General discussion
Aim of the research described in this thesis was to provide more insight into the associations between hearing impairment and several domains of daily life, in a young and middle-aged adult and young-elderly population. Each of the preceding chapters focused on a specific domain. In this chapter, the main findings of the separate studies will be discussed and integrated, followed by some methodological considerations, recommendations for clinical practice, and for future research.

Main findings

The results of the four studies showed that hearing impairment may have an adverse effect on an individual’s functioning in several domains of daily life in adults aged between 18 and 70 years. The first study revealed that hearing impairment is associated with higher levels of distress, somatisation, depression, and loneliness. The effect-modification for age indicated that the associations are different for different age groups. This study is among the first ones describing differences in consequences of hearing impairment in different age groups. A study by Tambs (2004) revealed highly similar findings with the relationship between hearing impairment and psychosocial problems being stronger in young and middle-aged groups than in those older than 65 years. It is likely that the psychosocial problems of middle-aged hearing impaired adults are related to work. This issue was addressed in the second study.

An often observed problem of employees with hearing impairment is a lack of energy or fatigue. Hence, it was hypothesized that people with hearing impairment experience higher levels of need for recovery after work. The results in Chapter 3 confirmed this hypothesis. For every dB SNR poorer hearing ability, the need for recovery score increases with 1.35 points on a scale from 0 to 100. To illustrate, when there are two persons with the same characteristics but one has a 1 dB SNR poorer hearing ability than the other, then it is likely that the need for recovery score of the first person is 1.35 points higher than that of the other person. The odds for risky levels of need for recovery after work increased significantly as well with a decreasing hearing ability. According to Broersen et al.
(2004), a risky level of need for recovery is associated with a higher risk to develop psychosocial problems and even drop out from work because of these complaints. This idea is supported by the findings in Chapter 4, which show that the higher level of need for recovery seems to influence the relationship between hearing ability and sick leave. A trend for a mediating effect from need for recovery in this association was found, and the higher odds for sick leave, which was observed in the unadjusted analyses, could partially be explained by need for recovery. Other contributing factors were educational level and the presence of other chronic conditions. Chapter 4 also reports on self-reported work productivity. The data show that for employees experiencing little social support, poorer hearing is associated with lower self-reported absolute work productivity. Poorer hearing ability seems to significantly increase the odds for experiencing limitations in the type or amount of work one can do.

Despite the adverse relationships between hearing ability and psychosocial health (Chapter 2) and work related problems (Chapter 3 & 4), differences between participants with and without auditory difficulties in health care use and costs, after excluding hearing-related care, were not found. It was expected that people with insufficient and poor hearing ability would have higher levels of health care use (and related costs) over and above the care directly related to their hearing problem, as many people do not directly see a link between their auditory difficulties and problems like fatigue. However, only when hearing related contacts were included, a significantly higher use and costs for overall primary, secondary, and occupational health care was observed in participants with insufficient and poor hearing, compared to their normally hearing peers. The results in Chapter 5 therefore suggest that adults with hearing loss (compared to normally hearing peers) do not make more use of health care resources over and above their hearing related health care contacts. Apart from a potential overcorrection for chronic conditions (depressive symptoms were among the chronic conditions evaluated), other possibilities to explain this finding are that psychosocial care is not offered to the patients and therefore not used. Another option is that individuals do just not wish to make use of this type of care. Also, the results of Chapter 2 show a wide distribution of the psychosocial health
scores, with people in the normal range and with clinically deviant scores whereas group mean scores for all hearing test categories fell in the normal range. As such, it is possible that the psychosocial health problems experienced by people with hearing impairment were mild enough to not require direct psychosocial care. It is an issue that deserves attention in future studies.

Whereas previous studies mainly focused on elderly populations, this thesis exclusively focuses on possible effects of hearing impairment in young and middle-aged adults and young-elderly. Also, the NL-SH is the first study on the association between hearing ability and various domains of daily life which used a speech-in-noise test over the Internet to determine hearing ability. As such, the current work is unique. Implications for clinical practice are discussed in the following paragraph.

**Implications for clinical practice**

Given the aging societies of today, and the focus of politicians on raising retirement age, it is likely that the proportion of workers with hearing impairment will rise in the coming years. Also, the focus is more and more on keeping people with an impairment active in the workforce. As such, the findings presented in this dissertation underline the need to further address and explore possible adverse effects of hearing loss in these age groups in clinical practice.

The findings presented in Chapter 2 show different associations between hearing ability and psychosocial health for different age groups. These dissimilarities possibly reflect the overall way in which hearing impairment is regarded in the different age groups. In older populations, hearing loss is quite common and seen as part of the aging process. However, in younger age and middle-aged adults groups, hearing loss is not as prevalent and consequently, may have a higher personal impact. The results of this study suggest that awareness of the differential effects in different age groups could be useful for clinicians when assisting people with auditory difficulties. Specific rehabilitation programs for different age groups are scarce and deserve more attention.
Another clinical implication relates to work. Work is a challenging activity, especially for people with hearing problems. This study shows that among workers, reduced hearing ability is associated with higher levels of need for recovery, perceived health-caused limitations at work, and, sometimes, with reduced self-reported work productivity. With the governmental focus of keeping people at work, these results stress the need for specific work-related support of people with hearing problems. Examples of such programs have been reported previously in the literature (Hétu and Getty 1991; Kramer 2008). Implementing the management of need for recovery (e.g. by learning efficient coping strategies or relaxation techniques) might be useful to avoid high levels of need for recovery or maybe even drop out from work. Social support at work is another topic which requires attention in these programs. The positive mean differential productivity in all three hearing test categories, the interaction effect for social support and the mediating effect from need for recovery reported in Chapter 4 suggest that with such efficient support, employees with reduced hearing ability might function just like their normally hearing colleagues. This is an encouraging outcome as it indicates that, with adequate support, hearing impaired workers can be remained in the workforce.

In this study, the Four-Dimensional Symptom Questionnaire (4DSQ), a questionnaire measuring distress, depression, somatization and anxiety was used. This questionnaire has been used in other studies addressing the psychosocial health of patient groups. One may wonder whether the impact of hearing impairment on an individual’s psychosocial health status is comparable to the impact of other chronic conditions. Mean 4DSQ scores are reported for a few different populations (Terluin et al. 2006). For example, the scores of employees participating in a health survey had more favorable scores (i.e. less psychosocial problems) when comparing these with the NL-SH participants with poor hearing ability. The latter group had scores similar to those of a group of general practice patients. However, it must be noted that a direct comparison is difficult to make or interpret as outcomes and study methods vary widely between studies.
Future research

The results of the present thesis support the need for specific rehabilitation programs for workers with hearing impairment, which is also stressed by several previous studies (i.e. Jennings and Shaw 2008). Future research could help to further develop, adapt or evaluate such vocational programs, and thereby improve the care for workers with hearing problems.

The study sample included consists of a mixture of people receiving help for their auditory problem and people not receiving help (yet). It would be interesting to examine if there are any differences between these groups, and to determine which factors influence help seeking. Such information may be useful for the organization of the care delivered to hearing impaired adults, and may help to reach those people with auditory problems not receiving help yet.

The National Longitudinal Study on Hearing started early 2006. In the present thesis, the results of the cross-sectional analyses of data collected during the period from November 2006 to January 2008 are described. Cross-sectional analyses do not provide information about the causality of the relationships. Hence, questions addressing the consequences of changes in hearing ability for psychosocial health, work situation, and health care use cannot be answered with these cross-sectional data. This requires longitudinal data. So far however, longitudinal data with a special focus on hearing ability and its possible consequences are scarce, especially for working aged adults. Hence, it is the aim of the NL-SH to start a second measurement cycle to collect longitudinal data on both hearing ability and the different life domains. By monitoring participants during a longer period, more insight can be gained into the effects of changes in hearing ability on, for example, psychosocial health or work situation. Also, the longitudinal design creates the opportunity to follow people who are normally hearing at baseline and who develop hearing problems in the period of investigation. In this way, more insight into the health care pathway, the (psychosocial) health effects, and the needs and help seeking behavior of these people can be gained.
Methodological considerations
The NL-SH is conducted over the Internet and used on-line questionnaires to collect the data. Whereas the use of Internet in general has been growing and became popular in the recent years, its application for research purposes is relatively new and requires some explanation and discussion.

Internet and research
One of the frequently reported concerns on using Internet for (population based) research purposes is the degree of access in the population. Although the proportion of people using the Internet has increased tremendously since its introduction, the penetration is not yet 100%. This implies that using the Internet for a study such as the NL-SH excludes participants without access, who would have been eligible otherwise. When those with and without access do differ on certain aspects (e.g. socio-economic status), then exclusion of these subjects might have led to selection bias and difficulties in translating the results to the general population. The risk for this type of bias decreases with an increasing access rate.

In The Netherlands, the proportion of the population having connection to the Internet is one of the highest in the world: in 2006, 80% of the households were connected at home, and in 2007 this proportion had increased to 83% (Dutch Statistics 2010). In 2006 and 2007, the proportion of households having broadband or high speed Internet was 66% and 74% respectively. In these years, an additional 2% of the households used the Internet at other places than home, for example at work (Dutch Statistics 2010). Furthermore, comparison of accessibility in the group aged 50-65 years and in the general population revealed that availability of the Internet was nearly the same in both groups (SCP 2010). Based on these findings, it was concluded that penetration was sufficiently certain at the start of the NL-SH.
**Study sample and selection bias**

Whereas it is concluded that the penetration of the Internet in the target population was sufficiently certain to minimize selection bias, there is another factor potentially causing selection bias which needs to be discussed here. This is the way participants were recruited for this study. Although we explored several approaches to recruit potential subjects (both normally hearing and hearing impaired), all had to actively subscribe themselves. This procedure could have led to a biased selection, more than one would expect when using random lists of addresses to invite potential participants. Comparing the NL-SH population to the general population, we indeed observed that the NL-SH population has a somewhat higher average educational level. This is in line with results of Ekman et al. 2006, who conducted a large population-based study on lifestyle and health. They compared a paper-and-pencil group with a group to whom web questionnaires were administered. In the online group the response rate was higher for those with a higher level of education and income. Ekman et al. 2006 stated, however, that the potential bias in survey studies caused by the use of the web is not larger than the one caused by the use of paper-and-pencil questionnaires. Though, women in the NL-SH population were on average younger then men and had poorer hearing ability, which is in contrast with some population studies. Also, hearing aid usage among those with insufficient and poor hearing ability was somewhat higher than expected in a general population. As such, it might be useful to extend the NL-SH in the future with inviting a randomly selected sample drawn from the general population to participate. This will increase the generalizability of the results even more. A huge advantage of the NL-SH, however, sample is that it is not limited to a group of clinical patients or clients. Whereas previous studies, especially those focusing on work related topics and health care use, mostly consisted of a sample selected at audiology clinics, the sample of the NL-SH comprised a mixture of a clinical and non-clinical population.
Paper-and-pencil versus online questionnaires

Another concern is the use of online questionnaires. One may wonder whether the data collected with online questionnaires are comparable to those obtained by paper-and-pencil versions. There is sufficient evidence to assume that there is no difference in outcome when questionnaires are administered by paper and pencil or online. To illustrate, Hallam et al. 2006. found, in a study on the psychosocial health among people with acquired hearing loss, highly similar results for both versions, and concluded that the groups could be combined for the analyses. Other studies comparing Internet and paper-and-pencil questionnaires, both on psychosocial health and other domains, revealed similar results: the paper-and-pencil responses where highly similar to those obtained by the Internet version (Kongsved et al. 2007; Vallejo et al. 2007; Touvier et al. 2010). We thus conclude that the NL-SH results obtained so far would have been comparable if all questionnaires would have been administered by paper-and-pencil. In this context, it is important to note that questionnaires with proven good reliability and validity were used in the NL-SH.

Hearing test

A limitation of using a speech-in-noise test to determine hearing ability, is that it does not detect middle ear problems or beginning high frequency hearing losses (Smits, et al. 2004; Smits and Houtgast 2005). Thus, people with a conductive type of loss might have a good score on the test, while they do experience problems in daily life. Also, as hearing ability was measured diotically, unilateral hearing loss could have been compensated by the other ear, resulting in a good hearing test score as well. However, these types of hearing problems are reported by only a small number of participants (about 7%), and as such it is assumed that the possible influence on the results is limited.

Another potential drawback of testing hearing ability over the Internet is that there is no control over the testing conditions. Participants were allowed to use either headphones or loudspeakers. Though, they were advised to use loudspeakers only when in a quiet environment, as using speakers in a noisy
environment might influence the test result. The majority of people used speakers instead of headphones. Therefore, for all analyses the possible influence of test condition (headphone versus speaker use) was checked. No significant confounding or effect-modification was found in any of the analyses, indicating little influence from test condition on the results. This is supported by a previous study of Culling et al. 2005, who showed that variations in equipment have negligible effects on speech-in-noise audiometry. Given these findings and the previously established reliability and validity of the test, the National Hearing Test is seen as a valuable way to objectively determine hearing ability in large samples.

CONCLUSIONS

The first, cross-sectional results of the NL-SH presented in this thesis indicate that limitations in hearing have an impact on psychosocial health and work in young and middle-aged adults and young-elderly. As such, these findings underline the need to further address and explore the adverse effects of hearing loss in these age groups, both in research and clinical practice. Continuation of NL-SH by collecting longitudinal data could help to obtain insight into the effects of changes in hearing ability on psychosocial health, work and health care use.

REFERENCES


