RATIONALE FOR THIS THESIS

Adult-onset hearing loss is highly prevalent. Indeed, it is the most prevalent disabling condition among adults worldwide. The bulk of the cases can be attributed to age-related hearing loss which generally kicks in around the sixth decade of life. Age-related hearing loss is characterized by an insidious, progressive, and symmetrical hearing loss occurring in both ears, first affecting mainly the high frequencies of the hearing spectrum. The hearing loss is of sensorineural origin, which means that cochlear structures and/or associated structures of the nervous system are affected. Currently, about 30% of all adults aged 55 and over suffers from hearing loss. However, due to the aging of the population this percentage and the absolute number of older adults with hearing loss is only expected to rise in the future.

In several studies, various potential demographic, health-related, cognitive, and environmental risk factors for hearing loss in older adults were investigated. However, the available evidence is mixed with regard to the relevance of the various factors, and a speech-in-noise measure was rarely used as the hearing measure in these studies. Mostly, hearing thresholds as determined by pure tone audiometry were used. Moreover, many investigators examined only a limited number of factors and applied a suboptimal cross-sectional study design, both hampering strong conclusions about cause and effect. Population-based studies focusing on the psychosocial effects of hearing loss also show mixed findings, i.e., it is still unknown whether or not hearing loss causes increased feelings of depression, loneliness, and anxiety. In addition, it is largely unknown whether certain subgroups of older adults are at increased risk of experiencing psychosocial problems caused by hearing loss (e.g., men vs. women). In only a limited number of the studies performed thus far a longitudinal study design was applied, and in none of the studies was it investigated whether the psychosocial effects were dependent on the rate of hearing decline. Additionally, no-one has structurally mapped which aspects of the lives of adults with hearing loss are relevant when it comes to daily life functioning. Such an overview is needed to determine the important aspects that should always be assessed in order to map an individual’s functioning with hearing loss. The lack of such a set of constructs currently hampers uniform, valid, and comparable measurement in the clinic and in scientific research. An important and indispensable perspective that should be reflected in this set is the patient perspective, i.e., which aspects do adults with hearing loss themselves find relevant?

The hearing loss of many (older) adults remains undiagnosed and/or untreated. Hearing screening programs may facilitate earlier recognition and treatment. Hearing aids are often viewed as the logical and only treatment option for hearing loss, but an important problem is the negative image of hearing aids, partially caused by the fact that
amplification only solves part of the hearing problem. As a result, hearing aids are often rejected or end up in the drawer, also when they are offered in the context of a hearing screening program. Offering other treatment options to hearing-impaired persons who are discovered through screening, such as training in speechreading, hearing tactics, and personal adjustment, may be a fruitful approach. However, an overview of the (alternative) interventions that have ever been offered to hearing-impaired adults in screening programs is lacking.

These above-mentioned problems and gaps in knowledge are of focus in this thesis. In five chapters, the following topics are addressed: factors influencing decline in older persons’ hearing status (Chapter 2), psychosocial consequences of hearing loss in older persons (Chapters 3 and 4), aspects relevant to hearing-impaired adults’ functioning (Chapter 5), and possible interventions following hearing screening in adults (Chapter 6). Chapter 7 includes a general discussion of this thesis’ findings.

**MAIN FINDINGS**

**Factors influencing older adults’ decline in speech-in-noise recognition (Chapter 2)**

Prior studies have not yet provided a decisive answer with regard to the relevance of various determinants of hearing loss in older adults. Chapter 2 reports on the decline in older persons’ ability to recognize speech in noise and how much various factors might influence this decline: demographic (age, level of education, gender), health-related (cardiovascular conditions), cognitive (fluid intelligence\(^1\), information processing speed), and environmental (smoking, alcohol use) factors. The data for this study were derived from a population-based sample of older (55 years old and over) adults from the Longitudinal Aging Study Amsterdam (LASA). Hearing status was measured using a digit triplet speech-in-noise test (SNT)\(^2\). In this test, digit triplets (e.g., 5-2-4; 3-1-8) are offered through headphones at various intensity levels against a constant level of stationary background noise. The test determines the signal-to-noise ratio at which the respondent recognizes 50% of the triplets correctly (i.e., the speech-reception threshold, SRT). The SRT data of 1298 older adults, aged 57 to 93 years old at baseline, measured across three to seven years of follow-up (three measurements) were modelled via multilevel analysis.

It was found that the average respondents’ SRT increased (i.e., speech-in-noise recognition deteriorated) by 0.18 dB signal-to-noise ratio per annum. The SRT increased

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\(^1\) The ability to deal with new information.

\(^2\) This test (Nationale Hoortest) is also publicly available online (http://www.hoortest.nl) or by telephone (0900-4560123).
faster in the oldest age groups. Second, it was found that decline in information processing speed had a relevant influence on the increase in SRT. Seventeen percent of the decline in speech-in-noise recognition could be attributed to the decline in information processing speed. None of the other factors influenced the decline in speech-in-noise recognition relevantly. These findings show the importance of declining cognitive capacities relevant to older adults’ speech recognition in noisy backgrounds.

**Adverse effects of hearing loss on older adults’ psychosocial health (Chapters 3 and 4)**

Studies aiming to determine the effects of hearing loss on depression and loneliness in older persons thus far show mixed results. A possible reason for this is that often a suboptimal cross-sectional study design is applied, allowing only relatively weak conclusions about causality as compared to when a longitudinal study design is used. In addition, investigations rarely consider possible differences in effects across certain subgroups of older persons. Studies addressing the effects of hearing loss on anxiety are largely absent. Chapters 3 and 4 focus on the longitudinal effects of hearing status on psychosocial health. **Chapter 3** describes the relationships between baseline hearing status (both self-reported and measured by the SNT) on the one hand, and four-year follow-up depression and loneliness on the other hand. It was explored whether there were differences in effects of hearing status across various subgroups defined by demographic factors, health-related factors, cognitive factors, and by hearing aid use (i.e., whether these factors acted as effect modifiers). Data of 996 (self-report sample) and 830 (SNT sample) LASA respondents aged 63 years old and over at baseline were used.

Regression models revealed that both hearing-status measures (self reported and SNT) showed statistically significant associations with loneliness (i.e., poorer hearing status at baseline was associated with increased loneliness at follow-up). However, the effects differed for social and emotional loneliness and were confined to specific subgroups only, i.e.:

- **men** (emotional loneliness)
- those **living with a partner** (social and emotional loneliness)
- those **without cardiovascular conditions** (emotional loneliness)
- those **with one or more chronic diseases** (emotional loneliness)
- those **with a higher level of education** (social and emotional loneliness)
- those **with a higher level of income** (social loneliness)
- **non-hearing aid users** (social loneliness and borderline significance for emotional loneliness).
These effects were absent in their counterpart groups (i.e., women, those living without a partner, etcetera). Some of the effects only emerged for one of the hearing measures. No significant effects were found for depression.

Underlying mechanisms could not be investigated with the LASA data, but can be explained using findings from other studies. Men may feel lonelier because of their poorer hearing status because men, more often than women, deny and underestimate their hearing loss. In addition, men more often than women rely solely on their partner for intimate, deeper social relationships. Because it is known that hearing loss can place a heavy burden on a couple’s relationship, this could contribute to increased feelings of emotional loneliness in men.

The burden that hearing loss places on a couple’s relationship could also be an explanation for the emotional loneliness effect that was found for older persons living with a partner. Another explanation for the loneliness effects in this group, but also for the effect found in persons with a high socioeconomic status, could be sought within social comparison of the hearing-impaired person. It is known that higher-educated older persons have a higher degree of social participation than lower-educated older persons, and older couples have larger social networks than older persons living alone. Because higher-educated hearing-impaired persons and hearing-impaired persons living together with a partner may compare their social contacts and interactions with that of their normally hearing, relatively socially active partners or peers, these might be experienced as degraded more strongly than for lower-educated persons or persons living alone.

Further, the findings regarding having other conditions (chronic diseases and cardiovascular conditions) suggest that hearing loss has an effect on emotional loneliness particularly when the older person does not have any other conditions. When older persons do have other conditions, these may be experienced as relatively more important or more disabling, causing the effects of hearing loss to be less apparent.

Finally, the current studies’ findings suggest that hearing aids can prevent restrictions in social contacts and activities and as such can prevent loneliness. This is in line with findings reported in prior studies.

Chapter 4 describes a study in which it was investigated whether the rate of hearing decline affects older persons’ psychosocial health. Again, it was examined whether subgroup-specific effects were present. Longitudinal SRT and psychosocial health data were used of 1178 LASA respondents across three to seven years of follow-up (three measurements). Difference scores ($T_2-T_1; T_3-T_2$) of the SNT and the psychosocial measures were calculated.
SUMMARY

Multilevel models showed that relatively faster declines in older persons’ hearing status result in stronger adverse effects on loneliness in two subgroups of older persons. Faster increase in SRT (i.e., deterioration) was associated with stronger increase in loneliness for:

- those with a moderate hearing status at baseline (social and emotional loneliness)
- those who recently lost their partner (emotional loneliness).

These effects were absent in their counterpart groups (i.e., those with a good or poor hearing status, those with a stable partner status). No significant relationships were found between the rate of hearing decline and the rate of increase in depression or anxiety.

Although the underlying mechanisms could not be investigated with the LASA data, explanations can again be deduced from other studies’ findings. Widow(er)s may have depleted general reserves impeding successful coping with hearing loss. Another explanation is that hearing loss may limit widow(er)s to seek emotional support in other close ties. Older persons who decline from an already insufficient hearing status could be faced with more noticeable and more severe restrictions in their daily social activities than those in early stages of hearing loss. The absence of an effect for those who deteriorated from a poor hearing status could be caused by their lesser responsiveness to decline resulting from their relatively long period of exposure and adjustment to hearing loss.

**Functioning, disability, and contextual factors relevant to adults living with hearing loss, as described by the International Classification of Functioning, Disability and Health (ICF) (Chapter 5)**

Currently, there is no internationally agreed, reliable, and evidence-based list of constructs available that should always be assessed when aiming to map the aspects relevant to an adults’ daily life functioning. The lack of such a set of constructs currently hampers uniform, valid, and comparable measurement in the clinic and in scientific research. This chapter reports on a study aimed at mapping relevant aspects of functioning as viewed from the perspective of adults with hearing loss themselves (patient perspective).

The mapping was done by using the International Classification of Functioning, Disability and Health (ICF; World Health Organization, 2001). The ICF provides a standard language and framework for the description and classification of health and health-related states. Chapter 5 concerns one of the preparatory studies that contributed to the development of the *ICF Core Sets for Hearing Loss* (Danermark et al., 2010). A Core Set is a selection of the most relevant ICF categories for a certain disease or condition, which can be used in
clinical or research practice. For this study, focus-group and individual-interview data were collected among 36 Dutch and South-African adults with hearing loss. The interviews were transcribed verbatim and were analyzed qualitatively and ICF linking was performed according to preset rules.

In total, 145 unique ICF categories were identified. Most of the categories belonged to the Activities & Participation component and the Environmental factors component of the ICF (34% and 33% of all ICF categories identified, respectively). Fewer categories concerned descriptions of Body functions and Body structures that are involved in hearing loss (27% and 6%, respectively). As expected, the bulk of the categories that were recognized directly or indirectly referred to Activities or Participation (e.g., conversation, remunerative employment) or to Environmental factors (e.g. instrumental aids, quality of environmental sound) relevant for oral communication. Many of the other Environmental factors identified belonged to the ICF chapters on support and relationships, and on attitudes and behaviour of others. Various Personal factors that were identified related to coping with hearing loss and personal attitudes towards hearing loss. More specifically, these often concerned the acceptance of hearing loss, openness about hearing loss, and hearing loss stigma. Lastly, many Body functions identified related to negative emotions or to the low energy level that many informants experienced as a result of the extra effort needed for them to understand speech. The findings illustrate the widespread impact of hearing loss on various aspects of adults’ lives. These underline the potentially far-reaching and socially disabling character of the condition. In addition, the findings stress the potential importance of physical consequences of hearing loss, which, in turn, affect functioning, such as with fatigue.

Possible interventions following hearing screening in adults (Chapter 6)

So far, an overview of the different intervention types that have been offered to adults whose hearing loss was identified through a screening program was lacking. Chapter 6 describes the findings of a systematic review of the literature on interventions following hearing screening in adults. A special focus was on intervention types other than hearing aid fitting.

In total, 37 studies were included. The large majority of the interventions comprised referral to a hearing specialist for further diagnostics and/or rehabilitation. This was the case for 26 out of the 37 studies described. In most of the other programs (i.e., seven), the intervention consisted of a standardized hearing aid rehabilitation program. Some studies offered alternative interventions options, but this was the case in just four studies. These alternatives consisted of elements of so-called communication programs, such as training
in speech reading and advice on hearing tactics, or concerned advice on environmental aids. Such alternatives may be valuable as an addition to or as a replacement of hearing aid fitting.

**General discussion (Chapter 7)**

Finally, in Chapter 7 the main findings of this dissertation are discussed. We reflect on the applied methodology and discuss possible implications of the results for future research and clinical practice.

The results firstly indicate the relevance of declining cognitive capacities to older person’s ability to recognize speech in noisy environments. The results further show that hearing loss has a potentially widespread impact on adults’ functioning, and also indicate the importance of internal (personal) factors and factors in the physical and social context of the hearing-impaired person that are involved. Another key finding of this thesis is that certain subgroups of older persons seem to be negatively affected by hearing loss, i.e., experience increased loneliness. Lastly, an important finding is that interventions that could serve as alternative to or as a replacement of hearing aid rehabilitation, such as communication programs, have rarely been offered to screen-positive adults with hearing loss. The findings of this thesis underline the need to further investigate the determinants and the consequences of hearing loss including their underlying mechanisms, in order to address them in clinical practice. The results from Chapter 5 added to a first version of the ICF Core Sets for Hearing Loss[^3]. The final validated version of the sets should ultimately contribute to comprehensive, valid, user-friendly, and universal assessments of functioning and disability of adults with hearing loss. Lastly, the results of this thesis underline that the investigation of (the effectiveness of) offering post-screening interventions as an alternative to or as an addition to hearing aid fitting deserves further attention.

REFERENCES

