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The association between hearing ability and psychosocial health before the age of 70 years

Published as:
Nachtegaal J, Smit JH, Smits C, Bezemer PD, Van Beek JHM, Festen JM & Kramer SE (2009). The association between hearing status and psychosocial health before the age of 70 years: Results from an Internet-based National Survey on Hearing. Ear and Hearing, 30 (3): 302-312.

ABSTRACT

There is a substantial lack of knowledge on the impact of reduced hearing on psychosocial functioning in adults younger than 70 years. The aim of this study is to examine the association between hearing ability and psychosocial health in adults aged between 18 and 70 years. Cross-sectional cohort study. Baseline data of the National Longitudinal Study on Hearing are analyzed, using regression models. The cohort consisted of 1511 participants. Hearing ability was determined using the National Hearing Test, a recently launched speech-in-noise screening test over the Internet. We assessed self-reported psychosocial health using a set of online questionnaires. Adjusting for confounding variables, significant adverse associations between hearing ability and distress, somatization, depression and loneliness are found. For every dB signal-to noise-ratio (dB SNR) reduction of hearing ability both the distress and somatization score increased by 2% (Distress: b=0.02; 95%-CI=0.00-0.03; p=0.03. Somatization: b=0.02; 95%-CI = 0.01-0.04; p<0.001). The odds for developing moderate or severe depression increase by 5% for every dB SNR reduction in hearing (OR=1.05; 95%CI=1.00-1.09; p=0.03). The odds for developing severe or very severe loneliness significantly increase by 7% for every dB SNR reduction in hearing (OR = 1.07; 95%CI = 1.02-1.12; p=0.004). Different age groups exhibit different associations between hearing ability and psychosocial health, with loneliness being an issue particularly in the youngest age group (18-30 years). In the group of middle-aged adults (40-50 years), the number of significant associations is highest. Hearing ability is negatively associated with higher distress, depression, somatization and loneliness in young and middle-aged adults. The associations are different in different age groups. The findings underline the need to seriously address the adverse effects of limited hearing among young and middle-aged adults both in future research and in clinical practice.

INTRODUCTION

Hearing impairment is one of the most frequent chronic conditions in human populations. More than 250 million people in the world are affected by hearing loss (Mathers et al. 2003). Despite the fact that the majority of persons with hearing impairments are older than 70 years, a considerable number of younger individuals are experiencing hearing problems. Community surveys in different countries worldwide revealed that the prevalence of hearing impairment in the adult population (18-70 years) varies between 10 to 20% (Davis 1989; Karlsmose et al. 2000; Mathers et al. 2003; Hannaford et al. 2005). Prevalence rates do depend on the tests and the criteria applied (Duijvestijn et al. 1999). In the studies above pure-tone audiometry and/or self-report was used. Davis (1989) found the prevalence of self-reported bilateral hearing impairment in a quiet environment to be lower than the prevalence when using pure-tone audiometry (10% versus 16%). According to Karlsmose et al. (2000), self-report of any difficulties with hearing led to a higher prevalence of hearing impairment (14.8%) compared to pure-tone audiometry (11.6%). When specifically assessing difficulties following conversations in background noise, rates are even higher. For example, Hannaford et al. (2005), reported a prevalence rate of 21.1% when assessing difficulties in following conversations in background noise compared to a prevalence rate of 18.3% when 'any difficulty with hearing' was assessed.

Hearing impairment inevitably affects health-related quality of life (Lee et al. 1999; Ringdahl and Grimby 2000; Dalton et al. 2003; Chia et al. 2007). In particular psychological, social and emotional functioning seem to be negatively influenced, rather than mobility and activities of daily living (Carabellese et al. 1993). Psychosocial variables found to be related to hearing impairment are depression (Cacciatore et al. 1999; Strawbridge et al. 2000; Kramer et al. 2002), loneliness (Knutson and Lansing 1990; Kramer et al. 2002; Fellinger et al. 2007; Hawthorne 2008), anxiety, distress, somatization [i.e. the tendency to experience somatic symptoms in response to psychological stress, to attribute them to physical illness and to seek medical help for them] (Eriksson-Mangold and Carlsson 1991) and poorer social functioning (e.g. Mulrow et al. 1990). For an overview see Table 2.1.

Table 2.1 Overview of studies on the association between hearing ability and psychosocial health, showing the characteristics of the population, the method of determining hearing ability, psychosocial health variables examined and results of the study. QoL: quality of life

Authors	Population		Hearing ability	Outcome measures	Results
	N	Mean age (range)			
Cacciatore et al. (1999)	1332	74.2 (65-96)	Self-report	Depression	Adverse correlation between hearing ability and depression score
Carabellese et al. (1993)	1191	- (70-75)	Free field voise test	Depression	Adverse association between hearing ability and depression (compared to persons with normal hearing & vision)
Chia et al. (2007)	2431	67.0 (49+)	Audiometry	Health-related QoL	Adverse association between hearing ability and physical and mental QoL
Dalton et al. (2003)	2688	69 (53-97)	Audiometry	Social functioning, mental health	Individuals with mild or moderate hearing loss were more likely to report lower mental health and social functioning
Erikson-Mangold & Carlsson (1991)	48	68.8 (55-74)	Audiometry self-report	Depression, anxiety, somatization	Adverse correlation between perceived hearing disability/handicap and anxiety & somatisation. No correlation with depression
Fellinger et al. (2007)	122	54.4; 51.4 (21-80)	Self-report	QoL, distress, anxiety, somatization, depression	Higher distress, somatisation & depression and lower QoL for individuals with poor hearing ability
Hallam et al. (2006)	373	-	Self-report	Depression, anxiety, post-traumatic stress symptoms	Depression significantly different from norm population. Subgroup with acquired profound hearing loss was severely distressed & handicaped
Hawtorne (2008)	3015	45.3 (15-60+)	Self-report	Loneliness	Hearing impairment was significantly associated with a higher odds for social isolation

Knutson & Lansing (1990)	27	49.1 (22-68)	Self-report	Depression, loneliness, anxiety, distress	Group mean scores were in the normal range, but many participants reported mild to moderate depression. candidates for cochlear implantation were similar to the loneliest group for which the UCLA scale was used
Kramer et al. (2002)	3107	- (55-85)	Self-report	Depression, lonelinees, self-efficacy, social network size	More depressive symptoms, lower self-efficacy and more feelings of loneliness for individuals with poor hearing
Lee et al. (1999)	7320	77.3 (70+)	Self-report	Overall functioning	Adverse correlation between hearing ability and overall functioning
Mulrow et al. (1990)	472	72 (HI) 69 (NH)	Audiometry	Depression	No association between hearing ability and depression after adjustment for age, education, visual acuity & number of medications
Naramura et al. (1999)	747	80.2 (65 – 94)	Audiometry	Depression	Adverse single (but not multiple) correlation between moderate to severe hearing impairment & depression
Ringdahl & Grimby (2000)	311	66 (–)	Audiometry	Social isolation, emotional reactions	More social isolation and emotional reactions in individuals with poor hearing
Strawbridge et al. (2002)	2461	65 (50-102)	Self-report	Depression, social functioning (loneliness)	Adverse association between hearing ability and depression and loneliness
Tambs (2004)	50398	50.2 (20-101)	Audiometry	Depression, anxiety, self-esteem, well-being	Adverse association between hearing ability and anxiety, depression, self-esteem and well-being among young & middle-aged persons. No such association found for older persons
Wallhagen et al. (1996)	356	72 (65-95)	Self-report	Depression	Higher depression scores in individuals with poor hearing ability

However, the vast majority of studies focusing on the relationship between hearing impairment and psychosocial health included samples of elderly people (Table 2.1). There is a substantial lack of knowledge about the impact of reduced hearing on psychosocial functioning in younger adults. People in different age groups are likely to emphasize psychosocial issues differently as lifestyles, occupational obligations and circumstances, communication needs, and listening conditions may differ. To our knowledge, only a small number of quantitative studies in the international literature focused on younger age groups (Table 2.1). Two were based on relatively small sample sizes (Knutson & Lansing 1990; Hallam et al. 2006). Tambs (2004) studied a large cohort comprising more than 50.000 subjects of 20 years and over and found younger (20-44 years) and middle-aged participants (44-65 years) reporting higher levels of anxiety and depression, lower self-esteem and subjective well-being compared to normally hearing peers. Moreover, among young and middle-aged adults with a hearing impairment the impact on psychosocial health was larger than among the oldest adults (> 65 years of age) with a hearing impairment. Earlier, Erdman and Demorest (1998) mentioned a possible difference in the adjustment to hearing impairment for different age groups, with adjustment being poorer among the youngest and oldest individuals.

Another issue that needs consideration within this context is the way hearing ability was determined. Whereas some studies used standardized audiometric techniques, or functional measures (e.g. free field whispered voice test (Carabellese et al. 1993)), the majority of investigations relied on self-report. Several studies have shown that self-report is a useful and satisfactory method to assess hearing impairment and activity limitations (Lutman et al. 1987; Kramer et al. 1996; Sindushake et al. 2001). 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; Gatehouse 1990; Smits et al. 2006a). Whereas pure-tone audiometry still serves as the golden standard for diagnostic purposes in audiological practice, it has been found to be an inaccurate predictor of the reduced ability to understand speech in adverse listening circumstances (e.g. Kramer et al. 1996;

Houtgast & Festen 2008), a limitation most frequently experienced among people with hearing impairment. This reduced ability to understand speech in adverse listening circumstances is one of the primary and most limiting manifestations of hearing impairment (Plomp & Mimpen 1979; King et al. 1992). A performance test offering a direct measure of a person's ability to understand speech in adverse listening conditions is a speech-in-noise test (Plomp & Mimpen 1979; Hagerman 1982; Nilson et al. 1994; Smits et al. 2004). It 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. Recently, a functional fully automatic speech-in-noise screening test for use by telephone and over the Internet was developed (Smits et al. 2006b). It is a self-test, measuring the speech reception threshold (SRT_n) in noise, using number triplets presented according to an adaptive procedure. The test is referred to as the National Hearing Test and is implemented in The Netherlands as well as in the UK and will be implemented in other countries soon.

With the present cross-sectional study we aimed to examine the relationship between scores on the National Hearing test and self-reported psychosocial functioning in a large cohort of young and middle-aged adults (<70 years) in The Netherlands. We also investigated whether the association differed for different age groups.

METHODS

Procedure

Data for this study were derived from the National Longitudinal Study on Hearing (NL-SH) conducted in The Netherlands. The NL-SH is an ongoing prospective cohort study examining the relationship between hearing impairment and several domains in life. The NL-SH is conducted over the Internet and uses a website to enroll and inform the participants and to collect data (www.hooronderzoek.nl). People are invited to participate in the NL-SH through advertisements and flyers

distributed at audiological centers and hearing aid dispensers throughout The Netherlands. Eligible participants are adults between 18 and 70 years of age. Both normally hearing and hearing impaired persons are invited to participate.
Each person who is interested to participate in the NL-SH is instructed to first perform the National Hearing Test on the Internet (details provided in the section *hearing ability*). After having finished this test, potential participants are redirected to the NL-SH website where they can complete their subscription.

The cross-sectional data analyzed in the present study are the baseline data of the NL-SH collected in the period from November 2006 to November 2007. After enrolment, the participants received an email with a link to the set of online questionnaires. An email reminder was sent to those who did not complete the questionnaires within one week. Participants who did not respond within a month received a letter by regular mail. The study was approved by the Medical Ethics Committee of the VU University medical centre.

Outcome Measures

Hearing ability

Hearing ability was determined using the "National Hearing Test", an adaptive speech-in-noise screening test (Smits et al. 2004). The test uses digit triplets (e.g. 6-2-5) that are presented against a background of masking noise, according to an adaptive (one-up, one-down) procedure. A total of 23 triplets are presented. The speech-reception-threshold corresponds to 50% intelligibility and is calculated by taking the average signal-to-noise ratio of the last 20 presentations. The signal-to-noise ratio (outcome of the test) is further referred to as the SRT_n. In general, SRT_n values range between about -10 (the best normally hearing individual) to + 4dB signal-to-noise ratio (dB SNR) (Smits et al. 2006b).

Initially, the test was developed for delivery by telephone. However, to provide access over the Internet, an identical version with the same stimuli was implemented on the Internet (Smits et al. 2006b) (www.hoortest.nl). For the Internet application, the telephone and telephone network were simulated by

filtering, compression and decompression of the original speech and noise files (see Smits & Houtgast 2006). The files were then compressed to MP3 format and a Macromedia Flash Player (Macromedia, Inc., San Francisco, CA) web application was designed. Also the test procedure over the Internet was similar to that of the telephone version.

Once at the website, subjects received the instruction to perform the test in a quiet environment, to use headphones instead of speakers, and when still using speakers to do so only in a quiet environment. To continue they had to click on the button “headphones” or “speakers”. Then, a triplet was presented repeatedly and subjects were instructed to use their PC’s volume control or the slider on the screen to adjust the volume to a level at which they could understand the triplet clearly. Next, an explanation of the test procedure followed and the participant could start the test. The listener had to respond by entering the digits on the computer keyboard or by clicking the digits on the screen with their mouse. (Smits et al. 2006b).

Comparing the telephone- and Internet version of the test, Smits et al. (2006b) concluded that both versions are equally feasible and reliable, except that older people prefer delivery by telephone. Smits et al. (2004) determined sensitivity and specificity of the test for an adult population. The Dutch speech-in-noise sentences test using headphones was taken as the golden standard. A sensitivity of 0.91 and a specificity of 0.93 were found (Smits et al. 2004). The test correlates highly (r= 0.87) with the standard speech-in-noise sentences test as used in the laboratory and clinical practice (Smits et al. 2004). Correlations with average pure-tone thresholds (av. 0.5, 1.0, 2.0, 4.0 kHz) are 0.73 for $PTA_{(0.5,1,2)}$ and 0.77 for $PTA_{(0.5,1,2,4)}$ (Smits et al. 2004). The National Hearing Test scores were classified into three categories representing: good (SRT_n<-5.5dB), insufficient (-5.5≤SRT_n≤-2.8) and poor hearing (SRT_n>-2.8dB). Test-retest data were available for 721 participants who accomplished the Internet version of the National Hearing Test twice within one year. The test-retest correlation was r= 0.87.

Psychosocial health status

Psychosocial health status was assessed using three questionnaires covering six variables (*distress, depression, anxiety, somatization, loneliness and self-efficacy).* Each of the questionnaires will be described below.

The 50-item Four-Dimensional Symptom Questionnaire (4DSQ) covering four subscales (Terluin et al. 2006), was used to assess distress, depression, anxiety and somatization. The 4DSQ has proven to be a reliable and valid instrument for use in The Netherlands with high internal consistency (Cronbach's Alpha's of the different scales varying from 0.84 and 0.94). It distinguishes non specific general distress from depression, anxiety and somatization. Each item has 5 response choices: "no", "sometimes", "regularly", "often", and "very often or constantly". Answers were recoded into 0 ("no"), 1 ("sometimes") and 2 (remaining categories). All mentioned cut-off scores were recommended by the test developers. *Distress* is defined as "the direct manifestation of the effort people must exert to maintain their psychosocial homeostasis and social functioning when confronted with stress" (Terluin et al. 2006). Symptoms are worry, tension, and poor concentration. An item example is "*During the past week, did you feel easily irritated*?" Scores on the distress scale (16 items) were summed when at least 10 items were completed. Summed scores higher than 9 indicated moderately elevated distress; a score higher than 20 indicated strongly elevated distress (Terluin et al. 2006). The *depression* scale (6 items) measures depressive thoughts (e.g. "*During the past week, did you feel that everything is meaningless*?"). Scores were summed when at least four items were completed. Summed scores higher than 2 indicated moderately elevated depression; a score higher than 5 indicated highly elevated depression (Terluin et al. 2006). Irrational fears, anxiety and avoidance behavior are included in the *anxiety* scale (12 items) (e.g. "*During the past week, did you suffer from trembling when with other people*?"). Scores were summed when at least 8 items were completed. Summed scores higher than 8 indicated moderately elevated anxiety; scores higher than 12 indicated highly elevated anxiety (Terluin et al. 2006). *Somatization* is defined as the tendency to experience somatic symptoms in response to psychological stress, to attribute them to physical illness and to seek medical help for them (Lipowski

1988). (e.g." *During the past week, did you suffer from nausea or an upset stomach area*?"). Summing occurred when at least 9 (of 16) items were completed. A summed score higher than 10 indicated moderately elevated somatization; a score higher than 20 indicated highly elevated somatization (Terluin et al. 2006).

Loneliness was measured using the 11-item Loneliness Scale. It is a widely used robust, reliable and valid instrument (Van Tilburg and De Leeuw 1991). Each item has 5 answer categories: "no!", "no" or "more or less", "yes" or "yes!". Loneliness refers to a lack of (quality of) certain relationships, e.g. "*I miss having a really close friend*". Answers on the 5-point scale were recoded into 1, indicating loneliness ("no!", "no" or "more or less" on a negatively formulated item; "more or less", "yes" or "yes!" on a positively formulated item) or 0 (no loneliness). Scores were summed when at least 10 items were completed. A score from 9 or 10 indicated severe loneliness, whereas a summed score of 11 indicated very severe loneliness (Van Tilburg and De Jong Gierveld 1999).

The General Self-Efficacy Scale measures the general expectation of *self-efficacy.* It includes 12 statements with a 5-point response scale. Bosscher and Smit (1998) have shown that the General Self-Efficacy Scale is a reliable and valid instrument for use in The Netherlands. Self-efficacy is defined as "the belief of a person in his/her ability to organize and execute behaviors necessary to produce attainments" (Bosscher and Smit 1998). An item example is *"If something looks too complicated, I will not even bother to try it*". Response categories ranged from 1 (I totally agree) to 5 (I totally disagree) with summed scores ranging from 12 (most negative) to 60 (most positive). Scores were summed when at least 9 items were completed.

Participants

The set of questionnaires was sent to 1796 people, of whom 1588 (88.4%) returned the questionnaires partially or totally completed. To test potential differences between responders and non responders (11.6%) a Chi-square test

(gender) and independent *t* tests (hearing ability, age) were conducted. Non responders were significantly younger (mean age: 42.05, SD: 13.7) (t=-4.03; $p<0.001$) than responders (Mean age:46.3, SD:12.5), but no significant differences in gender and hearing ability were found. Of the 1588 participants who responded, 77 participants were excluded because of leaving the majority of the psychosocial health items blank or implausible answers. As such, data of 1511 participants (546 men and 965 women) could be included in the analyses. Their ages ranged from 18 to 70 years (mean: 46.3, SD: 12.5). In all, 355 (23.5%) participants reported to have hearing aids.

Potential confounders

As demographic and socio-economic variables are known to be associated with psychosocial health (Palinkas et al. 1990; Wang et al. 2005; Koster et al. 2006), age, gender, marital status (married or not), educational level, living arrangements and income were adopted as covariates to control for confounding effects. *Educational level* was determined by asking the participants to report their highest completed education. Three levels were distinguished: low (no finished elementary school to lower vocational), mid (general intermediate to general secondary) and high education (higher vocational to post-academic). *Living arrangement* was classified into two categories: living alone (1); with a partner and/or others (2). *Income* was measured by asking the participants to choose their gross monthly income category: low (less than € 1050), mid (between €1050 and €2550), high income (more than €2550), or unknown (don't know; don't want to report).

Statistical analyses

All analyses were conducted using SPSS version 15.0.

Linear regression analyses were used to examine the unadjusted associations between hearing ability and the psychosocial variables (model 1), followed by multiple linear regression analyses adjusting for all potential confounders (model 2). The analyses were run with (log transformed) distress, (log transformed)

somatization and self-efficacy successively as dependent variables. The National Hearing Test score was entered as a continuous independent variable in all analyses. As the distribution of the loneliness, depression and anxiety scores were extremely positively skewed, these variables were dichotomized into 0 (no loneliness, depression or anxiety) and 1 (moderately to severely elevated levels) and analyzed using logistic regression.

Interaction effect among the National Hearing Test score and age was examined by entering the product of the National Hearing Test score and age, as well as those variables separately in the regression models. Similarly, the interaction between the National Hearing Test score and gender was examined. No significant interaction with gender was found. However, the interaction of age (stratified into decades) with the National Hearing test score appeared to be significant in the models predicting self-efficacy, loneliness and depression. Hence, regression analyses were run for each of the five age strata (18-29, 30-39, 40-49, 50-59, and 60-70 years) separately to examine whether different age groups exhibited different associations between hearing ability and psychosocial health. Furthermore, we examined whether the association between hearing ability and psychosocial health was influenced by the way participants performed the National Hearing Test. Despite the instruction to use headphones instead of speakers during the test, a considerable number of participants did not use headphones (headphones; 35.6% speakers: 64.4%). Therefore confounding and interaction effects of headphone/speaker use were examined.

Item non response rates were less than 2% for all items in the questionnaires. When the number of missing values did not exceed the maximum allowed according to guidelines provided by the developer of the questionnaire, we replaced the missing value by the mean of the remaining scale items. Otherwise, the scale score was not computed.

RESULTS

Description of the study population and hearing ability

Figure 2.1 shows the distribution of the National Hearing test scores. About half of the participants had “insufficient” or “poor” hearing according to the National Hearing Test. Figure 2.2 illustrates the percentages of participants with good, insufficient and poor National Hearing Test scores for each age group. The proportion of people with “poor” hearing increased with increasing age.

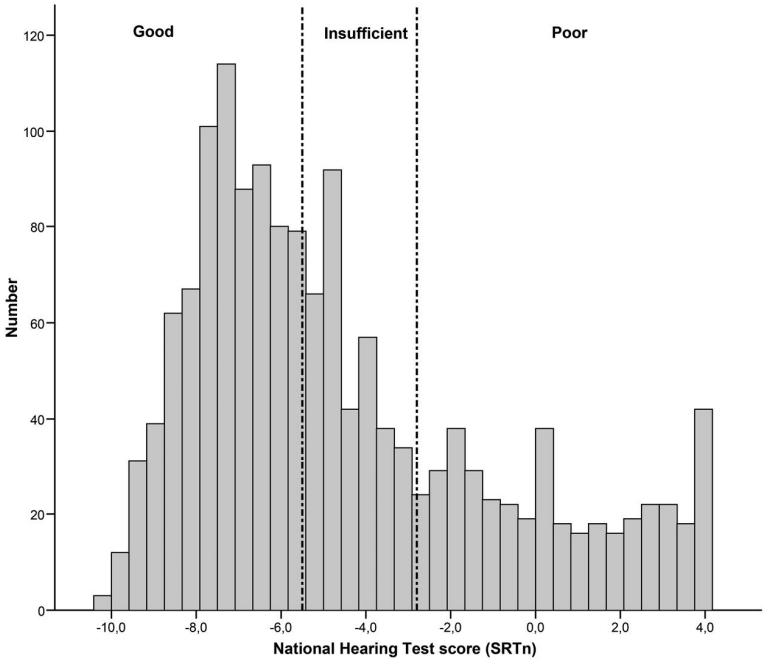

Figure 2.1. Histogram of National Hearing Test scores. Dotted lines mark the cut-off point for good, insufficient, and poor hearing.

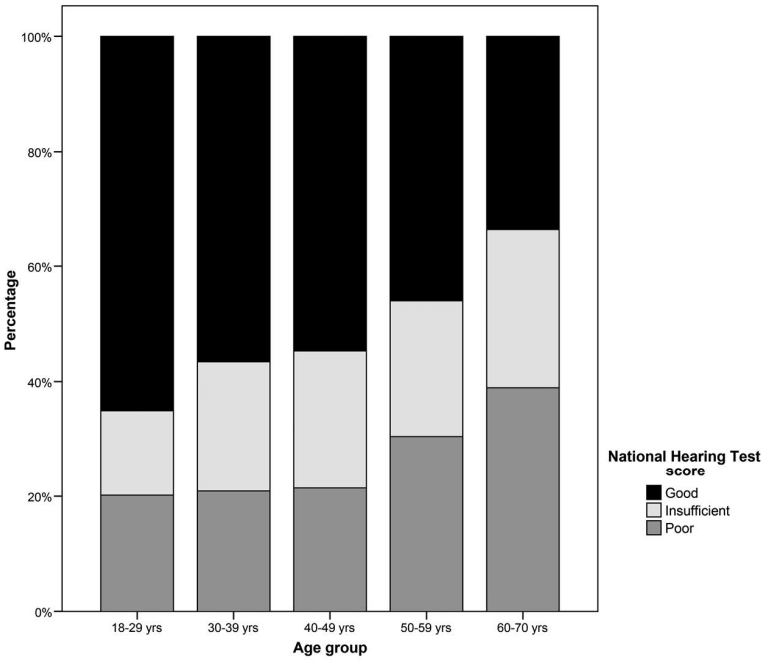

Figure 2.2. Distribution of good, insufficient and poor National Hearing Test scores for different age categories.

Medians with interquartile ranges (distress, somatization, loneliness, depression and anxiety) and means with standard deviations (age, hearing ability, and self-efficacy), stratified by age category, are shown in Table 2.2. Supplementary to the median scores in Table 2.2, mean scores for the total sample were 8.2 (SD=7.0) for distress, 6.7 (SD=5.5) for somatization, 3.3 (SD=3.3) for loneliness, 1.0 (SD=2.2) for depression, and 2.0 (SD=3.3) for anxiety. Note that for all psychosocial variables higher values indicated poorer psychosocial health. The opposite was true for self-efficacy. On average, women were significantly younger than man ($p < 0.001$), had significantly poorer SRT_n scores ($p = 0.002$) and had significantly higher distress ($p < 0.001$), somatization ($p < 0.001$) and self-efficacy scores ($p = 0.001$). No significant gender differences for depression, anxiety and loneliness were found. Whether participants used headphones or speakers did not influence the associations between hearing ability and psychosocial health: neither interaction effects ($p>0.105$) nor confounding effects were found.

Table 2.2. Descriptive statistics for psychosocial status and covariates stratified by age group. Variables are presented as median [interquartile range] for all variables except for age, hearing ability (SRT_n), and self-efficacy. For those variables (marked with §) means and standard deviations are presented.

	18-29 yrs (n=223)		30-39 yrs (n=244)		40-49 yrs (n=364)	
Variables	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**
Age §	24.9 (3.2)	18.2 – 30	35.7 (2.7)	30 – 40	45.6 (2.9)	40 – 50
SRT_n §	-5.4 (3.4)	-10.0 – 4.0	-5.0 (3.3)	-10.4 – 4.0	-4.9 (3.6)	-10.2 – 4.0
Distress	6 [3 – 6]	0 – 31	6.5 [3.5 – 6.5]	0 – 31	6 [3 – 6]	0 – 32
Depression	0 [0 – 1]	0 – 12	0 [0 – 1]	0 – 12	0 [0 – 1]	0 – 12
Anxiety	1 [0 – 2]	0 – 17	1 [1 – 2]	0 – 16	1[1 – 1]	0 – 27
Somatization	5 [2 – 4]	0 – 29	5 [2 – 5]	0 – 28	5 [3 – 5]	0 – 28.8
Self-efficacy §	36.3 (3.6)	27.0 – 46.8	36.1 (3.8)	27 – 47	35.8 (3.6)	26 – 46
Loneliness	2 [2 – 3]	0 – 11	2 [2 – 4]	0 – 11	2.0 [1.75 - 4.0]	0 – 11
	50-59 yrs (n=472)		**60-70 yrs (n=208)**		**Overall (N=1511)**	
Variables	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**
Age §	55.1 (2.9)	50-60	62.7 (2.0)	60-70.6	46.3 (12.5)	18.2-70.6
SRT_n §	-4.0 (3.7)	-9.6 – 4.0	-3.6 (3.4)	-9.6 – 4.0	-4.5 (3.6)	-10.4 – 4.0
Distress	7 [4 – 5]	0 – 32	4 [2 – 5]	0 – 29	6 [3 – 6]	0 – 32
Depression	0 [0 – 1]	0 – 12	0 [0 – 0]	0 – 11	0 [0 – 1]	0 – 12
Anxiety	1 [1 – 2]	0 – 21	1 [1 – 1]	0 – 15	1 [1 – 1]	0 – 27
Somatization	7 [4 – 3]	0 – 31	5 [3 – 4]	0 – 23	5.3 [2.3 – 4.7]	0 – 31
Self-efficacy §	35.7 (3.8)	25 – 49	35.6 (4.6)	0 – 23	35.9 (3.9)	19 – 49
Loneliness	2 [2 – 4]	0 – 11	2 [2 – 3]	0 – 11	2 [2 – 4]	0 – 11

Hearing ability and psychosocial health

Table 2.3 shows the associations between hearing ability and psychosocial health. Multiple linear regression analyses revealed that hearing ability was significantly associated with distress (b=0.02; 95% confidence interval (95% CI) =0.00 – 0.03; p=0.031) and somatization (b=0.02; 95% CI=0.01 – 0.04; p<0.001), adjusting for all confounders. People with higher (poorer) National Hearing Test scores reported higher levels of distress and somatization than people with better hearing. Note that back transformation was performed for a useful interpretation. After back transformation, the exponent of the regression coefficient represents a fractional

increase or decrease of the dependent variable. For every dB SNR reduced hearing ability, both the distress and somatization score increased by 2%, adjusting for all confounders. No significant associations between hearing ability and self-efficacy were observed. Adjusted and unadjusted logistic regression models revealed weak but significant associations between hearing ability and depression (OR = 1.05) and hearing ability and loneliness (OR = 1.07). For every dB SNR reduced hearing ability, the odds for moderately or severely elevated depression increased by 1.05 times (95% CI=1.00 – 1.09; p=0.03). The odds for severe or very severe loneliness increased by 7% for every dB SNR reduction in hearing ability (95% CI=1.02 – 1.12; p=0.004). No significant association between hearing ability and anxiety was found.

Table 2.3. Association between hearing ability, as measured by SRT_n screening test, and psychosocial health in the total sample (N=1511). A. Unstandardized regression coefficients (b), 95% confidence intervals (CI) and *p*-values. B. Odds ratios (OR), 95% confidence intervals (CI) and *p*-values.

A	**Distress**			**Somatization**			**Self-efficacy**		
	b	**95%-CI**	***p***	**b**	**95%-CI**	***p***	**b**	**95%-CI**	***p***
Model 1	0.02*	0.00 – 0.03	0.009	0.03*	0.02 – 0.04	<0.001	0.05	-0.01 – 0.11	0.070
Model 2	0.02*	0.00 – 0.03	0.031	0.02*	0.01 – 0.04	<0.001	0.03	-0.03 – 0.08	0.315
B	**Loneliness**			**Depression**			**Anxiety**		
	OR	**95%-CI**	***p***	**OR**	**95%-CI**	***p***	**OR**	**95%-CI**	***p***
Model 1	1.07*	1.03 – 1.12	0.002	1.05*	1.01 – 1.10	0.013	1.04	0.99 – 1.12	0.149
Model 2	1.07*	1.02 – 1.12	0.004	1.05*	1.00 – 1.09	0.032	1.05	0.99 – 1.12	0.130

Model 1: univariate
Model 2: controlling for gender, age, living arrangement, marital status, income & educational level
*: *p*-value < 0.05

The proportion of the population with hearing aids was 23.5%. The above results showed that the risk for psychosocial health problems increased with poorer hearing ability. Subsequent analyses were done for people with an insufficient or poor hearing ability to identify if having hearing aids (yes, no) significantly influenced psychosocial health. No significant differences in psychosocial health were found for those with insufficient or poor hearing ability not having a hearing aid compared to those having hearing aids.

Table 2.4. Association between hearing disability, as measured by the SRT_n screening test, and psychosocial health, stratified by age group. A. Unstandardized regression coefficients (b), 95% confidence intervals (CI) and *p*-values. B. Odds ratios (OR), 95% confidence intervals (CI) and *p*-values.

A	Distress			Somatization			Self-efficacy		
	b	**95%-CI**	***p***	**b**	**95%-CI**	***p***	**b**	**95%-CI**	***p***
18-29									
Model 1	-0.02	-0.05 – 0.01	0.221	0.01	-0.02 – 0.04	0.535	-0.03	-0.17 – 0.11	0.640
Model 2	-0.02	-0.06 – 0.02	0.266	0.00	-0.03 – 0.04	0.778	-0.06	-0.20 – 0.09	0.448
30-39									
Model 1	0.04*	0.01 – 0.08	0.021	0.06*	0.03 – 0.09	<0.001	0.04	-0.10 – 0.19	0.591
Model 2	0.04*	0.01 – 0.09	0.022	0.04*	0.01 – 0.07	0.012	-0.01	-0.16 – 0.15	0.893
40-49									
Model 1	0.03*	0.01 – 0.06	0.011	0.04*	0.02 – 0.07	0.001	0.21*	0.11 – 0.31	<0.001
Model 2	0.03*	0.00 – 0.05	0.043	0.02	-0.00 – 0.05	0.068	0.15*	0.05 – 0.26	0.004
50-59									
Model 1	0.01	-0.01 – 0.03	0.279	0.03*	0.02 – 0.05	0.003	-0.03	-0.13 – 0.06	0.510
Model 2	0.01	-0.01 – 0.03	0.471	0.02*	0.00 – 0.04	0.028	-0.05	-0.14 – 0.05	0.341
60-70									
Model 1	0.04	-0.00 – 0.07	0.063	0.02	-0.01 – 0.06	0.244	0.15	-0.03 – 0.34	0.108
Model 2	0.02	-0.01 – 0.06	0.203	0.01	-0.02 – 0.05	0.528	0.08	-0.11 – 0.26	0.397

B	Loneliness			Depression			Anxiety		
	OR	**95%-CI**	***p***	**OR**	**95%-CI**	***p***	**OR**	**95%-CI**	***p***
18-29									
Model 1	1.19*	1.05 – 1.35	0.005	1.08	0.96 – 1.21	0.200	0.98	0.83 – 1.15	0.770
Model 2	1.20*	1.04 – 1.38	0.010	1.08	0.93 – 1.19	0.427	1.01	0.84 – 1.21	0.953
30-39									
Model 1	1.06	0.97 – 1.19	0.308	1.03	0.93 – 1.14	0.608	0.99	0.84 – 1.16	0.884
Model 2	1.08	0.96 – 1.21	0.207	1.06	0.95 – 1.18	0.315	0.99	0.83 – 1.19	0.932
40-49									
Model 1	1.05	0.97 – 1.14	0.219	1.15*	1.07 – 1.24	<0.001	1.12	0.99 – 1.26	0.067
Model 2	1.07	0.98 – 1.17	0.150	1.18*	1.08 – 1.28	<0.001	1.16*	1.01 – 1.32	0.034
50-59									
Model 1	1.04	0.96 – 1.12	0.321	0.97	0.90 – 1.04	0.370	1.02	0.92 – 1.13	0.696
Model 2	1.03	0.96 – 1.12	0.405	0.96	0.89 – 1.03	0.248	1.03	0.92 – 1.14	0.624
60-70									
Model 1	1.17*	1.01 – 1.35	0.035	1.11	0.98 – 1.28	0.108	1.20	0.99 – 1.44	0.064
Model 2	1.11	0.94 – 1.32	0.211	1.06	0.90 – 1.24	0.490	1.15	0.92 – 1.45	0.215

Model 1: univariate
Model 2: controlling for gender, age, living arrangement, marital status, income & educational level
*: *p*-value < 0.05

Table 2.4 shows the regression models for the different age groups. In the youngest group (18-30 years), decreased hearing appeared to be significantly associated with increased loneliness (OR=1.20; 95% CI=1.04 – 1.38). Poorer

hearing ability predicted higher levels of distress (b=0.03; 95% CI=0.00 – 0.05) self-efficacy (b=0.15; 95% CI=0.05 – 0.26), depression (OR=1.18; 95% CI=1.08 – 1.28) and anxiety (OR=1.16; 95% CI=1.01 – 1.32) in adults aged 40-49 years. Somatization (b=0.02; 95% CI=0.00 – 0.04) showed a significant (adverse) relationship with hearing ability in the group aged 50 to 60 years. In the oldest age group (60 - 70 years), none of the (adjusted) associations reached significance.

DISCUSSION

The present study focused on the association between psychosocial functioning and hearing ability in a large cohort of adults younger than 70 years of age. Significant adverse relationships between hearing ability and psychosocial functioning were found when adjusting for confounding variables. The association was such that for every dB SNR reduction in hearing ability, the risk for psychosocial dysfunction increased. This finding is quite alarming, taking into account that a considerable number of young and middle-aged people in the population worldwide suffer from limited hearing.

When regarding the psychosocial health variables in the current study, we must note that the group mean scores were often in the normal range. Nevertheless, every psychosocial variable showed a wide distribution of scores, with participants in the normal range (a score below the cut-off score) and with clinically deviant scores (Table 2.2). An example is the depression score. Even though the mean depression score fell under the cut-off score, we found that with every dB SNR reduction of hearing ability, the odds for developing moderate or severe depression increased by 5%. It means that for someone with a Hearing Test score of 2dB SNR, the odds for developing a depression was 1.6 times higher compared to someone with a score of -8 dB SNR. Moderate depression (summed score between 2 and 5) is regarded as a prompt to consider a depressive disorder, whereas severe depression (summed score > 5) should be taken as a prompt to diagnose a depressive disorder without delay (Terluin et al. 2006). The mean somatization and distress scores fell within the normal range too. Nonetheless, the results demonstrated that for every dB SNR reduced hearing ability, both the

distress and somatization score increased by 2%, adjusting for all confounders. Experiencing a few somatic symptoms in the absence of a disease is considered normal under stressful circumstances. However, the higher the somatization level, the more likely the symptoms reflect psychological problems, such as depression (Mayou & Farmer 2002). Similarly, mild distress states are considered part of normal life and do not interfere with normal social functioning. However, elevated levels of distress with symptoms such as worry, irritability, tension, poor concentration and insomnia may force a person to give up and withdraw from major social roles, especially the occupational role (Terluin et al. 2006). A large drop out amongst adults with hearing disability may have large societal and economical impact (Ruben 2000). We therefore argue that the societal impact of hearing impairment in adults younger than 70 years may even be greater than the impact in elderly people.

We observed differences in associations between hearing ability and psychosocial health in different age groups. These dissimilarities could reflect differences in the time of onset of the hearing impairment or differences in use of health care. The differences could also reflect the way hearing impairment is generally regarded. Whereas among elderly people, decreased hearing is usually acknowledged as being part of the ageing process, young and middle-aged adults often attach a stigma to hearing impairment. Consequently, a hearing impairment may have greater personal impact in young adults. Our results demonstrated that in particular loneliness seemed to occur in that group. Knutson and Lansing (1990) reported comparable findings and concluded that limited communication with family and friends may lead to extreme levels of loneliness.

Self-efficacy increased with decreasing hearing in those aged 40-49 years, despite large adverse psychosocial effects of hearing impairment in this age group. Based on our clinical experience, we argue that this age decade is typical for people starting to recognize their limitations in hearing activity, in particular in case of a gradual onset of hearing impairment. Despite their limitations, people still have to be fully active both in working and in family life. To function and to communicate optimally, they need to anticipate in difficult communication situations (Hétu

1996). Successful anticipation requires a person to believe in his or her ability to execute certain behaviors, which is reflected by the self-efficacy score. So, increased self-efficacy with decreasing hearing at this age most likely resulted from compensatory behavior to adjust for limited hearing to communicate optimally. It seems as if this age group demonstrated a more active anticipation towards hearing impairment than the other age groups. Interestingly, Erdman and Demorest (1998) reported similar findings. Their study involved over 1000 research participants ranging in age from 16 to 97 years. The authors carefully suggested a nonlinearity in the relationship between age and adjustment to hearing impairment, with adjustment (as measured with the Communication Profile for the Hearing Impaired) being poorer among the youngest and oldest individuals.

Overall, our findings support the results of Tambs (2004) who also reported a stronger negative effect of hearing impairment on psychosocial wellbeing among younger and middle-aged people compared to older people. It must be noted, however, that the age range in Tambs' study (20 – 102 years) was larger than in the current study (18-70) indicating that we are not able to compare the associations between hearing impairment and wellbeing in those older than 70 years of age.

The sample in the present study was a mixture of people with and without hearing aids. One may wonder whether hearing aids had a significant influence on the psychosocial health status. Subsequent analyses (among people with poor or insufficient hearing test scores) revealed no differences in the psychosocial health between the two groups. In other words, the psychosocial health status was similar for those having hearing aids compared to those not having hearing aids. This result does not provide a basis for concluding that hearing aids are useless. People with hearing aids may have benefited from their hearing aids significantly and their status may have been much worse without. It is known that even with hearing aids, the majority of persons with severe hearing impairment still do not hear as those with good hearing. The relation between hearing ability and psychosocial health could also be influenced by interventions other than hearing

aids (e.g. auditory training). Information on whether respondents received help (other than hearing aids) for their hearing impairment or not was not available. We assume that some participants received additional interventions whereas others did not. We cannot conclude that the data reported in this study are based on the effects of untreated hearing impairment. The availability and adequacy of interventions and their influence on the relationship between hearing ability and psychosocial health need further attention in future research.

Data were collected over the Internet. An often mentioned concern is whether Internet data are equivalent to those collected via regular mail. Several studies in the international literature dealt with this issue and compared Internet versions of health-related questionnaires with paper-and-pencil versions. Fairly equivalent results for both methods were demonstrated in the majority of the studies, with less missing data and slightly higher response rates for Internet versions. Overall, it can be stated that there is satisfactory evidence for the reliability, validity and feasibility of online questionnaires (Hallam et al. 2006; Kongsved et al. 2007; Vallejo et al. 2007).

A possible limitation of speech-in-noise hearing screening over the Internet is the lack of control over the testing conditions and the potential variety of equipment used by the participants. Although participants were requested to do the test with headphones, a considerable number of participants in the current study indicated to have used speakers during the test, which might have influenced the associations found. Analyses, however, did not show a confounding or interaction effect from speaker or headphone use on the association between hearing ability and psychosocial health. Comparable findings were reported by Culling et al. (2005). They showed that variations in the type of headphone used during speech-in-noise hearing screening tests had negligible effects on speech-in-noise audiometry. Additionally, when using loudspeakers in a living room environment, the scores were extremely similar to those obtained when using headphones (Culling et al. 2005). Also, the highly satisfactory test-retest reliability in the current study confirms the consistency of scores.

To avoid excluding groups of respondents and create bias, accessibility to the Internet should be guaranteed. We argue that in our study, accessibility was sufficiently certain, as in The Netherlands, the proportion of households having access to Internet at home is 83%. It is one of the highest percentages in the world (Dutch Statistics 2007). Moreover, the percentage of people aged 50 and 65 years having access to Internet is nearly similar to that of the general population (SCP 2007). It may thus be assumed that access to the Internet was similar for all age groups. In addition, Smits et al. (2006b) investigated the efficiency and feasibility of the self-screening Hearing Test over the Internet. Participants who had accomplished the test were asked whether they found the test easy to perform. Ninety-five percent of the participants responded positively reporting that they had had no or little difficulty doing the test. This result further demonstrates the feasibility and accessibility of the method used.

Non responders were significantly younger. Apparently, maintaining young adult's interest in participating in scientific research is difficult. Also, more women than men participated. An explanation may be that women are inclined to assign greater importance to effective social communication than males, report greater problem awareness and show less denial associated with hearing impairment (Garstecki and Erler 1999). Also, females tend to take greater responsibility for maintaining the conversation (Garstecki and Erler 1999). Another possibility is that women in general are more expressive regarding to health problems and have a lower threshold to seek help for their problems (Verbrugge 1985; Kroenke et al. 1998). Also, women were significantly younger than men and the proportion of participants with a high educational level was higher compared to the general Dutch population (46% versus 25%). These facts indicate that our sample is representative for Internet users in general as Internet users are more likely to have a higher educational level; young women are more likely than young men to be online; and older men are more likely than older women to be online (Fallows 2005; SCP 2007). Monthly income and living arrangements of the participants of the current study and the general population were comparable.

Finally, we conclude that this is the first study in the literature that related speech-in-noise screening test scores with psychosocial health in a large cohort of adults younger than 70 years of age. The inability to understand speech in noisy listening situations is seriously disabling and associated with psychosocial dysfunction. The results inevitably indicate that adverse effects of hearing impairment in young and middle-aged adults should not be neglected, but seriously addressed both in clinical practice and in future research.

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