>To investigate the role of cognitive resources in everyday functioning, comparing visually impaired, hearing impaired, and sensory unimpaired older adults.</p> <p>Cross-sectional study.</p>	<p>Visually impaired: n = 121 (Female = 58.7%). Ethnicity/race was not reported. Mean age = 82.6±4.6 years. Years of education, mean = 9.21±1.84 years.</p> <p>Hearing impaired: n = 116 (Female = 41.4%). Ethnicity/race was not reported. Mean age = 82.7±5.1 years. Years of education, mean = 9.47±2.21 years.</p> <p>Sensory unimpaired: n = 150 (Female = 49.3%). Ethnicity/race was not reported. Mean age = 82.3±4.5 years. Years of education, mean = 9.65±2.03 years.</p> <p>Dual sensory impaired: n = 43 (Female = 39.5%).</p>	<p>Outpatients from local clinics and random sample of two cities in Germany. Sensory impairments must be diagnosed at least two years prior to study entry.</p>	<p><b>Sensory</b></p> <ul style="list-style-type: none"> <li>- Vision: near vision screening, distance visual acuity test, and subjective vision capacity report.</li> <li>- Hearing: audiometric assessment and self-reported hearing loss.</li> </ul> <p><b>Cognition</b></p> <ul style="list-style-type: none"> <li>- Counting Backwards, Animal Naming, and two subtests from the WAIS-R, which are Digit Span Backwards and Similarities.</li> </ul> <p><b>Functional outcome</b></p> <ul style="list-style-type: none"> <li>- 10 items from the classic ADL and IADL scales that are performed out of the home, and another 10 leisure activities.</li> </ul> <p><b>Quality of Life</b></p> <ul style="list-style-type: none"> <li>- None.</li> </ul>	<ul style="list-style-type: none"> <li>• Participants with visual impairments and dual sensory impairments reported significantly more difficulties with out-of-home ADL and IADL than participants with hearing impairments and those without sensory impairments.</li> <li>• Participants with visual impairments had less out-of-home leisure activities than participants with hearing impairments and those without sensory impairments.</li> <li>• The correlations between cognitive function and ADL and IADL were significant in the visually impaired group and in the hearing impaired group. The strength of path between everyday functioning and cognition was similar in the visually impaired group and the hearing impaired group. The path was not significant in the unimpaired group.</li> <li>• The number of correlations between cognitive function and ADL and IADL was fewer in the dual sensory impaired group, which may due to a weaker statistical power.</li> </ul>
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		Ethnicity/race was not reported. Mean age = 83.4±4.5 years. Years of education, mean = 8.77±1.70 years.			
Jagger 2005 England	To investigate the role of sensory (vision and hearing) and cognitive function on the onset of activity restriction in older people.  <b>Longitudinal</b> study (10 years).	n = 448 (the gender information was not reported). Ethnicity/race was not reported. Mean age was not reported. Median age = 78 years. Years of education was not reported.	Population registered in a large general practice which serving regional areas.	<b>Sensory</b> - Self-reported difficulty with vision and hearing. <b>Cognition</b> - MMSE. - The Information/orientation subtest of the Clifton Assessment Procedure for the Elderly. <b>Functional outcome</b> - Seven ADL items: mobility around the home, getting to and from the toilet, transfer from chair, transfer from bed, feeding, dressing and bathing. <b>Quality of Life</b> - None.	<ul style="list-style-type: none"> <li>• Dual vision and hearing difficulties were significantly associated with the onset of activity restriction (RR=2.36) compared to no sensory deficits. Hearing or vision impairment alone did not increase the risk.</li> <li>• The information/orientation subtest of the Clifton Assessment Procedure for the Elderly at baseline was indicative of increased risk of activity restriction (RR=1.10). However, the other cognitive assessment, MMSE, was not.</li> </ul>
Kurichi 2017 USA	To develop prediction models identifying both risk factors and protective factors for functional deterioration, institutionalization, and death.  <b>Longitudinal</b> study (2 years).	n = 21,264 (Female = 56.4%). Non-Hispanic White = 82.1%. Non-Hispanic Black = 8%. Hispanic = 6.8%. Other = 3.1%. Mean age was not reported. 56.1% of the sample aged between 65 and 74	Data from the 2001-2008 Medicare Current Beneficiary Survey.	<b>Sensory</b> - Self-reported severe hearing loss or were deaf, and self-reported severe vision impairment or no usable vision. <b>Cognition</b> - Self-reported Alzheimer’s disease. <b>Functional outcome</b> - The degree of difficulty in six ADL items: eating, toileting, dressing, bathing/showering, getting in or out of bed/chair, and walking.	<ul style="list-style-type: none"> <li>• Alzheimer’s disease, hearing impairment, and vision impairment are individual risk factors for functional deterioration over a 2-year period.</li> </ul>

		years, and the rest were 75 or above. Years of education, 74% of the sample had a high school diploma or higher education.		<b>Quality of Life</b> - None.	
Laforge 1992 USA	To examine the relationship of visual and hearing impairments to the incidence of functional decline and mortality among elders.  <b>Longitudinal</b> study (1 year).	n = 1,315 (Female = 62.1%). Non-Black = 72.5% Black = 27.5% Mean age was not reported. Years of education was not reported.	Data from the baseline and 1-year follow-up of the "Study of the Well-Being of Older People in Cleveland, Ohio, 1975-76."	<b>Sensory</b> - Self-reported poor vision or blindness, or poor hearing or deafness. <b>Cognition</b> - Short Portable Mental Status Questionnaire <b>Functional outcome</b> - The degree of dependency on four ADLs and two IADLs (bathing, dressing, transferring, feeding, shopping, and transportation), using a hierarchical scale. <b>Quality of Life</b> - None.	<ul style="list-style-type: none"> <li>• Persons with cognitively impaired were twice as likely to decline in functioning compared to the unimpaired (RR=2.20).</li> <li>• Out of those who were independent or only had IADL dependencies (not ADL) at baseline, persons with hearing only impairments did not differ significantly from those with no impairments (OR=1.17), but persons with impairments in vision (OR=2.48) and impairments in both vision and hearing (OR=3.46) were at significantly greater risk than the unimpaired.</li> <li>• Vision or vision and hearing impairment were at 2.5-3.5 greater risk for functional decline than those with no visual or hearing impairments.</li> <li>• The risk of functional decline in persons with hearing, vision, and cognitive impairments is more than six times greater than those with none of these impairments.</li> </ul>

<p>Martin 2018 USA</p>	<p>To evaluate physical functioning in extreme old age and a model evaluating the interrelationship between physical, sensory, and cognitive function between the US and Japanese samples of the oldest old (<math>\geq 98</math> years).  Cross-sectional study.</p>	<p>Georgia sample: n = 245 (Female = 82.2%). White = 77.4% Black = 22.6% Mean age = 100.3<math>\pm</math>2.0 years. Years of education, 72 % had college or post college education.  Tokyo sample: n = 304 (Female = 78.6%). Asian = 100% Mean age = 101.1<math>\pm</math>1.7 years. Years of education, 43% had college or post college education.</p>	<p>Data from Phase 3 of the Georgia Centenarian Study and Tokyo Centenarian Study.</p>	<p><b>Sensory</b> - Yes-no coding to vision and hearing problems. <b>Cognition</b> - MMSE. <b>Functional outcome</b> - Dressing, grooming, and bathing items from the Barthel index (Tokyo sample) or OARS-ADL scale (Georgia sample). <b>Quality of Life</b> - None.</p>	<ul style="list-style-type: none"> <li>• The results indicate that both cognition and vision were significant predictors of the ADL outcome in the Tokyo sample but only cognition was a significant predictor in the Georgia sample.</li> </ul>
<p>Patel 2020 USA</p>	<p>To evaluate the association of co-occurring dementia and self-reported visual impairment on daily functioning.  Cross-sectional study.</p>	<p>n = 7,124 (Female = 55.3%). Non-Hispanic White = 80.4%. Non-Hispanic Black = 8.5%. Non-Hispanic Other = 3.8%. Hispanic = 7.3%. Mean age was not reported. 56% age range was between 65 to 74 years. Years of education ranged from less</p>	<p>Data from the 2015 National Health and Aging Trends Study.</p>	<p><b>Sensory</b> - Self-reported vision problems: could not read newspaper print even with glasses or could not see across the street, and blindness. <b>Cognition</b> - Probable dementia, possible dementia, or no dementia based on a report of physician diagnosis of dementia and AD 8 Dementia Screening Interview of proxy respondents, and performance tests of memory, orientation, and executive function. <b>Functional outcome</b></p>	<ul style="list-style-type: none"> <li>• Participants with self-reported visual impairment had lower functional scores compared with those without self-reported visual impairment in mobility, self-care, and household activities.</li> <li>• Participants with probable dementia had the lowest expected functional ability scores on all 3 outcomes, followed by those with possible dementia, and those with no dementia.</li> <li>• Participants with both possible or probable dementia and self-reported visual impairment had</li> </ul>



		<p>than a high school diploma to college degree or more.                  Mean years of education was not reported.</p>		<ul style="list-style-type: none"> <li>- Mobility activities: going outside, getting around inside, and getting out of bed.</li> <li>- Self-care activities: eating, dressing, toileting, and bathing.</li> <li>- Household activities: doing laundry, shopping for groceries, making hot meals, paying bills, and banking, and keeping track of medications.</li> </ul> <p><b>Quality of Life</b></p> <ul style="list-style-type: none"> <li>- None.</li> </ul>	<p>lower functional activity scores than independent contributions of visual impairment and dementia status alone.</p>
<p>Spiers 2005                  United Kingdom</p>	<p>To report the association between self-reported diseases and impairments and 2-year onset of disability in a prospective study of people aged 65 years or older.</p> <p><b>Longitudinal</b> study (2 years).</p>	<p>n = 8,142 (Female = 56.5%).                  Ethnicity/race was not reported.                  Mean age was not reported. 79% were between 65 to 79 years old.                  Years of education, 40.4% had &gt;9 years                  Mean years of education was not reported.</p>	<p>Data from the Medical Research Council Cognitive Function and Ageing Study. Participants were selected from the National Health Service primary care lists.</p>	<p><b>Sensory</b></p> <ul style="list-style-type: none"> <li>- Self-reported suffering from poor hearing or eyesight that interfered with day-to-day living or the interviewer observed problems that interfered to a marked extent with the interview process.</li> </ul> <p><b>Cognition</b></p> <ul style="list-style-type: none"> <li>- MMSE.</li> </ul> <p><b>Functional outcome</b></p> <ul style="list-style-type: none"> <li>- Modified Townsend ADL scale, which covers eight activity items and one mobility item.</li> </ul> <p><b>Quality of Life</b></p> <ul style="list-style-type: none"> <li>- None.</li> </ul>	<ul style="list-style-type: none"> <li>• Baseline cognitive impairment was independently associated with the onset of disability (OR=1.5 for MMSE scored 22-25) and OR=3.6 for MMSE 0-21).</li> <li>• Eyesight problems were associated with the onset of disability (OR=1.3), while the hearing problems were not.</li> </ul>

<p>Tomioka 2015 Japan</p>	<p>To clarify the relationship between self-reported hearing loss and 5-year decline in high level functional capacity in high-functioning older adults.</p> <p><b>Longitudinal</b> study (5 Years).</p>	<p>n = 3,936 (Female = 49.9%). Ethnicity/race was not reported. Mean age = 72.4 years (range: 65-93). Years of education, 28% of the sample had less than high school education.</p>	<p>Data from the Fujiwara-Kyo Study (baseline data in 2007-2008 and follow-up data in 2012-2013).</p>	<p><b>Sensory</b> - One yes/no self-reported hearing loss question and one yes/no self-reported visual impairment question.</p> <p><b>Cognition</b> - MMSE.</p> <p><b>Functional outcome</b> - Tokyo Metropolitan Institute of Gerontology Index of Competence subscales: IADL, intellectual activity, and social role.</p> <p><b>Quality of Life</b> - None.</p>	<ul style="list-style-type: none"> <li>• Hearing loss is associated with 5-year decline in intellectual activity (OR=1.39) and social role (OR=1.34) but not IADL after adjusting covariates.</li> <li>• Visual impairment was significantly associated with 5-year decline in the subscale of the intellectual activity, social role, and IADL.</li> <li>• Cognitive impairment was significantly associated with 5-year decline in the subscale of the intellectual activity, social role, and IADL.</li> </ul>
<p>Whitson 2007 USA</p>	<p>To determine the risk of disability in individuals with coexisting visual and cognitive impairment and to compare the magnitude of risk associated with visual impairment, cognitive impairment, or the multimorbidity.</p> <p><b>Longitudinal</b> study (6 years).</p>	<p>n = 3,878 (Female = 64.8%). Black = 53.7% &lt;1% of participants were neither black nor white. Mean age = 73.3 ± 6.5 years. Years of education: less than 7 years = 43.4%; 8 to 11 years = 33.5%; more than 11 years = 23.1%.</p>	<p>Data from the North Carolina Established Populations for the Epidemiologic Studies of the Elderly (1986 to 1987).</p>	<p><b>Sensory</b> - Two self-reported visual impairment questions.</p> <p><b>Cognition</b> - 10-item Short Portable Mental Status Questionnaire.</p> <p><b>Functional outcome</b> - Five questions related to Katz ADL scale (bathing, dressing, transferring from a bed to a chair, using the toilet, and eating), five questions related to IADL (driving, shopping, preparing meals, doing housework, and handling finances), and three questions related to mobility from the Rosow- Breslau health scale (climbing stairs, doing heavy housework, and walking half a mile).</p> <p><b>Quality of Life</b> - None.</p>	<ul style="list-style-type: none"> <li>• Visual impairments were significantly associated with the disability of ADL (OR = 1.68), IADL (OR = 2.87), and mobility (OR = 2.27).</li> <li>• Cognitive impairments were significantly associated with the disability of ADL (OR = 2.03), IADL (OR = 2.58), and mobility (OR = 1.56).</li> <li>• The odds for each type of disability was greatest when both cognitive and visual impairment were present together (ADL OR = 2.84, IADL OR = 6.5, &amp; Mobility OR = 4.04).</li> </ul>

<p>Whitson 2014 USA</p>	<p>To examine the relationship between comorbid cognitive and vision impairment with disability status in an Asian population.</p> <p>Cross-sectional study.</p>	<p>n = 4,508 (Female = 53.4%). Chinese = 83.3% Malay = 9.1% Indian = 6.2% Other = 1.4% Mean age = 69.2 ± 7.2 years. Years of education: 28.6% of the sample had less than primary education.</p>	<p>The Singapore Social Isolation, Health, and Lifestyles Survey</p>	<p><b>Sensory</b> - Self-rated visual impairment.</p> <p><b>Cognition</b> - 10-item Short Portable Mental Status Questionnaire.</p> <p><b>Functional outcome</b> - Self-reported difficulty in seven basic ADL items (dress, take a bath/shower, sit down and stand up, walk around the house, go outside, use the toilet, and eating) and seven IADL items (prepare meals, shop, use the phone, light housework, use public transport, take medication as prescribed, and manage financial matters).</p> <p><b>Quality of Life</b> None.</p>	<ul style="list-style-type: none"> <li>• Visual impairment alone increased the risk of ADL disability (OR = 2.40) and IADL disability (OR = 1.93).</li> <li>• Cognitive impairment alone increased the risk of ADL disability (OR = 2.73) and IADL disability (OR = 2.26).</li> <li>• Participants with co-existing vision and cognitive impairment had higher odds of ADL disability (OR = 3.26) and IADL disability (OR = 2.50).</li> </ul>
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<p>Wood 2005 USA</p>	<p>To examine the relative importance of cognitive (e.g. speeded and nonspeeded) and sensory factors in relation to older adults' functional abilities.</p> <p>Cross-sectional study.</p>	<p>n = 530 (Female = 60%). White = 90.3% Black = 9.4% Other = 0.2% Mean age was not reported. Age range = 62-94 years. Years of education: 92% of the sample had high school education or above.</p>	<p>Participants in the Staying Keen in Later Life study, from two cities in the United States.</p>	<p><b>Sensory</b></p> <ul style="list-style-type: none"> <li>- Vision: far visual acuity, near visual acuity, and contrast sensitivity</li> <li>- Hearing: audiometer</li> </ul> <p><b>Cognition</b></p> <ul style="list-style-type: none"> <li>- MMSE.</li> <li>- Literacy (The Adult Dyslexia Test)</li> <li>- Processing speed (UFOV test, letter comparisons, pattern comparison, WAIS-R digit symbol substitution, and digit symbol copy).</li> <li>- Attention switching (Shape Color Size).</li> <li>- Lexical Decisions.</li> <li>- Working memory (WMS-III spatial span, WMS-III digit span, Hopkins verbal learning test).</li> <li>- Intellectual functioning (WAIS vocabulary and WAIS matrix reasoning).</li> <li>- Executive functioning (Trails A and B and Stroop).</li> </ul> <p><b>Functional outcome</b></p> <ul style="list-style-type: none"> <li>- Timed IADL test.</li> <li>- Mobility Questionnaire, which measured life-space, driving-space, and driving exposure.</li> </ul> <p><b>Quality of Life</b></p> <ul style="list-style-type: none"> <li>- None.</li> </ul>	<ul style="list-style-type: none"> <li>• All non-speeded cognitive factor, speeded cognitive factor, and sensory factors accounted for a significant amount of variance of Timed IADL test and the Mobility Questionnaire.</li> <li>• The non-speeded cognitive factor accounted for the most variance of Timed IADL test.</li> <li>• Cognitive speed factor accounted for the most variance in the life-space, driving-space, and driving exposure.f</li> </ul>
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<p>Xu 2019 China</p>	<p>To investigate ADL and influencing factors in the older Chinese population.  Cross-sectional study.</p>	<p>n = 1,087 (Female = 43.5%). Ethnicity/race was not reported. Mean age = 77.8 ± 8.1 years. Years of education: 42.8% of the sample had middle school or more than middle school education.</p>	<p>Recipients of long-term care services in Jiangxi province, China.</p>	<p><b>Sensory</b> - Self-reported visual ability. <b>Cognition</b> - MMSE. <b>Functional outcome</b> - Barthel ADL Index. <b>Quality of Life</b> - None.</p>	<ul style="list-style-type: none"> <li>• Cognitive impairment and visual impairment were individually associated with services recipients who had poor ADL scores.</li> </ul>
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Note. ADAS-COG = Alzheimer’s disease assessment scale-cognitive subscale. ADL = activities of daily living. IADL = instrumental activities of daily living. MMSE = mini mental status exam. OARS = Older Americans Resources and Services. OR = odds ratio. UFOV= useful field of view. WAIS-R = Revised Wechsler Adult Intelligence Scale. WMS = Wechsler Memory Scale.

Supplementary Table 3: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
<b>TITLE</b>			
Title	1	Identify the report as a scoping review.	1
<b>ABSTRACT</b>			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5
<b>METHODS</b>			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	5-6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	5-6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Supplementary Table 1
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6-7
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	7
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	6-7

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Critical appraisal of individual sources of evidence <sup>§</sup>	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	NA
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	7-8
<b>RESULTS</b>			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	8 and Figure 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Supplementary Table 2, 8-11
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	NA
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Table 2
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	12-16
<b>DISCUSSION</b>			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	16
Limitations	20	Discuss the limitations of the scoping review process.	17-20
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	21
<b>FUNDING</b>			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Title page.

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

\* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

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