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RESEARCH ARTICLE

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Weaker association between hearing loss and non-employment in recent generations: the HUNT cohort study

Astrid Ytrehus Jørgensen[a], Bo Engdahl[b], Ingrid Sivesind Mehlum[a] and Lisa Aarhus[a]

[a]Department of Occupational Medicine and Epidemiology, National Institute of Occupational Health, Oslo, Norway; [b]Department of Chronic Diseases and Ageing, Norwegian Institute of Public Health, Oslo, Norway

ABSTRACT

Objectives: To examine the prevalence of hearing loss (HL) among employed persons, the association between HL and non-employment, assessing whether this has changed over the last two decades. To identify susceptible groups for HL-related work problems and examine the association between HL and co-worker relations.

Design: Cross-sectional analyses of working-age participants (20–66 years). HL was defined as the pure-tone average threshold of 0.5–4 kHz in the better hearing ear: 20–34 dB (mild) or ≥35 dB (disabling). Associations were assessed with logistic regression.

Study sample: Data from two waves of the Trøndelag Health Study (HUNT): HUNT2 1996–1998 (*N* = 38,603), HUNT4 2017–2019 (*N* = 19,614).

Results: The nationally weighted prevalence of HL among employees was 5.8%. HL was associated with non-employment, more strongly in HUNT2 (odds ratio (OR) 2.2, 95% confidence interval (CI) 2.0–2.4) than HUNT4 (OR 1.9, CI 1.7–2.1). HL was not associated with poorer co-worker relations. The association between HL and non-optimal work performance was stronger among white-collar workers than blue-collar workers.

Conclusions: Our study shows that HL is common in the employed population. It also indicates a weakened association between HL and non-employment in recent generations. White-collar workers appear to be more vulnerable to HL-related work problems than blue-collar workers.

SUMMARY

This paper evaluates employment and work performance among hearing impaired. We show a prevalence of hearing loss (HL) among employed persons of 5.8% and that HL is associated with higher odds of non-employment. Our study indicates that the association between HL and non-employment has weakened in recent generations.

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Hearing loss; employment; working population; epidemiology

Introduction

Hearing loss (HL) is considered one of the most common disabilities of modern society (Vos et al., 2016). More than 430 million people globally experience disabling HL, and the WHO estimates that this number could expand to nearly 700 million by 2050 (World Health Organization, 2021). The Global Burden of Disease (GBD) Expert Group on Hearing Impairment defines HL as mild if hearing threshold is 20–34 dB or disabling if ≥35 dB, using the average hearing threshold at 0.5, 1, 2 and 4 kHz in the better hearing ear (Olusanya et al., 2019). A recent and large population study showed an age- and sex-adjusted prevalence of disabling HL (definition by GBD) of 5.9% in the Norwegian population (Engdahl et al., 2021). Impaired hearing is related to communication challenges, psychosocial problems and high health care costs (Cunningham and Tucci, 2017).

Little is known about the prevalence of HL among the employed population. Although studies have addressed hearing status among specific occupations (Engdahl and Tambs, 2010), or among people in working age (Hoffman et al., 2017), less is known about the prevalence of HL for the employed population. The average age of retirement will likely rise in the future, due to a growing proportion of elderly people within the total population (Wang et al., 2020). HL prevalence increases with age (Cunningham and Tucci, 2017). This could lead to an increase in the number of people with HL in the workplace, which underlines the need of increasing knowledge about HL in working life.

Work is an important aspect of life for most people. Throughout the world, people with disabilities experience a significantly lower employment rate compared with persons without disabilities (World Health Organization, 2011). This has also been shown among hearing impaired (Shan et al., 2020). Difficulties for employees with HL may include oral communication challenges, a high degree of exhaustion after work (Svinndal et al., 2018), and increased risk of early retirement (Helvik et al., 2013). Earlier research has found that dissatisfaction at work is

CONTACT Astrid Ytrehus Jørgensen astrid.jorgensen@stami.no

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associated with periods of sick leave (Roelen et al., 2008) and early retirement (Böckerman and Ilmakunnas, 2020). This carries a cost for the individual, employers, and the society. The importance of social support at work among workers with HL, has been highlighted by previous studies (Nachtegaal et al., 2009). A Swedish study has found that perceived levels of social support at work were lower for people with HL (Danermark and Gellerstedt, 2004), and state that: «there is a need for further research into the mechanisms in the psychosocial work environment that produce health problems and lack of wellbeing among hearing impaired workers.

In recent years, there has been increased focus on the inclusion of people with disabilities in employment (Dale-Olsen, 2005). Accordingly, increased awareness of HL in the workplace may have led to a heightened focus on occupational support and resources for employees with HL. In addition, increased digitalisation during the last two decades (Norwegian National Institute of Occupational Health, 2018) might have improved work performance among hearing impaired. To our knowledge, no study has examined whether the association between HL and employment has changed in newer generations.

Increased knowledge about HL, employment and work performance is important for employers and policy makers. The aims of this large population study are (research question (RQ1) to estimate the prevalence of HL among employed persons, (RQ2) the association between HL and non-employment, and to assess whether this association has changed during the last two decades. Further, (RQ3) we examine the association between HL and work performance to identify susceptibility factors, such as age, sex, or type of work, for HL-related work problems. Identifying susceptible groups will enable more targeted support for HL in the workplace. Lastly, (RQ4) we aim to study HL and co-worker relations to give us more information on the current situation for people with HL in the workplace and whether this is an area of work in need of support.

Methods

Participants

The Trøndelag Health Study (The HUNT Study) is a longitudinal population health study performed in the Norwegian county of Trøndelag. The study comprises data from questionnaires, clinical measurements, and samples, and provides a solid foundation for population health research on a wide range of conditions and lifestyle factors. HUNT is considered one of the most extensive cohort studies ever conducted, with data and samples collected from four health surveys of the general adult population (HUNT1, 2, 3, and 4) spanning the years 1984–2019.

Audiometric investigations were only performed in HUNT2 (1996–1998) and in HUNT4 (2017–2019). HUNT2 Hearing included participants from 17 of the 24 municipalities in the county. The participation rate was 63%, and altogether 50 560 persons attended (Engdahl et al., 2021). HUNT4 Hearing took part in the six larger municipalities, representing about two thirds of the county. The participation rate was 43%, and altogether 28,388 persons attended. The hearing studies are described in depth elsewhere (Engdahl et al., 2021). For simplicity, HUNT2 Hearing and HUNT4 Hearing are referred to as 'HUNT2' and 'HUNT4' hereafter.

Measurements

Both hearing studies included pure-tone audiometry, otoscopy, and a questionnaire.

Explanatory variables

Hearing loss. Both HUNT2 and HUNT4 used the same audiometric procedure. Pure-tone air-conduction hearing thresholds levels (HTLs) were determined in accordance with ISO 8253-1 (International Organization for Standardization, 2010), with fixed frequencies at the eight test frequencies 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz, using an automatic procedure ('press the button as soon as you hear a sound'). Manual audiometry was offered to elderly or persons not able to follow the automatic procedure. Bone conduction thresholds was not measured, and masking was not used. The audiometry procedure has been described in detail previously (Engdahl et al., 2021). Using the Global Burden of Disease (GBD) definition of HL, the present study constructed a categorical variable using the average of the hearing thresholds measured at the frequencies 0.5, 1, 2, and 4 kHz and the best hearing ear. The categories were defined as follows: normal hearing (hearing threshold best ear $<$20 dB, worse ear $<$35 dB) as the reference category [0], unilateral HL (best ear $<$20 dB, worse ear $\geq$35 dB), mild HL (hearing threshold 20–34 dB) [1], disabling HL (hearing threshold $\geq$35dB) [2]. We also constructed a dichotomous variable with normal hearing as the reference category and any HL (unilateral, mild, or disabling) as the exposure. Participants with missing audiometric data were excluded from the study.

Outcome variables

Employment status. We gained information on employment from Statistics Norway (SSB) yearly, from 2000 to 2017. All SSB data were matched with HUNT data based on the personal identification number given to all Norwegian citizens. These identification numbers were removed before making the matched data material available to the researchers. We merged the HUNT2 data with employment data registered in 2000, and the HUNT4 data with employment data registered in 2017. The employment data from SSB were categorised in 5 groups: wage earner, self-employed, unemployed, outside of workforce (retired, disabled, student, homemaker) or in labour market programs. Labour market programs are part of the Norwegian social welfare system aiming to improve chances of finding employment, offering job-finding measures, work experience and job training. We combined the groups wage earner and self-employed to form the category employed. The groups unemployed, outside of the workforce and in labour market programs were combined to form the category non-employed. We made the binary variable occupational status, coded 0 for employed and 1 for non-employed. Participants with missing values (488 out of 58 749 persons in the pooled sample) were excluded from this analysis.

Self-perceived work performance. This variable was only assessed in HUNT4: «I'm not performing optimally at work because I cannot hear properly» (scored 0 = no, 1 = yes). Participants with missing values (239 out of 16,044 employees in HUNT4) were excluded from this analysis.

Relations between co-workers. These variables were only assessed in HUNT4 for participants 30 years and older: 1. «There is an atmosphere of togetherness at work» (scored 0 = yes, 1 = no); 2.

«I get along well with my colleagues» (scored 0 = yes, 1 = no); 3. «My colleagues offer me support» (scored 0 = yes, 1 = no); 4. «Have you been bullied/harassed at your workplace?» (scored 0 = no, 1 = yes). Participants with missing values on an outcome variable were excluded from this analysis.

Potential confounders and effect modifiers

Age and sex. We adjusted for age and sex in all analyses. There was no missing data.

Education. We used education data from Statistics Norway (SSB), which were categorised in 4 groups: primary school, secondary school, university < 4 years, university ≥ 4 years. We constructed a dichotomous variable by combining primary school and secondary school to form the category 'lower education' and university < 4 years with university ≥ 4 years to form the category 'higher education'.

White-collar/blue-collar. We used occupational codes from SSB, which were based on the Norwegian version of the International Standard Classification of Occupations, ISCO88 (Statistics Norway, 1998). At the one-digit level, the occupations are divided into ten major groups: 0 = Armed forces and unspecified; 1 = Legislators, senior officials and managers; 2 = Professionals; 3 = Technicians and associate professionals; 4 = Clerks; 5 = Service workers and shop and market sales workers; 6 = Agricultural, forestry and fishery workers; 7 = Craft and related trades workers; 8 = Plant and machine operators and assemblers; 9 = Elementary occupations (example subgroups of this occupational code include cleaners, construction labourers, street vendors, and refuse workers). We coded the occupational codes 1, 2, 3, 4, and 5 into = 1 (mainly white-collar workers), and the codes 6, 7, 8, and 9 into = 0 (mainly blue-collar workers). Persons who were not registered with an occupational code (not working or lack of registrations/missing data) and persons with occupational code 0 (group 0 = armed forces and unspecified, therefore not possible to classify as blue or white collar), were excluded from this analysis.

Variables used in descriptive statistics

We assessed the prevalence of self-reported HL and hearing aid use in HUNT4. The question 'Do you think you have a hearing loss', was followed by the question "Do you use a hearing aid?". Participants who answered 'no' to the initial question, did not answer the follow-up question on hearing aid. We set the 105 missing values (out of 16,411 persons) to 'no'.

Statistical analyses

We used STATA version 16.0. Statistical tests were calculated at a 95% confidence interval.

Prevalence of HL among employed persons in HUNT4

Nationally representative population estimates of the HL prevalence among adults >19 years of age in Norway were obtained using weights reflecting the age-, sex-, and occupational field specific working population in Norway in 2018, obtained from SSB. Probability weights were applied for 94 (2 × 47) unique groups with sex and age in years.

We performed several logistic regression analyses to assess the association between HL and the various outcome variables. We adjusted for age and sex in all analyses (expect in the age- and sex-stratified analyses).

HL and non-employment (pooled cross-sectional sample – HUNT2 and/or HUNT4)

We assessed the association between HL and non-employment in the total sample and stratified by age, sex, education, or cohort (HUNT2 vs. HUNT 4). We also tested interaction terms (HL*age group, HL*education, HL*cohort) at 95% significance level. To account for dependency in the data because some participants took part in both surveys, we estimated cluster-robust standard errors using the vce (cluster) option in STATA with subjects' ID as the cluster variable. As a supplement we estimated risk differences using ordinary least square regression with robust standard errors.

HL and non-optimal work performance (employed persons in HUNT4)

We assessed the association between HL and subjective poor work performance ascribed to HL in the total sample and stratified by age, sex, or type of work (mainly white-collar or blue-collar work). We also tested interaction terms (HL*age group, HL*sex, HL*type of work) at 95% significance level.

HL and co-worker relation (employed persons in HUNT4 aged 30–66 years)

We assessed the association between HL and four different items pertaining to co-worker relations.

Ethics

The Regional Committees for Medical and Health Research Ethics (23178 HUNT hearing) have approved the study. General Data Protection Regulation (GDPR) requirements are met, and a Data Protection Impact Assessment (DPIA) was conducted. Only participants who had given written consent were included in this study.

Results

Participants

HL and non-employment

The present study included a pooled cross-sectional sample, namely persons attending HUNT2 (N = 50,560) and/or HUNT4 (N = 28,388). Among these, 13,022 subjects attended both hearing studies. As a result, our study included 65,926 persons, and 78,948 observations for analysis. In Norway, the pension age is 67 years, and school age include persons up until 19 years of age. We excluded persons in the following order: persons not in working age 20-66 years (N = 18 288), persons with missing audiometric data (N = 212), persons with missing questionnaires (N = 1743), and persons with missing values for employment status (N = 488). After this, our sample included 38,603 subjects from HUNT2 and 19,614 subjects from HUNT4, of whom 6877 attended both hearing studies. Our final pooled sample included 51,340 persons, and 58,217 observations for analysis (Supplementary Figure 1).

HL, non-optimal work performance and co-worker relations

To assess the current status regarding HL, non-optimal work performance and co-worker relations, we investigated two subgroups in HUNT4 (2017–2019) that had been given questionnaires with the relevant questions for these analyses (Supplementary Figure 1). The questions on co-worker relations were only given to participants from 30 years of age and older.

Descriptive results

Characteristics of the study sample

Background data of the pooled sample (*N* = 58,217), HUNT2 (*N* = 38,603) and HUNT4 (*N* = 19,614) are presented in Table 1. The HUNT2 sample was younger than the HUNT4 sample (mean age 43.7 vs. 46.5 years), the proportion of males was higher (47.0% vs. 42.6%), and the HL prevalence was slightly higher (9.5% vs. 8.9%). The proportion of employed people was higher in HUNT 4 (83.7%) compared to in HUNT2 (77.4%). The HUNT2 sample had a somewhat higher proportion of participants with a higher education level compared to the HUNT4 sample (57.8% vs. 54.7%).

Prevalence of HL among employed persons in HUNT4

Table 2 shows the nationally representative prevalence of HL among employed people in Norway based on HUNT4 (N = 16,411). The prevalence of HL among employed participants was 5.8%; 0.7% for unilateral HL, 4.4% for mild HL, and 0.7% for disabling HL. Among adults above 44 years, the prevalence was 1.1% for unilateral HL, 9.0% for mild HL and 1.2% for disabling HL. HL was more frequent among men compared to women, and more frequent among older than younger adults. The prevalence of self-reported hearing problems among employed participants was 33.7%. Among all employed persons, 1.9% reported using a hearing aid. This number was 1.6% in HUNT2 (1996–1998) and 2.7% in HUNT4 (2017–2019).

Table 1. Background data of the pooled cross-sectional sample (age range 20–66 years). The Trøndelag Health Study, Norway: HUNT2 (1996–1998) and HUNT4 (2017–2019).

	Total sample *N* = 58,217[a]	Pooled cross-sectional Normal hearing *N* = 52,808	Hearing loss *N* = 5409	HUNT2 (1996–1998) *N* = 38,603	HUNT4 (2017–2019) *N* = 19,614
Age – mean, (SD)	44.7 (12.7)	43.5 (12.4)	55.9 (9.3)	43.7 (12.3)	46.5 (12.2)
Female *N*, (%)	31,711 (54.5)	29,572 (56.0)	2139 (39.5)	20,450 (53.0)	11,261 (57.4)
Male *N*, (%)	26,506 (45.5)	23,236 (44.0)	3270 (60.5)	18,153 (47.0)	8353 (42.6)
Working *N*, (%)	46,274 (79.5)	43,109 (81.6)	3165 (58.5)	29,863 (77.4)	16,411 (83.7)
Hearing loss *N*, (%)	5409 (9.3)	–	–	3658 (9.5)	1751 (8.9)
High education *N*, (%)	33,034 (56.7)	30,102 (57.0)	2932 (54.2)	22,315 (57.8)	10,719 (54.7)
Hearing aid use *N*, (%)	1131 (1.9)	230 (0.4)	901 (16.7)	598 (1.6)	533 (2.7)

SD = standard deviation.
[a]51,340 persons, 6877 of whom had repeated measurements, yielding 58,217 observations for analysis.

Table 2. Nationally weighted prevalence of hearing loss among employed persons (20–66 years). The Trøndelag Health Study, Norway: HUNT4 (2017–2019).

	All participants *N* = 16,411 (%)	Men *N* = 7188 (%)	Women *N* = 9223 (%)	Age ≤44 years *N* = 6777 (%)	Age >44 years *N* = 9634 (%)
Any hearing loss	5.8	6.8	4.6	1.3	11.3
Unilateral hearing loss	0.7	0.7	0.6	0.3	1.1
Mild hearing loss	4.4	5.4	3.3	0.8	9.0
Disabling hearing loss	0.7	0.7	0.6	0.2	1.2
Hearing aid users	1.9	2.1	1.6	0.5	3.6
Self-reported hearing loss	33.7	38.9	27.8	25.6	43.7
Self-perceived poor work performance due to hearing loss	3.9	3.4	4.5	2.6	5.6

Table 3. The association between hearing loss and non-employment among persons aged 20–66 years. The Trøndelag Health Study, Norway: HUNT2 (1996–1998) and HUNT4 (2017–2019).

	Any hearing loss OR (95% CI)	Unilateral hearing loss OR (95% CI)	Mild hearing loss OR (95% CI)	Disabling hearing loss OR (95% CI)
Total sample (*N* = 58,217[a])	2.1 (2.0–2.3)	1.7 (1.4–2.0)	2.0 (1.9–2.2)	3.2 (2.8–3.7)
Stratified analyses				
Men (*N* = 26,506)	2.2 (2.1–2.4)	1.6 (1.2–2.1)	2.1 (1.9–2.3)	3.6 (3.0–4.3)
Women (*N* = 31,711)	2.0 (1.8–2.2)	1.8 (1.4–2.3)	1.9 (1.7–2.1)	2.6 (2.1–3.2)
Younger adults =/<44 year (*N* = 27,532)	2.2 (1.8–2.7)	1.9 (1.3–2.8)	2.0 (1.6–2.7)	3.4 (2.2–5.3)
Older adults >44 year (*N* = 30,685)	1.7 (1.6–1.8)	1.6 (1.2–1.9)	1.6 (1.4–1.7)	2.4 (2.0–2.8)
Low education (*N* = 25,183)	2.3 (2.1–2.5)	1.8 (1.4–2.4)	2.2 (2.0–2.4)	3.4 (2.8–4.1)
Higher education (*N* = 33,034)	2.0 (1.8–2.2)	1.5 (1.2–1.9)	1.9 (1.7–2.1)	3.0 (2.4–3.6)
HUNT2 (i = 38,603)	2.2 (2.0–2.4)	1.6 (1.3–2.0)	2.1 (1.9–2.3)	3.2 (2.7–3.8)
HUNT4 (*N* = 19,614)	1.9 (1.7–2.1)	1.7 (1.2–2.4)	1.8 (1.6–2.1)	2.5 (1.9–3.3)

CI = confidence interval. OR = Odds ratio.
[a]51,340 persons, 6877 of whom had repeated measurements, yielding 58,217 observations for analysis.
$p < 0.05$ for all analyses in this table.
All analyses are adjusted for age and sex.
In the sex stratified analyses, the estimates are adjusted for age.
In the age stratified analyses, the estimates are adjusted for sex.

Regression analyses

HL and non-employment, assessed in the pooled cross-sectional sample

HL showed a statistically significant association with non-employment (Table 3). People with disabling HL had a threefold increase in odds of non-employment compared with people with no HL. Among people with mild HL, the odds were doubled. People with unilateral HL had a smaller, but significant, increase in odds of non-employment. The difference in absolute risk of non-employment in participants with disabling HL compared with no HL was about 26% (Supplementary Table 1).

In the stratified analyses, both men and women with HL had increased odds of non-employment compared to normal hearing, this increase was greater for the males. Compared to normal-hearing participants, the odds of non-employment were higher for younger adults with HL compared to older adults, and higher for participants with lower education level compared with people with higher educational level. The odds of non-employment among people with HL in HUNT4, compared to normal hearing people, were lower than what the people with HL in HUNT2 had. The absolute risk difference was also smaller in HUNT4 than in HUNT2 (Supplementary Table 1). The following interaction terms were statistically significant: mild HL*age group; disabling HL*sex; HL (mild and disabling)*HUNT cohort (HUNT2 vs HUNT4) and mild HL*education. In addition, all these interactions with any HL were statistically significant.

HL and self-perceived non-optimal work performance due to hearing problems (employed persons in HUNT4)

People with HL had considerably increased odds of HL-related non-optimal work performance compared with people with no HL (Table 4). Compared to normal-hearing participants, white-collar workers with disabling HL had considerably increased odds of non-optimal work performance compared to blue-collar workers. In addition, women confirmed not doing their job properly due to hearing problems more than men. The following interaction terms statistically significant: any HL*age; mild HL*age; any HL*sex; disabling HL*white-collar/blue-collar; any HL*education.

HL and co-worker relations (employed persons aged 30-66 years in HUNT4)

Associations between HL and not having strong collegial relations, not getting on well with colleagues, not having supporting colleagues, or being bullied at work were not statistically significant (Table 5).

Discussion

Main findings

This study shows a prevalence of HL among employed persons of 5.8%; 0.7% for unilateral HL, 4.4% for mild HL, and 0.7% for disabling HL. Among adults above 44 years, the prevalence was 1.1% for unilateral HL, 9.0% for mild HL and 1.2% for disabling HL. People with HL had increased odds of non-employment. The association between HL and non-employment was stronger among younger adults compared to older adults, and stronger in 2000 compared with 2017. HL showed no statistically significant associations with not having strong collegial relations, not getting on well with colleagues, not having supporting colleagues, or with being bullied at work. The prevalence of self-perceived non-

Table 4. The association between hearing loss and non-optimal work performance. The Trøndelag Health Study, Norway: HUNT4 (2017–2019).

	Any hearing loss OR (95% CI)	Unilateral hearing loss OR (95% CI)	Mild hearing loss OR (95% CI)	Disabling hearing loss OR (95% CI)
Total sample (*N* = 16,411)	5.1 (4.3–6.2)	3.7 (2.2–6.3)	3.9 (3.1–4.8)	19.5 (13.9–27.5)
Stratified analyses:				
Men (*N* = 7188)	3.7 (2.8–4.9)	2.1 (0.8–5.2) [a]	3.0 (2.2–4.1)	12.6 (7.6–20.8)
Women (*N* = 9223)	6.6 (5.1–8.4)	5.3 (2.8–10.1)	4.6 (3.4–6.2)	27.9 (17.3–45.2)
Younger adults =/< 44 year (*N* = 6777)	8.8 (5.0–15.4)	1.8 (0.2–13.2) [a]	8.5 (4.2–17.4)	32.3 (10.8–96.2)
Older adults > 44 year (*N* = 9634)	4.9 (4.0–5.9)	4.0 (2.3–6.8)	3.7 (2.9–4.6)	18.5 (12.9–26.4)
Low education (*N* = 7354)	6.1 (4.6–7.9)	3.8 (1.8–8.3)	4.4 (3.2–6.0)	26.4 (15.8–44.0)
Higher education (*N* = 9057)	4.5 (3.5–5.8)	3.7 (1.8–7.4)	3.5 (2.6–4.7)	15.3 (9.6–24.4)
White-collar occupation (*N* = 12 561)	5.6 (4.6–6.9)	3.9 (2.2–7.1)	4.2 (3.3–5.3)	26.0 (17.2–39.4)
Blue-collar occupation (*N* = 3028)	4.0 (2.5–6.4)	3.2 (0.9–10.9) [a]	3.6 (2.1–6.0)	8.1 (3.5–18.8)

CI = confidence interval. OR = Odds ratio.
[a]$p < 0.05$ for all analyses in this table, except those marked 'a'.
For the variable white/blue collar, persons without registered data (not working or not registered data) were excluded from this analysis ($n = 15,589$).
All analyses are adjusted for age and sex.
In the sex stratified analyses, the estimates are adjusted for age.
In the age stratified analyses, the estimates are adjusted for sex.

Table 5. The association between hearing loss and co-worker relations. The Trøndelag Health Study, Norway: HUNT4 (2017–2019).

	Total sample	Any hearing loss		Unilateral hearing loss		Mild hearing loss		Disabling hearing loss	
	N (%)	*N* (%)	OR (95% CI)	*N* (%)	OR (95% CI)	*N* (%)	OR (95% CI)	*N* (%)	OR (95% CI)
Not strong collegial relations	826 (7.6)	58 (6.3)	1.0 (0.8–1.3)	9 (8.9)	1.3 (0.7–2.6)	47 (5.9)	0.9 (0.7–1.2)	11 (8.8)	1.3 (0.7–2.5)
Not getting along well with colleagues	412 (3.7)	23 (2.5)	0.9 (0.6–1.3)	5 (5.0)	1.5 (0.6–3.7)	21 (2.6)	0.8 (0.5–1.3)	2 (1.6)	0.5 (0.1–2.0)
Not getting support from colleagues	808 (7.4)	68 (7.4)	1.1 (0.8–1.4)	9 (8.9)	1.3 (0.6–2–6)	57 (7.2)	1.0 (0.8–1.4)	11 (8.8)	1.3 (0.7–2.4)
Bullying/harassment at work	502 (4.6)	30 (3.3)	1.4 (1.0–2.0)	7 (6.9)	0.7 (0.3–1.5)	28 (3.5)	1.4 (1.0–2.1)	2 (1.6)	3.3 (0.8–13.4)

CI = confidence interval. OR = Odds ratio.
$p > 0.05$ for all analyses in this table.
All analyses are adjusted for age and sex.
In the sex stratified analyses, the estimates are adjusted for age.
In the age stratified analyses, the estimates are adjusted for sex.

optimal work performance due to hearing problems in HUNT4 was 4.9%. The association between disabling HL and self-perceived non-optimal work performance due to hearing problems was stronger among white collar than blue collar workers.

Evaluation of results and comparisons with other studies

Prevalence of HL among employed persons

Our study showed a high prevalence of both HL measured by pure-tone audiometry (5.8%) and self-reported hearing problems (33.7%) in the employed population. For HL measured by pure-tone audiometry, we used the definition of HL by GBD, which is PTA 0.5–4 kHz >20 dB HL in the better hearing ear. Self-reported hearing problems, which was assessed by the item 'do you think you have a hearing loss', probably also include people with other forms of HL (e.g. unilateral HL, high- or low frequency HL or minimal HL) or other types of hearing problems that are not revealed by pure-tone audiometry.

Other studies have investigated prevalence of HL within a working-age population. Hofmann et al. found an overall prevalence of HL of 14.1% among working-age (age 20–69) US adults in 2011–2012 (Hoffman et al., 2017), of which 6.6% were unilateral HL and 7.5% were bilateral HL. The differences in prevalence between the forementioned study and the present findings, may to some extent be explained by differences in age range of included participants and different definitions of HL (the Hofmann study defined HL by PTAs >25 dB). There may be national differences in prevalence between Norway and the United States. Also, Hofmann's study includes all people of working age, whereas the present study presents the prevalence of audiometrically measured HL in a working population, excluding people of working age that are not employed. The present findings, describing the size of the problem of HL in the employed population, yields important information for employers and policy makers when planning assistive resources.

HL and non-employment

Our study showed that HL was associated with marked higher odds of non-employment compared to normal hearing. This finding complies with prior studies. For example, a systematic review by Shan et al. published in 2020, summarised the current literature on the association between HL and employment (Shan et al., 2020). Among the seven included studies, six demonstrated a significant association between HL and unemployment, underemployment, or disability pension. There may be several reasons for the strong relationship between HL and non-employment, including oral communication challenges (Cunningham and Tucci, 2017) and a high degree of exhaustion after work (Svinndal et al., 2018). HL is related to communication problems and a survey-based study showed that people with a HL are more sensitive to background noise (Kramer et al., 2006). The same study reported a significantly higher proportion of employed persons with HL reporting sick leave due to stress-related complaints, compared to persons with normal hearing.

HL and non-employment – generational differences:

We believe that this is the first study showing that the association between HL and non-employment has become weaker during the last two decades. There was an age difference between the cohorts studied, with mean age 43.7 in the HUNT2 sample and 46.5 in the HUNT 4 sample. This is relevant, as the association between HL and non-employment is age dependent. However, the same finding was also present in the pooled sample when controlling for age, meaning that the difference in age between the cohorts did not influence the association.

We can only speculate about the possible explanations for the generational improvement. Increased use of hearing aids may be a contributing factor. Better education for people with HL could increase their chances of employment later in life. A recent study investigated educational attainment among Norwegian adults, comparing persons with sensorineural HL as children to persons without HL, based on data from the HUNT study. Although the authors found that the education level gap between people with and without HL remains, their results showed that educational attainment in general has increased in both groups (Idstad and Engdahl, 2019). Lately, there has been increased focus on the inclusion of people with disabilities in employment (Dale-Olsen, 2005). Accordingly, increased awareness of HL in the workplace may have led to a heightened focus on occupational support and resources for employees with HL. Moreover, working environments have changed over time, which could potentially affect employees with a HL differently than employees with normal hearing. The increased digitalisation over the recent decades may have had a positive effect on hearing impaired workers. Computerised data processing and communication via the internet and mobile phones have significantly altered working life (Norwegian National Institute of Occupational Health, 2018). The advancement of technology also influences our working methods, and the concept of 'new ways to work' describes a development of a more flexible approach to the organisation of work, with workplaces not being as tied to time and place as more traditional arrangements (Nijp et al., 2016), all factors that may be of help for employed people with HL.

On the other hand, there has been a considerable change from cellular offices to open-plan and shared workspaces over the last few decades (Nielsen and Knardahl, 2020). It has been shown that open-plan offices affect employees with a HL negatively (Jahncke and Halin, 2012). Recent generations of hearing impaired may face new challenges related to changes in employment structure. Generally, there has been a switch from primary and secondary industries over to tertiary industries in Norway over the last 50 years (Statistics Norway, 2020). Increased employment within the service sector leads to a larger proportion of employed people working in direct contact with customers and clients, making communication a salient feature of modern working life and giving another motivation to heighten awareness of the need for support for HL in the workplace.

HL and non-optimal work performance – susceptible groups

Our study showed that the association between disabling HL and the reporting of not doing your job properly due to hearing problems was markedly stronger among white-collar than blue-collar workers. White-collar occupations, for instance teaching and sales and marketing jobs, are probably more dependent upon oral communication than most blue-collar jobs. This could possibly explain the difference between white-collar and blue-collar workers.

In addition, women confirmed not doing their job properly due to hearing problems more than men. Possible reasons for our findings are explored here. Some occupations have a higher proportion of men whilst others a higher proportion of women. This situation has been labelled 'occupational gender segregation' (Alonso-Villar et al., 2012). Data from SSB showed that 80.4% of health and social workers were women (Statistics Norway, 2008), whereas for construction workers only 8.7% were female (Statistics Norway, 2007). For most health and social workers, oral communication constitutes a major part of their work. Although oral communication has a role within construction, it would not be considered a major factor in construction work. This shows how occupational gender segregation may explain the tendency of women with HL reporting to experience hearing related job problems more than men with HL. A recent personality research study examined how occupational segregation can be attributed to psychological differences between men and women (Wright et al., 2015). Perhaps this difference might also contribute to how a HL affects their perceived work performance.

HL and social support from co-workers

Our results revealed no difference between employed people with and without HL in their experienced support from colleagues. This is different from the findings of Danermark et al., who found that perceived levels of social support at work were lower for people with HL (Danermark and Gellerstedt, 2004). Other studies have looked at various aspects of HL and psychosocial work characteristics. A Dutch study found a significant relationship between psychosocial work characteristics and need for recovery, however, they found that this relationship was not influenced by hearing status (Nachtegaal et al., 2009). It has been shown that perceived support from colleagues has positive associations with job satisfaction (Mérida-López et al., 2019). Consequently, it is positive to find that perceived social support from co-workers is no worse for employed persons with HL than for those with normal hearing.

Implications of the findings

HL is a disability that is expected to increase globally during the coming decades (World Health Organization, 2021). Previous literature has shown that persons with HL experience lower employment rates (Shan et al., 2020). The results of this large population-based design study add to the evidence of this fact: There was a 26%-points higher unemployment rate among hearing impaired. Increased knowledge about HL in working life yields important information for employers and policy makers when planning assistive resources. Altogether, the high prevalence of HL in the working population, the high unemployment rate among hearing impaired and the high proportion of HL-related work problems among employed persons underline the importance of HL support in the workplace, such as improving acoustics in offices, adjusting layout of meeting rooms, and assistive technology. White-collar workers appear to be more vulnerable to experience HL-related work problems than blue-collar workers. Possible reasons for this include a greater reliance on oral communication in white-collar occupations compared to in blue-collar occupations. There is a need for further research into the effect of HL on different occupational groups, to enable both appropriate forms of support and sufficient support for HL in the workplace.

Strengths and limitations of the study

Selection bias

A major strength of our study is its large population-based design with two cohorts set 20 years apart. It was completed in the county Trøndelag, which can be considered representative of Norway in aspects such as geography, economy, industry and sources of income, age distribution, morbidity, and mortality (Krokstad et al., 2013). However, it does not have any large cities. Trøndelag is similar to the national average when it comes to the number of hearing aids dispensed in relation to the number of inhabitants (Balteskard and Otterdal, 2017), hence likely comparable in terms of the burden of HL affecting the population. We chose to show the prevalence of HL among employed persons weighted by the age and sex distribution of employed persons in Norway, as weighted numbers were more representative of the general working population. There are also limitations to consider. Participation rates were somewhat lower in HUNT4 compared to HUNT2 (Engdahl et al., 2021), in keeping with a general trend of declining health survey participation rates during the past decades (Galea and Tracy, 2007). Generally, non-participation rates in health surveys are often higher among some subgroups, such as low socio-economic groups (Harald et al., 2007) and people with poor physical health, which could give an underrepresentation of these groups in a sample. This could potentially contribute to an underestimation of the associations in our study.

Information bias

Hearing was measured with pure tone audiometry, considered the gold standard method for measuring hearing levels. The audiometric procedure performed was identical for both cohorts, and the differences in the equipment used are considered minor and not a cause of systematic differences (Engdahl et al., 2021). Information on employment and non-employment was taken from SSB and should represent up-to-date employment status at the time of the survey. Our study could not focus on the specific reasons for non-employment, since the category ‘outside workforce’ included different subgroups, such as retired, disabled, student, and homemaker, which could not be separated. For example, full-time students could not be excluded. This could potentially have made the sample somewhat less representative of people outside the workforce. However, we checked employment in the age group most likely to contain students (20–25 years of age) and found that most people less than 25 years of age were in employment (78%), thus we did not exclude this age group. We excluded persons of 67 years of age and above, as 67 is the state pension age in Norway. Anonymity and confidentiality were granted, increasing likelihood of truthful responses.

Conclusion

The present large population study shows that HL is common in the employed population. It indicates that the relationship between HL and non-employment is weaker in recent generations. White-collar workers appear to be more vulnerable to experience HL-related work problems than blue-collar workers. Our study shows that employed people with HL continue to face challenges, and research into intervention and support is required.

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