Impact of hearing impairment and cochlear implantation on productivity and social well-being in a professionally active but severely hearing-impaired group: protocol of the ‘Hear again, work again’ longitudinal prospective cohort study

Cato Philips,1,2 Laure Jacquemin,1,2 Marc JW Lammers,1,2 Kristien Wouters,3,4 Julie Moyaert,1,2 Olivier Vanderveken,1,2 Vincent Van Rompaey1,2

ABSTRACT

Introduction Severe hearing loss is a sensory deficit with considerable impact on the patient’s daily life and on society. Previous research has established occupational obstacles in professionally active patients with hearing loss. However, studies investigating the impact of severe hearing loss and cochlear implantation (CI) on work performance using a quantitative and longitudinal study design and validated questionnaires are lacking. This study aims to answer the following research question: ‘What is the impact of unilateral and bilateral severe hearing loss and CI on the cost for society, health state, employment, productivity and social well-being?’ We hypothesise that hearing impairment will influence work performance. After establishing the impact, we will be able to enhance the support of hearing impaired patients to maintain employed.

Methods and analysis A total of 200 professionally active adults between 18 and 65 years old with severe hearing loss will be included for assessment at baseline and reassessment at 3, 6 and 12 months. The following four study groups are included: bilateral severely hearing impaired participants without CI (1) and with CI (2) and unilateral severely hearing impaired participants in acute (3) and chronic (4) setting. The primary outcome of this study is the change in index score on the Work Limitations Questionnaire, which evaluates the degree of limitations and health-related productivity loss. Secondary outcome measures include audiometric and cognitive evaluations and validated questionnaires evaluating employment, work productivity, quality of life and direct healthcare costs. Linear mixed models will assess the evolution in time and the difference in evolution between groups.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Work performance will be evaluated using validated questionnaires in a large study population.
⇒ The inclusion of multiple study groups and extensive audiological assessment enables comparison between the different groups of hearing impaired patients.
⇒ The comprehensive study protocol will provide a broad insight into the everyday difficulties patients with severe hearing loss and cochlear implants experience.
⇒ Insight into the cognitive function will be provided as an adapted neuropsychological test will be executed that was developed especially for hearing impaired individuals.

BACKGROUND

Patients with severe hearing loss have an average air conduction (AC) hearing threshold between 71 and 90 decibels hearing level (dBHL) according to the American Speech Language Hearing Association.1 As communication abilities deteriorate with an increasing degree of hearing loss, it may be hypothesised that the impact of the hearing impairment is most significant in patients with severe hearing loss compared with patients with mild or moderate hearing loss.2

The quality of life (QoL) is significantly decreased in patients with severe hearing loss, which can be attributed to an increased presence of distress, social isolation, anxiety and depression in this population.2,4 Hearing-related fatigue due to an increased listening
effort is known to be an important contributing factor of reduced QoL, cognitive abilities and workplace productivity.7–9 While it may be presumed that greater levels of fatigue will be present in patients with severe hearing loss as a result of increased communication difficulties and listening effort, this association cannot be confirmed by Hornsby et al and Wang et al.7,10

When hearing loss develops at a professionally active age, work performance can also be affected by increased stress, lack of control, social isolation, need for recovery and reduced productivity, which can all lead to sick leave, early retirement, unemployment and underemployment.5,11–15 This impact may be greater in patients with severe hearing loss, although this relationship is less clear. Nachtegaal et al stated that the need for recovery—a predictor of work stress, subjective health problems and sick leave—is related to degree of hearing loss, although the study by van der Hoek-Snieders et al could not confirm this association.12,16–18 Workability, the balance between the resources and work demands, is negatively associated with severe hearing loss. One study evaluated unemployment rates and revealed that unemployment rates are significantly higher in women with severe hearing loss compared with women with better hearing thresholds.11,19 While patients with severe hearing loss may experience higher degrees of fatigue, social isolation and less energy due to the effort needed to participate in conversations compared with their normal hearing peers, being employed full-time increases their QoL.4,11

Furthermore, hearing loss has a significant economic burden. In the USA, Mohr et al calculated that the lifetime cost for the society of severe-to-profound hearing loss amounts to $297,000 per person, where 67% can be attributed to reduced work productivity.20 Due to the growing and ageing population, it is expected that the prevalence of hearing impairment will rise which will further increase the economic burden.21

Considering the consequences of severe hearing loss on daily life, work performance and economic burden, adequate hearing rehabilitation in this population is necessary. Cochlear implantation (CI) has become the golden standard treatment for patients with bilateral severe sensorineural hearing loss leading to an increment of the prevalence of CI among adults over the past decades.22–24 CI can restore the hearing function in patients with severe sensorineural hearing loss by directly stimulating the auditory nerve which will lead to improvements of hearing ability, speech perception and QoL.24–30 The impact of a CI on work productivity is less clear. The review of Nijmeijer et al suggested that CI improves work performance, employment status and income, although no definite conclusion could be made due to methodological differences in the included studies.28 To date, the literature on this topic is scarce and not all studies established a difference in work performance, employment status and income before and after implantation.31–33

STUDY RATIONALE

Rigorous studies investigating the impact of CI and severe hearing loss on work performance with a quantitative study design, sufficient statistical power and using validated questionnaires, are currently lacking. As full-time employment has a positive impact on the QoL and economic burden, it is important to ensure that this population remains employed.3,20 In order to do this, it is necessary to identify the challenges that they experience at work.

OBJECTIVES

The aim of this study is to investigate the impact of a bilateral severe postlingual hearing loss and CI on the cost for society, health state, employment, productivity and social well-being in a professionally active group with bilateral severe hearing loss with and without CI. Additionally, participants with unilateral postlingual hearing loss will be included to investigate the impact of a unilateral severe hearing loss on those outcome measures. The study will use validated questionnaires to collect data.

METHODS

Study setting

This prospective cohort study will be performed at the Department of Otorhinolaryngology, Head and neck Surgery of the Antwerp University Hospital (UZA). Patients who present with hearing loss in the clinic, and who meet the inclusion criteria, will be asked to participate in the study.

Eligibility criteria

A total of 200 professional active adults between 18 and 65 years old with a severe (ie, average hearing threshold of at least 70 dBHL calculated based on the three worst hearing thresholds out of the following frequencies: 500 Hz, 1 kHz, 2 kHz and 4 kHz) postlingual sensorineural or mixed hearing loss will be included. All participants use oral communication as main communication strategy. Table 1 gives an overview of the inclusion and exclusion criteria.

Study groups

We aim to include 100 patients with a hearing loss subdivided into two cohorts. In Belgium, patients receive reimbursement for a unilateral CI if the following three conditions are fulfilled: bilateral severe pure tone audiometry thresholds of 70 dBHL or worse calculated as stated above (1), limited speech discrimination (unaided phoneme score of 50% or less and limited benefit of hearing aids) (2) and auditory brainstem response (ABR) thresholds of 75 dBHL or worse (3). Based on our clinical data, we expect that half of this population of patients with bilateral severe hearing loss on pure tone audiometry, will eventually not qualify for CI due to reasons such as satisfactory speech discrimination after optimal hearing
aid fitting, ABR thresholds above 75 dBHL or physical contra-indications. These participants will be included in the first study group (G1). The other 50 participants, who receive a CI, will be part of the second study group (G2). Additionally, two study groups of 50 participants with a unilateral severe hearing loss in acute setting (developed in the past 3 months and regardless of recovery) (G3) and chronic setting (unilateral severe hearing loss present for at least 3 months) (G4) without CI will be included.

Study design
For this longitudinal study, participants will be followed 1 year at four different test moments: baseline and reassessment at 3, 6 and 12 months. A comprehensive study protocol consisting of different validated questionnaires and an audiometric assessment will be executed. During the baseline measurement and the 12-month follow-up, an additional cognitive assessment will be conducted. In patients with a CI, baseline measurement will take place before implantation while the reassessments will take place after CI. During these reassessments, subjective and objective use of the CI will be questioned. An overview of the different test moments is provided in table 2.

The audiometric and cognitive assessment will be carried out by a trained audiologist that has an International Conference on Harmonisation Good Clinical Practice certificate (E6R2). We anticipate that the protocol in the hospital will take 2 hours at baseline and last follow-up and 1 hour for the other follow-up moments. In addition, there will be an extra hour for completing the questionnaires at home or at the hospital. Although all questionnaires are validated in Dutch, the questionnaires are general questionnaires and are therefore not validated for hearing impaired individuals or CI users except the treatment-specific Health-Related Quality of Life (HRQoL) questionnaires.

Outcomes
Primary outcome measure
The primary outcome of this study is the degree of limitations on-the-job due to health problems and health-related productivity loss in the past 2 weeks measured with the Work Limitations Questionnaire (WLQ). This questionnaire consists of four scales with a total of 25 items where the participant has to rate their level of difficulty or ability to perform specific job demands. It consists of four scales: the 5-item time management scale, the 6-item physical demands scale, the 9-item mental-interpersonal demands scale and the 5-item output demands scale. Each scale is scored on a scale from 0 (limited none of the time) to 100 (limited all of the time). The WLQ index score, which ranges from 0 to 28, and the percentage of at-work productivity loss can be calculated using an algorithm based on the WLQ scale scores.

Secondary outcomes measures
Questionnaires
In order to get a broad overview of the difficulties experienced by patients with severe hearing loss, different validated questionnaires will be conducted. The following domains that may be affected by the hearing loss will be surveyed: treatment-specific and disease-specific HRQoL, utility scores, employment and work performance, and socio-professional reintegration.

Table 1

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
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<tr>
<td>Between 18 and 65 years of age</td>
<td>Already implanted with a cochlear implant</td>
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<tr>
<td>Unilateral or bilateral severe-to-profound sensorineural or mixed hearing loss</td>
<td>Conductive hearing loss</td>
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<tr>
<td>Ability to understand and speak Dutch</td>
<td>Congenital hearing loss</td>
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<td>Resident in Flanders</td>
<td>Inability to complete audiological or cognitive evaluation</td>
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<td></td>
<td>Inability to complete questionnaires (eg, lack of knowledge and lack of ability to understand written Dutch)</td>
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Table 2

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<tr>
<th>Timepoint</th>
<th>Baseline</th>
<th>Follow-up</th>
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<tr>
<td></td>
<td>T₀</td>
<td>T₁ (3 months)</td>
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<tr>
<td>Questionnaires</td>
<td>x</td>
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<tr>
<td>Audiological assessment</td>
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<td>x</td>
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<tr>
<td>Cognitive assessment</td>
<td>x</td>
<td></td>
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<tr>
<td>Evaluation cochlear implant*</td>
<td>x</td>
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*In participants with a cochlear implant.
users.35 This questionnaire consists of 60 items formulated as statements divided into six subdomains: basic sound perception, advanced sound perception, speech production, self-esteem, activity and social interaction. For every statement, except the last five statements, the following five response alternatives are given: never (1 point), poorly (2 points), moderate (3 points), adequate (4 points) and always (5 points). The last five items represent the ability to perform a stated task with five response alternatives: no (1 point), poorly (2 points), moderate (3 points), adequate (4 points) and good (5 points). When the item is not applicable for the participants, the option ‘not applicable’ can also be chosen. First, the answers for each item can be converted into scores: 0 for 1 point, 25 for 2 points, 50 for 3 points, 75 for 4 points and 100 for 5 points. Some of the statements are phrased in opposite forms and will be transformed before the items scores can be converted. Second, the subscale score is calculated by averaging the scores of the 10 items belonging to the subscale. A higher score indicates a better HRQoL.

The self-reported Amsterdam Inventory for Auditory Disability and Handicap questionnaire assesses the everyday hearing disability by five subdomains: detection, localisation, discrimination, speech perception in quiet and speech perception in noise.36 Thirty specific situations are questioned, supported visually with an image of the auditory situation. A 4-point Likert scale with the following response options: almost never (0 points), occasionally (2 points), frequently (1 point) and almost always (0 points) measures the ability to hear effectively in the stated situation. The participant can also indicate that they only know this situation with hearing aids. The sum of each item will be the final score. A higher impairment is indicated by a higher final score.

### Utility questionnaires

The EQ-5D-5L is a descriptive system for the assessment of health status that consists of five dimensions: mobility, self-care, usual activities, pain/discomfort, anxiety/depression with five response options each.37 These responses can be converted into an EQ-5D-5L profile with an index value between 0 (death) and 1 (perfect health). Additionally, a visual analogue scale assesses the self-perceived health with a scale from 0 (worst possible health status) to 100 (best possible health status).

The Health Utilities Index Mark 3 (HUI3) and Mark 2 (HUI2) also assesses health status.38 This questionnaire uses seventeen items with four or five response options. The HUI3 is based on eight attribute levels (vision, hearing, speech, emotion, pain, ambulation, dexterity and cognition). For each attribute level, the single-attribute score can be calculated and converted into an HRQoL score. Afterward, these scores can be converted into the HUI2 with six multi-attribute levels (sensation, mobility, cognition, self-care, emotion and pain) resulting in a multi-attribute score that can be converted in an HRQoL score that varies between 0 (death) and 1 (perfect health).

Coping with daily hassles and adaptation after experiencing stressful life events can be predicted with the General Self-Efficacy scale (GSE).39 This questionnaire with 10 items and a 4-point scale (ie, completely incorrect (1 point), hardly incorrect (2 points), somewhat correct (3 points) and completely correct (4 points)) assesses the general sense of perceived self-efficacy. The final composite score ranges between 10 and 40. Higher grades of self-efficacy are seen in individuals with a higher score on the GSE.

#### Direct cost calculation

The Medical Consumption Questionnaire evaluates the total direct cost for each type of healthcare provider based on 18 questions related to frequently occurring contacts with healthcare providers (home care, general practitioner, rehabilitation, long-term care, psychologist and paramedical care).40 The sum of the amount of each resource used will be multiplied by its associated unit costs to evaluate the direct cost for overall healthcare use in the last 3 months. Additionally, the direct costs for healthcare use without hearing related healthcare use will be calculated. The unit costs will be derived from the Belgian National Institute for Health and Disability Insurance.

#### Disease specific QoL questionnaire

The Hospital Anxiety and Depression Scale (HADS) evaluates the disease specific QoL.41 Anxiety and depressive symptoms are screened based on 14 items. Both the ‘anxiety’ (HADS-A) and ‘depressive’ (HADS-D) subscales are composed of seven items scored with a range from 0 to 21. For each subscale, a score of seven or lower is assessed as normal, a score of 11 or higher as a mood disorder and a score in between those two as borderline.42

#### Employment and work performance

The Work Productivity and Activity Impairment Questionnaire for a specific health problem (ie, hearing loss) based on six items investigates the impact of hearing loss on work productivity.43 Four different percentages due to hearing loss can be calculated: missed work time, impairment while working, overall work impairment and activity impairment.

The 6-item subscale of the Dutch Vragenlijst Beleving en Beoordeling van de Arbeid questionnaire assesses the short-term effects of fatigue caused by work activities to investigate the need for recovery after work.44 For each statement four response alternatives are possible: always (3 points), often (2 points), sometimes (1 point) and never (0 points). The total score of this subscale ranges between 0 and 18 and can be converted into a percentage where a higher score indicates a higher need for recovery after work.

#### Socio-professional reintegration

The Quickscan will be conducted in participants who are on sick leave.45 Based on 18 items with a 6-point Likert scale from 0 to 5 the need for guidance to improve the socio-professional reintegration can be identified.
**CI data logging**

The CI usage (ie, average hours per day and the number of days per week the CI was used) will be assessed objectively and subjectively in the participants who receive a CI. Objective device usage will be obtained from the online fitting programme while the subjective device usage will be reported by the participant.

**Audiometric assessment**

Pure tone audiometry and speech perception tests will be conducted in a soundproof booth. For the free field measurements, the participant is placed at 0° azimuth at 1-metre distance from the loudspeaker.

- Pure tone audiometry

  The pure tone audiometry will be performed using insert-earphones, a bone conductor and a two-channel AC-40 audiometer (Interacoustics, Assens, Denmark) to investigate the AC and bone conduction (BC) ear specific thresholds with the modified Hughson-Westlake technique. The AC thresholds will be measured at 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz and 8 kHz. The BC thresholds will be measured at 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz and 4 kHz when the AC thresholds between 250 Hz and 4 kHz exceed normality levels (20 dBHL). Additionally, both an unaided and best aided free field measurement will be conducted.

- Speech-in-quiet test

  The Dutch NVA lists from the Dutch Society for Audiology (Nederlandse Vereniging voor Audiologen) will be used to investigate speech comprehension in quiet. One list consists of 11 monosyllabic words composed of a consonant-vowel-consonant and one training word. Both a free field unaided and best aided measurement will be executed at 65 decibel sound pressure level (dB SPL).

- Speech-in-noise test

  Speech comprehension in noise in free field in an unaided and best aided test condition will be evaluated using an adaptive procedure by the Leuven Intelligibility Sentences Test. One list of this test contains 10 sentences. In this adaptive procedure, the noise level is constant at 65 dB SPL while the speech level will be adapted with 2 dB SPL based on the participant’s responses. The speech reception threshold (in dB SPL) will be calculated as the average speech level of the last five sentences and the determined level of an imaginary 11th sentence.

- Auditory Speech Sounds Evaluation (A§E)

  To evaluate discriminatory power of the cochlea with and without hearing aids, the A§E will be executed in free field in both unaided and best aided condition. Twenty speech sound pairs, consisting of two speech sounds that are linguistically representative, will be presented in this oddity test at 70 dB SPL. One of the two speech sound is the background sound while the other is the odd speech sound. The background sound repeats an arbitrary amount of times (between three and eight) before the odd speech sound will be presented. When the participant notices the odd speech sound, the contrast is well discriminated and the next sound pair will be tested.

**Cognitive assessment**

The Repeatable Battery for the Assessment of Neuropsychological Status adjusted for Hearing-impaired individuals (RBANS-H) and the Corsi-block tapping task will be used to evaluate the cognitive function.

- RBANS-H

  The RBANS-H is derived from the RBANS for the cognitive assessment of individuals with hearing loss.

  To support the oral instructions, written explanation is provided with a PowerPoint presentation to make sure that the instruction is clear as all relevant stimuli are orally and visually presented. Five cognitive domains, that is, immediate memory, visuospatial/constructional, language, attention and delayed memory will be assessed with 12 subtests. To examine immediate memory, a list of ten words is offered four times in the List Learning subtest and a 12-item short story is presented two times for the Story Memory subtest. The participant has to recall as much of the words (List Learning) or the story (Story Memory) after every presentation. The Figure Copy test and the Line Orientation test are two subtests of the visuospatial/constructional domain. For the Figure Copy test, the participant copies a geometric figure. In the Line Orientation test two lines must be matched according to their orientation. The language domain is examined with the Picture Naming subtest, for which the participant must name 10-line drawings, and the Semantic Fluency subtest, for which as much as possible examples of a semantic category must be generated by the participant. The attention domain is examined using the Digital Span and Coding subtests. In the first subtest, the participant is asked to repeat a string of digits correctly. For the second subtest, the participant has 2 minutes to connect as many symbols as possible to the corresponding digits using the key at the top of the page. To evaluate delayed memory, the words of the List Learning subtest and the story of the Story Memory subtest are requested another time and the geometric figure of the Figure Copy subtest must be drawn again. The raw score for each subtest will be converted to norm scores using age-specific index score tables. Those index scores will be added up to obtain the total scale score of cognition which is convertible to an age-corrected standard score with a mean of 100 and SD of 15.

- Visuospatial short-memory

  Visuospatial short-term memory will be evaluated using the digital version of the Corsi Block-Tapping task from the Mental Information processing and Neuropsychological Diagnostic System diagnostic test programme. Nine blocks are presented on a computer screen where sequences of blocks will light up. The participant has to reproduce the sequence by ticking on the right blocks. Every sequence will be tested with two different combinations of blocks. The sequence length will start with two items and increases with one item when one of the two sequences were reproduced correctly. When the participant is not able to repeat either sequence the test ends.
The number of blocks in the last correct sequence is the Corsi span score.

Sample size and power
The primary outcome of this study is the change in WLQ index score before and 12 months after CI. Based on the literature we assume an SD of 5 for WLQ at baseline and conservatively estimate the correlation between baseline and 12-month measurements at zero, leading to an SD on the difference in WLQ of 7.54-56 The power calculation using a paired sample t-test revealed that 45 participants who will receive a CI (G2) have to be included to detect a significant difference of three points on the WLQ index score with a power of 80% and a two-sided significance level of 0.05. To cover a possible 10% drop-out, 50 participants who will receive a CI will be recruited. An equal number of participants will be included in the other study groups (G1, G3 and G4) resulting in a total of 200 participants in this study.

Data collection and management
All participant-related data will be collected and stored for 20 years using Research Electronic Data Capture (REDCap), an electronic data capture tool (V.12.0.3) hosted at UZA.57 58 REDCap is a secure, web-based application designed to support data capture for research studies, providing: an intuitive interface for validated data entry (1), audit trails for tracking data manipulation and export procedures (2), automated export procedures for seamless data downloads to common statistical packages (3) and procedures for importing data from external sources (4). Different validation checks (e.g., range checks) are implemented to minimise the number of errors. The collected information in this study is strictly confidential and both individual information and results will be coded. The access to this password-protected database is exclusively for the investigators who are the only ones who know the code for each participant.

Statistical methods
The statistical analyses will be executed using IBM SPSS Statistics V.27 or higher (IBM; Armonk, NY, USA). Descriptives will be given to summarise all quantitative data with mean and SD for normally distributed outcomes and median and IQR for non-normally distributed outcomes. To evaluate the evolution in time and the differences in evolution between groups, linear mixed models will be conducted with fixed effects group, time and interaction between time and group. Log or other transformations will be applied if necessary. Post-hoc comparisons will be performed to look at differences between the groups at each test moment. Bonferroni-Holm correction will be applied to correct for multiple testing. A significance level of p=0.05 will be used.

Patient and public involvement
Patients or the public were and will not be involved in the design, or conduct, or reporting, or dissemination plans of our research.

DISCUSSION
There is a growing awareness and interest into the impact of CIs on the patient’s daily life, work performance and economic burden although prior research has not reached consensus. Therefore, the primary aim of this study is to investigate the impact of CI on employment, productivity and social well-being.

Research into the impact of severe hearing loss on these relevant aspects of a patient’s life is scarce, and the few studies have heterogeneous methodologies and report inconsistent outcomes. Important methodological shortcomings including small study populations and the lack of validated questionnaires makes it impossible to draw conclusions based on the current literature. Furthermore, it may be hypothesised that patients with unilateral severe hearing loss also experience negative consequences in their daily life and work performance due to decreased speech perception in noise, sound localisation and QoL.59 Up till now, no research has been done into the impact of unilateral hearing loss on work performance. Therefore, the second aim of this study is to examine the impact of unilateral and bilateral severe hearing loss on employment, productivity and social well-being.

To our knowledge, this is the first longitudinal study protocol that will investigate the impact of CI and severe hearing loss on work performance using validated questionnaires. The use of validated questionnaires decreases measurement errors and increases the confidence with which conclusions can be drawn. Questionnaires are relatively quick and easy to administer. However, some self-report measures have limitations. Questionnaires are subjectively and might lead to socially desirable answers or the answers may be influenced by the interpretation of the participant leading to high inter-individual variability.60 Recall bias also can occur when answers of the participant depends on their ability to recall the event.61 Another possible limitations related to the use of a great amount of questionnaires is that fatigue may occur leading to less attentive responses.62

Several factors that may affect work performance will also be evaluated. First, HRQoL questionnaires, both disease-specific and utility-based, will be used to assess QoL. Second, hearing loss can have a negative impact on work performance, which can be addressed with a comprehensive audiometric evaluation. Finally, cognition may have an impact on work performance and will be assessed using a cognitive assessment.

With the inclusion of research groups with and without CI, the effects of CI on individuals with similar hearing impairment can be directly compared. Furthermore, it will be possible to see whether CI is as cost-effective in Belgian adults as it is in other high-income countries.63 64 By including patients with a unilateral hearing loss in this study, the impact of unilateral hearing loss on work performance and possible differences or similarities with bilaterally hearing-impaired patients can be explored. The combination of validated questionnaires, audiometric and cognitive assessments and different study...
groups in this longitudinal study makes it possible to provide a broad insight into the impact of CI and severe hearing loss on cost and health state on one hand, and employment, productivity and social well-being on the other hand. This knowledge is needed to develop guidelines for rehabilitation of severely hearing impaired patients with specific actions that can be taken to better support this population in order to ensure that they can remain employed.

Although CI is the golden standard treatment, a large proportion of the severely hearing impaired population uses hearing aids. Moreover, hearing aids restore the hearing function in patients with a mild and moderate hearing loss. It might, therefore, be interesting to also investigate the impact of hearing aids on employability in further research, as this is not in the scope of this study.

Author affiliations
1 Experimental Laboratory of Translational Neurosciences and Dento-Otorhinolaryngology, University of Antwerp, Faculty of Medicine and Health Sciences, Wilrijk, Antwerp, Belgium
2 Department of Otorhinolaryngology/Head and Neck Surgery, Antwerp University Hospital, Edegem, Antwerp, Belgium
3 Clinical Trail Center, Clinical Research Center Antwerp, Antwerp University Hospital, Edegem, Antwerp, Belgium
4 Faculty of Medicine, University of Antwerp, Wilrijk, Antwerp, Belgium

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Contributors
CP drafted and submitted the manuscript with support of WR, LJ and MJWL. VVR, OV, LJ and MJWL conceived and designed this study and KW provided a broad insight into the impact of CI and severe hearing impairment: quality of life, psychosocial consequences and associated costs. J Otolaryngol Head Neck Surg 2010;52:91–8.


30 McCracken TR, Bauschard M, Hatch JL, et al. Meta-Analysis of quality-of-life improvement after cochlear implantation and


