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# Hearing and quality of life among community-dwelling older adults

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## ABSTRACT

**Objectives:** Hearing loss is a common health concern in older people, and the prevalence of hearing loss increases with aging. Poor hearing may cause difficulties in everyday life situations and reduce quality of life (QoL). The aim of this study was to assess the associations between different domains of QoL (physical, psychological, social, and environmental), perceived hearing difficulties in various everyday situations, and audiometrically measured hearing level among community-dwelling older adults.

**Methods:** Cross-sectional analysis of 76 to 91-year-old community-dwelling adults. Data on QoL (WHO Quality of Life Assessment short version) and perceived hearing difficulties were gathered via postal questionnaires (n=706) and screening pure-tone audiometry was performed at the participants' homes for a random subsample (n=161). Data were analyzed with linear regression models.

**Results:** Factor analysis on the perceived hearing difficulties questionnaire identified three dimensions: Speech hearing, Socioemotional effects and Spatial hearing. All the perceived hearing difficulty factors, but not the pure-tone audiometry results, were significantly associated with poorer values in all the QoL domains and the total QoL score.

**Discussion:** Perceived hearing difficulties in various everyday life situations are more strongly associated with older adults' quality of life than audiometrically assessed hearing impairment.


Key Words: Aging, Cohort, Hearing, Life-space, Quality of life.

# INTRODUCTION

Age-related hearing loss (presbycusis) is one of the most common chronic health conditions among older adults and prevalence of it increases notably with age. Age-related degenerative changes in auditory system impair older adults' hearing ability (Gates & Mills, 2005). This influences notably an individual's capability to communicate and cope with everyday listening situations and to participate in everyday activities (Wallhagen, 2010), thus potentially having a negative effect on older adults' quality of life (QoL).

The conceptual basis of this study comes from the ecological model of ageing, also known as the press-competence model (PCM) (Lawton & Nahemow, 1973), which considers individuals' well-being to be strongly related to the person's capabilities and the environment where a person lives. According to PCM, the fit between an individual's capacities, such as health, sensory and motor skills and cognitive functioning, and the demands of the environment, is crucial for the individual's wellbeing. The environment includes both physical and the social context. Wellbeing deteriorates if a person cannot cope with environmental demands.

In this study, we explored QoL according the World Health Organization (WHO) definition, which states that QoL is "an individual's perception of their position in life in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards and concerns" (WHOQoL Group, 1998). According to the WHO, QoL comprises various important aspects of an individual's life: physical health, psychological health, environment and social relations (WHOQoL Group, 1998).

The present study defines hearing difficulties as hearing-related problems which an individual perceives to have in his/her everyday life. One of the most established hearing difficulties among older adults is difficulty in hearing speech (Arlinger, 2003), particularly in competing contexts such as sound-reverberating environments, or in the presence of background noise (Gatehouse & Noble, 2004). Hearing difficulties, by hampering an individual's social interaction, have negative socioemotional consequences (Hogan, O'Loughlin, Miller, & Kendig, 2009) and can cause feelings of embarrassment, frustration and being left out (Gopinath et al., 2012b). In addition, difficulties in spatial hearing impedes environmental orientation by weakening perception of acoustic information from the environment (Arlinger, 2003; Gates & Mills, 2005), which can also reduce the desire to participate in out-of-home activities (Mikkola et al., 2015b).

Several previous studies have reported an association between hearing difficulties and poorer QoL among older adults' (Chia et al., 2007; Dalton et al., 2003; Gopinath et al., 2012a; Hogan et al., 2009; Zhang et al., 2012). However, these studies either have not identified specific aspects of perceived hearing difficulty in everyday life (e.g. difficulties in speech comprehension, failure to detect and localize sounds, and, negative feelings and social constraints due to hearing problems), or have not differentiated between the different domains of QoL (Gatehouse & Noble, 2004; Hallberg, Hallberg, & Kramer, 2008).

The association between hearing ability and QoL may be confounded by sociodemographic factors and some health related factors, such as chronic diseases and cognitive functioning. Higher age and male gender are risk factors for hearing loss (Agrawal, Platz, & Niparko, 2008; Arlinger, 2003). According to previous studies, also QoL is negatively associated with age ( Von Dem Knesebeck, Wahrendorf, Hyde, & Siegrist, 2007) and in older age groups men report having better QoL compared to women (Pinquart & Sorensen, 2001). Persons, and particularly men, with less education may have been more exposed to occupational noise than those with higher educational level, thus having a higher risk for hearing loss (Agrawal et al., 2008). In addition, it has been shown that higher educational level has a positive association with QoL (Von Dem Knesebeck et al., 2007). Further, some chronic diseases, such as diabetes (Agrawal et al., 2008), cardiac, circulatory (Agrawal et al., 2008) and neurological diseases (Crews & Campbell, 2004) are known to be associated with hearing loss among older adults, and furthermore, persons with chronic diseases frequently report lower QoL (Sprangers et al., 2000). According to previous studies, hearing loss is also associated with cognitive decline (Arlinger, 2003), which may have negative effect on older adults' QoL.

This study was conducted in a Finnish context. In general, according to OECD report, Finland does very well in most of the dimensions which are considered to be essential to a good life, such as education, subjective well-being, health status, personal security, environmental quality, earnings and social connections (OECD, 2014). In Finland, as in other Western counties, the proportion of older adults' increases and consequently also age-related hearing problems are becoming more prevalent (Mäki-Torkko, 2001). As Western cultures are typically information and communication societies, where ability to communicate effectively in everyday life is essential, the effects of hearing difficulties in everyday life can be substantial (Sorri, Jounio-Ervasti, Uimonen, & Huttunen, 2001). Public health services are available to all citizens in Finland. Some services are without charge and some services with small fees. Audiological services, such as hearing aid fitting, are provided for free after physician's referral from primary health care and are thus easily available (Mäki-Torkko, 2001). These services have the potential to improve older adults' QoL by decreasing the negative effects of hearing difficulties.

As search of the previous literature revealed, it remains unclear whether different aspects of perceived hearing difficulties are similarly associated with the different domains of QoL in older adults. In this study, based on the press-competence model, we explore the effect of different aspects of perceived hearing difficulty (i.e., hearing speech, hearing-related socioemotional problems and spatial hearing) in real-life environments, and audiometrically assessed hearing on different domains of QoL (i.e., physical, psychological, social and environmental) among community-dwelling older adults. We hypothesized that perceived difficulties in speech hearing and hearing-related socioemotional problems would have the strongest association with the psychological and social domains of QoL and, that spatial hearing would be associated mainly with the environmental domain of QoL. Further, we hypothesized that perceived hearing difficulties would be more strongly associated with QoL than audiometrically measured hearing.

## METHODS

### Study design and participants

In this study, the association between perceived hearing difficulties and QoL was analyzed by conducting cross-sectional analyses on the data obtained from a second follow-up of the "Life-Space Mobility in Old Age" (LISPE) project (Rantanen et al., 2012). The data from a new substudy were used to examine the cross-sectional association between audiometrically measured hearing and QoL.

The LISPE is a two-year prospective cohort study of Finnish community-dwelling older adults. The study design and methods, including non-respondent analysis, have been reported in detail earlier (Rantanen et al., 2012). A random sample of people aged 75-90-years (N=2550) was obtained from the Finnish national register at baseline, and a total of 2269 persons were contacted by a letter and over the phone to screen eligibility and willingness to participate. The inclusion criteria were: community-dwelling in the study area and able to communicate (i.e. able to understand the questions and provide answers to them). A total of 1 070 persons declined (unwilling to participate n = 551, poor health n = 398, no time n = 121), 304 were not eligible, and 41 persons withdrew their consent between the phone interview and the home interview. Four participants were excluded due to communication problems during the home interview and the data of two persons were lost due to a technical problem. Thus, in total, 848 eligible persons participated in the baseline home-interviews during spring 2012. During the two-year follow-up period, 41 participants deceased, 15 were admitted to institutional care, and 12 persons could not be re-interviewed due to declined ability to communicate. Other reasons for attrition were unwillingness to continue (n=6), moving outside the study area (n=6), poor health (n=5) and not reached (n=2). Hence 761 persons participated in the two-year follow-up, which consisted of a telephone interview and postal questionnaire. The follow-up participation rates have been reported in detail elsewhere (Rantakokko et al., 2015). If the participant was unable to answer the questions over the phone due to hearing problems, the possibility to take part in a face-to-face interview in their homes (n=3) or, to answer the study questions via a postal questionnaire (n=10) was offered. The two-year follow-up postal questionnaire, which included questions on both perceived hearing difficulties and QoL, was returned by 712 participants.

For a new substudy, titled as "Hearing, cognition and well-being", a random sample of 230 participants was drawn from the original LISPE baseline cohort in January 2014. The aim of the substudy was to determine the degree to which difficulties in hearing and/or vision influence older adults' social participation, life-space mobility and functional ability. In total, 216 people from this sample were eligible to take part in the substudy. During the 2-year follow-up telephone call, the interviewer informed these eligible participants about the substudy and asked if they would be willing to participate in it. Of this group, a total of 169 people agreed to participate in the substudy and the measurements were conducted in their homes during spring 2014. Audiometric measures were drawn from the data of this substudy (Figure 1).

The LISPE project and its substudy were approved by the Ethical Committee of the University of Jyväskylä. Participants were informed about the project and signed a written informed consent.

## Hearing

### *Perceived hearing ability*

Perceived hearing ability was assessed using a 16-item postal questionnaire titled Hearing in Real-Life Environments (HERE). Participants were asked to assess their hearing in daily situations by choosing the number on a scale from 0 to 10 that best corresponded to their perceived hearing ability (Table 1). Higher scores indicated poorer performance/more difficulties. Participants, who owned a hearing aid gave two answers to each question: one assessing their hearing with, and the other without, their hearing aid. The items used in the questionnaire were modified from items in the Abbreviated Profile of Hearing Aid Benefit-questionnaire (APHAB) (Cox & Alexander, 1995), the Speech, Spatial and Qualities of Hearing Scale (SSQ) (Gatehouse & Noble, 2004) and the Hearing Handicap Inventory for the Elderly (HHIE)(Ventry & Weinstein, 1982). The idea of two scales for those with a hearing aid was further developed from APHAB. The rationale for developing a new questionnaire was the need for a compact questionnaire which would provide comparable information on hearing difficulties with and without a hearing aid. We chose a numerical rating scale to ensure sufficient variation in data.

[Table 1 here]

We took for analysis the best hearing performance for each item with or without a hearing aid, whichever was better. This was considered to be the best indicator of perceived hearing performance in everyday life, as some people may only use hearing aids in situations where they perceive a benefit doing so.

## Hearing sensitivity

Pure-tone screening audiometry (Oscilla USB-330) with Peltor noise-reducing headphones with a noise reduction rating of 21 dB was used to measure the pure-tone air-conduction hearing thresholds for both ears in the participants' homes. The automatic Hughson-Westlake protocol was used at frequencies 0.125, 0.25, 0.5, 1, 2, 4 and 8 kHz for each ear separately. The frequency was first set to 1 kHz and a tone was automatically given at an intensity of 30 dB. If the participant gave no response, the intensity was increased by 5 dB each time the tone was presented. For each response the sound intensity was decreased by 10 dB and, conversely, increased by 5 dB when there was no answer. The maximum intensity was 90dB. If the participant was unable to hear at an intensity of 90dB, 100dB was marked as the hearing threshold. The test uses the 2 out of 3 method of answering in determining when to proceed to the next frequency in order to find the lowest sound intensity the person was able to detect. The audiometry data were automatically stored on a personal computer. Hearing aids were not worn during the hearing examination. Background noise was measured prior to testing by using a Standard ST-805 sound level meter. The mean level of background noise was 17 dB, ranging between 10dB and 44 dB, and in 86% of cases was 21dB or less, which is the level that headphones can filter out.

The better ear hearing threshold level (BEHL), defined as the pure-tone average (PTA) over the speech frequencies of 0.5-4 kHz (World Health Organization, 2000) was used in the analyses as a continuous variable.

**Quality of Life**

Quality of Life (QoL) was assessed with the 26-item World Health Organization Quality of Life Assessment short version (WHOQOL-BREF)(WHOQoL Group, 1998) via a postal questionnaire. The scale consists of four domains: physical health (7 items: mobility, ability to carry out daily activities, energy, pain, need for medication or other treatment, sleep and, working capacity), psychological health (6 items: involves topics that reflect level of positive and negative feelings, self-esteem, body image, cognition and spirituality), social relationships (3 items: individual's satisfaction with personal relationships, sex life and social support), and environment (8 items: reflects individual's satisfaction with the physical environment and its safety, financial resources, opportunities to obtain health care services and information, opportunities to participate in leisure activities and, possibilities to use public transportation) (Skevington, Lotfy, & O'Connell, 2004; WHOQoL Group, 1998).

Higher scores in each domain indicate better QoL. Scores for each domain were transformed on scale from zero to 100. In addition, a total QoL score for all domains was calculated. The total score ranges from 0 to 130, higher scores indicating better QoL. The WHOQOL-BREF domain scores have good discriminant validity, content validity, internal consistency and test-retest reliability (Skevington et al., 2004; WHOQoL Group, 1998). The overall QoL score was calculated when less than 20% of items were missing. Information on QoL was available for 706 of the 712 participants. As data were missing for less than 1% of the participants, missing values were not imputed.

## Covariates

*Age and gender* were derived from the population register. Other covariate information was based on face-to-face interviews at baseline. *Number of years of education* was used as a socioeconomic indicator. *Self-reported physician diagnosed chronic conditions* were obtained from a list of 22 chronic conditions and with an open-ended question. Chronic conditions that could theoretically be risk factors for both hearing difficulties and poorer QoL, namely diabetes, cardiac, circulatory and neurological diseases, were chosen as potential covariates. *Cognitive functioning* was assessed using the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975).

## Statistical analyses

Factor analysis was used to test the structure of the 16-item scale on perceived hearing difficulties. Factor analysis was performed in Mplus using the oblique geomin-rotation of the factor solution (version 7, 2012; Muthén &Muthén, Los Angeles, CA). Estimation was based on the maximum likelihood method with the assumption that missing data were missing at random, thereby also permitting inclusion of partial response patterns. Subjects were excluded from the analysis only when scores were missing for all items. Table 1 shows the factor loadings on each item in the questionnaire for each factor. Communalities represent the share of item variance explained by the factor solution. Factor scores were computed using the exploratory structural equation modelling approach. Subscale Cronbach alpha coefficients were computed in SPSS (version 22.0).

A three-factor structure was found suggesting that coherent entities were measured. The three dimensions reflect different aspects of perceived hearing difficulties, i.e. *Socioemotional effects, Speech hearing and Spatial hearing.* One item from the questionnaire ("I find traffic noises uncomfortably loud") was excluded from the final analyses as it had a weak loading (.13-.35) on all three factors (Table 1). Exclusion did not change the factor structure or factor loadings significantly. Cronbach alphas for the final factors were 0.93 for Socioemotional effects, 0.96 for Speech perception and 0.89 for Spatial hearing. In total, four participants had missing data on all items and were not included in the analyses. Information on speech hearing was missing for 8% (n= 59), and information on spatial hearing and, socioemotional effects were missing for 6% of the participants (n= 44 and 45, respectively).

The characteristics of the participants are described using means and standard deviations (SD) or percentages. Pearson correlation coefficients were calculated between the dimensions of perceived hearing difficulties and $BEHL_{(PTA\ 0.5\text{-}4kHz)}$. Of the 169 participants in the substudy, eight persons did not return the postal questionnaire, and thus information of QoL was available for 161 participants. Audiometric measures were available for 168 of the substudy participants. As audiometric data were missing only for one participant, missing values were not imputed.

Linear regression analyses were used to assess the strength of the association between QoL and the dimensions of perceived hearing difficulties in the whole sample and between QoL and the audiometric measures in the substudy sample. Factor scores for perceived hearing difficulties were used in these analyses. The interaction of gender and hearing difficulties on QoL was tested, and since no such interaction was found, men and women were included in the same linear regression models. In all models, the inclusion criterion for the covariates was an association ($p \leq .20$) with both the predictor (i.e. hearing) and the outcome variable (i.e. QoL). Of the potential covariates, only age was associated with measured hearing threshold (BEHL) and QoL, while age, gender and cardiac diseases were associated with both QoL and self-reported hearing difficulties. A value of $p<.05$ was chosen as the level of statistical significance. IBM SPSS version 22.0 (SPSS Inc. Chicago, IL) was used for the regression analyses.

**RESULTS**

The sample characteristics are presented in Table 2. The mean age of the participants was 82 years, 63% were women and 18% reported owning a hearing aid. The mean QoL total score was 95.0 (range 54-130). The characteristics of the substudy participants with audiometric data (N=168), did not materially deviate from the characteristics of the total sample. Among the participants in the substudy, the mean $BEHL_{(PTA\ 0.5\text{-}4kHz)}$ was 39 dB (SD 14.4, range 10dB - 83dB) (Table 2). BEHL correlated moderately with all the dimensions of perceived hearing difficulties (Speech hearing $r=.471$, $p<.001$; Socioemotional effects $r=.423$, $p<.001$; and Spatial hearing $r=.299$, $p<.001$).

[Table 2 here]

The associations between the dimensions of perceived hearing difficulties and QoL domains are presented in Table 3. Higher scores in any dimension of perceived hearing difficulties were significantly associated with poorer QoL in each QoL domain. The regression coefficients varied between -.192 and -.296 for the association of the dimensions of speech hearing and socioemotional effects with the QoL total score, and with the physical, psychological and environmental domains of QoL, whereas for the association with the social domain of QoL, the regression coefficients ranged between -.134 and -.173. The dimension of spatial hearing showed a somewhat weaker association with all the domains of QoL with regression coefficients between -.102 and -181. Further adjustment for covariates did not materially change the results (Table 3).

[Table 3 here]

Table 4 shows the results of the regression analysis for the association between measured hearing level and QoL domains in the substudy. No significant associations were found between measured hearing level (BEHL $_{PTA\ 0.5\text{-}4kHz}$) and any of the QoL domains (Table 4). Models adjusted for hearing aid use were also constructed (data not shown in the table). This adjustment did not essentially change the results, but the association between measured hearing level and the psychological domain of QoL became borderline significant ($\beta$=.186, p=.068). In addition, we conducted a sensitivity analysis to test the influence of hearing aid use on results by conducting the analysis separately for hearing aid users and non-users. Results remained largely unchanged.

[Table 4 here]

## DISCUSSION

Our study showed that perceived hearing difficulties in different real-life environments, but not the audiometrically assessed hearing, were negatively associated with the different domains of QoL among community-dwelling older adults.

QoL has been shown to decline notably after age 75 years in the general population and especially in older adults with hearing disability (Hogan et al., 2009). Our findings support the previously noted association between perceived hearing difficulties and poorer QoL (Chia et al., 2007; Dalton et al., 2003; Gopinath et al., 2012a; Hallberg et al., 2008; Hogan et al., 2009; Zhang et al., 2012), although there are differences between the studies in the samples used, the instruments used to measure QoL and the methods used to measure hearing difficulties. Moreover, our study gives more detailed information than has previously been reported on the associations between the different dimensions of perceived hearing difficulties in everyday life situations and domains of QoL.

In this study participants assessed how much their perceived hearing difficulties affected their ability to manage on in real-life environments, thus reflecting the fit between individual competencies and environmental demands according to the press-competence model by Lawton and Nahemov (1973). There are several plausible explanations for our findings. Perceived hearing difficulties can hamper various daily activities, leading people to feel handicapped and lowering their psychological wellbeing (Gatehouse & Noble, 2004; Hallberg et al., 2008; Hogan et al., 2009). Commonly reported hearing-related communication problems, such as difficulties in hearing speech, and associated feelings of exclusion can cause e.g. withdrawal from social activities and other situations that pose a challenge to hearing (Arlinger, 2003; Gopinath et al., 2012b; Mikkola et al., 2015b). The psychological domain of QoL includes items such as self-esteem, enjoyment and meaningfulness of life, while the social domain of QoL relates, e.g., to individuals satisfaction with their personal relationships. Thus it is understandable that perceived difficulties in hearing speech in various situations and the resultant difficulties in communication, or hearing-related socioemotional problems were associated with poorer QoL in these domains. It should be noted, that even though some items used to assess socioemotional effects of perceived hearing difficulties and items in social domain of the QoL scale may seem similar, they are not overlapping. WHOQOL-BREF identifies how people feel and how satisfied they are in general, while HERE assessment focuses specifically on the effects of perceived hearing difficulties.

Hearing difficulties not only complicate interaction with others, but difficulties in spatial hearing can also make observation of the acoustic environment uncertain (Arlinger, 2003; Gates & Mills, 2005). As Gatehouse and Noble (2004) point out, a persons' ability to reliably and accurately detect acoustic cues in the environment is crucial for safe orientation when moving around and thus "serves the observer's wellbeing and sense of proper connection with the world" (Gatehouse & Noble, 2004). While acknowledging that the associations between spatial hearing and domains of QoL were rather modest in our study, we conclude that difficulties in spatial hearing may increase feelings of insecurity while moving around and so impede this "sense of well-connectedness", thereby also impairing QoL in the environmental domain.

Further, hearing impairment has also been shown to correlate with poorer functional status measured by ADL and IADL functions (Dalton et al., 2003) and difficulties in lower limb performance and mobility (Mikkola et al., 2015a). This could explain the association between perceived hearing difficulties and the physical domain of QoL, which includes items such as mobility and the ability to manage daily activities.

Zhang et al. (2012) reported that hearing-related difficulties in daily tasks were significantly associated with poorer QoL scores in every domain, the effects being greatest in the physical and social domains of QoL, and lowest in the environmental domain (Zhang et al., 2012). The estimated effect sizes resemble those in our study, although in our sample the social domain showed a slightly weaker association with perceived hearing difficulties compared to the other domains of QoL. This unexpected difference is probably due to differences in the method used to evaluate perceived hearing difficulties. Zhang and colleagues used a single question and did not assess hearing difficulties in specific situations.

The present study found no significant association between audiometrically assessed hearing and QoL. Previous studies have reported conflicting findings. In some studies, the severity of the hearing loss was associated with poorer QoL (Chia et al., 2007; Dalton et al., 2003), while other studies found no such association (Gopinath et al., 2012b; Hogan, Phillips, Brumby, Williams, & Mercer-Grant, 2015; Teixeira et al., 2008). For example, Teixeira and colleagues did not observe a relationship between the presence or degree of hearing loss and any domain of QoL (Teixeira et al., 2008).

These findings support our view that physiologic hearing deficit (i.e. audiometric data) does not automatically reflect how people perceive their hearing difficulties and the consequences this has for them in everyday life (Gopinath et al., 2012a). Pure-tone audiometry assesses mainly one component of hearing performance, namely peripheral sensory functioning in optimal circumstances, whereas, e.g., speech understanding is a far more complicated process that also involves aspects of cognitive processing (Gatehouse & Noble, 2004). Furthermore, two individuals with same audiometric results may face different challenges in their everyday lives, depending on the environment they are living in and the demands it puts on the individual. For example, for individuals who engage in activities that require interpersonal contacts poor hearing may have different psychosocial consequences from those experienced by people who prefer more individual activities (Scherer & Frisina, 1998).

As PCM bring forward, individual's ability to cope with environmental demands is crucial for the individual's wellbeing (Lawton & Nahemow, 1973). Therefore, even a severe audiometrically assessed hearing loss may not affect QoL if the person is able to cope with it, for example by avoiding situations which are demanding on hearing (Wiley, Cruickshanks, Nondahl, & Tweed, 2000). However, QoL may decline if a person experiences hearing difficulties as hampering everyday life (Hogan et al., 2015). Thus, QoL may be more closely associated with perceived hearing ability in the community than with actual audiometrically measured hearing (Chia et al., 2007).

The strengths of our study are that our data were collected from a population-based cohort rather than from a cohort with specific hearing difficulties. Our cohort thus comprised participants with and without hearing difficulties and the associations observed in this study likely represent those prevalent in a similar-aged general population in Finland. We assessed several aspects of hearing, namely perceived hearing difficulties in various everyday situations and audiometrically measured hearing. This approach produces a more complete picture of hearing difficulties than a single question.

Some limitations should be taken into account. The audiometric measurements were conducted in the participants' homes instead of in standardized conditions. We used only pure tone audiometry, which measures the ability to hear tones, but not the ability to understand words or speech. In addition to the pure tone test, using more direct test for assessing difficulties in hearing speech (for example Hearing in Noise Test) in the further studies would provide more detailed information on the association between measured hearing and QoL.

Also, the data were cross-sectional and therefore it is not clear whether hearing loss preceded the decline in QoL. Longitudinal research is needed to examine the temporal order and potential causality. We cannot exclude the possibility of residual confounding caused by unmeasured factors. It should also be noted that both perceived hearing difficulties and QoL were self-reported in the present study. Thus it is possible that there are some endogenous associations, meaning that both self-evaluations are shaped by a confounder such as personality traits or general health pessimism (Podsakoff et al., 2003). This may partly explain why perceived hearing difficulties were more strongly associated with QoL than audiometrically assessed hearing. However, persons' own perception of his/her hearing performance in various everyday situations and of QoL cannot be captured without self-reports (Weinstein, 2015). Also, some persons were excluded from the study because they were not able to communicate due to hearing problems. Therefore, it is likely that persons with severe hearing impairment were under-represented and selection bias cannot be completely ruled out. Had these persons participated, the associations observed between hearing difficulties and QoL might have been stronger.

To conclude, our results indicate that perceived hearing difficulties in everyday life situations are more strongly associated with older adults' wellbeing than audiometrically assessed hearing impairment, as associations were observed with all the domains of QoL. Hearing difficulties are often seen as an inevitable consequence of aging, and therefore their impact is easily dismissed. However, our findings imply that, along with audiometric measurements, health care practitioners should also take into account the effects that hearing problems have on people's ability to manage in everyday life.

In future, it is also important to explore similarities and differences in the associations between hearing difficulties and QoL in different cultural contexts. Even though age-related impairment in hearing is universal, there may be cross-cultural differences in the ways the hearing difficulties affect older adults' everyday life (Zhao et al., 2015). As QoL is culturally constructed, those variables that most influence QoL in Western cultures may not be completely equivalent in different cultural settings.

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Table 1. Hearing in Real-Life Environments (HERE)-scale. Geomin-rotated exploratory factor analysis loadings, communality estimates and subscale Cronbach alphas for hearing scale items.

| Item | | Factor | | | Communality |
|---|---|---|---|---|---|
| | | 1 Socioemotional effects α=0.93 | 2 Speech hearing α=0.96 | 3 Spatial hearing α=0.89 | |
| My hearing difficulties hamper my social life (for example meeting friends or acquaintances, participating in leisure-time activities or different gatherings). | | **0.81** | 0.08 | 0.04 | 0.66 |
| I feel left out when I am with a group of people because of my hearing difficulties. | | **0.90** | 0.01 | 0.01 | 0.81 |
| Hearing problems cause me to feel frustrated. | | **0.94** | -0.01 | -0.03 | 0.89 |
| Hearing problems cause me to feel embarrassed. | | **0.85** | -0.01 | -0.08 | 0.73 |
| I need help from other people because of my hearing difficulty. | | **0.59** | 0.23 | 0.00 | 0.40 |
| How is your hearing. | | -0.10 | **0.91** | 0.00 | 0.83 |
| When I am having a conversation with another person at my home I find it difficult to hear his/her speech. | | -0.01 | **0.90** | -0.09 | 0.82 |
| I have to ask the person I´m talking to repeat what he/she is saying when having a conversation in a quiet room. | | 0.06 | **0.84** | -0.12 | 0.73 |
| It is difficult for me to follow what another person in saying when other people are simultaneously talking around us. | | -0.02 | **0.85** | 0.11 | 0.73 |
| It is difficult for me to follow what performers are saying at the theatre, in a concert or some other similar situation | | 0.05 | **0.81** | 0.11 | 0.67 |
| It is difficult for me to follow speech in places where you can hear an echo (e.g. priest's sermon in church). | | -0.00 | **0.82** | 0.14 | 0.70 |
| I have to strain to hear when listening to something or someone. | | 0.10 | **0.84** | -0.01 | 0.71 |
| I can estimate from a sound the direction from which the sound is coming (e.g. dog barking or sound of a car). | | 0.47 | 0.04 | **0.51** | 0.48 |
| I can estimate from the sound how far away the sound source is (e.g. dog barking or sound of a car). | | 0.46 | -0.00 | **0.63** | 0.60 |
| I can estimate from the sound whether the sound source is coming towards me or going away from me (e.g. a barking dog or a car). | | 0.59 | -0.01 | **0.47** | 0.54 |
| I find traffic noises uncomfortably loud. | | 0.35 | 0.28 | 0.13 | 0.22 |
| Factor correlations | 1 | 1.0 | | | |
| | 2 | 0.74 | 1.0 | | |
| | 3 | 0.37 | 0.51 | 1.0 | |

Table 2. Sample characteristics of the total sample and substudy sample.

| | Total sample | | Substudy sample | |
|---|---|---|---|---|
| | **n** | **Mean (SD)** | **n** | **Mean (SD)** |
| Age | 712 | 81.7 (4.2) | 161 | 82.2 (4.2) |
| Education in years | 712 | 9.8 (4.2) | 158 | 9.6 (4.3) |
| MMSE score (range 0-30) | 712 | 26.4 (2.6) | 161 | 26.1 (2.5) |
| Quality of life | | | | |
| QoL total score (range 0-130) | 706 | 95.0 (13.8) | 160 | 94.1 (13.6) |
| Physical domain (range 0-100) | 706 | 64.0 (18.6) | 161 | 62.8 (17.9) |
| Psychological domain (range 0-100) | 706 | 64.4 (14.3) | 161 | 64.3 (14.1) |
| Social domain (range 0-100) | 705 | 64.4 (18.7) | 160 | 63.5 (17.2) |
| Environmental domain (range 0-100) | 706 | 72.8 (15.3) | 160 | 71.3 (16.0) |
| Self-reported hearing [a] | | | | |
| Speech hearing (range 0-10) | 653 | 2.8 (2.1) | 157 | 2.7 (2.1) |
| Socioemotional effects (range 0-10) | 667 | 1.4 (1.7) | 160 | 1.3 (1.7) |
| Spatial hearing (range 0-10) | 668 | 2.4 (2.1) | 159 | 2.1 (1.9) |
| BEHL (PTA0.5-4kHz), dB | | | | 38.8 (14.4) |
| | | **%(n)** | | **%(n)** |
| Women | 712 | 62.5 (445) | 161 | 62.1 (100) |
| Hearing aid owners | 711 | 17.8 (127) | 161 | 18.6 (30) |
| Diabetes | 712 | 17.4 (124) | 161 | 15.5 (25) |
| Cardiac diseases | 712 | 41.0 (292) | 161 | 44.7 (72) |
| Circulatory diseases | 712 | 64.2 (457) | 161 | 62.7 (101) |
| Neurological diseases | 712 | 6.3 (45) | 161 | 6.2 (10) |

Notes: IQR= Interquartile range , MMSE= Mini-Mental State Examination, BEHL= Better ear hearing threshold level, PTA= pure tone average 0.5-4kHz, dB= decibel

a= Mean scores of the items in each factor. Higher scores indicate poorer performance/more difficulties.

Table 3. Association between dimensions of perceived hearing difficulties and quality of life in the total sample (N=706). Linear regression analysis.

| | | Model 1[a] | | | Model 2[b] | | |
|---|---|---|---|---|---|---|---|
| | | β | SE | p | β | SE | p |
| **QoL domain** | **Dimension of hearing difficulty** | | | | | | |
| Total score | | | | | | | |
| | Speech hearing | -.259 | .51 | <.001 | -.226 | .50 | <.001 |
| | Socioemotional | -.296 | .52 | <.001 | -.269 | .50 | <.001 |
| | Spatial hearing | -.181 | .58 | <.001 | -.151 | .56 | <.001 |
| Physical | | | | | | | |
| | Speech hearing | -.260 | .70 | <.001 | -.222 | .67 | <.001 |
| | Socioemotional | -.275 | .70 | <.001 | -.243 | .67 | <.001 |
| | Spatial hearing | -.178 | .79 | <.001 | -.144 | .75 | <.001 |
| Psychological | | | | | | | |
| | Speech hearing | -.218 | .54 | <.001 | -.199 | .54 | <.001 |
| | Socioemotional | -.269 | .54 | <.001 | -.252 | .54 | <.001 |
| | Spatial hearing | -.180 | .60 | <.001 | -.162 | .60 | <.001 |
| Social | | | | | | | |
| | Speech hearing | -.134 | .72 | <.001 | -.115 | .72 | .001 |
| | Socioemotional | -.173 | .72 | <.001 | -.157 | .72 | <.001 |
| | Spatial hearing | -.114 | .70 | .002 | -.098 | .80 | .009 |
| Environmental | | | | | | | |
| | Speech hearing | -.192 | .58 | <.001 | -.171 | .58 | <.001 |
| | Socioemotional | -.235 | .58 | <.001 | -.219 | .58 | <.001 |
| | Spatial hearing | -.102 | .65 | .007 | -.082 | .65 | .028 |

Notes: β= Standardized coefficient beta, SE= the standard errors of the coefficients, QoL= quality of life.
a: Crude model
b: adjusted for sex, age and cardiac diseases

Table 4: Association between measured uncorrected hearing level (BEHL $_{PTA\ 0.5\text{-}4kHz}$) and quality of life in the substudy sample (N=161). Linear regression analysis.

| | Model 1[a] | | | Model 2[b] | | |
|---|---|---|---|---|---|---|
| | β | SE | p | β | SE | p |
| **QoL domain** | | | | | | |
| Total score | -.004 | .08 | .958 | .084 | .08 | .325 |
| Physical | .022 | .10 | .784 | .119 | .11 | .164 |
| Psychological | .057 | .08 | .475 | .141 | .08 | .099 |
| Social | -.089 | .10 | .266 | -.031 | .10 | .717 |
| Environmental | .025 | .09 | .750 | .089 | .10 | .306 |

Notes: β= Standardized coefficient beta, SE= the standard errors of the coefficients, BEHL= better ear hearing threshold level, PTA= pure tone average 0.5-4KHz.

a: Crude model

b: adjusted for age

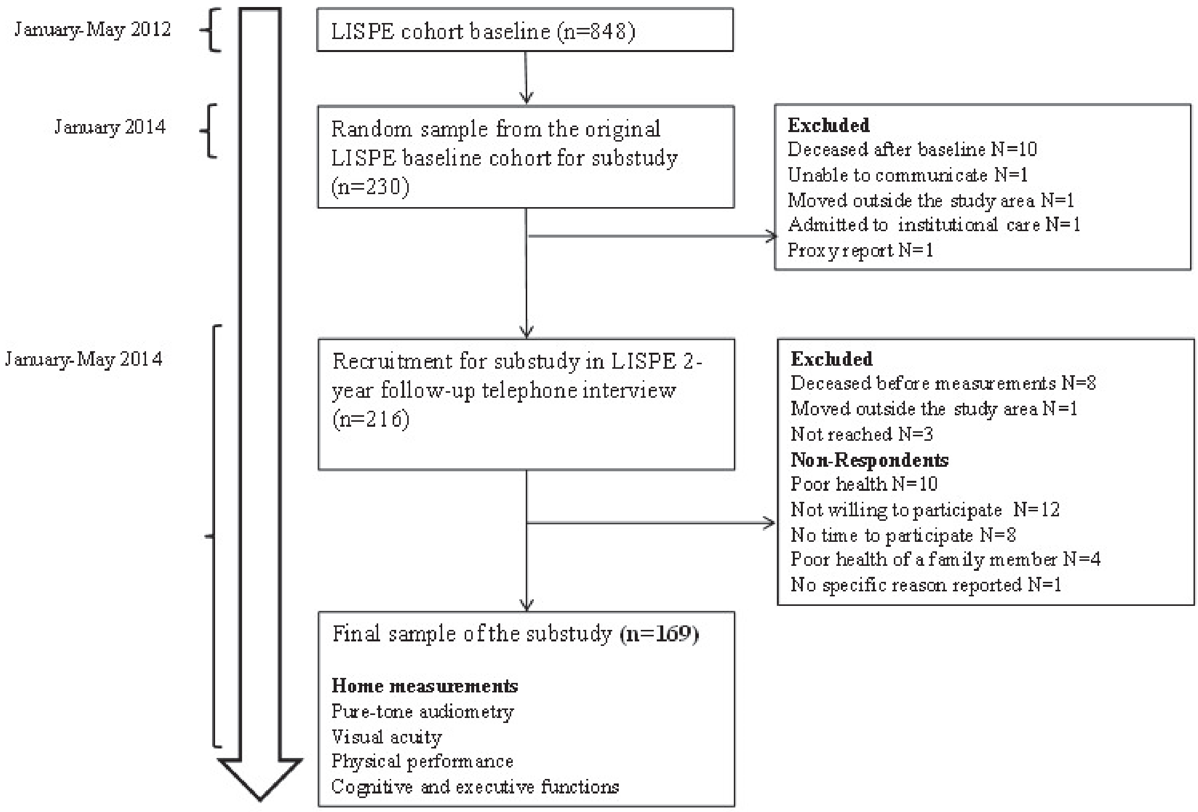


Figure 1. Flow chart of the “ Hearing, cognition and well-being”-substudy.