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General introduction
[...] In seminars he was aware that he was talking far too much himself because it was easier than straining to hear what the students were saying. Meetings became stressful too, for the same reason, and there seemed to be more and more of them in the 1990s. [...] More and more he found himself struggling to pick up the gist of an argument, falling silent, afraid to intervene in case he had got the wrong end of the stick, eventually giving up altogether and falling into bored reverie – unless of course he was chairing the meeting himself. Then he would sometimes catch the ghost of a smile on someone’s lips or an exchange of amused glances across the table and realise that he had misunderstood something or made an inapposite remark.

From: Deaf sentence, David Lodge.

The phrases above are just a lucid illustration of the difficulties people with hearing impairment may face in their daily life. Worldwide, more than 250 million people experience problems with hearing (Mathers et al. 2003). Depending on the definition of hearing impairment and the criteria applied, prevalence rates in adult populations vary from 10 to 20 percent (Davis, 1989; Karlsmose et al. 2000; Mathers et al. 2003; Hannaford et al. 2005). Although the prevalence of auditory disability is highest in older age groups (i.e. > 65 years), there is still a large number of younger people with hearing problems. In 2004, Dutch Statistics estimated that about 1.5 million persons aged 12 years and older experienced problems with hearing when in a conversation with three or more persons, whereas in a conversation with one other person 290.000 individuals reported difficulties (Gommer & Poos 2010). The numbers of individuals younger than 75 years in these groups were 1.2 million and 227.000 respectively (Gommer & Poos 2010). The most prevalent type of hearing impairment is irreversible, which makes it a common chronic condition in human populations.

There is a wide range of disabilities that people may experience as a result of their hearing loss. A framework for describing health and health-related states is the International Classification of Functioning, Disability and Health (ICF; WHO 2001). In this model, disability and functioning are regarded as outcomes of interactions between an individual’s health condition and contextual factors. Three levels of human functioning are classified by the ICF: functioning at the level of the body or body part (body functions and structures), the whole person (activities), and the whole person in a social context (participation), see Figure 1.1.
According to the model, disability involves dysfunctioning at one or more of these levels: impairments (which reflect problems in body function or structure, e.g. hearing impairment), activity limitations (describing difficulties one may have in executing activities), and participation restrictions (indicating the problems one may experience in involvement in life situations). Activity limitations as a result from hearing loss may occur, for instance, when an individual has difficulty with using the telephone to communicate or when (s)he has difficulty localizing sounds. Participation restrictions are, for example, experienced when an individual has difficulty with communicating with others during a meeting or when a person with hearing loss feels restricted in participating in leisure activities. The WHO has designed a coding system to classify categories of body functions and structures, activities and environmental factors (WHO, 2001). Activity limitations and participation restrictions are combined into a list of concepts, including ‘handling stress and psychological demands’, ‘social life’, and

Figure 1.1. The ICF framework with examples of how various factors interact and determine the functioning of an individual with hearing loss.
Psychosocial health

So far, studies addressing the relationship between hearing impairment and psychosocial health focused on a range of outcomes, varying from generic variables like overall health-related quality of life to specific domains such as depression or social isolation. In most of the studies looking at overall health related quality of life, a negative influence of hearing impairment was found, with hearing impaired individuals reporting lower levels of quality of life than people with normal hearing (Fellinger et al. 2007; Chia et al. 2007). Depression is one of the specific variables which was found to be related to auditory disability. Several studies described significantly more depressive symptoms in those with impaired hearing compared to normally hearing individuals (Knutson & Lansing 1990; Carabellese et al. 1993; Wallhagen 1996; Cacciatore et al. 1999; Strawbridge et al. 2000; Kramer et al. 2002; Tambs 2004; Hallam et al. 2006). Others found hearing impaired people to feel lonelier or socially isolated than their normally hearing peers (Knutson & Lansing 1990; Ringdahl & Grimby 2000; Strawbridge et al. 2000; Kramer et al. 2002; Hawthorne 2008). Higher levels of anxiety and distress among persons with hearing impairment were also reported (Eriksson-Mangold & Carlsson 1991; Tambs 2004). Another variable for which an adverse relation with hearing impairment is reported is somatisation (Eriksson-Mangold & Carlsson 1991; Fellinger et al. 2007). Somatisation is defined as the tendency to experience somatic symptoms in response to psychological stress, which is attributed to physical illness, and for which medical help is sought (Lipowski 1988).

Whereas the relationship between hearing impairment and psychosocial health has been studied in a substantial number of studies, the vast majority of these included samples of elderly people. Relatively little is known about the impact of hearing loss on psychosocial health among younger adults. Because of differences in circumstances and lifestyles between individuals in the working age and elderly people (i.e. working life versus being retired), the psychosocial impact of hearing
impairment might be different among different age groups. Hence, results from studies exclusively including elderly populations might not apply to younger age groups.

Also, most of the studies used self-report to determine the participant’s hearing ability. Although self-report has shown to be a reliable method to assess hearing disability, people in different age groups are likely to rate their hearing ability differently, with older age groups being less likely to report limitations than younger age groups (Smits et al. 2006a). Others used pure-tone audiometry. However, previous studies have reported only moderate relationships between pure-tone thresholds and a person’s ability to understand speech in adverse listening conditions (Kramer et al. 1996; Houtgast & Festen 2008). It is known that difficulties with understanding speech in a noisy environment is one of the primary complaints of people with hearing impairment, and is often experienced as very limiting (Plomp & Mimpfen 1979; Lutman et al. 1987; Kramer et al. 1996). Therefore, hearing ability expressed as the ability to understand speech in adverse listening conditions might be a better measure when looking at the relationship between hearing ability and psychosocial health. So far, studies exploring impaired speech comprehension in noise in relation to psychosocial functioning have not been reported in the literature.

Working life

Another major life area which might be influenced by impaired hearing is working life. Several studies showed that workers with hearing loss comprise a vulnerable group on the labour market. They seem to have lower levels of education and greater likelihood of low income compared to groups with normal hearing (Järvelin et al. 1997; Hogan et al. 2009; Rydberg et al. 2010). Also, higher levels of un(der)employment are reported and people with hearing loss seem to be overrepresented in the group taking early retirement (Parving et al. 2001; Danermark & Gellerstedt 2004). Mohr et al. (2000) demonstrated that adverse work-related consequences of hearing impairment are associated with high
societal costs. Though, the exact implications of hearing impairment in the workplace are not well understood yet (Jennings and Shaw 2006).

Only a few studies addressed the implications of hearing impairment in the workplace. A condition often mentioned by employees with hearing impairment is a lack of energy or fatigue (Ringdahl and Grimby 2000; Backenroth et al 2003; Danermark and Gellerstedt 2004). For example, Grimby and Ringdahl (2000) interviewed 35 full-time workers with hearing impairment. The participants expressed their concern about stress and strain resulting from conversations in the coffee room or in their offices, leading to exhaustion both at work and during the hours after work. The degree to which employees are able to recover from fatigue and distress after work is an important factor influencing their physical and mental health status. In occupational health care, this so-called need for recovery after work is seen as an acute, short-term reaction to work related fatigue. Repeated insufficient recovery after work has been found to be an intermediate stage between stressful working conditions (high job demands and low job control), and the development of psychosomatic health problems (Sluiter et al. 2003). Also, need for recovery has been found to be related to the duration of future sick leave (Sluiter et al. 2003). Several studies have shown associations between chronic conditions and increased levels of need for recovery (Jansen et al. 2002; Weijman et al. 2004). The association between hearing impairment and need for recovery has not been studied so far. Though, some studies have examined psychosocial job characteristics, expressed by job demand and job control, among employees with hearing impairment. The findings show that those with hearing problems experience significantly more often an imbalance between the psychological demands of their job and the degree of control over their working conditions (Danermark & Gellerstedt 2004; Kramer et al. 2006). This imbalance is mainly caused by lower levels of job control experienced among workers with hearing loss compared to their normally hearing colleagues (Danermark & Gellerstedt 2004; Kramer et al. 2006). Although it is often suggested that the prevalence of long-term sick leave is higher among employees with reduced hearing, there is not much evidence yet. Recent work found a higher level of sick leave among those with impaired hearing compared to those with
normal hearing (Kramer et al. 2006). This study suggested that the difference in sick leave between the groups was caused by a higher incidence of psychological distress in those with auditory problems (Kramer et al. 2006). The studies presented in this thesis provide more insight into the relationship between hearing ability and need for recovery, psychosocial work characteristics and sick leave.

Health care use
Nowadays, the use of health care resources and the costs related to it are important issues for health economists and politicians. As the consumption of care in the population is likely to increase because of the aging society, insight into the health care use and the related costs of people with reduced hearing is also important. It is likely that health care use, and costs related to it, are influenced by the inability to hear sufficient. Not only because of the use of resources directly related to hearing impairment, such as contacts with an audiology clinic or ENT doctor, but also because of a higher number of contacts with health care providers for care indirectly related to hearing impairment. For example, psychosocial health problems, such as depression, often coincide with hearing impairment, as discussed earlier. Depression itself has been found to be associated with an increase in health care use (Johnson et al. 1992; Grabe et al. 2009). When psychosocial health complaints are also more often reported in people with hearing impairment, it is reasonable to assume that they have a higher amount of health care contacts and costs compared to those with normal hearing. Some previous research demonstrated differences in health care use between normally hearing and hearing impaired individuals, with the latter group having more contacts. However, almost none of the studies conducted so far accounted for confounding variables like educational level or income. Only one study distinguished between hearing related contacts and health care contacts which were not directly related to hearing impairment (Green & Pope 2001).
National Longitudinal Study on Hearing

The preceding sections illustrate that there is still a lack of knowledge about hearing loss and its possible influence on different domains of daily life, in particular among adults in the working age. To gain more insight into the relationship between hearing impairment and areas of psychosocial health, work situation, and health care use, the National Longitudinal Study on Hearing (NL-SH) was set up in 2006. This study specifically focuses on a working age population: adults between 18 and 70 years of age. The NL-SH is completely conducted over the Internet: hearing ability is measured using the Internet version of the National Hearing Test, online questionnaires are used to examine psychosocial health, work related variables, and health care use.

Procedure

Enrolment to the study

Both persons with and without hearing impairment were encouraged to participate in the NL-SH. We made use of several ways to recruit participants, which are described below:

- Participants could visit our website and subscribe for the study. On the website (www.hooronderzoek.nl) the main aim of the NL-SH is described, as well the focus of the study including instructions as to how to subscribe.
- Flyers with information, including the link to the website of the NL-SH, were distributed at Audiology clinics and most hearing aid dispensers in the Netherlands.
- We distributed the flyer at several occasions, like meetings of the Dutch organization for Hard of Hearing (NVVS) (patient organization).
- Information about the study was posted on several websites (both hearing-related and non hearing-related).
- We placed an advertisement in local newspapers.
- A number of participants learned about our study by word-of-mouth.
- A connection was made between the website of the National Hearing test (see next section) and the NL-SH website. So, the link to the website of the
NL-SH was presented to everybody who performed the National Hearing Test over the Internet. Media attention to hearing in general and the test in particular indirectly led to attention to the NL-SH. Before enrolment to the NL-SH, it was necessary for people to do the Internet version of the National Hearing test. At the end of the test, people were redirected to the website of the study were they could subscribe. After subscription, contact details and the results of the National Hearing test were stored in a database.

**National Hearing test**

As described above, self-reported hearing ability is a useful and satisfactory method to assess hearing impairment and activity limitations (e.g. Lutman et al. 1987; Kramer et al. 1996). However, people in different age groups are likely to assess their hearing problems differently, with older people being less likely to self-report activity limitations compared to younger respondents (Lutman et al. 1987; Smits et al. 2006a). Pure-tone audiometry, on the other hand, has been found to be an inaccurate predictor of the reduced ability to understand speech in difficult listening circumstances (e.g. Kramer et al. 1996; Houtgast & Festen 2008). This reduced ability to understand speech in noise is a limitation which is frequently experienced among people with hearing impairment, and which is one of the primary and most limiting manifestations of hearing impairment (Plomp & Mimpfen, 1979; King et al. 1992). As such, it was chosen to determine hearing ability with The National Hearing test, an adaptive speech-in-noise test using digit triplets presented against a background noise. Such a test provides a more realistic estimation of the perceived limitations in hearing, as it measures how well a person understands speech in the presence of noise. The development and procedure of the test has been described in several studies by Smits et al. (Smits et al. 2004; Smits & Houtgast 2005; Smits et al. 2006a; Smits et al. 2006b). The test was initially developed for delivery by telephone, but a version for Internet use was launched autumn 2004. This Internet version is identical to the telephone version; it is a simulation of the telephone network using the same filtering, compression and decompression of the original speech and noise files (Smits et al.
2006b). These were compressed to mp3 format and are presented to the participants by using a flash player (Smits et al. 2006b). A series of studies demonstrated the validity and reliability of the National Hearing test. (Smits et al. 2004; Smits & Houtgast 2005; Smits et al. 2006a; Smits et al. 2006b). The telephone and Internet versions appeared to be equally feasible, except that elderly persons prefer the telephone version (Smits et al. 2006b). As the participants of the NL-SH were all younger than 70 years, the requirement of Internet is no limitation here.

Participants were instructed to perform the test in a quiet environment, and they had to indicate whether they did the test using headphones or speakers. The advice was to use speakers only when in a quiet environment. A total of 23 triplets are presented to the listener using an adaptive procedure. The average signal-to-noise ratio (SNR) over the last 20 triplets was used to determine the speech reception threshold corresponding to 50% intelligibility (Smits et al. 2006b). This speech reception threshold at 50% intelligibility will be further referred to as SRT_n. According to Smits et al. (2006a), the score on the test can be divided into three categories: good (SRT_n < -5.5 dB), insufficient ( -5.5 dB ≤ SRT_n ≤ -2.8 dB), and poor (SRT_n > -2.8 dB) hearing ability (Smits et al., 2006b). These cut-off scores correspond to SRT_n -3.0 and 0.0 dB on the sentences SRT_n test by headphones of Plomp and Mimpen (1979) (Smits & Houtgast 2005).

Data collection

All data for the NL-SH were collected over the Internet, including psychosocial health status, work situation, and health care use. After enrolment, participants received a link to a set of online questionnaires. When participants did not complete all questionnaires within one week, an email remainder was sent to them. If we received no or incomplete response from them, within one month, a postal letter (providing the link to the questionnaire) was sent to their home address, followed by an email reminder the same week.
A web survey tool was used to create the questionnaire (Roelofsma et al. 2005). An advantage of such a tool is that ‘routing’ can be applied to the design. This implies that questions not applicable for a certain person are not presented to that respondent. For example, a question about the type of contact with the general practitioner (GP) was skipped for those respondents who, in the preceding question, indicated that they had not contacted their GP. Also, with pre-defining the range of scores for a certain item, we could avoid incorrect answers. For example, for the question addressing the number of days someone had missed at work during the past 28 days, we defined a fixed range between 0 and 28. With such a procedure and the option to make questions obligatory to answer before respondents can proceed to the next one, the number of missing or incorrect values within a questionnaire can be reduced considerably. Also, electronic data collection allows a direct access to a database, which decreases the likelihood of errors in the process of data entry. Thus data quality can be improved by the use of online questionnaires. Another advantage of online questionnaires is reflected in the reduced costs, as there is no need for printed paper-and-pencil versions. Additionally, the use of e-questionnaires minimizes the time between data collection and data entry and storage.

**Internet and research**

The use of Internet and the World Wide Web has increased rapidly during the past years. Within four years of its introduction, 50 million started using the web worldwide (Cook et al. 2000). Compared to radio or television use, this is remarkable: to reach a comparable amount of users, it took the radio almost 30 years and the television about 13 years (Cook et al. 2000). In the Netherlands, a user growth of nearly 270% was observed in the period from 2000 to 2009 (Internet World Stats 2010). As such, the Internet is of potential value for research purposes as well. It may, for example, facilitate the inclusion of a non-clinical population of people with hearing impairment in studies.
Outline of this thesis

This thesis describes the first, mostly cross-sectional, results of the NL-SH. In chapter 2 the association between hearing ability and different psychosocial health variables among adults aged 18 to 70 years is studied. Chapters 3 and 4 focus on the relationship between hearing ability and various work related variables: in chapter 3 the relationships between hearing ability and psychosocial work characteristics and need for recovery after work are described respectively. The associations between hearing ability and self-reported work productivity, sick leave, and limitations at work caused by health problems are reported in chapter 4. A comparison of health care use and the related costs between hearing impaired and normally hearing participants is described in chapter 5. Chapter 6 presents and discusses the general conclusions of this thesis.

REFERENCES


