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Comparing occupational well-being between cochlear implant users and individuals with hearing loss or typical hearing

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ABSTRACT

Objective and Design: With this cross-sectional study, we aimed to assess whether cochlear implant (CI) users have different occupational well-being than individuals with hearing loss (HL) without CI (HL group) and those with typical hearing (TH). We used validated questionnaires to assess all outcomes.

Study sample: We included 98 CI users (mean age 51 y), 52 HL group participants (mean age 49 y) and 54 TH group participants (mean age 46 y).

Results: Capabilities, physical and psychosocial working conditions were similar overall across the three groups. However, compared to the HL group, the CI group had significantly better outcomes on a range of variables, reporting fewer psychosomatic symptoms, better health, higher acceptance of their HL, better verbal coping strategies, fewer interruptions during work, and lower perceived noise level. There were no variables indicating that CI users performed worse than their peers from the HL group.

Conclusions: Overall, CI users show occupational well-being and capabilities comparable to those of other groups. However, CI users appear to be more advanced in their progress towards acceptance of their HL, use of verbal coping strategies, are better adjusted at work, and report better health than individuals with HL without a CI.

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Cochlear implant; hearing; work; well-being; coping strategies; acceptance

Introduction

Hearing loss (HL) can affect physical and mental health, quality of life (Lailach et al. 2024), education, and employment status (Kramer, Kapteyn, and Houtgast 2006; Lailach et al. 2024; Olsson et al. 2022; World Health Organization 2024). While individuals with mild to severe HL can be supported with hearing aids, cochlear implantation is the recommended treatment for individuals with severe-to-profound sensorineural HL. Between 1985 and 2023, 9298 adults and children have been implanted with a cochlear implant (CI) in the Netherlands (https://opciweb.nl/ci-centra/). Despite the relatively large number of implantations, there is limited insight into the work performance of CI users (Nijmeijer et al. 2021; Philips et al. 2023).

Previous findings have shown that post-lingually deafened CI users reported that, prior to implantation, their job did not reflect their capabilities. However, after cochlear implantation, they were able to seek out better employment opportunities, reported an improved feeling of job security, participated in spontaneous conversations and felt part of the workplace (Hogan, Stewart, and Giles 2002). Implantation also resulted in larger self-confidence and workplace satisfaction (Olgun et al. 2024). Nevertheless, potential employers could (possibly) perceive that cochlear implantation provides insufficient hearing to facilitate further career development (Kos et al. 2007).

Our former study showed that job characteristics such as working hours and type of tasks at work are comparable among CI users, peers with HL without a CI (HL group), and those with typical hearing (TH

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group) (Feenstra et al. 2025). Despite the similarities between the groups, CI users and the HL group reported more effortful listening than listeners with TH. Interestingly, the CI users unexpectedly reported lower levels of need for recovery after work and also less need for guidance to manage their hearing problems at work than the HL group. We assumed that this could be attributed to the extensive rehabilitation program provided to CI users at audiological centres. This includes fine-tuning of the CI settings, speech perception training, optimising CI usage and advice on coping with HL. Such a program is not standard available for individuals with HL without CI in the Netherlands.

To adequately assess a person's disability and functioning, a multifactorial approach is essential, as outlined in the International Classification of Functioning, Disability and Health (ICF) framework (WHO 2001). According to the ICF, functioning and disability are understood as outcomes of the interaction between an individual's health condition (e.g. hearing loss) and contextual factors. Contextual factors include environmental elements (e.g. workplace features, support from colleagues, tasks) as well as personal factors (e.g. age and coping).

In our previous study we mainly focused on job characteristics, hearing activities at work and workplace features, which are primarily part of the component "Activities and Participation" in part I "Functioning and Disability" of the ICF (Granberg et al. 2014). In our current study, we focus more on the occupational well-being of CI users by examining environmental and personal factors at work and comparing these to those of HL and TH groups. Occupational well-being is a multi-faceted construct. It refers to a sense of satisfaction and fulfilment gained through work and includes a good work-life balance. It also includes the aspects that participants consider important in a job and the extent to which they are able to realise these aspects, further referred to as "capabilities" (Meerman and Klink van der 2017). These factors relate to part II "Contextual factors" of the ICF. We compared the CI, HL and TH groups to provide a comprehensive perspective and to contextualise the findings related to the CI group. To the extent of our knowledge, there are no previous studies comparing occupational well-being between CI users and individuals with HL and TH. Also, a systematic exploration of CI users' ability to cope is required to gain a better understanding of the role of such coping strategies at work.

Based on Feenstra et al. (2025), we expected that CI users would experience similar or relatively better occupational well-being compared to listeners with HL, but without a CI. We hypothesised that the TH group would have the most favourable occupational well-being, followed by the CI group and finally the HL group. We expected CI users would have received more adjustments to their jobs, positions, departments, tasks and work environments than the HL group as suggested by Hogan, Stewart, and Giles (2002).

Methods

Study sample

Participants with HL (CI and HL group) were recruited from patients of the Amsterdam University Medical Centre (Amsterdam UMC) and Leiden University Medical Centre (LUMC). Inclusion criteria for the study were: aged 18 to the age of retirement (67 years), normal or corrected-to-normal eyesight, proficient in Dutch, and having paid or voluntary employment or being in education. The onset of profound HL or deafness for the CI users had to be post-lingual (>7 years of age). In addition, CI users had to have received their CI after the age of 12 years and at least 1 year before participating in the study. CI and HL groups were not matched for severity of HL. There were no inclusion criteria regarding the degree of HL or hearing aid use in the HL group. Individuals who were incapacitated for work were not included in this study. Another exclusion criterion was intellectual disability, as all participants had to be able to complete the questionnaires without assistance. These criteria were checked in the patient records by the audiologist or speech therapist before recruitment.

In total, 105 CI users, 56 participants with HL, and 70 participants in the TH group were enrolled in this study. They were asked to complete a set of questionnaires (details presented in the next paragraph) and those in the TH group were asked to perform the Digits-In-Noise (DIN) test (Smits, Theo Goverts, and Festen 2013) to assess their hearing status. Only those who had completed the survey fully (all groups) and who had completed the DIN test (TH group) were included in the analyses. Due to incomplete survey data, 7 participants in the CI group, 4 in the HL group and 9 in the TH group were excluded. In addition, 7 TH group participants were excluded due to a missing DIN test score (4 cases), or a score not confirming TH (3 cases). This increased the total

exclusions in the TH group to 16 participants. We extracted data on the hearing status of the CI and HL groups from their electronic patient records.

Eventually, the data of a total of 204 participants were included in the study: 98 in the CI group, 52 in the HL group, and 54 in the TH group. Of these 204 participants, only 3 individuals were enrolled in education: 2 in the CI group and 1 in the TH group. In the introduction to the questionnaires, it was stated that wherever work or workplace was mentioned, this also applied for their educational setting. The demographic characteristics of the participants are presented in Table 1. For information about non-respondents and more demographic details, we refer to our previous study, Feenstra et al. (2025).

None of the HL group participants were eligible for a CI, based on; a) their aided consonant-vowel-consonant (CVC) phoneme score in quiet at a presentation level of 65 dB SPL (cut off score <70%) and if phoneme scores were not present b) their unaided pure-tone average hearing threshold (0.5, 1, 2 and 4 kHz), for air-conduction (all thresholds were < 70 dB HL). The mean age of CI, HL and TH group participants was 51, 49 and 46 years, respectively. A one-way ANOVA with Bonferroni-corrected post hoc comparisons revealed the CI group was significantly older than the TH group ($p = .022$, 95% confidence interval = [0.57–9.92]).

Ethical considerations

The Medical Ethical Committees of Amsterdam UMC, location VUmc (project number SQC2022-008) and the Leiden, The Hague and Delft METC LDD (project number N22.012) reviewed the study protocol and confirmed that the research was not subject to Medical Research Involving Human Subjects Acts. Participants signed a digital informed consent (Castor Electronic Data Capture, 2023, NY, USA).

Questionnaires

The electronic data-capture environment Castor EDC was used to administer previously validated questionnaires. The CI and HL group completed 6 questionnaires, the TH group completed 4 questionnaires (Table 2). The following paragraph describes each questionnaire along with its response scale and scoring.

1. The "Acoustic Annoyance in Open-Plan Offices" (GABO) questionnaire was developed and validated by the National Research Institute for well-being in France. It covers 4 sections (Perrin Jegen and Chevret 2017):
Section 1 "General information about yourself and your workspace" included a question on the number of people with whom the workspace is shared. It also addressed the participant's general satisfaction with their physical work environment (14 items): satisfaction with control/privacy (7 items) and with comfort/functionality (7 items). An example item is" Is equipment (a printer, machines, tools, coffee, toilets) available in your work space?". For each item, a 5-point scale ranging from 1 "Not at all satisfactory" to 5 "Quite satisfactory" was used.
Section 2 "Assessment of the noise environment of your workspace" assessed the presence of 5 specific noise sources (machines, ringing telephones, (un)intelligible conversations and people walking by, 5 items) and the annoyance due to these noise sources (5 items). A 5-point scale was used ranging from 1 "Never (hearing the noise source)" to 5 "Permanently (hearing the noise source)" or 1 "Not at all (annoying)" to 5 "Quite (annoying)". Only if participants scored 2 or higher on all 5 items of specific noise sources, the follow-up questions on annoyance were completed.
Section 3 "Your relation to noise in general" assessed the participants' sensitivity to noise and needs and/or challenges in dealing with a noisy environment. An example item is: "I perform considerably worse in noisy environments". This section consisted of 12 items covering three themes: noise sensitivity at night (during sleep), at home and at work. Participants indicated their level of agreement with the statements, using a 4-point scale ranging from 0 "Strongly disagree" to 3 "Strongly agree". Scores were reversed for two items of noise sensitivity at home and for one item of noise sensitivity at night. A score below 1.11 indicates no sensitivity to noise, while a score above 1.63 indicates noise sensitivity.
Section 4 "You and your health" assessed participants' perceived health, which resulted in a general health score and five subtheme scores: physical health (e.g. "how do you rate your health"), psychological health (self-confidence, feeling full of energy), physical symptoms (back, neck, arm- and/or leg-related pain, sleeping problems), psychosomatic symptoms (headaches, digestive problems, chest pain, feeling exhausted) and stress (exhausting work, experienced stress in

Table 1. Age, gender, duration of CI use and hearing acuity. Means (SD; range), median (interquartile range) or counts (%) are presented.

	CI (n = 98)	HL (n = 52)	TH (n = 54)
Age (years)	**51 (11.5; 19–66)**	49 (11.1; 24–66))	**46 (11.7; 18–65)**
Female	61 (62.2%)	32 (61.5%)	32 (59.3%)
Duration CI use (years)	7 (3-11.3)[b]		
CVC score (%) in quiet[a]	87 (10; 54–100)		
CVC score (%) in quiet[a]		97 (89–100)[b]	
Better ear average: 0.5, 1, 2 & 4 kHz[c]		37 (20.4; 2.5–77.5)	

A statistically significant difference for age between the CI and TH group is indicated in bold.
[a]Consonant/vowel/consonant in quiet, 65 dB Hearing Level, aided condition, in free field. [b]Median (interquartile range) is shown). [c]Better ear hearing threshold average at 0.5, 1, 2 and 4 kHz, dB Hearing Level, unaided condition, headphones. SD = Standard Deviation.

Table 2. Overview of the questionnaires administered in each group.

Questionnaires	CI group	HL group	TH group
1. Acoustic Annoyance in Open-Plan Offices (GABO)	X	X	X
2. Communication Profile for the Hearing Impaired (CPHI)	X	X	
3. Physical and psychosocial working conditions (P&PWC)	X	X	X
4. Job Content Questionnaire (JCQ)	X	X	X
5. Capability Set for Work (CSW)	X	X	X
6. Amsterdam Checklist for Hearing and Work (Amsterdam Checklist)	X	X	

work and private situations). This section consisted of 15 statements of which 12 were rated on a 4-point scale ranging from 1 to 4. One item of subtheme physical health and 2 items of stress were rated on a 5-point scale ranging from 1 to 5, to indicate the level of agreement. Scores concerning physical symptoms, psychosomatic symptoms and stress were reversed. Therefore, for each subtheme, higher scores indicated more favourable outcomes. Scores $\geq$ 3.5 indicate a good health; scores $\geq$ 2.5 and $<$ 3.5 indicate average health; scores $<$ 2.5 poor health (Fleury-Bahi and Marcouyeux 2017; Grosjean et al. 2017; Pierrette et al. 2015). Scores from all four sections were averaged, except for the number of colleagues in the same workspace, which was treated as a categorical variable.

2. The "Communication Profile for the Hearing Impaired" (CPHI) (Mokkink et al. 2010) assessed coping behaviour. Subscales were Maladaptive Behaviours (8 items), Verbal Strategies (8 items), Non-Verbal Strategies (7 items), Self-Acceptance (6 items), Acceptance of HL (8 items), and Stress and Withdrawal (15 items). Depending on the question, the 5-point response scale represented either an agree–disagree continuum or a multiplicity continuum. Scores were averaged, ranging from 1 to 5 with higher scores indicating better coping.
3. With a questionnaire on physical and psychosocial working conditions (P&PWC) (Robelski et al. 2019) we examined: (a) perceived ability to work and perform at work (concentration, productivity, and self-organisation), (b) psychosocial working conditions (the occurrence of social interaction at work, separation of work and private life, and reconciliation of work and private life), (d) health behaviour at work (healthy food habits, physical activity, and lunch breaks), (e) job satisfaction, (f) interruptions during work, (g) perceived noise level at work. We analysed 12 statements (e.g. "I get often interrupted on the job" and "the noise level is high"), with a 5-point scale to indicate the level of agreement. To allow ordinal regression analyses, we rescored the responses into three categories: (1) "totally agree" and "rather agree", (2) "neutral", and (3) "rather disagree" and "totally disagree". Two negatively formulated items were reversed, such that for each outcome, the "totally agree" option indicated the most favourable outcome. Note that we did not analyse the outcomes of the "privacy" and "ergonomic workspace" items as they fully overlapped with "general satisfaction with the physical workspace" of the GABO questionnaire (see 1. GABO).
4. The "Job Content Questionnaire" (JCQ) measured decision latitude (job control), social support from colleagues (social support), psychological demand, and job insecurity (Karasek et al., 1998). Job control was defined by the sum of skill discretion (6 items) and decision authority (3 items). The summed scores could range from 24 to 96 with higher scores indicating more control (van Leeuwen et al. 2022). Social support was defined by the sum of co-worker support (4 items) and supervisor support (4 items). The summed scores could range from 8 to 32, with a higher score

indicating more social support. Psychosocial demand was assessed by nine items (Hoang et al. 2013) addressing work pace, excessive work and conflicting demand. Scale scores ranged from 12 to 48 with higher scores indicating a higher demand. Job insecurity (3 items) had a range from 3 to 10, with higher scores indicating more job insecurity. Weighted scale scores were computed with the job content instrument scale construction formulae (Edimansyah et al. 2007). Some data were missing for this questionnaire (see Table 5 for details), but all subscale scores were calculable, as $\leq$1 item was missing per participant per scale. Missing values were replaced by the mean score calculated from the available data.

5. The questionnaire "Capability Set for Work" (CSW) (Meerman and Klink van der 2017) assessed 7 capability aspects: (1) using your knowledge and skills, (2) developing your knowledge and skills, (3) involvement in important decisions, (4) having meaningful working relationships, (5) setting own goals, (6) earning a good income, (7) creating something valuable. Three questions were asked for each aspect (21 items in total): (A) How important is the specific aspect in your work?, (B) Does your work offer enough opportunities to achieve the aspect?, (C) To what extent do you succeed to actually realise the aspect? Two scores were calculated. The *capability score* was determined by the number of valued aspects (question A) and for which participants had sufficient opportunities to realise it (questions B and C). Scores could range from 0 (none of the aspects) to 7 (all aspects). Higher scores indicated higher sustainable employability. The *discrepancy score* indicated the number of valued aspects (1 to 7), while these aspects could not be achieved. Sustainable employability is at risk if this score is $\geq$ 4 (Meerman and Klink van der 2017).
6. The 'Amsterdam Checklist for Hearing and Work' section 'HL and Work' (Amsterdam Checklist) (Kramer, Kapteyn, and Houtgast 2006) covered job changes, adjustments in tasks, work environment or work position, transfers to other departments. Here, we did not distinguish between adjustments initiated by the employee or by a (prospective) employer. Note that these questions were only completed by the CI and HI groups. The checklist also asked the question of whether things ever went seriously wrong at work because the respondent's did not hear something (properly). This question was answered by the CI, HL and TH groups. Response categories for all questions were (0) no and (1) yes. If the question "Did things ever went seriously wrong" was responded with yes, it was followed up with an open-ended question asking to elaborate on what exactly went wrong.

Statistical analysis

To examine whether there were differences in outcomes between CI users and the two reference groups, we used generalised estimation equations analysis, Pearson Chi-Square test or a logistic regression for nominal outcomes. For continuous outcomes, we used a Kruskal–Wallis test or one-way ANOVA, depending on the outcome measure's distribution which were all visually checked with histograms.

Age differed significantly between the CI (mean 51 years) and TH group (mean 46 years) (p=.022, 95% confidence interval = [0.57–9.92]). Therefore, we assessed whether age was a confounding covariate when testing the effect of group (CI, HL and TH) on all outcomes. This was done by the following procedures, where step 1 to 3 were performed for each outcome (see Supplementary Content, Flowchart for details):

1. The association between age and the outcome was tested using Pearson or Spearman correlations, or using logistic regression.
2. Linearity between age and each outcome was assessed by Analysis of Covariance (ANCOVA) or logistic regression. Age was included as a continuous variable in step 3 when a linear relationship was found, and as a categorical variable when it was non-linear.
3. Effect modification by age was assessed by testing the interaction between group and age for all outcome measures. If age was an effect modifier, we stratified the results based on two age subgroups: (a) 18 to 50 years ($n = 102$), (b) 51 to 66 years ($n = 102$).
4. Step 4 was only performed in case of a significant association between age and the outcome (Step 1), but in the absence of effect modification (Step 3). Step 4 tested whether age was a confounder (criterion: >10% difference in the effect of group on the outcome between the age-adjusted versus the unadjusted model).

If age was a confounder, the statistical model was adjusted (ANCOVA or logistic regression). If age was neither an effect modifier nor a confounder, we did not include age and presented the results of the unadjusted model (ANCOVA, Kruskal–Wallis or logistic regression) (see Supplementary Content, Flowchart). An age-adjusted model was applied for: physical symptoms (GABO), the stress and withdrawal scale (CPHI), occurrence of social interaction at work, separate/combine private and work life (P&PWC) and the capability score (CSW). Age-stratified results were presented for general satisfaction (physical work environment), satisfaction with control/privacy and satisfaction with comfort/functionalities (GABO), concentration, interruptions, lunch breaks (P&PWC), job control and social support (JCQ). Post-hoc tests following ANCOVA or logistic regression were performed with a Bonferroni correction. Analyses were performed using SPSS version 28 (IBM SPSS Statistics, New York, USA) with the significance level set at alpha = 0.05.

Results

GABO

Results are presented in Table 3. There were no significant differences between the CI, HL and TH groups in number of colleagues, satisfaction with physical work environment and assessment of the noise environment. However, an ANCOVA revealed a significant difference between the groups for noise sensitivity (F(2,201) = 13.69, p<.001). Post-hoc analyses with Bonferroni correction indicated noise sensitivity was significantly lower in the CI group (score 1.20) compared to both the HL and TH group (respectively scores of 1.59 and 1.72) ((CI vs HL, p=.001, 95% confidence interval [−0.66 – −0.13]) (CI vs. TH, p<.001, 95% confidence interval [−0.78 - −0,26])).

Noise sensitivity consisted of three subscales "during sleep", "at home" and "at work" which were separately analysed to assess the nature of the main group effect. The ANOVA indicated no significant differences between the CI, HL and TH groups for noise sensitivity at work. However, there was a significant difference between the groups both for noise sensitivity during sleep (F(2,201) = 26.17, $p<.001$) and at home (F(2,201) = 14.29, $p<.001$). *Post hoc* analyses with Bonferroni correction showed that the mean sensitivity during sleep was significantly lower in the CI group compared to the HL and TH group (CI vs HL, $p<.001$, 95% confidence interval = [−1.05 – −0.37]) (CI vs TH, $p<.001$, 95% confidence interval = [−1.26 – −0.59]). Additionally, the mean sensitivity at home was significantly lower in the CI group (score 1.08) compared to the HL and TH group (scores 1.38 and 1.65, respectively) (CI vs HL, $p=.018$, 95% confidence interval = [−0.57 - −0.04]) (CI vs TH, $p<.001$, 95% confidence interval [−0.83 - −0.31]).

Furthermore, a one-way ANOVA revealed a significant difference between the groups for the GABO "You and your health" section covering the overall domain "general health" (F(2,201) = 4.19, $p=.016$) and the following subdomains: physical health (F(2,201) = 4.71, $p=.010$), psychological health (F(2,201) = 3.71, $p=.026$) and psychosomatic symptoms (F(2,201) = 5.37, $p=.005$). *Post hoc* analyses indicated significantly better general health in the CI group (score 3.3) compared to the HL group (score of 3.1) ((CI vs HL, $p=.050$, 95% confidence interval [0.00–0.37]). *Post hoc* tests also indicated better perceived physical health in the CI group (score 3.6) compared to the HL group (score 3.3) ((CI vs HL, $p=.015$, 95% confidence interval [0.04–0.54]) and better psychological health in the CI group (score 3.0) compared to the HL group (score 2.8) ((CI vs HL, $p=.033$, 95% confidence interval [0.02–0.51]). Finally, there were significantly fewer perceived psychosomatic symptoms in the CI and TH groups (both scores equalled 3.4) compared to the HL group (score of 3.1) ((CI vs HL, $p=.007$, 95% confidence interval [0.06–0.47]) (HL vs. TH, $p=.023$, 95% confidence interval [−0.49 - −0,03])). No significant differences in physical symptoms and stress were found.

CPHI

The ANOVA indicated that the CI group reported a significantly higher acceptance of their HL (F(1,148 = 9.64, $p=.002$) and better verbal coping (F(1,148 = 5.51, $p=.020$) compared to the HL group. The other coping strategies (maladaptive behaviours, non-verbal strategies, self-acceptance and stress and withdrawal) were not significantly different in the two groups (Figure 1).

P&PWC

Ordinal regression analyses revealed no significant differences between the groups in the P&PWC outcomes, except for "concentration", "interruptions" and "perceived noise level". As shown in Table 4, the HL group was less able to concentrate than the TH group in the younger age category, (OR: 0.3 [95%

Table 3. Results of the GABO questionnaire.

	CI ($n = 98$)	HL ($n = 52$)	TH ($n = 54$)	p-value
General information about yourself and your workspace. Counts [%]				
Colleagues in same workspace				.336[c]
>50	5 (5.1%)	1 (1.9%)	1 (1.9%)	
16–49	8 (8.2%)	7 (13.5%)	10 (18.5%)	
7–15	12 (12.2%)	8 (15.4%)	5 (9.3%)	
3–6	26 (26.5%)	8 (15.4%)	7 (13.0%)	
1–2	43 (43.9%)	24 (46.2%)	29 (53.7%)	
I don't know	4 (4.1%)	4 (7.7%)	2 (3.7%)	
Satisfaction physical work environment (higher scores indicate positive outcomes). Means (SD, 95% confidence interval).				
General satisfaction[1]				
Age category 18 to 50	3.8 (0.7; 3.6–4.0)	3.5 (0.8; 3.2–3.8)	3.8 (0.7; 3.5–4.0)	.236[f]
Age category 51 to 66	3.7 (0.7; 3.5–3.9)	3.7 (0.8; 3.4–4.1)	3.8 (0.8; 3.5–4.2)	.816[f]
Control/ Privacy[2]				
Age category 18 to 50	3.6 (0.8; 3.3–3.8)	3.2 (1.0; 2.8–3.6)	3.6 (0.9; 3.3–3.9)	.157[f]
Age category 51 to 66	3.5 (0.9; 3.2–3.7)	3.5 (1.0; 3.1–3.9)	3.7 (0.9; 3.3–4.1)	.683[f]
Comfort/ Functionality[2]				
Age category 18 to 50	4.0 (0.7; 3.8–4.2)	3.8 (0.7; 3.5–4.1)	3.9 (0.7; 3.7–4.2)	.512[f]
Age category 51 to 66	4.0 (0.7; 3.8 –4.1)	4.0 (0.6; 3.7–4.2)	4.0 (0.7; 3.7–4.3)	.982[f]
Assessment of noise at work (lower scores indicate positive outcomes). Means (SD, 95% confidence interval).				
Hearing noise sources[3]	2.6 (0.9; 2.4–2.8)	2.6 (1.0; 2.3–2.9)	2.8 (0.9; 2.5–3.0)	.505[e]
Annoyance due to noise sources[4] (CI n = 38, HL n = 18, TH n = 26)	2.4 (0.6; 2.1–2.6)	2.5 (0.8; 2.0–2.9)	2.2 (0.8; 1.9–2.5)	.451[e]
General relation to noise (lower scores indicate positive outcomes). Means (SD, 95% confidence interval).				
Noise sensitivity[5]	**1.20 (0.6; 1.1–1.3)**	**1.59 (0.8; 1.4–1.8)**	**1.72 (0.6; 1.6–1.9)**	**<.001[e]**
Noise sensitivity divided into 3 subthemes				
During sleep	**0.92 (0.8; 0.8–1.1)**	**1.63 (0.9; 1.4–1.9)**	**1.84 (0.8; 1.6–2.1)**	**<.001[e]**
At home	**1.08 (0.6; 1.2–1.6)**	**1.38 (0.7; 1.2–1.6)**	**1.65 (0.6; 1.5–1.8)**	**<.001[e]**
At work	1.59 (0.8; 1.4–1.8)	1.77 (1.0; 1.5–2.0)	1.66 (0.9; 1.4–1.9)	.501[e]
You and your health (higher scores indicate positive outcomes). Means (SD, 95% confidence interval).				
General health[6]	**3.3 (0.4; 3.2–3.4)**	**3.1 (0.5; 3.0–3.3)**	**3.3 (0.5; 3.2–3.4)**	**.016[e]**
Physical health[7]	**3.6 (0.6; 3.5–3.7)**	**3.3 (0.6; 3.1–3.5)**	**3.5 (0.5; 3.4–3.7)**	**.010[e]**
Psychological health[7]	**3.0 (0.6; 2.9–3.1)**	**2.8 (0.6; 2.6–2.9)**	**3.0 (0.5; 2.9–3.1)**	**.026[e]**
Physical symptoms[8]	3.2 (0.6; 3.1–3.3)	3.1 (0.7; 2.9–3.3)	3.2 (0.5; 3.1–3.4)	.636[f]
Psychosomatic symptoms[8]	**3.4 (0.5; 3.3–3.5)**	**3.1 (0.6; 2.9–3.3)**	**3.4 (0.4; 3.3–3.5)**	**.005[e]**
Stress[9]	3.5 (0.6; 3.4–3.6)	3.4 (0.7; 3.2–3.6)	3.5 (0.6; 3.3–3.6)	.538[e]

Mean (SD; 95% confidence interval) or counts (%) and level of significance are presented. Statistically significant group differences are indicated in bold. [a]Wald test, [b]Wald test, including age as covariate, [c]Pearson Chi Square, [d]Kruskal–Wallis test, [e]ANOVA, [f]ANCOVA, including age as covariate.
[1]Average of 14 items, ranging from 1 (Not at all satisfactory) to 5 (Quite satisfactory). [2]Average of 7 items, ranging from 1 (Not at all satisfactory) to 5 (Quite satisfactory). [3]Average of 5 items, ranging from 1 'Never' (hearing the noise source) to 5 "Permanently" (hearing the noise source), [4]Average of 5 completed items, ranging from 1 "Not at all (annoying)" to 5 "Quite (annoying)". [5]Needs and/or challenges in dealing with a noisy environment. Average of 12 items. [6]Average of 15 items, [7]Average of 2 items, [8]Average of 4 items, [9]Average of 3 items.

confidence interval 0.1–1.0]). In the older age category, the CI group perceived interruptions (e.g., by coworkers) less often compared to the HL group (OR: 0.3 [95% confidence interval 0.1–0.8]). Second, the CI group perceived less noise during work compared to the HL group (OR: 0.5 [95% confidence interval 0.3–1.0]) (see Table 4).

JCQ

No significant group differences were found for job control, psychological demand and job insecurity. Significant differences between the three groups were however observed in the younger age category for social support ($F(2,99) = 3.30$, p=.041), with the CI and TH groups reporting to receive more social support (scores 25.7 and 25.6, respectively, 95% confidence interval = 24.5–26.8), than the HL group (23.6, 95% confidence interval = 22.2–25.0) (Table 5). However, post-hoc analyses revealed there were no significant differences between groups after Bonferroni correction: CI versus HL (p=.062), CI versus TH ($p = 1.000$) and HL versus TH (p=.086).

CSW

Kruskal–Wallis tests and ANCOVA indicated that there were no significant differences between the groups concerning the capability and discrepancy scores (Table 6).

Amsterdam checklist

A generalised estimation equations analysis showed no significant differences between the CI and HL groups in reported job changes, adjustments in tasks, work environment or work position and transfers to other departments. Also, no significant differences were found between the three groups concerning the question whether things ever went seriously wrong at work because the participant could not hear properly (Table 7). When asked what went wrong at work

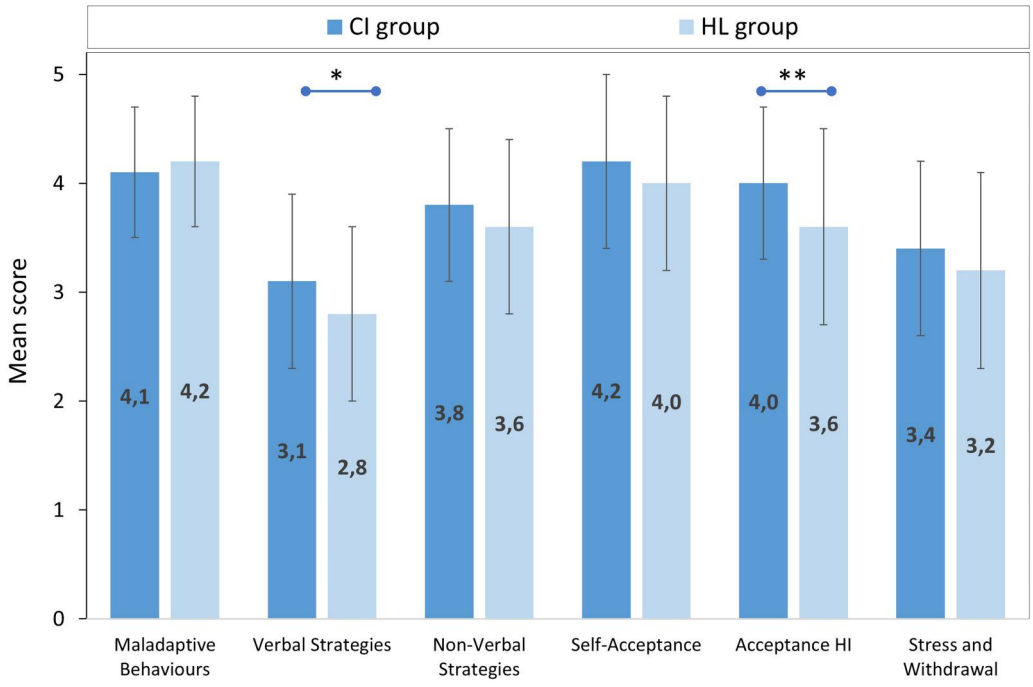

Figure 1. Results for the CPHI. Means are shown with error bars reflecting 1 standard deviation. Score range: 1–5, higher scores indicating better coping. ANOVA tests were performed. For the outcome "Stress and Withdrawal" a corrected model was presented (ANCOVA, including age as covariate). $^{*}p = .020$, $^{**}p = .002$

(a follow-up question), the participants mainly referred to miscommunication or consequences of miscommunication, for example "transport arranged too late" or "wrong order details".

Discussion

We compared occupational well-being of post-lingually deafened CI user with that of HL and TH individuals. To provide more context for the interpretation of the results of the CI group, we also compared outcomes of the HL group and the TH group. The current study builds upon previous work where we compared the three groups on activities and participation characteristics (ICF part I) (Granberg et al. 2014). That previous study focused on a range of job characteristics such as type of contract, number of working hours and type of tasks at work (Feenstra et al. 2025). Surprisingly, compared to HL and TH individuals, CI users were not disadvantaged on these variables in that study, despite reported effortful communication. The aim of the current study was to substantiate these findings and to further explore group differences in a number of environmental and personal factors related to functioning at work (ICF part II "Contextual factors") (Granberg et al. 2014). We used five questionnaires to compare the occupational well-being of CI users with those of their HL and TH peers. The questionnaires covered more than 30 subscales, and for each of these, we examined differences between the three groups. A notable outcome of this study is that in the majority of comparisons, no significant differences were found between the groups. This suggests that overall, the employment or educational opportunities of the CI group are not significantly different from those of the other groups. They are not more disadvantaged or vulnerable and appear to have equal well-being, opportunities and capabilities. Interestingly, a significant difference was found in thirteen of the outcome variables. In the younger age category, the CI and TH groups reported more social support than the HL group, but this was not significant after Bonferroni correction. For other outcomes, CI users significantly outperformed the HL group. Overall, this is a positive outcome, which further substantiates the results we previously reported (Feenstra et al. 2025).

Sustainable employability

The three groups in our study had similar sustainable employability: the opportunity to realise the aspects they valued, like being able to use their knowledge and skills. Also, the discrepancy scores were similar,

Table 4. Results of the P&PWC.

		CI (n = 98)	HL (n = 52)	TH (n = 54)	CI vs HL / CI vs TH / HL vs TH
			n (%)		p-value
CONCENTRATION					
Age category 18 to 50	Totally/rather agree	33 (78.6)	16 (61.5)	28 (82.4)	.108/.567/**.046**[c]
	Neutral	5 (11.9)	5 (19.2)	6 (17.6)	
	Totally/rather disagree	4 (9.5)	5 (19.2)	0 (0)	
Age category 51 to 66	Totally/rather agree	42 (75.0)	15 (57.7)	15 (75.0)	.086/.994/.186[c]
	Neutral	11 (19.6)	7 (26.9)	4 (20.0)	
	Totally/rather disagree	3 (5.4)	4 (15.4)	1 (5.0)	
SELF-ORGANIZATION	Totally/rather agree	73 (74.5)	35 (67.3)	34 (63.0)	.365/.203/.758[a]
	Neutral	14 (14.3)	10 (19.2)	14 (25.9)	
	Totally/rather disagree	11 (11.2)	7 (13.5)	6 (11.1)	
INTERRUPTIONS					
Age category 18 to 50	Totally/rather agree	8 (19.0)	8 (30.8)	6 (17.6)	.761/.276/.208[c]
	Neutral	16 (38.1)	6 (23.1)	8 (23.5)	
	Totally/rather disagree	18 (42.9)	12 (46.2)	20 (58.8)	
Age category 51 to 66	Totally/rather agree	24 (42.9)	5 (19.2)	8 (40.0)	**.020**/.777/.100[c]
	Neutral	17 (30.4)	8 (30.8)	6 (30.0)	
	Totally/rather disagree	15 (26.8)	13 (50.0)	6 (30.0)	
PRODUCTIVITY	Totally/rather agree	83 (84.7)	45 (86.5)	45 (83.3)	.729/.877/.659[a]
	Neutral	11 (11.2)	6 (11.5)	8 (14.8)	
	Totally/rather disagree	4 (4.1)	1 (1.9)	1 (1.9)	
OCCURRENCE OF SOCIAL INTERACTION AT WORK	Totally/rather agree	68 (69.4)	38 (73.1)	39 (72.2)	.778/.957/.844[b]
	Neutral	15 (15.3)	6 (11.5)	9 (16.7)	
	Totally/rather disagree	15 (15.3)	8 (15.4)	6 (11.1)	
SEPARATE PRIVATE AND WORK LIFE	Totally/rather agree	70 (71.4)	37 (71.2)	40 (74.1)	.834/.924/.790[b]
	Neutral	21 (21.4)	10 (19.2)	10 (18.5)	
	Totally/rather disagree	7 (7.1)	5 (9.6)	4 (7.4)	
COMBINE PRIVATE AND WORK LIFE	Totally/rather agree	66 (67.3)	38 (73.1)	42 (77.8)	.553/.342/.736[b]
	Neutral	25 (25.5)	10 (19.2)	9 (16.7)	
	Totally/rather disagree	7 (7.1)	4 (7.7)	3 (5.6)	
PERCEIVED NOISE LEVEL	Totally/rather agree	51 (52.0)	20 (38.5)	30 (55.6)	**.046**/.831/.053[a]
	Neutral	31 (31.6)	16 (30.8)	14 (25.9)	
	Totally/rather disagree	16 (16.3)	16 (30.8)	10 (18.5)	
LUNCHBREAKS[1]					
Age category 18 to 50	Totally/rather agree	29 (69.0)	16 (61.5)	19 (55.9)	.585/.338/.743[c]
	Neutral	4 (9.5)	4 (15.4)	7 (20.6)	
	Totally/rather disagree	9 (21.4)	6 (23.1)	8 (23.5)	
Age category 51 to 66	Totally/rather agree	33 (58.9)	13 (50.0)	14 (70.0)	.901/.402/.401[c]
	Neutral	6 (10.7)	8 (30.8)	1 (5.0)	
	Totally/rather disagree	17 (30.4)	5 (19.2)	5 (25.0)	
HEALTHY FOOD HABITS	Totally/rather agree	80 (81.6)	38 (73.1)	41 (75.9)	.213/.414/.704[a]
	Neutral	15 (15.3)	11 (21.2)	11 (20.4)	
	Totally/rather disagree	3 (3.1)	3 (5.8)	2 (3.7)	
PHYSICALLY ACTIVE	Totally/rather agree	53 (54.1)	28 (53.8)	24 (44.4)	.789/.361/.576[a]
	Neutral	25 (25.5)	11 (21.2)	18 (33.3)	
	Totally/rather disagree	20 (20.4)	13 (25.0)	12 (22.2)	
WORK SATISFACTION	Totally/rather agree	76 (77.6)	40 (76.9)	46 (85.2)	.890/.235/.238[a]
	Neutral	18 (18.4)	9 (17.3)	8 (14.8)	
	Totally/rather disagree	4 (4.1)	3 (5.8)	0 (0.0)	

The number and percentages of participants per age category is shown. Significant group effects are indicated in bold. For all scales, higher agreement indicates a beneficial working condition.
[a]Ordinal Regression, unadjusted results, [b]Ordinal Regression, adjusted results with age as covariate, [c]Ordinal Regression, stratified results.

Table 5. Results of the JCQ.

	CI (n = 98)	HL (n = 52)	TH (n = 54)	p-value
Job Control[1]	Means (SD, 95% confidence interval).			
Age category 18 to 50	77.1 (9.4; 74.2–80.0)	75.5 (11.3; 70.9–80.0)	73.9 (8.5; 71.0–76.9)	.367[b]
Age category 51 to 66	72.0 (9.2; 69.5 –74.4)	73.6 (8.9; 70.0–77.2)	73.2 (10.4; 68.3–78.1)	.732[b]
Social support[2]				
Age category 18 to 50	**25.7 (3.7; 24.5–26.8)**	**23.6 (3.5; 22.2–25.0)**	**25.6 (3.3; 24.5–26.8)**	**.041**[b]
Age category 51 to 66	24.2 (3.9; 23.2–25.3)	22.8 (3.0; 21.6–24.0)	23.7 (4.2; 21.7–25.6)	.268[b]
Psychological demand[3]	28.9 (4.9; 27.9–29.9)	29.8 (5.0; 28.4–31.2)	30.0 (5.3; 28.5–31.4)	.378[a]
	Median scores (25^{th} – 75^{th} percentile).			
Job insecurity[4]	4.0 (3.0–4.0)	4.0 (3.3–6.0)	4.0 (3.0–4.0)	.054[c]

Mean (SD; 95% confidence interval) or median scores (25th – 75th percentile) and levels of significance are presented. Statistically significant differences are indicated in bold. Higher scores indicate more positive outcomes for Job control and Social support from colleagues, but more negative outcomes for Psychological demand and Job insecurity.
[a]ANCOVA, [b]ANCOVA, including age as covariate, [c]Kruskal–Wallis test.
[1]Missings CI, HL group, respectively $n = 3$, $n = 1$, [2]Missings CI, HL group, respectively $n = 3$, $n = 2$ [3]Missings CI group, $n = 2$, [4]Median (25^{th}–75^{th} percentile).

indicating that the groups did not differ in the extent to which they observed limitations to realise specific job aspects. All mean scores were below 4, showing that sustainable employability was not at risk, as defined by the CSW norms. This is consistent with our previous results demonstrating that CI users, once enrolled in work, have equal opportunities as HL and TH colleagues (Feenstra et al. 2025). Our findings are also in line with the results of qualitative study of Rijke et al. (2022) who showed that (young) CI users had similar capability outcomes to their peers using hearing aids.

Noise sensitivity

As there was a significant group effect for noise sensitivity, we separately analysed the subscores related to noise sensitivity "at work", "at home" and "during sleep". Scores of the TH and HL groups were relatively high indicating that these groups were, on average, sensitive to noise at work (mean scores > 1.63), but not significantly different from the CI group. In contrast, the CI users reported to be significantly less sensitive to noise at home and during sleep than the TH and HL groups. One assumption is that most CI users turn their CI off at night and this reduces the perception of ambient sounds. Velluti et al. (2010) studied the effects of CI use during sleep at night and found differences in sleep characteristics when the implant was turned on versus off. However, the authors did not report on subjective sleep quality in this study.

Table 6. Results of the CSW.

	CI (n = 98)	HL (n = 52)	TH (n = 54)	p-value
Capability score	5.0 (3.0–6.0)	5.0 (3.0–6.0)	5.0 (3.8–6.0)	.840[a]
Discrepancy score	1.0 (0.0–3.0)	1.0 (0.3–2.8)	1.0 (0.0–2.3)	.793[b]

The medians (25^{th}–75^{th} percentile) for each group and levels of significance are presented. Higher scores indicate more positive outcomes for the capability score, but more negative outcomes for the discrepancy score.
[a]ANCOVA, including age as covariate, [b]Kruskal–Wallis Test.

Health

The CI group reported better general health (total score), physical health (self-rated health, health comparison), and psychological health (self-confidence, feeling energetic) than the HL group. Both the CI and TH group reported fewer perceived psychosomatic symptoms (headaches, digestive problems, chest pain, feeling exhausted) than the HL group. The groups did not differ in the domains physical symptoms and stress. These findings also indirectly support our former study (Feenstra et al. 2025) in which we found a significant higher need for recovery after work for the HL group compared to the TH group. de Croon, Sluiter, and Frings-Dresen (2003) showed that incomplete recovery from work can lead to psychosomatic health problems. However, note that the average scores for each group on these scales were relatively high overall (> 2.5), indicating average or even good health. Beneficial health outcomes were also observed by Olsson et al. (2022) who explored how health-related quality of life and work satisfaction changed from pre- to post CI implantation in adults with severe to profound hearing loss. They suggested that the use of CIs may promote increased health, higher work satisfaction and productivity gain. Also, Huang et al. (2024) observed that in general, more severe hearing loss in adults without CI was associated with poorer health-related quality of life (Huang et al. 2024).

Coping strategies

Coping strategies "acceptance of HL" and "verbal strategies" (such as asking others to repeat themselves) were significantly better in the CI group than in the HL group. Relevant factors might be that the acceptance of HL is a slow and gradual process that involves a social network of family, friends and colleagues. Also, more severe HL is associated with a higher acceptance of HL (Wänström et al. 2014). An explanation for the current findings might thus be that CI users are relatively more advanced in their

Table 7. Results of the Amsterdam Checklist.

	CI (n = 98)	HL (n = 52)	TH (n = 54)	p-value
Odds ratio (95% Wald confidence interval): 1.3 (0.78–2.2)				.305[a]
Have you ever changed jobs because of your HL?	24.5%	11.5%		
Have you ever taken the initiative to adjust your position or environment due to your HL?	44.9%	40.4%		
Have your tasks or workspace been adapted for your HL?	30.6%	17.3%		
Need for an adjustment in tasks or environment due to your HL	9.2%	13.5%		
Have you ever been transferred to another department because of your HL?	5.1%	9.6%		
Have things ever gone seriously wrong at work because you didn't hear something (properly)?	16.3%	11.5%	1.9%	.074[b]

The percentage of participants responding yes is shown and levels of significance are presented.
[a]GEE analysis, Wald Chi-Square test, [b]Wald test

progress towards acceptance, as the duration of HL is often longer and the degree of HL more severe than in the HL group (Feenstra et al. 2025). Also, CI recipients usually receive extensive training as part of standard hearing health-care in the Netherlands. This care is aimed at optimising CI usage, coping with HL and fine-tuning the CI settings. This might have contributed to the relatively favourable outcomes for the CI group relative to the HL group as individuals with HL without a CI generally do not receive such extended training. Bennett et al. (2022) showed that the use of verbal strategies (communication repair strategies) was described by adults with HL as an important skill for maintaining inclusion. The researchers included verbal strategies as coping mechanism that facilitates 'seeking support'. Their participants described a lack of coping strategies to manage their HL, while coping strategies heavily influence the experience of HL and subsequent social and emotional challenges. Therefore, many of their participants tended to avoid social interaction, deepening their isolation and loneliness. Bennett et al. (2022) and Garnefski and Kraaij (2012) pointed out that in general, many people with HL do not receive the psychological help they need. The authors recommended to include some form of (minimal) guidance (e.g. self-help-intervention) or coaching.

Concentration, interruptions at work and noise level

HL group participants were less likely to be able to concentrate at work than the TH group, but the CI group did not differ from the TH group. Moreover, older CI users perceived fewer interruptions (e.g., by coworkers) and noise at work, compared to the older HL subgroup. These findings reflect more favourable working outcomes for the CI group, which might explain the relatively favourable Need for Recovery scores for CI users observed in our previous study (Feenstra et al. 2025). This deserves further investigation in future research.

Changing jobs, tasks or work environment

Although not significantly different, more CI users changed their job (24.5%), compared to the individuals with HL without CI (11.5%), see Table 7. Also, 30.6% of the CI users confirmed adjustments had been implemented in tasks or workspace, which was more often than in the HL group (17.3%), although non-significant. We assume that the longer duration of HL in CI users, along with their more advanced progress of acceptance of HL, may underlie the greater number of adjustments made to their job, tasks and workspace. Bennett et al. (2022) considered adjusting the listening environment is an effective coping strategy. However, for the CI users in our research, it is not clear whether changes in job, workplace or tasks were carried out pre- or post CI implantation and whether these were initiated or needed by the CI users themselves or whether the prospective employer took the initiative. These issues require further research. We assume these changes represent beneficial adjustments made to better match individual abilities to job characteristics. This is consistent with Hogan, Stewart, and Giles (2002) who reported that post implantation, deafened adults were able to seek out better suited employment opportunities.

Limitations

A limitation of our study is that post lingually deafened CI users in the Netherlands typically receive a single (unilateral) CI. Our results thus may not be entirely representative for countries where post lingually deafened CI users can have a bilateral CI-fitting. Second, our study did not explore the possible presence or absence of inclusion policies in workplaces such as deaf awareness training or additional support for individuals with hearing loss, which can play an important role. Third, all results were self-reported outcomes. There is potential individual variability in interpretation of the questions and results may have been influenced by social, emotional, motivational and recall biases. One way to address this is through conducting a qualitative study. Future research could make use of qualitative methods to provide more in-depth contexts for differences in experiences between the groups.

Conclusions

Hearing status (CI, HL or TH) did not affect sustainable employability and perceived physical and psychosocial working conditions, for example productivity. The CI users experienced similar occupational well-being as individuals with TH. Furthermore, we observed relatively favourable outcomes for post-lingually deafened CI users regarding physical health, psychosomatic health and psychosomatic symptoms, their noise sensitivity, verbal coping strategies and acceptance of their HL, compared to the HL group

without CI. We infer that CI users are more advanced in their progress towards acceptance of their HL, are better adjusted at work and receive more support from colleagues than individuals with HL without a CI.

This study contributes to the knowledge on the occupational well-being of CI users. Our work shows that within occupationally active individuals, CI users experience their workplace well-being equally well as individuals with TH, and for some facets, better than individuals with HL without CI. We hypothesise that targeted professional guidance offering coping strategies may benefit the occupational well-being of individuals with HL.

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Author contributions

CRediT: **V.E.E. Feenstra**: Formal analysis, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing – review & editing; **A.A. Zekveld**: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing; **M.W. Kaandorp**: Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Validation, Writing – review & editing; **H.C. Stronks**: Conceptualization, Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing; **J.J. Briaire**: Conceptualization, Funding acquisition, Supervision; **J.H.M. Frijns**: Conceptualization, Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing; **S.E. Kramer**: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

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