Comorbidities of hearing loss and the implications of multimorbidity for audiological care

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Abstract

With increasing age, the risk of developing chronic health conditions also increases, and many older people suffer from multiple co-existing health conditions, i.e., multimorbidity. One common health condition at older age is hearing loss (HL). The current article reflects on the implications for audiological care, when HL is one of several health conditions in a multimorbidity. An overview of health conditions often co-existing with HL, so called comorbidities, is provided, including indications for the strength of the associations. The overview is based on a literature study examining cohort studies that were published in the years 2010–2018 and examined associations of hearing loss with other health conditions, namely Visual impairment, Mobility restrictions, Cognitive impairment, Psychosocial health problems, Diabetes, Cardiovascular diseases, Stroke, Arthritis, and Cancer. This selection was based on previous publications on common chronic health conditions at older age and comorbidities of hearing loss. For all of these health conditions, it was found that prevalence is larger in people with a HL and several longitudinal studies also found increased incident rates in people with a HL. The examined publications provide little information on how hearing loss should be managed in the clinical care of its comorbidities and vice versa. The current article discusses several options for adaptations of current care. Nonetheless, solutions for an integrated audiology care model targeting HL in a multimorbidity are still lacking and should be subject to future research.

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Introduction

Methodology

Selection of comorbidities

Inclusion criteria for publications

Summary of findings

1. Vision impairment
2. Mobility restrictions
3. Cognitive impairment
4. Psychosocial health
5. Diabetes mellitus
6. Cardiovascular disease
7. Arthritis
8. Cancer
9. Stroke

Discussion

Conclusions

Funding

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1. Introduction

The proportion of older people (60 years or over) in the world's population is increasing, as a consequence of increased longevity and general population growth (UN, 2015). There is an increased risk of developing various types of chronic health disorders at older age. Chronic conditions often occur in combination (Bayliss et al., 2003) and multimorbidity, the coexistence of 2 or more chronic conditions, is common in older people (Britt et al., 2008; WHO, 2015; Wolff et al., 2002). The high prevalence of multimorbidity is of huge concern, not only because of its detrimental impact on patients' functioning and quality of life (QoL), but also because healthcare costs increase exponentially with the number of co-existing chronic conditions in a person (Valderas et al., 2009). The relationship between co-existing diseases is usually difficult to assess and diseases can also co-exist without an etiologic relationship (Valderas et al., 2009). Independent of etiologic relationships, multimorbidity increases the treatment burden for patients and adds complexity to treatment plans (Bayliss et al., 2003). Care providers should therefore be aware of potential comorbidities in order to act appropriately, define the right multimorbidity management plan, and thus promote patient care and well-being (Kernick, Chew-Graham and O'Flynn, 2017; Muth et al., 2014; Stam et al., 2014).

One of the most prevalent chronic health conditions in older age is hearing loss (HL; Stevens et al., 2013). In a meta-analysis of 42 studies from different regions of the world, Stevens et al. (2013) found that the prevalence of HL was less than 10% for people of 50 years, 20% for people of 60 years, more than 40% for people of 70 years, and more than 50% for people of 80 years. HL is often observed in combination with other (chronic) diseases (Kramer et al., 2002; Stam et al., 2014). In clinical care, one of the chronic conditions is often considered as the primary or “index” disease, which is the main focus of the clinical pathway in question, while other co-existing diseases are referred to as comorbid diseases or comorbidities (Valderas et al., 2009). Depending on the severity of the co-existing diseases, the treatment of HL may play a secondary role in patient care. Nonetheless, the understanding, appropriate counseling, and treatment of hearing impaired patients with comorbidities is of high importance (Stam et al., 2014); and the process of rehabilitation should ideally take all comorbidities into account.

The purpose of the current article was to reflect on the management of HL in a multimorbidity situation. On the one hand, possibilities of handling multimorbidity in audiological care are discussed. On the other hand, considerations are given on how hearing loss could be accounted for in the clinical care of health conditions, where hearing loss is a comorbidity to another index disease. First, an overview of common comorbidities of hearing loss is given, providing short definitions of the respective health conditions and condensed information about the strength of their observed associations with hearing loss, as found in previous publications. The overview is based on a literature study examining cohort studies published in 2010 or later that had at least 400 participants. The latter choice was made to limit the study to studies that have enough power to examine associations between HL and comorbidities, while controlling for potential confounders, such as age, smoking habits, and bodyweight (see Rigters et al. (2016) for a list of determinants of HL). The health conditions considered in the literature study are Visual impairment, Mobility restrictions, Cognitive impairment, Psychosocial health problems, Diabetes, Cardiovascular diseases, Stroke, Arthritis, and Cancer. This selection was based on a list of chronic health conditions that are common in old age according to the WHO (2015) and on two previous relatively large-scale studies examining associations of hearing loss with other health issues (McKee et al., 2017; Stam et al., 2014); further details are provided in Section 3.1. After the overview of comorbidities of hearing loss, we discuss possibilities for adaptations to current hearing care to account for the potential co-existence of several chronic health conditions.

2. Methodology

2.1. Selection of comorbidities

The “World Report on Ageing and Health” (WHO, 2015) lists sensory impairments, back and neck pain, chronic obstructive pulmonary disease, depressive disorders, falls (mobility restrictions), diabetes, dementia and (osteo-)arthritis as health conditions associated with ageing. For the literature search, we considered those of the listed conditions that showed a significant association with hearing loss in at least one of two recent large-size cohort studies (cf. McKee et al., 2017; Stam et al., 2014). Accordingly, “back and neck pain” and “chronic obstructive pulmonary disease” were excluded from the literature search. On the other hand, based on Stam et al. (2014) and McKee et al. (2017), three additional conditions were added, which were not listed by the WHO, i.e., cardiovascular diseases, stroke, and cancer, to be significantly associated with hearing loss. Furthermore, based on Stam et al. (2014), the depressive-disorders category was extended to psychosocial health. We added these conditions to the literature search. Thus, finally, the literature search concerned relationships between HL and the following health conditions: Visual impairment, Mobility restrictions, Cognitive impairment, Psychosocial health problems, Diabetes, Cardiovascular diseases, Stroke, Arthritis, and Cancer.

2.2. Inclusion criteria for publications

Studies that met the following criteria were included in the literature study: (1) Cross-sectional and prospective longitudinal studies with at least 400 adult participants; (2) Publication was in English and took place between January 2010 and May 2018; (3) A direct association between HL and a comorbidity was examined. Explicitly excluded were studies focusing on Meniere's disease, cochlear implant users, and/or pediatric study groups. A separate search query was issued for each of the comorbidities. All queries included the search terms “hearing loss OR hearing impair” OR hearing problem OR hearing” in combination with search terms specific for the respective health condition (e.g., diabetes: “diabetes OR diabetes mellitus”). To limit the number of search results, both the hearing and the comorbidity search terms needed to occur in the title of the article. We are aware that this might result in potentially missing suitable publications. However, the idea was to restrict the search outcome to studies that focused on hearing loss, given that many cohort studies measure hearing loss as a confounder but do not necessarily analyze associations between hearing loss and other comorbidities. Moreover, search
terms included the keywords "cohort" study OR population" study OR longitudinal OR cross-sectional" to more specifically find articles that met the inclusion criteria.

Inclusion of the publications into the literature study was based on information provided in the title or abstract of the publication and ultimately on the full text, if the abstract was inconclusive.

3. Summary of findings

This section summarizes the findings of the examined studies by comorbidity, for a complete list of studies see Table 1. The reported measure of association between HL and the comorbidities differed between the studies; but most often, odds ratios (OR) with 95% confidence intervals (CI) were reported. The OR describes the probability of an outcome given a certain exposure, compared to the outcome without this exposure; for example, the probability of HL in a diabetes vs. a non-diabetes patient (Bland and Altman, 2000; Szumilas, 2010). Hazard ratios (HR) were mainly found in longitudinal analyses as this ratio considers changes over time (Stare and Maucort-Boulch, 2016); that is, incidence of an outcome given another factor. Less frequently, the relative risk (RR) or the incidence rate ratio (IRR) were reported. The RR compares the risk or incidence of a disease in two different groups, whereas the IRR reflects the number of incidences in relation to the population at risk taking the person-time at risk into account (cf. Stare and Maucort-Boulch, 2016). For the purpose of his article, we kept the outcome measures used in the original publications but summarized findings in a way that should make interpretation straightforward, independent of the applied measure. Whenever the studied publications reported statistical models adjusted for age, sex or other confounding factors, we considered only the results of the most adjusted model.

3.1. Vision impairment

Increasing prevalence of sensory impairment at older age is not limited to hearing loss but includes vision impairment (VI). Several of the retrieved studies reported prevalence rates for HL only, VI only, and so-called dual-sensory impairment (DSI; Fisher et al., 2014; Gopinath et al., 2014; Liu et al., 2016; Mitoku et al., 2016; Schneck et al., 2012). Prevalence in percent ranged between 3.1 and 18.2% for DSI; between 12.8 and 28.1% for HL only; and 2.4 and 14.4% for VI only (Fisher et al., 2014, Gopinath et al., 2014, Schneck et al., 2012, Mitoku et al., 2016, Liu et al., 2016). While none of the above publications examined risks of the one sensory impairment in the presence of the other; the finding that the prevalence for DSI was higher than the product of the prevalence of each individual impairment in all of the studies, indicates that HL and VI are not independent from each other. None of the viewed studies discussed the underlying physiological mechanisms that might drive the association between HL and VI, with the exception of Gopinath et al. (2014) who found indications for an influence of nutrient intake.

3.2. Mobility restrictions

Mobility restrictions are often a consequence of postural control, mainly reflected in balance and orientation disorders with increased risks of falling. Balance problems are common amongst older individuals and can lead to reduced QoL, limited independence, and severe injuries, which in turn lead to a decline of health status or even death (e.g., Agmon et al., 2017; Vergheese et al., 2006). Individuals with HL show stronger restrictions in mobility than NH individuals and restrictions increase with increasing HL (Mikkola et al., 2015; Polku et al., 2015). The examined studies reported age-corrected odds of falling or dizziness causing falling that were 1.4–2.5 higher in groups with HL compared with NH individuals (Gopinath et al., 2016; Liljas et al., 2017; Lopez et al., 2011; Stam et al., 2014). Moreover, longitudinal analyses found that individuals who were categorized as ‘pre-frail’ at baseline showed a higher risk of becoming frail within a period of four years (adjusted OR = 1.64, 95% CI [1.07–2.51]), when they had a HL (Liljas et al., 2017).

The mechanisms underlying the association of declined postural control and hearing loss seem to be diverse and are not fully understood. It is suggested that neural mechanisms, such as age-related changes in the corpus callosum could similarly influence hearing and walking in elderly individuals by slowing down the inter-hemispheric transfer (Agmon et al., 2017; Gates and Mills, 2005; Rosano et al., 2005). Moreover, age-related changes or changes due to inner-ear diseases might affect the cochlea as well as the vestibular system, which could result in simultaneous hearing problems and reduced postural control (Agmon et al., 2017; Gispen et al., 2014). Also cognitive and behavioral mechanisms might influence the association between mobility limitations and hearing loss (Agmon et al., 2017; Clark, 2015).

3.3. Cognitive impairment

Dementia and milder forms of cognitive decline are common at older age. In 2010, approximately 35.6 million people lived with dementia worldwide and estimates are that the absolute numbers will double approximately every 20 years (Prince et al., 2013). There are indications that dementia and HL are connected, and the studies we reviewed confirm this notion. Cross-sectional analyses found the prevalence of cognitive impairment to be higher in people with HL, both for tested HL (Davies et al., 2017; Dawes et al., 2015; Heywood et al., 2017; Hung et al., 2015; Su et al., 2017; Teipel et al., 2015) and for self-reported HL (Amieva et al., 2015; Davies et al., 2017). Prevalence of dementia is also related to the severity of the hearing loss: Davies et al. (2017) found an OR of 4.4 (95% CI [1.9–9.9]) for dementia in people with poor hearing and an OR of 1.6 (95% CI [1.0–2.8]) for people with moderate hearing compared to NH people.

In addition to cross-sectional prevalence analyses, the relationship between hearing loss and cognitive impairment has been examined in a considerable number of longitudinal studies in recent years. Several studies (Davies et al., 2017; Deal et al., 2016; Fritze et al., 2016; Golub et al., 2017; Gurgel et al., 2014; Heywood et al., 2017; F. R. Lin et al., 2011; F. R. Lin et al., 2013; Mitoku et al., 2016; Su et al., 2017) found increased incidence risks of dementia compared to people without a hearing loss, with HRs typically in the range 1.2–1.5. Also the rate of cognitive decline over time seems to be affected by HL. Amieva et al. (2015) found in a longitudinal study over 25 years (with follow-up visits every 2–3 years) that people with self-reported HL had a higher rate of cognitive decline than people with NH. The incidence of dementia was found to be related to severity of HL (F. R. Lin et al., 2011).

In sum, evidence shows that the prevalence and incidence of dementia and the rate of cognitive decline are associated with hearing loss. Furthermore, greater severity of HL leads to greater risks for incident dementia. At present, it is unclear what causes the link between cognitive impairment and hearing loss. One potential explanation is that the association is driven by changes in brain structure and function that affect hearing and cognition equally. Another hypothesis is that the HL leads to a continuously increased cognitive load during listening, which then leads to cognitive overload and decline (McCoy et al., 2005; Tun et al., 2009). Finally hearing loss can lead to social isolation and thus cognitive under-stimulation, which could have negative consequences for cognitive health (e.g., Dawes et al., 2015; Golub et al., 2017; F. R. Lin et al.,
Table 1

| Reference and sample | Study Design | Association with comorbidity and HL |
|----------------------|-------------|-------------------------------------|
| Schneck et al., 2012 | Cross-sectional analysis | Significantly higher risk of HL in low vision: |
| n = 464 (57% f); NH n = 389 (58% f); HL n = 57 (53% f) | model adjusted for age | - Low contrast (< 0.1%) OR = 1.50, 95% CI: [1.02–2.22] |
| M age = 79.9 y | Hearing screening (tones at 40 dB: 0.5, 2, 4 kHz) | - Low contrast/low luminance OR = 1.46, 95% CI: [1.07–1.98] |
| Gopinath et al., 2013 | Longitudinal study (5 years) | - Low contrast in glare OR = 1.40, 95% CI: [1.02–1.91] |
| n = 1,478 (78% f); NH n = 893 (543 f); HL n = 440 (236 f) | models adjusted for age, sex, walking disability, visual impairment and 3 or more co-morbidities | Additonal references on visual impairment: |
| age: ≥ 49 y | HL measured by PTA (0.5–4 kHz) | Fisher et al., 2014: longitudinal; higher risk of mortality (cardio-vascular disease) for patients with HL; higher risk for (all cause) mortality in patients DSI. |
| Liljas et al., 2017 | - Cross-sectional analysis of data; models adjusted for age, sex and age (wealth, education, CVD, cognition, and depression); | Gopinath et al., 2013: longitudinal; patients with DSI had a higher risk of dying 10 years later. |
| n = 2,836 (44% f); HL n = 643 | - Longitudinal study with a 4-year follow-up; model adjusted for sex and age | Gopinath et al., 2016: longitudinal; risk of falling greater in hearing aid users; risk of falling greater with co-existing best-corrected visual impairment and mild HL. |
| categorization into not-frail, pre-frail, frail | self-reported hearing | Liu et al., 2016: longitudinal; individuals with visual, cognitive and hearing impairment had increased odds of (instrumental) activities of daily living and low self-rated health. |
| Lopez et al., 2011 | Longitudinal study (6.36 years) | Mitolu et al., 2016: longitudinal; greater risks of cognitive decline in patients with DSI and HL; greater risk of mortality with DSI and cognitive impairment and HL and cognitive impairment. |
| n = 5,354 (3557 f); HL n = 1,228 | model adjusted for Body-Mass-Index | Vision impairment |
| age: 76–81 y | self-reported hearing | Balance disorders |
| Stam et al., 2014 | Cross-sectional analysis | Gopinath et al., 2016: longitudinal; DSI more prevalent in groups with low total diet score. |
| n = 1,865; NH n = 975; HL n = 890 | models adjusted for age and sex | Fisher et al., 2014: longitudinal; higher risk of mortality (cardio-vascular disease) for patients with HL; higher risk for (all cause) mortality in patients DSI. |
| age: 18–70 y | Hearing screening (digits-in-noise test) | Additional references on visual impairment: |
| | | Gopinath et al., 2013; longitudinal; greater risks of cognitive decline in patients with DSI and HL; greater risk of mortality with DSI and cognitive impairment and HL and cognitive impairment. |
| Deal et al., 2016 | Longitudinal study (7-year follow up) | Cognitive impairment |
| n = 1,889; NH n = 786 (63% f); mild HL n = 716 (50% f); moderate HL n = 387 (35% f) | models adjusted for age, sex, race, education, and study site, smoking status, hypertension, diabetes, stroke. | Davies et al., 2017; cross-sectional; major HL was associated with difficulties in stair-climbing and longer-distance walking; major HL associated with more difficulties in activities of daily living. |
| age: 70–79 y | Hearing screening (PTA; 0.5, 1, 2, and 4 kHz) | Golub et al., 2017; cross-sectional; major HL was associated with difficulties in stair-climbing and longer-distance walking; major HL associated with more difficulties in activities of daily living. |
| Fritze et al., 2016 | Longitudinal study (6 years) | Ahlstrom et al., 2016; longitudinal; higher risk of dementia among women with hearing loss. |
| n = 14,602; bilateral HL | model adjusted for age, gender, tinnitus, and co-morbidities | Additional references on mobility restrictions: |
| n = 3,238; NH n = 7,035 | pre-study professional diagnosis | Messina et al., 2017; cross-sectional; 42.9% of Vertigo patients showed hearing loss; 80% reported on set before BPPV diagnosis (potentially also driven by age). |
| Golub et al., 2017 | Longitudinal study (mean 7.3 years follow up) | Mikkola et al., 2015; cross-sectional; major HL was associated with difficulties in stair-climbing and longer-distance walking; major HL associated with more difficulties in activities of daily living. |
| n = 1,881; HL n = 204 (63% f); NH n = 1,667 (70% f) | observed hearing (by examiner) or self-reported hearing | Additional references on mobility restrictions: |
| M age = 75.8 y | | fences et al., 2014; longitudinal; higher risk of dementia with bilateral HL: |
| Gurler et al., 2014 | Longitudinal study | - self-reported hearing: OR = 1.6, 95% CI: [1.1–2.4] (moderate hearing); OR = 2.9, 95% CI: [1.7–4.0] (poor hearing) |
| NH n = 3,627 (60% f); HL n = 836 (45% f) | model adjusted for gender, presence of APOE-e4 allele, education, baseline age | - objective hearing: OR = 1.6, 95% CI: [1.0–2.8] (moderate hearing); OR = 4.4, 95% CI: [1.9–9.0] (poor hearing) |
| M age = 75.4 y (SD = 6.9 y) | observed hearing (by examiner) | Risks of developing dementia for moderate and poor hearing:HR = 1.4, 95% CI: [1.0–1.9]; HR = 1.6, 95% CI: [1.1–2.0]. |
| Heywood et al., 2017 | Longitudinal study and cross-sectional analysis of data | Incidence of dementia in HL higher:HR = 1.55, 95% CI: [1.10–2.19]. |
| n = 2,599; NH n = 2,530 (64% f); HL n = 69 (48% f) | model adjusted for sex, age, ethnicity, education, central obesity, hypertension, diabetes, dyslipidemia, smoking, alcohol, leisure time activity, cardiac diseases, depressive symptoms | |
| Hung et al., 2015 | Cross-sectional analysis | Hearing screening (whispered voice test) |
| Alzheimer n = 488 (56% f) | model adjusted for age, hearing loss, depression, diabetes mellitus, | - Higher risk for Alzheimer’s disease with HL: OR = 1.39, 95% CI, [1.05–1.84] |
| M age = 76.20 y | | |

**Additional references on mobility restrictions:**

- Messina et al., 2017: cross-sectional; 42.9% of Vertigo patients showed hearing loss; 80% reported on set before BPPV diagnosis (potentially also driven by age).
- Mikkola et al., 2015; cross-sectional; major HL was associated with difficulties in stair-climbing and longer-distance walking; major HL associated with more difficulties in activities of daily living.
- Polku et al., 2015; longitudinal; higher restriction of life-space mobility with mild HL and major HL (at baseline); higher risk of life-space restriction at follow-up in mild and major HL group.
| Reference and sample | Study Design | Association between comorbidity and HL |
|----------------------|-------------|----------------------------------------|
| control n = 1952 (56% f) | M age = 75.24 y | head injury, hyperlipidemia, hypertension, Parkinson’s disease hearing status based on medical record |
| Lin et al., 2013 | Longitudinal study (6 years follow up) | - Increased risk of cognitive impairment with HL: HR = 1.24, 95% CI: [1.05–1.48] |
| n = 3075; HL n = 1162 (45% f); NH n = 1913 (62% f) | models adjusted for age, sex, race, education, study site, smoking, hypertension, diabetes, stroke history hearing screening (PTA) | - Overall lower scores in cognitive tests and greater annual decline for HL group compared with NH group. |
| Lin et al., 2011 | Longitudinal study (mean 11.9 years) | - Higher risk of dementia with HL: mild HL: HR = 1.89, 95% CI: [1.00–3.58]; moderate HL: HR = 3.00, 95% CI: [1.43–6.30]; severe HL: HR = 4.94, 95% CI: [1.09–22.4] |
| n = 639 | models adjusted for age, sex, race, education, diabetes mellitus, smoking, hypertension hearing screening (PTA) | - Increasing incident all-cause dementia with severity of baseline HL: HR = 1.27 per 10-dB loss; 95% CI: [1.06–1.50] |
| Cho et al., 2016 | Cross-sectional analysis | Increased risk of hearing impairment with increasing levels of eGFR and UACR |
| n = 1206 (44% f) | M age = 61.2 y | - eGFR (highest level): OR = 2.77, 95% CI [1.35–5.62];UACR = 2.00, 95% CI [1.10–3.61] |
| Kim et al., 2017 | Cross-sectional | Increased risk of hearing impairment with increasing levels of eGFR and UACR |
| n = 649; M age = 61.8 y | overall 50% ≥ 65 y; 38 f | - UACR (highest level): OR = 2.77, 95% CI [1.35–5.62]; |
| Kim et al., 2016 | Cross-sectional | - 0–29 y/m/f: aHR = 2.80, 95% CI [1.20–5.83]; |
| n = 6136 (44% f) | NH n = 24,544 (44% f) | - 30–59 y/m/f: aHR = 1.47, 95% CI [1.17–1.84]; |
| age: 0–85+y | | - 60–85+y/m/f: aHR = 1.45, 95% CI [1.20–1.75];n.s. |

**Psychosocial Health issues**

**SSNHL n = 3552 (48% f); M age = 51.3 y controls n = 10,566 (47% f); M age = 51.2 y**

- Cross-sectional; adjustment for geographic region, hypertension, diabetes, hyperlipidemia, renal disease, coronary artery disease; Hearing status based on medical record

**Contrera et al., 2017**

- Cross-sectional Hearing screening (PTA; 0.25-8 kHz)

- Higher risk of prevalent anxiety with mild HL: OR = 1.32, 95% CI [1.01–1.73] and moderate or greater HL: OR = 1.59, 95% CI [1.14–2.22]

- 12% higher risk of prevalent anxiety per 10 dB increase in PTA: OR = 1.12, 95% CI [1.02–1.23]

**Hsu et al., 2016**

- Longitudinal; adjustment for age, sex, comorbidity variables; Hearing status based on medical record

**Kim et al., 2016**

- Cross-sectional; adjustment for age, sex, income, region of residence, dementia, hypertension, diabetes, dyslipidemia; Hearing screening (PTA; 0.5, 1, 2 kHz)

- Increased risk for depression with HL

**Tseng et al., 2016**

- Longitudinal analysis (10 years)

**Additional references to psychosocial health**

**Dawes et al., 2015**

- cross-sectional; poorer hearing was associated with poorer cognition; HA use was associated with better cognition; social isolation was associated with both poorer cognition, poorer hearing and higher frequency of depression.

**Teipel et al., 2015**

- Cross-sectional; strong association between dementia and hearing impairment.

**Conrada et al., 2017**

- Cross-sectional Hearing screening (PTA; 0.25-8 kHz)

**Stam et al., 2016**

- Longitudinal; HL associated with higher risk of social and emotional loneliness.

**Tseng et al., 2016**

- Longitudinal; prevalence and development of depression higher in SSNHL than in NH, especially below age of 60 y.

**Diabetes mellitus**

**Cho et al., 2016**

- Cross-sectional analysis models adjusted for sex and age

**Jung et al., 2017**

- Cross-sectional analysis models adjusted for age, sex, high-density lipoprotein cholesterol levels, triglyceride levels, estimated glomerular filtration rate, systolic blood pressure, diastolic blood pressure, body mass index, alcohol consumption, smoking behavior, glycosylated hemoglobin levels, exposure to explosives or occupational noise

- Propective longitudinal study (median 4 year-follow up)

**Kim et al., 2017**

- Cross-sectional analysis models adjusted for age, sex, study centre and year of visit, exposure to occupational noise, BMI, smoking, alcohol and vigorous exercise, total

- Increased risk of hearing impairment with increasing levels of eGFR and UACR

- eGFR (highest level): OR = 2.77, 95% CI [1.35–5.62];

- UACR (highest level): OR = 1.981, 95% CI [1.146–3.424]

- Higher risk for HL with high UACR levels: OR = 1.172, 95% CI [1.04–1.32]

- Severity of HL related to levels of UACR

- Presence of albuminuria had modest effect on hearing thresholds regardless of presence of DM

- DM without albuminuria was also associated with high hearing thresholds

- Risk of hearing loss in comparison with no-diabetes participants

* (continued on next page)
### Table 1 (continued)

| Reference and sample | Study Design | Association between comorbidity and HL |
|----------------------|--------------|---------------------------------------|
| age: 18.0–87.1 y all NH at baseline testing | and high-density lipoprotein (HDL) cholesterol, triglycerides, hypertension. | - DM: aHR = 1.36, 95% CI [1.19–1.56] |
| Oh et al., 2014 | Cross-sectional analysis models adjusted for age, hypertension, DM, gender Hearing screening (PTA; 0.5, 1, 2, 4 kHz) | Diabetes mellitus independent predictor of HL: OR = 1.4, 95% CI [1.20–1.63] |
| Seo et al., 2015 | Cross-sectional analysis models adjusted for age, hypertension, DM, gender Hearing screening (PTA; 0.5, 1.24 kHz) | - Higher risk of HL in patients with IFG - Males higher risks for high-frequency HL with insulin resistance: OR = 1.61, 95% CI [1.09–2.37] |
| Lin et al., 2016a | Longitudinal study (follow up every 2 years) models adjusted for age Self-reported hearing | - b-cell dysfunction OR = 0.46, 95% CI [0.26–0.80] |
| Chang et al., 2011 | Cross-sectional analysis models adjusted for age, educational level, triglyceride level -> 150 vs. < 150 mg/dl; tobacco use, alcohol consumption, regular exercise Hearing screening (PTA; 0.5, 1, 2, 4 and 6 kHz) | - Males < 70 y higher risk of high-frequency HL with IFG: OR = 1.44, 95% CI [1.056,1.967] |
| Chang et al., 2011 | Prospective cohort study for at least 3 years Models adjusted | Higher insulin resistance: OR = 1.45, 95% CI [1.039–2.101] |
| Lin et al., 2016b | Cross-sectional analysis models adjusted for age models adjusted for age, BMI, race, profession, smoking, hypertension, diabetes, elevated cholesterol, aspirin, NSAID, acetaminophen use Self-reported hearing | - b-cell dysfunction: OR = 0.45, 95% CI [0.274–0.729] |
| Shargorsky et al., 2010 | Longitudinal study models adjusted for age Self-reported hearing | Higher risk of HL in hypertension group: high HL: OR = 1.48, 95% CI [1.02–2.15] |
| McKee et al., 2017 | Cross-sectional analysis models adjusted for age, insurance status, sex, race/ethnicity, marital status, income, education, region of residence, BMI, 30, other disability status, smoking status, age by hearing loss interaction terms Self-reported hearing | - Higher risk of ISSNHL in HCh cohort: aHR = 1.60, 95% CI [1.39–1.85] |
| Lin et al., 2016a | Longitudinal study (follow up every 2 years) models adjusted for age Self-reported hearing | - Higher risk of developing ISSNHL for HCh cohort with newly diagnosed stroke: aHR = 1.48, 95% CI [1.08–2.04] |
| Tan et al., 2017 | Cross-sectional analysis models adjusted for gender, age group, family history of hearing loss Hearing screening (PTA; 0.5, 1, 2, 4 kHz) | - Higher risk of developing ISSNHL for HCh cohort with newly diagnosed stroke combined with coronary artery disease: aHR = 1.69, 95% CI [1.18–2.43] |
| Huang et al., 2018 | Retrospective cohort study Models adjusted for sex, age, diabetes, hyperlipidaemia, hypertension, hyperthyroidism, hypothyroidism, BHd, stroke, CKD, autoimmune diseases No HL based on medical record | Higher risk of HL in hypertension: RR = 1.04, 95% CI: [1.01, 1.07] |
| Jeong et al., 2016 | Cross-sectional cohort study Models are adjusted Hearing screening (PTA; 0.5-6 kHz) | With HL, higher prevalence of cardiovascular disease: OR = 1.48, 95% CI [1.33–1.66] and high blood pressure: OR = 1.29, 95% CI: [1.17–1.43] |
| Jeong et al., 2016 | Cross-sectional cohort study Models adjusted No HL based on medical record | - Higher risk of HL in hypercholesterolemia: aHR = 1.10, 95% CI [1.02–1.18] |
| Huang et al., 2018 | Cross-sectional analysis models adjusted for age, BMI, race, profession, smoking, hypertension, diabetes, elevated cholesterol, aspirin, NSAID, acetaminophen use Self-reported hearing | Increased risk of HL with | - history of peripheral arterial disease: OR = 2.26, 95% CI [0.48–4.05] |
| McKee et al., 2017 | Cross-sectional analysis models adjusted for age, BMI, race, profession, smoking, hypertension, diabetes, elevated cholesterol, aspirin, NSAID, acetaminophen use Self-reported hearing | - history of CVD: OR = 1.31, 95% CI: [0.33–2.28] |
| Jeong et al., 2016 | Cross-sectional cohort study Models are adjusted Hearing screening (PTA; 0.5-6 kHz) | - high triglyceride: OR = 0.42, 95% CI [0.18–0.67] |
| Jeong et al., 2016 | Cross-sectional cohort study Models are adjusted Hearing screening (PTA; 0.5-6 kHz) | - high fasting blood glucose: OR = 0.29, 95% CI [0.04–0.53] |
| Jeong et al., 2016 | Cross-sectional cohort study Models are adjusted Hearing screening (PTA; 0.5-6 kHz) | - high glycedated haemoglobin: OR = 0.30, 95% CI [0.06–0.54] |
| Jeong et al., 2016 | Cross-sectional cohort study Models are adjusted Hearing screening (PTA; 0.5-6 kHz) | - high blood pressure (systolic: OR = 0.35, 95% CI: [0.09–0.60]; diastolic: OR = 0.26, 95% CI [0.01–0.52] |

### Additional references on diabetes mellitus:
- Bener et al., 2016: Longitudinal; treatment of SSNHL improved PTA better in patients without diabetes, in those with better pre-treatment hearing and with less treatment delay.
- Nwosu and Chime 2017: cross-sectional; prevalence of hearing loss was significantly higher (overall and for all frequencies) in patients compared with controls.
- Uchida et al., 2010: cross-sectional; significantly worse hearing thresholds in younger group with diabetes; effect not significant for older group.

### Cardiovascular diseases
- Bener et al., 2016: longitudinal; treatment of SSNHL improved PTA better in patients without diabetes, in those with better pre-treatment hearing and with less treatment delay.
- Nwosu and Chime 2017: cross-sectional; prevalence of hearing loss was significantly higher (overall and for all frequencies) in patients compared with controls.
- Uchida et al., 2010: cross-sectional; significantly worse hearing thresholds in younger group with diabetes; effect not significant for older group.

### Additional references on cardiovascular diseases:
- Engdahl et al., 2015; longitudinal; higher risk for HL associated in patients with cardiovascular risk factors.
- Helzner et al., 2011; cross-sectional; higher risk for HL associated in patients with cardiovascular risk factors.
- Rigerst et al., 2016; cross-sectional; increased risk ok HL with systolic blood pressure (0.03 dB loss per increase in 1 mm Hg of blood pressure).

### Arthritis
- Huang et al., 2018: Retrospective cohort study Models adjusted for sex, age, diabetes, hyperlipidaemia, hypertension, hyperthyroidism, hypothyroidism, BHd, stroke, CKD, autoimmune diseases No HL based on medical record | - Higher risk of HL in RA patients: aHR = 1.91, 95% CI [1.70–2.14] |
- Less risk of HL in patients getting medication: aHR = 0.12, 95% CI [0.07–0.20] |
- Higher risk of HL in RA patients with cardiovascular disease | Higher prevalence of arthritis with HL: OR = 1.41, 95% CI: [1.27–1.57] |
3.4. Psychosocial health

Given that HL is a condition that can have serious effects on the ability to communicate with other people, it seems intuitive that HL has consequences for the affected person’s psychosocial health, including depression and anxiety. Greater levels of anxiety were found in people with HL compared with the general population (OR = 1.49, 95% CI [1.34–1.66], p < 0.001; Chung et al. (2015); Carlsson et al. (2015)). Anxiety was affected more by an increasing degree of HL, as well as in younger compared with elderly hearing impaired individuals (Chung et al., 2015; Contrera et al., 2017). In contrast, Stam et al. (2014) did not find an association between anxiety and hearing impairment (measured as speech-in-noise recognition ability).

Similar to anxiety, there are findings for the relationship between HL and depression. Poor hearing has been found to be associated with higher frequency of depressive episodes and more depressive symptoms (Dawes et al., 2015; Keidser and Seeto, 2017; Keidser et al., 2015). Longitudinally, Hsu et al. (2016) found the risk of depression to be higher in the HL group than in NH controls (aHR = 1.73, 95% CI [1.49–2.00]) with incidence rates of 9.50 and 2.00% respectively. On the other hand, Pronek and her colleagues (2014; 2011) and Stam et al. (2014) did not find any effects of HL on depression.

Other psychosocial concerns are social isolation and loneliness. Dawes et al. (2015) found poorer hearing to be associated with social isolation and poorer hearing was also found to be associated with higher social and emotional loneliness (Pronek et al., 2011; Stam et al., 2016).

3.5. Diabetes mellitus

Diabetes Mellitus is a group of metabolic diseases characterized by high blood glucose (hyperglycemia) caused by deficiency of insulin secretion and/or resistance to the action of insulin. Diabetes is a chronic and disabling condition that is managed by pharmaceutical interventions and lifestyle changes that aim to keep blood glucose levels as near normal as possible. Increasing evidence suggests that hearing problems may be a complication of diabetes. A higher prevalence of hearing loss was recorded in diabetes patients compared to non-diabetes healthy adults (46.9% vs. 15.6%, Nwosu and Chime (2017); 17.3% vs. 6.5%, Oh et al. (2014)). In a multivariate analysis diabetes was indeed a significant predictor of hearing loss, independent of the potential confounding effects of age and hypertension (OR = 1.4, 95% CI [1.2–1.6]; Oh et al. (2014); Jung et al. (2017)). Impaired fasting glucose (IFG) and insulin resistance (IR) are key clinical markers of deteriorating glycemic control (Inzucchi et al., 2012). See, Lee, and Moon (2015) revealed that prevalence of both high- and low-/mid-frequency hearing impairment among subjects with IFG was higher compared with those with normal blood glucose regulation (42.2% vs. 24.5%; 14.7% vs. 7.8%, respectively).

Both hearing loss and diabetes are chronic health conditions that develop gradually with time, thus assessing their mutual association benefits from longitudinal analysis (e.g., Kim et al., 2016; C. F. Liu, Lee, Yu, and Lin, 2016b; Kim et al. (2016)) conducted such a study in young and middle-aged men and women (n = 253,301). The rate of hearing loss in participants with normal glucose levels, pre-diabetes and diabetes were 1.8, 3.1 and 9.2 per 1000 person-years, respectively (p < 0.001). Hazard ratios for incident hearing loss for participants with pre-diabetes and diabetes compared with those with normal glucose levels were: HR = 1.04 (95% CI 0.84–1.30) for pre-diabetes and HR = 1.21 (95% CI 1.05–1.40) for diabetes.
and HR = 1.36 (95% CI: [1.19–1.56]) respectively. Finally, higher levels of HbA1c (representing higher long-term glucose levels and poorer glycemic control) were progressively associated with HL risk (Kim et al., 2016).

Overall, cross-sectional and longitudinal studies indicate a relationship between hearing loss and diabetes. Causal relationships are not yet established. However, it has been suggested that the underlying pathophysiology may be mediated by microangiopathy, neuropathy and mitochondrial damage (Helzner and Contrera, 2016). Further longitudinal research is required, in particular, to split out the potential confounding effects of vascular and neural function.

3.6. Cardiovascular disease

Cardiovascular disease (CVD) and related cardiovascular risk factors such as an elevated body-mass index (BMI), smoking, hypertension, or elevated cholesterol are common in elderly people (Helzner et al., 2011; B. M. Lin et al., 2016a). Several large population studies have found an increased risk of hearing loss in patients with hypertension or other cardiovascular risk factors (Chang et al., 2011; Engdahl et al., 2015; B. M. Lin et al., 2016a; McKee et al., 2017). For example, individuals diagnosed with CVD or hypertension had 1.3–1.5 higher odds of developing hearing loss than NH controls (Chang et al., 2011; McKee et al., 2017). Furthermore, the prevalence of hypertension in hearing impaired individuals has been found to be 42–43% and thus about 10% higher than in NH controls (Chang et al., 2011).

Another study found a linear relationship between blood pressure and HL, i.e., the increase in 1 mm Hg of blood pressures was related to an increase in hearing loss of 0.03 dB HL (Ritgers et al., 2016). Often, medication is applied to reduce risks and symptoms of CVD. Potentially, the use of medication to lower the symptoms of hypertension might increase the relative risk of hearing loss (B. M. Lin et al., 2016a; Tan et al., 2017).

The physiological mechanisms causing the elevated risk of HL in cardiovascular risk factors are to date not fully understood. It is thought that high blood pressure or disrupted blood supply might affect the rich capillary supply within the cochlea, specifically the stria vascularis, which might result in hearing loss (Engdahl et al., 2015; Helzner et al., 2011; Shargorodsky et al., 2010; Tan et al., 2017).

Lower frequency hearing loss is more often associated with these risk factors, suggesting that the apex of the cochlea is especially sensitive to ischemia (Helzner et al., 2011; Tan et al., 2017). However, it should be noted that the associations between HL and cardiovascular risk factors were overall relatively modest and Engdahl and colleagues argue that the clinical relevance of these associations is little, as in their own observations, despite the large sample size and representative data, the explained variance in hearing loss regarding the general population was only about 0.2%–0.4% (Engdahl et al., 2015). Further studies are needed to disentangle the effect of reducing cardiovascular risk factors on the development of hearing loss.

3.7. Arthritis

Arthritis is a chronic inflammatory disease of the joints often including inflammations of the periphery of affected joints. The prevalence of arthritis is about 21% in the US adult population (Helmick et al., 2008) and specifically osteoarthritis seems to be related to age, which increases the prevalence rates of osteoarthritis in the US population above 55 years up to 68% (Elders, 2000). Amongst other consequences, hearing loss seems to be closely related to arthritis (Huang et al., 2018; Jeong et al., 2016; McKee et al., 2017; Spankovich et al., 2017; Stam et al., 2014). A few studies investigated specific types of arthritis such as rheumatoid arthritis (RA) and found an increased risk of hearing loss in RA patients (aHR = 1.91, 95% CI [1.70–2.14]), Huang et al., 2018; OR = 1.47, 95% CI [1.05–2.06]), Jeong et al., 2016). Other studies used more generalized terminology to report arthritis, but similarly found an association with hearing loss (Spankovich et al., 2017; McKee et al., 2017). Stam et al. (2014) on the other hand separated different types of arthritis (osteoarthritis, rheumatic arthritis, other chronic arthritis). Their analysis did not reveal any association between rheumatic arthritis and osteoarthritis but an increased risk of HL for all other types of arthritis (OR: 1.87, 95% CI [1.10–3.19]; p = 0.022).

The underlying mechanisms of the observed associations are not yet clear. Neurovascular inflammation or the use of medication against arthritis might harm the cochlea. Another cause might be an immune response that could induce HL, as well as other factors related to RA, such as hypertension (Huang).

3.8. Cancer

Cancer, or any malignant condition, often requires intensive medical treatment to promote patient survival. A well-known negative side effect of current treatments such as radiotherapy or cisplatin-based chemotherapy is sensorineural hearing loss (Theunissen et al., 2015). However, the current literature is lacking large-sized cohort studies investigating the association between hearing loss and cancer treatment. Only two studies report about a significantly higher risk of hearing loss in populations with self-reported cancer diagnosis (McKee et al., 2017; Stam et al., 2014). Stam et al. (2014) only found a significant association for their unadjusted model (OR = 2.52, 95% CI [1.04–6.12]); whereas McKee et al. (2017) observed the association also in the model corrected for insurance status, sex, race/ethnicity, marital status, income, education, region of residence, BMI≥30, other disability status, smoking status, and age by hearing loss interaction terms (OR = 1.35, 95% CI [1.21–1.51]).

The most likely mechanism that induces HL in cancer patients seems to be medication; in particular, the use of radiotherapy and chemotherapy appears to have a negative impact on hearing.

3.9. Stroke

Experiencing a stroke can have tremendous consequences for the QoL of patients and often results in long-term care. Several studies observed a relationship between hearing loss and stroke. A higher prevalence of stroke was observed in a group of individuals with age-related hearing loss compared with age-matched normal hearing controls (HL 43.3% vs. NH 34.9%) (Su et al., 2017).

Baseline levels of hearing were associated with a history of stroke (β = 2.56, SE = 1.10) but a history of stroke was not predictive for a longitudinal change in hearing thresholds (Kiely et al., 2012). In a national cohort study with n > 7000 patients, the odds ratio for an association between hearing loss and stroke was OR = 1.72 (Park et al., 2017).

Sudden sensorineural hearing loss (SSNHL) usually appears within a very short period of time and can have a huge impact on a patient’s QoL. A study by Kuo et al. (2016) showed a higher risk for SSNHL in stroke patients (adjusted HR = 1.71, 95% CI [1.24–2.36]), which increased even further during the first years of follow-up.
(adjusted HR = 5.65, 95% CI [3.07–10.41]) and while undergoing steroid therapy (adjusted HR = 5.14, 95% CI [2.08–12.75]). The risk of (ischemic) stroke seems to be not increased after a period of hearing loss (Ciorda et al., 2015), which might indicate that stroke is a risk factor to develop hearing loss but not vice versa.

4. Discussion

The findings from the literature study confirmed associations of hearing loss (HL) with other health conditions; specifically, with stroke, cancer, visual impairment, mobility issues, cognitive impairment, psychosocial health, diabetes, arthritis, and cardiovascular risk factors. For all of these health conditions, it was found that prevalence is larger in people with a HL, and several longitudinal studies also found increased incident rates in people with a HL. Furthermore, in some cases it was observed that the magnitude of the risk of the other morbidity under consideration was related to the degree of HL; for example, for incident dementia (F. R. Lin et al., 2011).

For essentially all of the examined associations between HL and other health conditions, the mechanisms driving these associations remain unclear and causal links are still under examination. For some health disorders, like cardiovascular diseases (CVD), arthritis and diabetes, it seems likely that if there is a causal link, the direction of causality proceeds from these health disorders to HL, rather than vice versa. For cognitive decline, vision impairment, and mobility problems, the directionality of the relationship is less evident. Regardless, the pertinent issue is that HL is often one of several concurrent physical and/or mental health problems suffered by older people. The evidence of this multimorbidity challenges the traditional healthcare service delivery model that typically addressed only one health domain at a time; and accordingly, it raises important questions regarding best practice going forward.

There are differences in how “medical” the treatment of the reviewed health conditions is. Diabetes, stroke, cancer, or CVD are typically treated in a strictly medical model; while mobility issues could be treated in a medical or paramedical setting. For cognitive impairment and psychosocial health problems, the decision to treat and the approach to treatment depend on the severity of the issues. Likewise, for sensory losses, treatments can involve medical staff like ear, nose and throat (ENT) doctors and ophthalmologists, but also could be conducted by hearing care professionals (HCPs) and opticians. The severity of the sensory loss and country-specific regulations usually determine the treatment path for sensory losses. How “medical” the treatment is also reflects how serious the respective health condition is usually considered to be. While sensory losses can have a serious impact on the affected person’s quality of life, their mobility, and their psychosocial health, they are usually viewed as less serious than conditions like diabetes and cardiovascular diseases, because they are not directly life threatening, and thus, they may not be considered in the treatment of other index diseases.

Notably, in 2017, the 70th World Health Assembly adopted a resolution1 on the prevention of deafness and hearing loss, which calls upon Member States to integrate strategies for ear and hearing care within the framework of their primary healthcare systems. Likewise, several of the examined articles acknowledged that HL should be taken into account during the treatment of patients with serious medical conditions (Calvin and Watley, 2015; Dowd, 2011; Helzner et al., 2011; Seo et al., 2015; Tan et al., 2017). For cardiovascular disease, several studies found that, the more pronounced the risk factors for CVD in a patient are, the higher is the risk to develop a hearing loss. Therefore, the unanimous notion is that addressing the reduction of cardiovascular risk factors in patients (e.g., medication or better cardiovascular fitness) might simultaneously minimize or slow-down the risk of hearing loss (Helzner et al., 2011; Seo et al., 2015; Tan et al., 2017). Furthermore, clinicians should encourage their CVD patients to check their hearing regularly. Similarly, for diabetes treatment, Dowd (2011) and Calvin and Watley (2015) suggested that diabetes educators and nurses should receive training about hearing loss and take an active role in screening their patients’ hearing status and referring them to appropriate hearing care. Obviously, early detection and treatment of HL is a goal by itself, but HL can also be a barrier in the communication between the patient and the clinician. And thus, compensating for HL can serve to improve treatment outcomes for comorbidities of HL. This is true especially for chronic conditions like diabetes, arthritis, and CVD, which require regular patient-clinician contacts over a long time. Furthermore, it has been found that sensory losses can lead to misleading test outcomes, for example in measurements on cognitive ability (Dupuis et al., 2015), illustrating the importance of compensating for sensory losses in the treatment of other health issues. With the currently ongoing evolution of optometric training in audiology, including both hearing assessment and adjustment of hearing devices, audiological care may actually be integrated into the treatment of comorbid index diseases more easily, without substantially increasing the treatment burden for the patient.

Another approach to providing integrated treatments was mentioned by Davis and Davis (2010), who suggested a “one-stop-shop” model with holistic healthcare services, taking into account the physical, sensory, mental-health, and social-care needs of each patient. Apart from such an ideal model of holistic treatment, another relevant question is, which service and care options could be offered in a typical audiological care setting to account for comorbidities of HL. None of the examined articles discussed this question in detail. Present audiological care focuses on compensating the hearing loss, typically by the provision of hearing aids. Very few studies examined whether the use of hearing aids can alleviate the negative consequences of HL in the studied multimorbidity condition. Polku, Mikkola, Gagne, et al. (2016) found indications that the use of hearing aids may reduce mobility restrictions. For cognitive decline, the findings are inconclusive. While Amieva et al. (2015) and Dawes et al. (2015) found better cognitive outcomes for hearing-aid users than for people with a HL, who did not use hearing aids, F. R. Lin et al. (2013) did not find such effects. As suggested by Schneck et al. (2012), HCPs could also add a vision screening to their portfolio, which is one example of how the current offering of the HCP could be extended. Similarly, the idea of training diabetes nurses to do hearing screening suggested by Dowd (2011) and Calvin and Watley (2015) could also be transferred into a training for diabetes screening in HCPs.

Extending the offering of treatment and counseling options in a regular hearing healthcare setting may serve the HCP, the patient, and the cost efficiency of the healthcare system. For the patient, convenience can be increased when they are able to receive care and services for several health conditions at a single location. Furthermore, check-ups for other health issues at the HCP may lead to earlier detection of comorbidities of hearing loss, allowing earlier application of treatment. For example, screening for balance problems could be done by trained audiologists. In fact, in many some countries, vestibular issues and balance assessment are already part of audiology training. As reported by (Goulios and Patuzzi, 2008), in 42% of the countries, audiologists with an university qualification can perform balance assessment and in 38% of countries they can also perform balance management.

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1 http://apps.who.int/gho/ebwha/pdf_files/WHA70/A70_R13-en.pdf#ua-1.
Furthermore, hearing-care professionals without university qualification can assess balance in 11% of the countries and manage it in 2% of the countries. If falls can be prevented by early detection of balance problems in an audiological setting, injuries can potentially be avoided that would otherwise have serious consequences for the affected person's mobility, quality of life, and general health status or even death (Agmon et al., 2017). Early detection of balance issues could therefore also reduce healthcare costs. It was estimated that the medical costs directly linked to falls and non-fatal falls among older adults in the US in 2015 were $32 billion (Burns et al., 2016).

For the HCP, offering additional care and services can be valuable in terms of positioning themselves as all-round experts for hearing healthcare, rather than simply hearing-aid dispensers. This more holistic hearing-care positioning could be advantageous to manifest the HCP's professional value in a world where over-the-counter models of hearing-aid acquisition gain momentum. While these models may be able to meet the patient's need for hearing-loss compensation, they cannot account for the patient's other hearing-care needs, such as: needs for counseling on communication strategies; learning how to deal with a hearing impairment in everyday life; becoming aware of, and dealing with, psychosocial consequences of hearing loss; involving significant others in the rehabilitation; receiving tinnitus treatment, balance advice, etc. (e.g., Kramer et al., 2002). Carlsson et al. (2015) pointed out that “Extended audiological rehabilitation focused on anxiety, depression, tinnitus and vertigo must be given, together with technical rehabilitation, early in the rehabilitation process in patients with severe or profound hearing impairment” in order to avoid strong negative effects on these patients’ quality of life. Yet, at present, only a small proportion of the patients receive this kind of treatment.

5. Conclusions

The current article reviewed literature examining the associations between HL and other health conditions and reflected on the management of HL in a multimorbidity situation. Findings from the studied literature indicated associations of HL with all of the included comorbidities, that is, Visual impairment, Mobility restrictions, Cognitive impairment, Psychosocial health problems, Diabetes, Cardiovascular diseases, Stroke, Arthritis, and Cancer. Several of the reviewed articles discussed how multimorbidity should be taken into account when treating one of the comorbid conditions. There is an opportunity for HCPs to significantly improve their patients’ quality of life by extending their portfolio of hearing-care services. However, the structure and functioning of an extended audiological care model remains unclear. Thus, further research should examine potential solutions for an integrated audiology care model targeting HL in multimorbidity and evaluate the benefits of such an extended model of audiological care to the patient, the HCP, and the healthcare system.

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