FACULTY OF MEDICINE AND HEALTH SCIENCES

MASTER'S DISSERTATION PART 2

THE EFFECT OF NOISE ON THE AUDIOVESTIBULAR FUNCTION IN ADULTS

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LIST OF ABBREVIATIONS

ASR	acoustic stapedius reflex
BAHPHL	Beliefs About Hearing Protection and Hearing Loss
BIAP	Bureau International d'Audiophonologie
C	control
CAS	contralateral acoustic stimulation
CI	confidence interval
cVEMP	cervical vestibular evoked myogenic potential
DPOAE(s)	distortion product otoacoustic emission(s)
ES	efferent suppression
FI	Fletcher Index
FL	force level
hAVICOP	hearing-related quality of life questionnaire for Auditory-Visual, Cognitive and Psychosocial functioning
HFA	high-frequency audiometry
(n)HL	(normalized) hearing level
HPD(s)	hearing protection device(s)
DNS	Diabetic Neuropathy Symptom score
DPOAE(s)	distortion product otoacoustic emission(s)
L	left
LAeq,l	lifetime equivalent noise exposure
ML	membrana limitans
NE	noise exposure
NIHHL	noise-induced hidden hearing loss
NIHL	noise-induced hearing loss
NIHVL	noise-induced hidden vestibular loss
NIVL	noise-induced vestibular loss
NSC-60	Neurotoxic Symptoms Checklist 60
oVEMP	ocular vestibular evoked myogenic potential
R	right
PTA	pure tone average
ROS	reactive oxygen species
SCC(s)	semicircular canal(s)
SD	standard deviation
SNR	signal-to-noise ratio
(pe)SPL	(peak equivalent) sound pressure level
TEOAE(s)	transient evoked otoacoustic emission(s)
vHIT	video head impulse test
VOR	vestibulo-ocular reflex
WHO	World Health Organization

PREFACE

This master's dissertation was carried out to obtain my degree of Master of Science in Speech Language and Hearing Sciences: Audiology. While working on this dissertation, I gained thorough knowledge and insights on the topics of vestibulology and preventive audiology. Moreover, I became more competent in performing a test protocol in which I professionally guided every participant through the process and I developed myself as a critical researcher. It has been two wonderful years of dedication and perseverance and I hope you may enjoy the reading as much as I enjoyed every phase to come to this end product.

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ABSTRACT (ENG)

Background: Considering the vestibular organ as a part of the inner ear, evidence is emerging for noise-induced vestibular loss (NIVL) besides noise-induced hearing loss (NIHL). However, the limited human studies on this issue report conflicting results on the vulnerability of the different parts of the vestibular organ and the outcomes of vestibular tests. Moreover, the symptomatology, and the relationship with NIHL remain unclear.

Aim: The purpose of this study was to investigate how NIVL manifests itself after occupational noise exposure, and how it is related to possible NIHL. Moreover, this study was a pilot study towards recommendations for a portable and sensitive vestibular screening tool.

Method: This study included 20 noise-exposed participants and 20 controls. First, otoscopy, tympanometry, acoustic stapedius reflex testing, pure tone and high-frequency audiometry, DPOAE, and efferent suppression measurements were performed, followed by cVEMP, oVEMP, and vHIT measurements. All participants had to complete a comprehensive questionnaire covering different general and hearing- or vestibular-related domains. Between-group statistical analysis were conducted and where applicable, participants were divided into three age-categories: 18-33 years; 34-49 years; 50 years or above.

Results: The NE-group showed more often an audiometric notch to the right ear (p=0.012), had more often left absent (p=0.039) or increased (left: p=0.038; right: p=0.023; 18-33 years right: p=0.029) 16000 Hz thresholds, both decreased 1500 (p=0.042) and 2000 Hz (p=0.008) right DPOAE responses, and reported more troubles with speech intelligibility in quiet situations (p=0.025). Young NE-participants (18-33 years) had higher right cVEMP thresholds (p=0.015) and higher gain values for the right horizontal (p=0.029) and both the right (p=0.010) and left anterior (p=0.016) vHIT measurements. In the oldest age-category, NE-participants presented more often right horizontal vHIT overt saccades (p=0.043), which was also described in the overall between-group comparison for this outcome measure (p=0.015). Any other conducted statistical analysis reached no significance (p>0.05), however, showed often promising trends within this small-scale study.

Conclusion: Occupational noise exposure can result in NIVL, which might be detectable with the cVEMP and/or vHIT. With the oVEMP, no utricular noise-induced damage could be distinguished. No vestibular symptoms could be related to noise exposure, prompting for NIHVL in terms of measurable NIVL with absent symptoms due to central compensation. Until now, the relationship between NIVL and NIHL remains unclear, however, statements in this study suspect early NIVL before measurable NIHL. As a recommendation for future hearing and balance conservation programs, cVEMP and vHIT measurements could be of value for all stakeholders in the prevention and protection of noise-induced hearing and vestibular loss.

Keywords: noise-induced vestibular loss, occupational noise exposure, vestibular screening, audiovestibular relationship, hearing and balance conservation programs

ABSTRACT (NL)

Achtergrond: Gezien het vestibulair systeem onderdeel is van het binnenoor, groeide het bewijs voor lawaai-geïnduceerd vestibulair verlies (NIVL) naast lawaai-geïnduceerd gehoorverlies (NIHL). Het beperkte onderzoek naar deze problematiek bij mensen toonde echter tegenstrijdigheden omtrent de gevoeligheid van de verschillende onderdelen van het vestibulair orgaan voor lawaai en de resultaten op vestibulaire testen. Bovendien is de symptomatologie, en het verband met NIHL nog onduidelijk.

Doelstellingen: Het doel van deze studie was om te onderzoeken hoe NIVL zich manifesteert na beroepsmatige lawaaiblootstelling en hoe het gerelateerd is aan NIHL. Bovendien was deze studie een pilotonderzoek naar aanbevelingen voor een draagbare en sensitieve vestibulaire screeningtool.

Methode: Twintig aan lawaai blootgestelde (NE) participanten namen deel aan het onderzoek, alsook 20 controlepersonen. Eerst werden otoscopie, tympanometrie, akoestische stapediusreflex testen, tonaal liminaire en hoogfrequente audiometrie, DPOAE en efferente suppressie metingen uitgevoerd, gevolgd door cVEMP, oVEMP en vHIT metingen. Alle participanten moesten een uitgebreide vragenlijst invullen waarin verschillende algemene en gehoor- of vestibulair-gerelateerde domeinen werden behandeld. Statistische vergelijkingen werden uitgevoerd tussen de NE en controlegroep en bij verschillende statistische analyses werden participanten opgedeeld in drie leeftijdscategorieën: 18-33 jaar; 34-49 jaar; 50 jaar of ouder.

Resultaten: De NE-groep had vaker een audiometrische dip bij het rechter oor (p=0.012), had vaker links afwezige (p=0.039) of toegenomen (links: p=0.038; rechts: p=0.023; 18-33 jaar rechts: p=0.029) gehoordrempels op 16000 Hz, hadden rechts zowel op 1500 (p=0.042) als 2000 Hz gedaalde DPOAE responsamplitudes (p=0.008) en rapporteerden meer moeilijkheden met spraakverstaanbaarheid in stilte (p=0.025). In de jongste leeftijdscategorie hadden NE-participanten hogere rechter cVEMP drempels (p=0.015) en hogere gain waarden bij de rechter horizontale (p=0.029) en zowel de rechter (p=0.010) als de linker (p=0.016) anterieure vHIT. Bij de oudste participanten werden meer horizontale overte saccades opgemeten bij de vHIT (p=0.043), dit resultaat werd ook bekomen bij de algemene vergelijking tussen de groepen (p=0.015). Alle andere uitgevoerde statistische testen bereikten geen significantie (p>0.05), niettemin toonden deze resultaten vaak veelbelovende trends binnen dit kleinschalig onderzoek.

Conclusie: Beroepsmatige lawaaiblootstelling kan leiden tot NIVL en kan gedetecteerd worden met een cVEMP of vHIT. Met de oVEMP werd geen utriculaire schade vastgesteld. Er konden geen vestibulaire symptomen gerelateerd worden aan lawaaiblootstelling, wat kan wijzen op NIHVL in termen van detecteerbare schade en afwezige symptomen door centrale compensatie. Tot nu blijft het verband tussen NIVL en NIHL onduidelijk, hoewel verklaringen in deze studie vroegtijdige NIVL doen vermoeden voor NIHL meetbaar is. Als aanbeveling voor toekomstige gehoor en balans zorgprogramma's, lijken cVEMP en vHIT metingen van toegevoegde waarde voor alle belanghebbenden bij de preventie en bescherming van lawaai-geïnduceerd gehoor- en vestibulair verlies.

Sleutelwoorden: lawaai-geïnduceerd vestibulair verlies, beroepsmatige lawaaiblootstelling, vestibulaire screening, audiovestibulaire relatie, gehoor en balans zorgprogramma's

INTRODUCTION

Noise exposure, both recreational and occupational, and its deleterious impact on the auditory function is described as a global issue of which the World Health Organization (WHO) has reported negative effects (World Health Organization, 2015). Unsafe listening conditions during recreational activities such as attending concerts and sports events, using personal listening devices, or practicing shooting sports (Degeest, Clays, Corthals, & Keppler, 2017; Ivory, Kane, & Diaz, 2014), are estimated by the WHO (2015) to cause hearing loss in 1,1 billion young people worldwide. Additionally, occupational noise corresponds to acoustic energy with moderate to high intensities to which employees are exposed during worktime (Concha-Barrientos et al., 2004). This source of noise exposure is responsible for 16% of the disabling hearing loss around the world, which comprises over four million disability-adjusted life years (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005), with symptoms of temporary or permanent hearing loss, tinnitus, hyperacusis, and difficulties with speech intelligibility (Ding, Yan, & Liu, 2019; Emara & Gabr, 2014; Shargorodsky, Curhan, & Farwell, 2010). Consequently, noise-induced hearing loss (NIHL) gets full attention in hearing conservation programs (Nelson et al., 2005); however, implementation and persistence of these programs are often with limited success (Rogers et al., 2009).

Because of its embryological and anatomical features, the vestibular organ might get damaged by excessive noise exposure as well. Although the cochlea is the human auditory receptor, the human saccule, one of the otolith organs of the vestibular organ, is evolutionary known to be activated, and possibly damaged by acoustic stimuli (Cazals, Aran, Erre, & Guilhaume, 1980; Young, Fernandez, & Goldberg, 1977). Moreover, the cochlea and vestibular organ have similar cellular structures and an equal common blood supply (Viola et al., 2020). Consequently, a reduction in blood flow, resulting from increasing noise exposure, might cause hearing loss as well as vestibular damage (Viola et al., 2020). Despite the emerging evidence highlighting the risk of noise-induced vestibular loss (NIVL), no vestibular follow-up exists in current prevention campaigns (Soylemez & Mujdeci, 2020). Although NIVL has been established in animals, research on the vestibular function in noise-exposed (NE) employees is scarce (Stewart et al., 2020). Moreover, literature is conflicting whether or not NE-employees experience subjective vestibular symptoms and what specific symptoms may occur. In analogy with noise-induced hidden hearing loss (NIHHL), not measurable with conventional audiometry nor otoacoustic emissions (Liberman, Epstein, Cleveland, Wang, & Maison, 2016), some authors use the term ‘noise-induced hidden vestibular loss’ (NIHVL), referring to subjective symptoms of dizziness and imbalance in NE-employees without objectively measurable damage due to limitations in the sensitivity of current vestibular assessments (Le, Straatman, Lea, & Westerberg, 2017). Contradictory, others refer to NIHVL when employees do not report subjective symptoms, yet have abnormal objective vestibular test results because of the chronic character of noise exposure, which allows central compensation (Soylemez & Mujdeci, 2020). These contradictions and uncertainties urge further thorough research concerning possible vestibular symptoms and measurable damage in NE-employees.

Generally, a vestibular dysfunction may cause imbalance, vertigo, dizziness, spatial disorientation, and oscillopsia resulting from impaired vestibular reflexes. In case of bilateral damage, individuals may feel postural unstable and have an unsteady gait (Strupp, Feil, Dieterich, & Brandt, 2016), especially in situations with partial sensory deprivation or fast movements due to a shortcoming in visual or proprioceptive information (Shupak et al., 1994). Acute unilateral vestibular damage is mostly characterized by vertigo, nausea, and postural instability (Halmagyi, Weber, & Curthoys, 2010). Although these acute symptoms may fade out due to central compensation, individuals may be left with experiences of instability in dynamic situations (Halmagyi et al., 2010). In addition, patients may experience long-term vestibular symptoms of dizziness, unsteadiness, and non-spinning vertigo in visually rich environments, for example, the supermarket (Staab et al., 2017). These symptoms may be the result of a developed visual over-dependency during the recovery process and might result in persistent postural perceptual dizziness (Appiah-Kubi & Wright, 2019; Cousins et al., 2014; Staab et al., 2017). Above all, patients with a vestibular loss can report symptoms of short-term memory loss, difficulties with multitasking, concentration loss, fatigue, and headaches (Danneels, Van Hecke, Keppler, et al., 2020). In patients with bilateral vestibular loss, these symptoms are explained by the impaired vestibulo-hippocampal pathways, which may cause hippocampal atrophy resulting in spatial memory and navigation deficits (Brandt et al., 2005; Danneels, Van Hecke, Keppler, et al., 2020). As each vestibular organ sends information to both hippocampi, this phenomenon will not occur in patients with unilateral vestibular loss (Brandt et al., 2005). Nevertheless, they might also experience these symptoms due to the constant need of compensating for the impaired vestibular reflexes. To compensate for this loss of automatized balance control, a higher amount of cognitive capacity is required, resulting in cognitive exhaustion with less cognitive reserve for other daily-life activities and work-tasks, which are often dual tasks (Danneels, Van Hecke, Keppler, et al., 2020; Danneels, Van Hecke, Leyssens, et al., 2020). Considering these consequences of vestibular loss, employees with noise-induced vestibular damage are at risk of work-related injuries (Adhikari, 2015; Shupak et al., 1994; Soylemez & Mujdeci, 2020). Combined with the deleterious impact of noise on the auditory function, this emphasizes proper research of the potentially damaged vestibular structures in order to support and protect noise-exposed employees.

For different mechanical and metabolic reasons has the saccule been hypothesized to be most vulnerable to noise-induced damage. First, its anatomical proximity to the stapes may induce pressure changes by the macula of the saccule (Békésy, 1935). Consequently, excessive noise exposure may damage the saccular sensory epithelium and hair cell stereocilia of the macula (Stewart et al., 2016). Second, the saccule is separated from the utricle and semicircular canals (SCCs) by the membrana limitans (ML) (Hara & Kimura, 1993), dividing the audiovestibular partition in a pars inferior (cochlea and saccule) and a pars superior (utricle and SCCs). Released reactive oxygen species (ROS) from excessive noise exposure may cause, in addition to cochlear damage, also vestibular damage (Tanigawa et al., 2008; Taura, Kikkawa, Nakagawa, & Ito, 2010; Wang & Young, 2007). Because of the ML, diffusion of deleterious substances to the pars superior gets delayed, leaving much high concentrations of these substances in the saccule, and damaging saccular

structures (Hara & Kimura, 1993). Therefore, registration of cervical vestibular myogenic potentials (cVEMPs), measuring the inhibitory reflexes of the saccule on the sternocleidomastoid muscle (m. SCM) (Colebatch, Halmagyi, & Skuse, 1994), may be beneficial in detecting NIVL (Akin et al., 2012). However, no consensus exists in literature on how saccular damage manifests in cVEMPs as some investigations reported delayed latencies (Abd El-Salam, Ismail, & El-Sharabasy, 2017; Emara & Gabr, 2014), whereas others found significant decreased amplitudes and increased thresholds (Akin et al., 2012; Viola et al., 2020). Moreover, there is currently no consensus whether utricular damage and damage to the SCCs are present after occupational noise exposure. The utricle and SCCs are anatomically separated from the cochlea and saccule by the ML, and are so presumed to be protected by deleterious noise-effects (Hara & Kimura, 1993). However, some investigations found abnormalities in ocular vestibular myogenic potentials (oVEMP) measuring the function of the utricle (Emara & Gabr, 2014), and in video head impulse tests (vHIT) measuring the function of the SCCs (Yilmaz, Ila, Soylemez, & Ozdek, 2018), which yields awareness of the effect of noise on these structures as well.

The proximity of the vestibular organ to the cochlea, the similar cellular structures, and the equal common blood supply, suspect a relation between auditory and vestibular damage after noise exposure (Viola et al., 2020). Wang and Young (2007), found a significant correlation between the audiometric notch at 4000 Hz and abnormal cVEMP responses in NE-participants. However, there is no consensus regarding the order of possible audiovestibular damage. Some authors believe saccular damage may occur before cochlear damage as the saccule is less able to withstand force than the cochlear Reissners' membrane (Raghunath, Suting, & Maruthy, 2012). Moreover, the cochlea has protecting mechanisms against NIHL such as cellular signaling processes with corticotropin-releasing factors, which have not yet been described in the vestibular organ, which could make the vestibular organ potentially more vulnerable to deleterious noise-effects (Abd El-Salam et al., 2017; Alqudah, 2019).

Despite the hypotheses in literature concerning the deleterious impact of occupational noise exposure on the audiovestibular function, there is a paucity of research on the entire vestibular organ and a lack of consensus regarding the outcome of vestibular tests in NE-employees. Moreover, little is known about the audiovestibular relation and the wide range of possible resulting (sub)clinical symptoms in persons exposed to noise. Therefore, the purpose of this study was to investigate how vestibular damage manifests itself after occupational noise exposure, and how it is related to employees' hearing(loss). Moreover, this study was a pilot study towards recommendations for a portable and sensitive vestibular screening tool, usable by all stakeholders in the prevention and protection of noise-induced hearing and vestibular loss.

METHOD AND MATERIALS

SUBJECTS

Twenty participants (18 males and 2 females; aged 20-60 years, mean 42,4 years (SD: 14,65)) with a self-reported current history of occupational noise exposure were matched by age and gender with 20 participants (C-group) without a current history of occupational-noise exposure (aged 20-62 years, mean 42,4 years (SD 15,04)) and also divided in one of three age-categories: 18 to 33 years, 34 to 49 years and 50 year and older. All participants were recruited through convenience and chain-referral sampling. Duration of employment within the current noise environment in the NE-group ranged from less than one year to more than ten years. Sectors in which these participants were employed were health care, trade and service, and industry (metal, printing, food, joinery, and construction). In **Appendix 1**, a concise overview is given of different demographic features of every NE-participant and its paired control.

Exclusion criteria consisted of candidates with congenital, familial or traumatic ear- and vestibular pathologies, the use of hearing aids or hearing implants, use of ototoxic medication, neurological problems, heart and vascular diseases, systemic disorders, and diabetes mellitus (**Appendix 2** for subject flow diagram). Participants were asked to avoid alcohol and nicotine intake 24 hours before examination and limit noise exposure 48 hours before the examination by e.g. wearing hearing protection devices (HPDs) or taking breaks in quiet environments. Recreational noise exposure was no exclusion criterium. However, considering the wide range of recreational activities with possible deleterious noise levels to the audiovestibular system, several activities were questioned and taken into account in further analysis.

The study was approved by the Ethical Committee of the Ghent University Hospital and was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki (BC-10113). All participants signed the informed consent before participation.

PROCEDURE

From September to October 2021, each participant underwent an audiological and vestibular test protocol in the Ghent University Hospital of Belgium. All tests were performed by one researcher (L.V.d.B). Together with the clinical tests, participants were asked to complete a comprehensive questionnaire (in Dutch) assessing general information about themselves and some specific domains relevant to the research (**Appendix 6**). An overview of the domains involved and the corresponding instruments is given in **Table 1**.

Table 1: Overview of different domains used in the questionnaire and corresponding instruments.

Domain	Instrument
Sociodemographic information	Set of self-developed questions (e.g. age, gender, smoking behavior, alcohol use)
General medical history	Set of self-developed questions (e.g. medication use, general health-related symptoms, chronic/systemic diseases, visual problems, familial hearing/vestibular problems, previous surgeries)
Neurological symptoms	Neurotoxic Symptoms Checklist 60 (NSC-60) (Hooisma & Emmen, 1992) (**Appendix 5 for subcategory calculation method**); Diabetic Neuropathy Symptom (DNS) score (Meijer et al., 2002)
Hearing-related symptoms	Set of self-developed questions (e.g. tinnitus, hyperacusis, and ear fulness); hearing-related quality of life questionnaire for Auditory-Visual, Cognitive and Psychosocial functioning (hAVICOP) (Ceuleers et al., 2022) (**Appendix 5 for subcategory calculation method**)
Noise exposure history and use of hearing protection devices	Set of questions based on Jokitulppo et al. (2006) and adapted in the context of recent research by De Poortere et al. (2022; *in preparation*) (**Appendix 5 for calculation method**); Beliefs about Hearing Protection and Hearing Loss (BAHPHL) (Keppler, 2010) (**Appendix 5 for subcategory calculation method**)
Vestibular-related symptoms	SO STONED* questionnaire (Wuyts, Van Rompaey, & Maes, 2016)

* Acronym referring to questions for complete history taking of patients with dizziness (Symptoms, Occurrence, Since when, Triggers, concurrent Otological symptoms, concurrent Neurological symptoms, Evolution, Duration).

The audiological test protocol consisted of otoscopy and tympanometry to exclude possible external and middle ear pathologies. Acoustic stapedius reflex (ASR) testing, pure tone audiometry, high-frequency audiometry (HFA), distortion product otoacoustic emissions (DPOAEs), and efferent suppression (ES) of otoacoustic emissions were performed in order to objectify possible noise-induced hearing loss.

Tympanometry and ASR were conducted using a TympStar (Granson-Stadler Inc., Eden Prairie, United States of America). Tympanometry was performed with a 226 Hz probe tone at 85 dB SPL. The middle ear status was interpreted in terms of static acoustic admittance (mmho), ear canal volume (ml), tympanometric peak pressure (daPa), and tympanometric shape (type A, As, Ad, B or C). With ASR, the reflexive contraction of the stapedius muscle and so the function of the vestibulocochlear nerve, the facial nerve, and the central nervous system was measured. Both ipsilateral and contralateral pathways were measured while presenting a stimulus of 1000 Hz ipsilateral and broadband noise contralateral, aiming to quantify an acoustic reflex threshold (dB HL) and to use as a base for the stimulus intensity in further ES measurements. The acoustic reflex threshold was interpreted as the lowest stimulus intensity at which a reduction in admittance of at least 0,03 ml could be obtained twice.

Pure tone and high-frequency audiometry were conducted with a clinical audiometer (Callisto Interacoustics, Middelfart, Denmark) performing the modified Hughson-Westlake method (Carhart & Jerger, 1959). Each octave frequency centered around 250 to 8000 Hz and the half-octave frequencies 3000 and 6000 Hz were

presented through air conduction using a TDH 39 supra-aural headphone (Interacoustics, Middelfart, Denmark). With a supra-aural HDA200 headphone (Sennheiser Inc., Old Lyme, United States of America), thresholds at 10000, 12500, 14000, 16000 and 20000 Hz were measured. When air-conduction frequencies exceeded 20 dB HL, the thresholds 250, 500, 1000, 2000 and 4000 Hz were also measured through bone conduction with a bone oscillator (RadioEar B71, Middelfart, Denmark). Two pure tone averages (PTA) were computed. First the PTA based on the Fletcher Index (FI) was calculated as the mean of the thresholds at 500, 1000 and 2000 Hz. Based on the ANSI 2004 classification, these thresholds were further classified from normal hearing thresholds (0-20 dB HL) to a mild (21-40 dB HL), moderate (first degree 41-55 dB HL; second degree 56-70 dB HL), severe (first degree 71-80 dB HL; second degree 81-90 dB HL) or profound hearing loss (first degree 91-100 dB HL; second degree 101-110 dB HL; third degree 111-119 dB HL). Additionally, a second PTA was calculated based on the norms by the *Bureau International d'Audiophonologie* (BIAP) as the mean of the thresholds at 500, 1000, 2000 and 4000 Hz. Moreover, a possible audiometric notch, reflecting a noise-induced threshold shift, was evaluated as present/absent using the criteria formulated by Niskar et al. (2001).

With distortion product otoacoustic emissions (DPOAEs), the integrity of the outer hair cells was measured using the ILO 292 USB II module and ILOv6 software (Otodynamics Ltd., Hatfield, United Kingdom). Probes were calibrated daily before commencing new measurements. Two pure tone frequencies were presented through a probe tip with a f2/f1 = 1.22 ratio at intensities of 65 dB SPL and 55 dB SPL for the first and second primary tone respectively and with f2 ranging from 841 to 10375 Hz. A noise artifact level of 6 mPa was used and measurements at individual frequencies were continued until the noise amplitude was below -5 dB SPL. The amplitude and signal-to-noise ratio (SNR) of the responses were assessed using an eight points per octave resolution for half-octave frequency bands with center frequencies of 1000, 1400, 2000, 2800, 4000, 6000, 8000, and 10000 Hz. The response was considered present with a SNR $\geq$ 6 dB.

As a final audiologic test, ES using contralateral acoustic stimulation (CAS) of transient evoked otoacoustic emissions (TEOAEs) was carried out using a method of fixed intensity according to Hood's recommendations (Hood, Berlin, Hurley, Cecola, & Bell, 1996). With ES, the inhibitory reaction on the outer hair cell motility was examined and so the functionality of the medial olivocochlear system. TEOAEs were measured using a linear stimulus paradigm with a stimulus rate of 50 clicks per second at 55 dB peSPL in a total of 260 sweeps. Only TEOAE responses, in the condition without CAS, with a SNR $\geq$ 3 dB were used in further analysis. Every 10 seconds, CAS of white noise at 60 dB peSPL was presented leading to response amplitudes with and without CAS for 1000, 1400, 2000, 2800, and 4000 Hz. The strength of ES was calculated by (a) a raw ES index (dB) and (b) a normalized ES index (%). The raw ES index (dB) is the difference in TEOAE response amplitude (dB) without and with CAS for every half-octave frequency. The normalized ES index (%) is the difference in TEOAE response amplitude (Pa) without and with CAS divided by the TEOAE amplitude without

CAS and multiplied by 100 (Keppler, Degeest, & Vinck, 2021). One participant had cerumen plugs in both ears and was therefore excluded from DPOAE and ES measurements (**Appendix 2**).

The vestibular test protocol consisted of cVEMP, oVEMP and vHIT to measure the function of the saccule, utricle and SCCs, respectively. Cervical VEMPs were conducted using Neuro-Audio equipment (version 2010, Neurosoft, Ivanovo, Russia). Potentials were measured through self-adhesive AG/AGCl surface electrodes placed on the participant's forehead (ground), halfway the m. SCM (positive) and on the sternum (negative). Before testing, the impedance between the skin and electrode had to be less than 5 kΩ, and between different electrodes it could not exceed 2 kΩ. During the test, the participant was in supine position with the head slightly lifted and turned away from the stimulated saccule to ensure accurate muscle tension. Before presenting the stimulus, a pre-measurement of 10.5 ms was conducted while the m. SCM was already in tension. During the monaural stimulation, a 500 Hz linear tone-burst stimulus starting at 95 dBnHL with alternating polarity was presented through insert-earphones (etymotic-ER-3) with a stimulus speed of 5,1 Hz, a rise/fall time of 1 ms, and a plateau of 2 ms. Each run contained 100 sweeps and was at least repeated once. Responses were considered present when the biphasic P1N1 waveform was reproducible. In this case, intensities were lowered by 10 dBnHL and increased by 5 dBnHL to determine the threshold. The bandpass filter was set from 10 to 1500 Hz and the response gain was amplified 5000 times. Cervical VEMP responses were interpreted by the absolute latency (ms) and interpeak corrected amplitude of the biphasic P1N1 waveform as well as by the thresholds (dBnHL). Besides the saccular function, with the cVEMP, also the functionality of the inferior vestibular nerve and the vestibulo-cervical pathway (Colebatch et al., 1994) were measured.

Ocular VEMPs, measuring the utricular functioning, the vestibulo-ocular reflex (VOR) and superior vestibular nerve (Curthoys, Vulovic, & Manzari, 2012), were also conducted using the Neuro-Audio equipment. Self-adhesive AG/AGCl electrodes were placed on the forehead (ground), on the inferior oblique muscle towards the lateral canthus (positive), and close to the medial canthus (negative) of the contralateral eye. Measurements could commence when reaching equal impedance values as described in cVEMP method. The participants had to look at least 30 degrees up during the test, to a marked spot on the ceiling. A binaural 500 Hz rarefaction tone-burst stimulus was presented through bone-conduction at 140 dB force level (FL) with a minishaker (type 4810, amplifier model 2706, Bruël & Kjaer P/L, Denmark), which was systematically held to the same place of the forehead by the investigator. The stimulus had a speed of 5,1 Hz and a rise/fall time and plateau of 2 ms. Each run contained 50 sweeps and was at least repeated once. Responses were considered present when the biphasic N1P1 waveform was reproducible. The bandpass filter was set from 20 to 500 Hz and the response gain was amplified 10000 times. Ocular VEMP responses were interpreted by the absolute latency (ms) and interpeak amplitude (µV) of the biphasic N1P1 waveform.

The vHIT was conducted using the ICS Impulse system (GN Otometrics, Taastrup, Denmark). With the vHIT, the SCCs, the VOR and depending on the tested canal, the high-frequency function of the superior (horizontal

and anterior canal) or inferior (posterior canal) vestibular nerve functioning were measured (Aw, Fetter, Cremer, Karlberg, & Halmagyi, 2001; Ulmer & Chays, 2005). Each participant was sitting, wearing ICS Impulse video-goggles and fixating a marked spot on the wall. A distance of 1,5 meters between the wall and the eyes of the participant was provided. Before the testing, a calibration of the goggles and computer software was conducted. During the vHIT, depending on the canals to be tested, the participant's head was quickly moved to the left and right (horizontal canals), up or down (anterior and posterior canals). Each hit had to be between 150-250°/s horizontally and between 120-250°/s vertically with an amplitude between 10-20°. Before cleaning and interpretation were possible, each canal was subjected to at least 25 decent hits. Overt and covert correction saccades were distinguished, as well as the gain parameter, which is ideally close to one.

STATISTICAL ANALYSIS

Statistical analysis was carried out using SPSS software (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp). All statistical analysis were performed two-tailed and statistical significance was concluded with a *p* value below 0.05.

First, descriptive parameters were calculated for all statistical relevant variables, followed by tests of normality (i.e. Shapiro-Wilk and QQ-plots). Second, for the between-group comparison of all outcome measures from the audiovestibular test battery and questionnaire, paired statistical analysis were performed (i.e. paired Student T tests, paired Wilcoxon tests, and McNemar tests). Statistical analysis from the questionnaire were often less reliable since many topics were incompletely filled in, resulting in an exclusion of these participants for that part of the questionnaire or else, the median was used in further calculations. Where applicable, a distinction was made between the left and right ear whereby both ears were separately analyzed (i.e. all audiovestibular outcome measure-related statistical analysis). Every analysis was supplemented with a comparison within the before-mentioned age-categories.

RESULTS

AUDITORY RESULTS

None of the participants showed indications of a middle ear pathology based on the results of otoscopy, tympanometry, ipsilateral ASR measurements, and pure tone audiometric thresholds. In both the NE- and C-group, one participant had a mild hearing loss in the right ear (27 dB HL and 25 dB HL, respectively), all other participants in both groups showed a normal hearing in both ears regarding the PTA FI. The mean outcome measures from the pure tone audiometry, high-frequency audiometry, DPOAE and ES measurements are presented in **Appendix 3**.

PURE TONE AUDIOMETRY AND HIGH-FREQUENCY AUDIOMETRY

Twenty-six of all 40 ears of the participants in the NE-group showed an audiometric notch; in the C-group, a notch was present in 13 ears. However, it was only for the right ear that the analysis showed a significant difference ($X^2(20)=0{,}0220$; $p=0.012$) between the NE- and C-group (**Appendix 4**). Two different pure tone averages (i.e. PTA FI and PTA BIAP) have been calculated for both the NE- and C-group (**Appendix 3**). Despite the higher PTA BIAP in the left and right ear of the NE-group, no statistically significant differences between the NE-participants and the controls were found in both the PTA BIAP, and the PTA FI ($p>0.05$). Neither was a significant difference obtained for the audiometric thresholds from 250 to 14000 Hz ($p>0.05$). Solely at 16000 Hz, the threshold was significantly more absent in the left ear of the NE-group ($X^2(20)=0{,}92$; $p=0.039$) compared to the C-group (**Appendix 4**). Also, the 16000 Hz threshold was left on average 9,25 dB HL and right 8,25 dB HL (95% *Confidence Interval (CI)*: left: 0,58 dB HL; 17,92 dB HL; right: 1,28 dB HL; 15,23 dB HL) higher in the NE-group compared to the C-group [left: $t(19)=2{,}234$; $p=0.038$; right: $t(19)=2{,}477$; $p=0.023$]. Moreover, the right 16000 Hz threshold in the youngest NE-group was on average 18,57 dB HL higher (95% *CI*: 2,62 dB HL; 34,53 dB HL) compared to the C-group [$t(6)=2{,}248$; $p=0.029$] (**Appendix 4**).

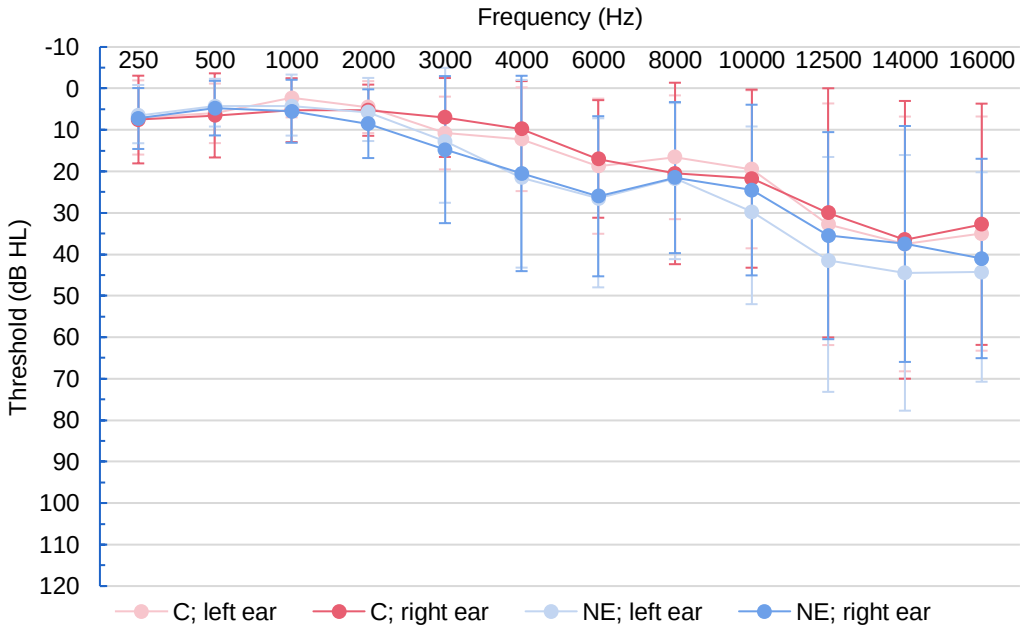

Figure 1: Representation of all mean hearing thresholds and standard deviations obtained through pure tone and high-frequency audiometry for both the noise-exposed (NE) and control (C) group.

DPOAE AND EFFERENT SUPPRESSION

Several participants had to be excluded for the analysis of DPOAE and ES measurements (**Appendix 3, Tables 11** and **12**), resulting in little to no paired data to obtain reliable statistical results. Only for the DPOAE amplitude of the right ears at 1500 and 2000 Hz, a statistical significance was found for the between-group analysis of the complete groups [1500 Hz: t(14)=2,233; *p*=0.042; 2000 Hz: t(12)=3,151; *p*=0.008] (**Appendix 4**). Both amplitudes were on average 5 dB SPL lower (95%*CI*: 1500 Hz: 0,18 dB SPL; 9,14 dB SPL; 2000 Hz: 1,40 dB SPL; 7,67 dB SPL) in the NE-group compared to the C-group. On all other DPOAE frequencies and all frequencies of the ES measurements, no significant differences in response amplitude were found for the complete groups. If analysis were possible within age-groups, they were also insignificant regarding the response amplitude.

VESTIBULAR RESULTS

In **Appendix 3**, an overview is given of the mean outcome measures from the cVEMP (i.e. amplitude, latencies, and threshold), oVEMP (i.e. amplitude and latencies), and vHIT (i.e. gain and saccades).

CERVICAL VEMP

In the NE-group, seven (17,5%) cVEMP responses were absent, which was slightly more than the five (12,5%) absent cVEMP responses in the C-group, yet there was no statistical significance in presence or absence of the cVEMP responses (*p*>0.05) (**Table 2**).

Table 2: Overview of the cVEMP presence in both the noise-exposed (NE) and control (C) group.

Outcome measures	Compared groups	NE		C	
		L	R	L	R
Amount of present responses	All participants	17	16	17	18
	18-33 years	7	7	7	7
	34-49 years	3	3	3	3
	50+ years	7	6	7	8

NE, noise exposure group; C, control group; L, left; R, right.

Regarding the cVEMP threshold for the right responses, a statistically significant difference was found between the NE-group and C-group in the 18 to 33 years age-category (*p*=0.015). The right cVEMP threshold in the youngest NE-participants was on average 6 dB nHL (95%*CI*: 1,55 dB nHL;9,88 dB nHL) higher than the cVEMP threshold of their counterparts in the C-group [t(6)=3,361, *p*=0.015] (**Figure 2, Appendix 4**). However, the difference in cVEMP thresholds between these two groups for the left response, showed no significant difference (*p*>0.05). Other between-group comparisons considering the cVEMP outcome measures for all participants or within age-categories, showed no statistically significant differences (*p*>0.05).

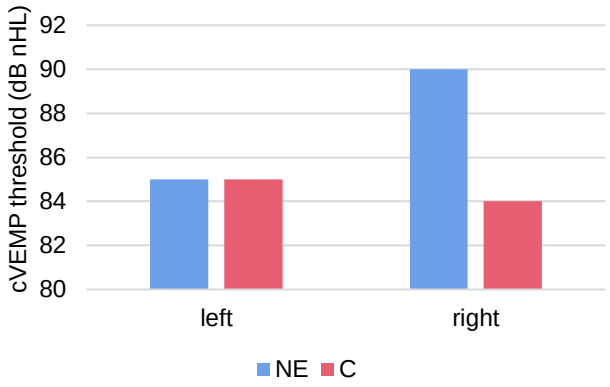

Figure 2: Overview of the mean threshold (dB nHL) of the left and right cVEMP responses for all noise-exposed (NE) and control (C) participants in the youngest age-category.

OCULAR VEMP

None of the between-group comparisons considering the oVEMP outcome measures showed a statistically significant difference (p>0.05). Moreover, descriptive statistical analysis showed no constant in what group (NE or C) showed on average considerably higher/lower amplitudes or shorter/longer latencies.

VIDEO HEAD IMPULSE TEST

A statistically significant difference was found in the youngest age-category for the horizontal and anterior vHIT gain (**Figure 3**). The right horizontal gain was higher (mean difference: 0,13) in the NE-group (95%*CI*: 0,02;0,23) compared to the C-group [t(6)=2,849; p=0.029]; The anterior gain was on average 0,20 higher for the right (95%*CI*: 0,07;0,34) and 0,14 higher for the left (95%*CI*: 0,04;0,24) measurement in the NE-group [right: t(6)=3,695; p=0.010; left: t(6)=3,301; p=0.016] (**Appendix 4**).

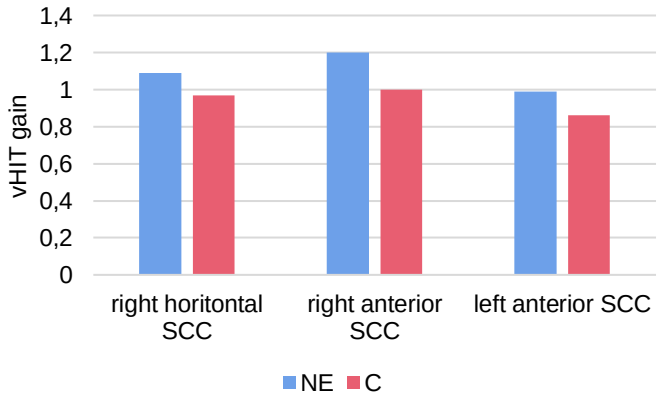

Figure 3: Overview of the mean gain of the right horizontal, right anterior, and left anterior vHIT responses for all noise-exposed (NE) and control (C) participants in the youngest age-category.

Considering the vHIT saccades, right horizontal overt saccades were significantly more often recorded in the NE-group compared to the C-group in both the comparison with all participants [t(19)=2,687; *p*=0.015] as in the comparison of the oldest age-category [t(9)=2,356; *p*=0.043] (**Appendix 4**). The amount of recorded overt saccades to the right in the between-group comparison including all participants, was on average 13% higher in the NE-group compared to the C-group (95%*CI*: 2,841%;22,859%), whereas this difference in the oldest age-category, was on average 15% (95%*CI*: 0,606%;29,794%). In both the left and right measurements of the posterior SCC, no statistically significant differences were obtained between the NE-group and C-group for both the response gain and recorded saccades (*p*>0.05). Moreover, none of the recorded saccades from the anterior SCC measurements showed significant differences (*p*>0.05). Despite no further statistically significant differences were found in the amount of recorded (c)overt saccades, in most measurements, the NE-group showed on average more saccades compared to the C-group (**Appendix 3**, **Table 15**).

RESULTS OF QUESTIONNAIRE

NOISE EXPOSURE HISTORY

Based on the responses from the questionnaire concerning the noise exposure history, two analysis of each participant's $L_{Aeq,I}$ were made (**Figure 4**). Considering different recreational and occupational activities in younger and older participants, comparisons were also made within age-categories between the NE- and C-group. First, regarding recreational noise exposure, a between-group comparison was made, resulting in no statistically significant differences for the complete groups, nor within the age-categories. When considering occupational noise exposure, a statistically significant difference was found in both the comparison between the complete groups and within the 50+ age-category. The occupational $L_{Aeq,I}$ for all NE-participants was on average 16 dB (95%*CI*: 2,53 dB;29,70 dB) higher than the exposure in the C-group [t(9)=2,683; *p*=0.025], and 22 dB (95%*CI*: 7,87 dB;37,02 dB) higher in the oldest age-group [t(4)=4,275; *p*=0.013]. (**Appendix 4**).

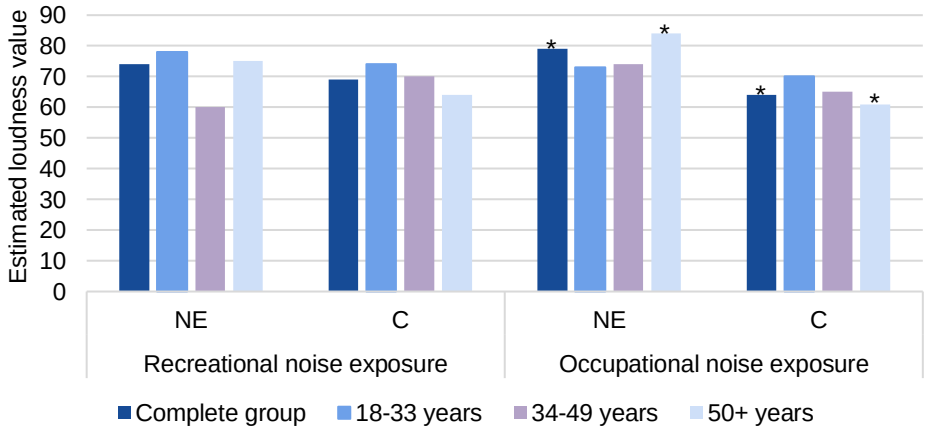

Figure 4: Overview of the recreational and occupational $L_{Aeq,I}$ values for the (NE) and control (C) group and within age-categories, with an asterisk (*) where significant between-group differences were obtained.

AUDIOLOGICAL SYMPTOMS

Table 3 provides an overview of the questioned subjective audiological symptoms and their occurrence within the NE- and C-group. In none of the audiological symptoms a statistical significant difference between both groups was found with McNemar analysis.

Table 3: Overview of auditory symptoms for both the noise-exposed (NE) and (C) group.

	Tinnitus		Hyperacusis		Ear fullness	
	Amount (n/20)	Percentage (%)	Amount (n/20)	Percentage (%)	Amount (n/20)	Percentage (%)
NE	6	30	2	10	2	10
C	5	25	3	15	2	10

NE, noise exposure group; C, control group; L, left ear; R: right ear.

VESTIBULAR SYMPTOMS

Three (15%) of the 20 NE-participants reported vestibular symptoms compared to nine (45%) in the C-group, obtained through the SOSTONED questionnaire. The presence of vestibular symptoms was therefore significantly higher in the latter ($X^2(20)=4{,}314$; $p=0.031$) (**Appendix 4**). In the NE-group, two of the participants who reported vestibular symptoms were subdivided in the youngest age-group, the third participant was 50 years or older. Five of the nine C-participants with vestibular symptoms were 18 to 33 years old, one participant was in the middle age-group and three were 50 years or older. **Table 4** gives an overview of all reported vestibular symptoms and accompanying possible triggers.

Table 4: Overview of all reported vestibular symptoms, their occurrence and possible triggers for both noise-exposed (NE) and control (C) participants.

Symptoms	How often reported		Triggers	How often reported	
	NE	C		NE	C
Dizziness	1	4	Head movement	1	2
Nausea	2	2	Turning in bed	1	
Vertigo	2	4	Looking upwards		3
Drunken feeling	1	1	Bending forwards/backwards		3
Disorientation	1		Laying down		1
Instability		1	Standing upright	1	4
Vomiting	1	1	Physical effort		2
Lightheadedness		2	Unstable ground		1
Swaying/rocking/bobbing	1		Car/plane trip		1
Lateropulsion		2	Fatigue	1	4
			Emotions		3
			Stress		3
			Medication		1
			Alcohol	1	4

NE, noise exposure group; C, control group.

HEARING-RELATED QUALITY OF LIFE

With the hAVICOP questionnaire concerning one's hearing-related quality of life for Auditory-Visual, Cognitive and Psychosocial functioning, a statistically significant difference was obtained for speech intelligibility in quiet. Noise-exposed participants scored themselves significantly lower on this subcategory compared to the C-group (Z=-2,244; p=0.025), which means they have significantly more often difficulties with speech intelligibility in quiet situations (**Table 5**; **Appendix 4**). Scores of speech intelligibility in noise could not be compared, as well as social functioning, the total score in auditory-visual functioning, and psychosocial functioning, since no responses were obtained for these categories by absence of the relevant questions in the questionnaire (**Appendix 6**). In further hAVICOP subcategories, no significant differences were found in the between-group comparisons (p>0.05). Nevertheless, NE-participants scored themselves on average lower on music perception, audiovisual functioning, working memory, selective attention, listening effort, psychological functioning, and the total score of cognitive functioning (**Table 5**). This could imply NE-participants having more difficulties for these subcategories compared to the controls.

Table 5: Overview of the scores on the different subcategories of the hAVICOP questionnaire from both the noise-exposed (NE) and (C) group.

Domain	Subcategory	Score Mean (SD)	
		NE	C
Auditory-visual functioning	Speech intelligibility in quiet	84,9 (21,44)	96,8 (5,77)
	Speech intelligibility in noise	/	/
	Music perception	90,1 (20,58)	92,67 (10,38)
	Localisation	89,0 (19,74)	85,8 (23,61)
	Audiovisual functioning	70,5 (35,69)	86,5 (21,78)
	Total score of auditory-visual domain	/	/
Cognitive functioning	Working memory	81,0 (22,77)	82,8 (19,92)
	Processing speed	83,5 (24,57)	83,4 (22,67)
	Selective attention	59,0 (36,15)	67,3 (27,22)
	Listening effort	77,5 (36,22)	79,8 (25,98)
	Total score of cognitive domain	77,6 (21,99)	79,9 (17,05)
Psychosocial functioning	Psychological functioning	86,7 (24,97)	95,1 (7,28)
	Social functioning	/	/
	Total score of psychosocial domain	/	/
Overall total score		*83,4 (16,03)*	*89,3 (9,35)*

NE, noise exposure group; C, control group; SD, standard deviation; /, no responses obtained.

ATTITUDE TOWARDS HEARING AND HEARING PROTECTION DEVICES

In the between-group comparison considering the BAHPHL questionnaire, no statistically significant differences were found in any of the subcategories (p>0.05). Moreover, descriptive statistical analysis (**Table 6**) showed no trend towards one of both groups with distinct differences in positive or negative attitudes towards hearing and HPD-usage.

Table 6: Overview of the scores on the different subcategories of the BAHPHL questionnaire from both the noise-exposed (NE) and (C) group.

	Score Mean (SD)	
	NE	C
Susceptibility to hearing loss	1,7 (0,63)	1,5 (0,47)
Severity of hearing loss	1,9 (0,85)	1,6 (0,55)
Benefits of preventive action	2,4 (0,47)	2,5 (0,47)
Behavioural intentions	2,0 (0,99)	2,2 (0,93)
Social norms	2,4 (1,20)	2,6 (0,95)
Self-efficacy	2,4 (0,82)	2,5 (0,70)
Barriers to preventive action	3,0 (1,11)	3,0 (0,58)
Total score	2,2 (0,54)	2,2 (0,39)

NE, noise exposure; C, control; SD, standard deviation.

NEUROLOGICAL SYMPTOMS

Lastly, considering neurological symptoms questioned with the NSC-60 and DNS, no statistically significant differences were obtained in the between-group comparison of the NE- and C-participants ($p>0.05$). In the NSC-60 responses, descriptively, no distinction could be made whether the NE- or C-group scored clearly higher on the subcategories tending towards more neurological complaints (**Table 7**), moreover, in the DNS questionnaire, both groups showed on average the same score of 0,26.

Table 7: Overview of responses on the different subcategories of the NSC-60 questionnaire from both the noise-exposed (NE) and (C) group.

Subcategory	Score Mean (SD)	
	NE	C
Memory difficulties	1,9 (0,59)	2,0 (0,55)
Chest complaints	1,3 (0,42)	1,4 (0,49)
Equilibrium	1,2 (0,39)	1,3 (0,41)
Sleeping difficulties	2,2 (0,67)	1,9 (0,67)
Neurotoxicity	1,7 (0,43)	1,8 (0,42)
Mood changes	1,8 (0,52)	1,8 (0,60)
Sensorimotor complaints	1,3 (0,46)	1,4 (0,40)
Somatic complaints	1,8 (0,62)	1,9 (0,47)
Fatigue	1,9 (0,55)	1,9 (0,66)

NE, noise exposure; C, control; SD, standard deviation.

DISCUSSION

The aim of the current study was to explore the effect of occupational noise exposure on the audiovestibular function in adults. As expected, NE-participants reported higher professional $L_{Aeq,l}$ values compared to controls, yet recreational $L_{Aeq,l}$ values were more or less the same. Moreover, except for one ear in one participant in both groups with a mild hearing loss, all participants had a normal hearing as evaluated with the PTA FI. In further discussion, the main focus will be on the vestibular results considering NIVL. Despite literature agrees that the saccule seems to be the most vulnerable part of the vestibular organ to noise-induced damage (Stewart et al., 2020), in the past, researchers made conflicting conclusions regarding the results on the cVEMP in NE-employees. Additionally, also noise-induced utricular damage and damage to the SCCs have been reported (Emara & Gabr, 2014; Ismail, Behairy, Galhom, & Metwally, 2021; Tseng & Young, 2012; Yilmaz et al. 2018), yet no consensus exists on how NIVL manifests itself in oVEMP or vHIT measurements. Moreover, little is known about possible noise-induced (sub)clinical vestibular symptoms and whether or not a relation exists between vestibular damage and employees' hearing(loss).

NOISE-INDUCED VESTIBULAR LOSS

For each part of the vestibular organ, one or more non-invasive and relatively fast tests exist. Within the current study, a vestibular test-battery with cVEMP, oVEMP and vHIT measurements was performed in order to investigate the effect of occupational noise exposure on the function of the entire vestibular organ. To the best of my knowledge this was the first study in which the entire vestibular organ was measured out in terms of sensitivity to noise induced damage with this specific vestibular test-battery.

SACCULAR FUNCTION

Within the NE-group, seven (18%) of the cVEMP responses were absent. In most previous research, the absence was around 30% or more (Abd El-Salam et al., 2017; Akin et al., 2012; Dalgıç, Yılmaz, Hıdır, Satar, & Gerek, 2015; Giorgianni et al., 2015; Ismail et al., 2021; Kumar, Vivarthini, & Bhat, 2010; Tseng & Young, 2013; Viola et al., 2020; Wang & Young, 2007), however, these studies were in participants with established NIHL. In NE-participants with no NIHL at all, Emara and Gabr (2014) described an absence in only 5% of the cVEMP responses. Despite the more or less corresponding percentage in absence regarding the heterogeneity of NIHL in the current NE-group, no significant difference was found in cVEMP presence compared to the C-group, since five (13%) cVEMP responses in this latter group were absent as well. As the saccule tends to be less sensitive with increasing age (Maes et al., 2010), this could be a plausible explanation to absent cVEMP responses, since the majority of participants were divided in the oldest age-category (mean age within oldest age-category: NE-group: 54,8 years; C-group: 55,1 years). However, cVEMP responses are expected to be more often absent starting around the age of 65 years (Maes et al., 2010), while the oldest participants were 60 years in the NE-group and 62 years in the C-group. Additionally,

absent cVEMP responses in the controls could suspect that they were not free from noise-induced damage, possibly resulting from deleterious recreational noise exposure in the past.

Considering cVEMP outcome measures, a significant difference was found in the threshold of the right saccule in the youngest age-category. Noise-exposed participants from 18 to 33 years had a significantly higher cVEMP threshold compared to the youngest controls. Although Blakley and Wong (2015) proposed to primarily evaluate the cVEMP threshold before other outcome parameters in clinical practice, merely in two other studies in the past, the cVEMP threshold had been described as a deviating parameter in NE-participants (Akin et al., 2012; Viola et al., 2020). First, Akin et al. (2012) reported an increased cVEMP threshold of 115 dB SPL in the poorer- and 117 dB SPL in the better-hearing ear of NE-military employees with asymmetric hearing loss, compared to a mean threshold of 111 dB SPL in 14 matched controls with a normal hearing and no history of military noise exposure. Furthermore, Viola et al. (2020) found no cVEMP responses at 100 dB SPL in any of the 25 NE-participants, which was significantly different from patients with sensorineural hearing loss, in which only two responses could not be obtained at this intensity. Decreases in cVEMP sensitivity to noise stimuli in NE-individuals should therefore be attributed to noise-induced vestibular damage instead of possible cochlear insults. More specifically, it presumes saccular noise-induced damage. In both the study of Akin et al. (2012) and Viola et al. (2020), participants had to sit upright during the examination instead of lying in supine position with a tilted head for sufficient tension in the m. SCM. Despite supine testing has high cVEMP response rates (Shahnaz & David, 2021) and is commonly used in the vestibular lab where all cVEMP measurements happened, the supine position may cause discomfort and fatigue for the participants (Isaradisaikul, Navacharoen, Hanprasertpong, & Kangsanarak, 2012). Therefore, the test position in future research should be reconsidered regarding the extensive cVEMP measurements for threshold determination. Moreover, in both previous researches, another decibel unit was adapted compared to the current study (i.e. dB SPL vs. dB nHL) (Akin et al., 2012; Viola et al., 2020). Consequently, the reported increases in cVEMP thresholds in previous research should not be compared to differences in thresholds from the current study.

Generally, the saccule is hypothesized as the most vulnerable part of the vestibular organ to noise because of the following reasons. First, the saccule lays closest to the cochlea, making its macula most susceptible to pressure changes induced by stapes movements following noise exposure (Stewart et al., 2016). Second, sound pressure waves following impulse noise in otolith organs cannot be divided as equally as in the SCCs, leaving higher pressure chances to the maculae compared to the cristae in the SCCs and so, potentially more damage (Perez, Freeman, Cohen, & Sohmer, 2002). Third, the sensory epithelium of the saccule seems more vulnerable to the deleterious effect of ROS, since they cannot easily migrate through the ML, leaving higher concentrations in the pars inferior (Hara & Kimura, 1993). Lastly, compared to the utricle, the saccular macula has considerably more amphora-shaped type I hair cells, which are predominantly innervated by irregular calyx-only afferents (Goldberg, 2016). The specific encapsulation by calyx-only afferents causes a higher vulnerability to excitotoxicity, since excessively released neurotransmitters

(glutamate) cannot be efficiently reabsorbed by surrounding support cells, causing synaptic overstimulation (Sedó-Cabezón, Boadas-Vaello, Soler-Martín, & Llorens, 2014). As a result of ototoxicity, a third type of hair cell damage may occur besides necrosis and apoptosis. Just as apoptosis, extrusion is a phenomenon in the vestibular organ, which minimizes local damage and inflammation, preserving tissue integrity. However, different from apoptosis resulting from sub-acute low-dose toxic exposure, extrusion is a resultant from sub-chronic low-dose exposure to ototoxic substances (Sedó-Cabezón et al., 2014). Although vestibular extrusion after noise exposure has not been described yet, the chronic, low-dose character of occupational noise exposure, suspects this type of cell death in NE-employees.

Regarding the cVEMP latencies and amplitudes, no significant differences could be obtained in the current study. Nevertheless, multiple previous researchers have reported—albeit conflicting—significant results when comparing these outcome measures in NE-participants to controls. Cervical VEMP latencies are often reported as delayed in the NE-group, whereas the cVEMP amplitude is frequently significantly decreased in this group (Abd El-Salam et al., 2017; Emara & Gabr, 2014; Giorgianni et al., 2015; Ismail et al., 2021; Kumar et al., 2010; Tseng & Young, 2013; Wang & Young, 2007). Differences in outcome with other studies may be related to the sample size, the fact that often NIHL instead of reported noise exposure was used as inclusion criterion, and methodological differences (i.e. sitting upright instead of supine position, not focusing on thresholds, other electrode placements...).

Within the youngest age-category of this study, no between-group differences were found considering auditory noise-induced damage, except for the right 16000 Hz pure tone threshold, which was higher in the NE-group compared to the C-group. Moreover, the self-reported $L_{Aeq,l}$ was more or less the same in both groups. Yet, possible noise-induced saccular damage was obtained. This finding suggests that (I) occupational noise exposure may be deleterious to the vestibular organ, also in the first years of work; and (II) supports previous research suggesting that saccular damage may occur before cochlear damage is present or measurable in a classical clinical setting, which presumes that both cVEMPs and high frequency audiometry could indicate early noise-induced damage (Abd El-Salam et al., 2017; Alqudah, 2019; Mehrparvar et al., 2014 Raghunath et al., 2012; Vetter, 2015). Therefore, cVEMPs are of high potential to add within preventive audiovestibular screening. The side-dominance in significance to the right ear could confirm that besides the cochlea, also the saccule to one side is more vulnerable to damage based on a person's hand-preference (Hong, Kerr, Poling, & Dhar, 2013). However, the cVEMP responses reported by Akin et al. (2012), showed on average slightly lower thresholds in the worse ear regarding the PTA in military employees with asymmetrical hearing loss. Side differences in cochlear damage should therefore not ultimately vouch for equal side differences in vestibular damage.

Additionally, in the oldest age-category in fact, no significant differences were found for any of the cVEMP outcome measures. However, it was in this category that the $L_{Aeq,l}$ of the NE-participants was significantly higher compared to the controls. The absence of significant differences could be attributed to influencing

age-effects in both the NE- and C-participants. Maes et al. (2010) described decreasing amplitudes and increasing thresholds in cVEMP measurements with increasing age, starting around the age of 55 years. Possible age-effects could therefore make the cVEMP less sensitive in detecting noise-induced saccular damage in older NE-employees. Furthermore, the absence of significant differences in the oldest age-category could also possibly be related to deleterious noise exposure in recreational activities. More specifically, legislations concerning maximum allowed noise levels and the obligatory provision of HPDs in recreational activities have not always existed (VLAREM II, 1995). Therefore, loud recreational activities from the past may have damaged the saccule in controls. Consequently, the sole effects of occupational noise exposure in the NE-group, without mandatory NIHL in the recruitment, were possibly masked in the current study.

UTRICULAR FUNCTION

No significant differences were found considering any of the oVEMP outcome measures. Nevertheless, within the only three studies concerning utricular damage in humans, possible noise-induced effects were reported (Emara & Gabr, 2014; Ismail et al., 2021; Tseng & Young (2013). Tseng and Young (2013) reported nine reduced and 11 absent responses, making a total of 33% abnormal oVEMP responses in their participants with NIHL. Similarly, in the subgroup of 20 NE-participants with established NIHL, Emara and Gabr (2014) recorded 40% absent oVEMP responses. Lastly, Ismail et al. (2021) compared 60 ears of participants with NIHL to 60 ears of 30 normal hearing participants, in which they found significantly delayed latencies and reduced amplitudes in the former studied group. From all participants with NIHL, abnormal oVEMP responses were reported in 34 ears of them.

The utricle is assumed to be protected from deleterious noise-induced substances such as ROS because of the ML (Hara & Kimura, 1993). Moreover, less type I hair cells are present in the macula of the utricle compared to the saccule which makes it possibly less vulnerable to glutamate excitotoxicity (Goldberg, 2016). Moreover, it has been argued in the past that smaller or absent oVEMP responses might result from both insufficient utricular innervation as well as poor saccular activation or saccular lesions (Rosengren, Govender, & Colebatch, 2011; Tseng & Young, 2013). This might be due to a partially common innervation through the superior vestibular nerve of all the utricular afferents and some anterior saccular afferents (De No, 1933).

The results of the current study should however be interpreted with caution and do not indicate exemption of noise-induced utricular damage. First, as stated before, noise-induced effects within the current NE-group are possibly lower compared to a group only consisting of participants with NIHL. Emara and Gabr (2014) did in fact conclude that vestibular damage was more likely measurable in persons with NIHL in their research compared to NE-participants without NIHL. Additionally, slightly different measurement techniques were used as Emara and Gabr (2014) and Ismail et al. (2021) used air conduction (AC) stimuli presented through

earphones instead of bone conduction (BC) stimuli in the current study. Previous research has argued that oVEMPs measured with BC stimuli have larger amplitudes and are more often present in healthy participants (Vanspauwen, Wuyts, Krijger, & Maes, 2017). Therefore, differences between the current results and previously described smaller or absent oVEMP responses might have been influenced by the stimulus type, in which a bigger response from BC stimuli might have masked possible subtle noise-induced effects. In contrast to cVEMP responses however, oVEMP responses conducted through BC stimuli seem to be less vulnerable to aging effects (Vanspauwen et al., 2017). Therefore, age seems to be of no influence considering the oVEMP responses in this study. Lastly, it has to be noticed that a minishaker was used of which the pressure to the skull was related to the given tension by the investigator, which might have influenced the results as well.

SEMICIRCULAR CANAL FUNCTION

In the current study, a significantly higher vHIT gain was found in the right horizontal and both the right and left anterior canals in NE-participants from the youngest age-category. This is in contrast with the research by Yilmaz et al. (2018) in which a reduction in vHIT gain for the horizontal and anterior canals in participants with NIHL was described. However, the current results should be interpreted with caution as all three gains differed on average with only 0,13, 0,20, and 0,14 respectively, from the gain of the C-group. Moreover, deleterious noise-effects were probably higher in the study of Yilmaz et al. (2018), since they again specifically included participants with NIHL whereas in the current study, the presence of occupational noise exposure was sufficient as inclusion criterion.

Considering the right horizontal vHIT measurements, both in the complete NE-group as well as in the oldest age-category, overt saccades were significantly more often recorded compared to the C-group. From all three SCCs, these results seem to vouch for most noise-induced damage to the horizontal SCCs, which is in accordance with the conclusions by Yilmaz et al. (2018) who attributed most noise-induced vulnerability to these canals as well. Moreover, this finding is partially in accordance with the findings by Stewart et al. (2016) who described stereocilia loss in both the horizontal and anterior SCCs of noise-exposed rats. For the posterior SCCs, least noise-induced vulnerability was described by Stewart et al. (2016). In the current study, the amount of (c)overt saccades was higher in the NE-group in most of the other vHIT measurements. However, without reaching further significant differences compared to the C-group, it is impossible to draw strong conclusions considering the vulnerability of the anterior and posterior SCCs to noise.

Until now, Yilmaz et al. (2018) have been unique in describing noise-induced damage in human SCCs. Despite most researchers believe the SCCs are least sensitive to noise exposure by reason of their positioning behind the ML (Hara & Kimura, 1993) and the possibility of sound energy to divide equally in the canals leaving less mechanical damage (Perez et al., 2002), reasonable hypotheses suspect a vulnerability of the SCCs. Although the ML delays diffusion of deleterious substances (Hara & Kimura, 1993), chances

are that e.g. ROS may cause damage to the SCCs, albeit slower or less than in the saccule. Moreover, the type I hair cells of the SCCs seem to be histologically more susceptible to toxic insults compared to those in the otolith organs (Nakashima, Teranishi, Hibi, Kobayashi, & Umemura, 2000; Van Hecke, Van Rompaey, Wuyts, Leyssens, & Maes, 2017). Since noise may be vestibulotoxic too, this could be a valid argument to further investigate the SCC functioning in NE-persons. Especially in older NE-individuals, in which noise-induced effects might be more widespread, vHIT measurements could be of value in screening for NIVL, since cVEMP responses become less reliable with increasing age (Maes et al., 2010).

Within the current study, the entire vestibular organ was measured. Nevertheless, with caloric and rotation testing, also the low- and mid-frequency functioning of the SCCs could have been investigated besides the high-frequency functioning as measured with the vHIT (Vallim, Gabriel, Mezzalira, Stoler, & Chone, 2021; Wuyts, Furman, Vanspauwen, & Van de Heyning, 2007). The purpose of the study was to develop a portable and usable vestibular test-battery which could be implemented at location during vestibular screenings for NE-employees. Therefore, only the vHIT was implemented to evaluate SCC functioning, supported by the fact that the most vulnerable irregular calyx-only afferents, innervating the type I hair cells, encode best for high-frequency and high-acceleration head movements (Hullar et al., 2005). Nevertheless, caloric and rotation testing have been performed in NE-participants, albeit with mixed results. Weak and abnormal caloric responses have already been reported in previous research, of which most deviations were found within participants with higher levels of NIHL (Ali, El-Maraghy, Ahmed, & Mohany, 2019; Emara & Gabr, 2014; Soylemez & Mujdeci, 2020; Tseng & Young, 2013). Shupak et al. (1994) found lower slow component velocities and an overall lower caloric response in persons with NIHL, but their results reached no significance. Moreover, Wang and Young (2007) did not find significant changes in the caloric test in persons with NIHL. Also in the study of Shupak et al. (1994), a significantly lower VOR gain was reported in participants with NIHL after submitting them to the rotation test. However, in analogy with Akin et al. (2012), they did not find abnormal phase and asymmetry values, supporting the role of central compensation (Shupak et al., 1994). Moreover, Akin et al. (2012) found normal rotation test VOR gain values.

VESTIBULAR SYMPTOMS

Symptoms of vestibular dysfunction can roughly be divided in two categories. First, directly resulting from impaired vestibular reflexes (i.e. vestibulo-ocular, -cervical and -spinal reflex), individuals may experience motion-related symptoms (Halmagyi et al., 2010; Staab et al., 2017; Strupp et al., 2016). In contrast to the nine participants in the C-group, only three NE-participants reported these symptoms, including: dizziness, nausea, vertigo, drunken feeling, disorientation, lightheadedness, and swaying, rocking or bobbing. However, their symptoms were clearly related to other underlying factors such as migraine, neck surgery and alcohol usage, which prudently excludes noise-induced vestibular symptoms in the current NE-group. In the past, symptoms of dizziness, vertigo, lightheadedness, nausea, vomiting, and instability have been reported in NE-participants (Abd El-Salam et al., 2017; Akin et al., 2012; Dalgıç et al., 2015; Emara & Gabr, 2014; Ogido,

Costa, & Machado, 2009; Wang & Young, 2007). Some studies have shown abnormal cVEMP responses more often in participants with both NIHL and vestibular symptoms (i.e. imbalance, dizziness and vertigo) compared to participants with solely NIHL (Abd El-Salam et al., 2017; Dalgıç et al., 2015). About half of the participants reporting dizziness in the study of Akin et al. (2012) showed deviations in cVEMP responses, whereas the other half had normal responses. Nevertheless, it should be remarked that besides the vestibular organ, vision, and proprioception, also the auditory function is responsible for balance to a certain extent (Vitkovic, Le, Lee, & Clark, 2016). Therefore, vestibular symptoms in a group of individuals with NIHL might be resultant from hearing loss as well (Soylemez & Mujdeci, 2020). Furthermore, there have also been studies in which no vestibular symptoms were reported, yet established vestibular loss in objective vestibular tests (Soylemez & Mujdeci, 2020; Viola et al., 2020; Yilmaz et al., 2018).

Secondly, persons with a vestibular dysfunction may experience inconveniences related to cognitive overload from compensating for the impaired vestibular reflexes and by reason of impaired vestibulo-hippocampal pathways (Brandt et al., 2005; Danneels, Van Hecke, Leyssens, et al., 2020). Therefore, in the current study, a frantic attempt has been made to report cognitive vestibular symptoms in the NE-group. Some sub-categories in the NSC-60 questionnaire could be related to cognitive complaints evoked by vestibular damage (i.e. memory difficulties, mood changes, and fatigue). However, statistical analysis of this questionnaire showed no extreme deviations at any of the sub-categories, nor did the outcome differ significantly between the NE- and C-group. Generally, cognitive vestibular symptoms in NE-employees have not yet been specifically investigated in previous research. Only Tseng and Young (2013) reported headaches in 33% of their 30 participants with NIHL, however, made no further link with possible noise-induced vestibular damage. Nevertheless, research in individuals with NIHL, apart from investigating vestibular damage, have yet reported cognitive symptoms. For example, in a recent systematic review by Yadav et al. (2021) concerning occupational NIHL in fish harvesters, headaches, fatigue, depression, and anxiety were described (Yadav, Sarkar, Shan, Rahman, & Moro, 2021). These symptoms might be a resultant from NIVL, especially since symptoms of dizziness were reported as well. Considering both motor and cognitive insults, Soylemez and Mujdeci (2020) have submitted 75 NE-individuals to different dual-task conditions in which both the motor and cognitive functioning of the participants were tested. Three groups were created, one with participants with the highest degree of NIHL, one with participants with a lower degree of NIHL, and one with NE-participants without NIHL. Besides having worse vestibular test results, those with the worse hearing loss from the NIHL-participants, performed reportedly worse in the dual-task situations in which a time-up-and-go test was combined with a backward digit span test (motor-cognitive dual-task) or carrying a glass of water (motor-motor dual-task) (Soylemez & Mujdeci, 2020).

The results of the current study could exclude noise-induced vestibular symptoms in noise-exposed individuals. Consequently, for the youngest NE-participants in which saccular vulnerability is suspected, and for the oldest NE-participants in which possible noise-induced damage to the horizontal SCCs was found, the abovementioned findings could be proof of noise-induced hidden vestibular loss as described by

Soylemez and Mujdeci (2020). On the other hand, for NE-participants without vestibular symptoms and normal vestibular test results, vestibular measurements were possibly insensitive in distinguishing NIVL from other confounding factors. In this case, damage could be referred to as NIHVL as described by Le et al. (2017). Within the scope of the current study, it would be inappropriate to make statements regarding the proper NIHVL interpretation. Future research should unambiguously search for noise-induced vestibular symptoms and possibly develop more sensitive diagnostic tools for NIVL-detection. Until then, both interpretations are considerable.

AN IMPETUS TO FUTURE BALANCE CONSERVATION PROGRAMS

Independently of existing disabling vestibular symptoms, NE-employees are in danger of NIVL and could therefore get involved in work-related accidents. Employees often have to perform dual-tasks during work time. Not surprisingly, these tasks have been indicated as potentially more risky to falls and accidents compared to solely motor or cognitive tasks (Soylemez & Mujdeci, 2020). Especially situations in which the vision or proprioception are unable to compensate for the loss of input by the vestibular organ, create a considerable risk (Shupak et al., 1994). Although some researchers made the need for vestibular screening and prevention in NE-employees explicit (Emara & Gabr, 2014; Viola et al., 2020; Yilmaz et al., 2018), prevention towards NIVL is currently non-exiting. Soylemez and Mujdeci were in 2020 the first and only ones to make proposals to protect NE-employees from vestibular damage and so from work-related accidents. They observed worse cognitive-motor dual-task performances in their studied group with the worst degrees of NIHL, in which the cognitive task got prioritized resulting in a changed walking-speed compared to the baseline motor-task condition (Soylemez & Mujdeci, 2020). The fact that the NE-participants prioritized the cognitive task, creates a possible higher risk for motor-task failure and consequently, possibly more accidents during work-time. Therefore, Soylemez and Mujdeci (2020) emphasized the importance of vestibular screening in NE-employees, in which they would perform a vestibular test-battery combined with dual-task evaluations. Moreover, they suggested evaluating the work environment, besides the obligated noise-levels, to possible increased falling risks with vestibular problems.

Just as in the prevention of noise-induced cochlear damage, prior concerns in avoiding NIVL must be laid in mitigating noise-levels to which NE-employees get exposed by engineering and administrative controls (Franks, Stephenson, & j Merry, 1996). Therefore, future research should determine the safe daily-dose levels of noise exposure without risks of NIVL. Prior in future research, it should be determined what vestibular test(s) are sensitive in detecting NIVL and how it could be implemented in current hearing conservation programs. Based on the current study, both the cVEMP and vHIT might be of added value for screening programs, however, the potential of oVEMPs and possibly other vestibular tests should be further explored. Thereafter, in work environments where the mandatory limiting noise-levels are infeasible or insufficient in preventing NIHL and NIVL, employees must be enrolled in hearing and balance conservation programs. Besides providing HPDs, giving counseling and education, and conducting hearing screening,

employers must subject their NE-employees to a vestibular screening, supplemented with education and counseling concerning fall-risks and vestibular symptoms. Furthermore, seeing the potentially deleterious effects of recreational noise exposure to the audiovestibular apparatus, a baseline measurement of the vestibular function should be performed in novice employees in order to provide proper follow up of the sole effects of occupational noise exposure to the cochlea and vestibular organ.

STRENGTHS AND SHORTCOMINGS

The current study was performed as a pilot study, providing a basis for further extensive research on the topic of NIVL. A major strength of this study was the implementation of different vestibular tests to create more clarity considering the vulnerability of the entire vestibular organ. Moreover, this study was the first to combine an extensive audiovestibular test-battery to concrete proposals for future hearing and balance conservation programs.

Since this was a pilot study, only a limited number of NE-participants were examined. Furthermore, there was a high heterogeneity within the 20 studied NE-participants. There was a big variation in the amount of work years and the exact amount of noise exposure remains unknown since it was impossible to measure all daily noise-levels within the protocol of this pilot study. Moreover, the heterogeneity was also obvious in the differences in NIHL. If NE-participants had noise-induced auditory damage, it remained within normal values concerning the PTA FI. Nevertheless, the more NIHL, the more previous research reported vestibular abnormalities. Despite NIVL is expected to occur before NIHL (Abd El-Salam et al., 2017; Alqudah, 2019; Raghunath et al., 2012; Vetter, 2015), one suspects increasing vestibular damage with increasing auditory damage (Abd El-Salam et al., 2017; Ylikoski, Juntunen, Matikainen, Ylikoski, & Ojala, 1988), which makes NIVL more easily measurable in persons with established moderate to severe NIHL. In that case, currently used vestibular tests might be not sensitive enough to determine early vestibular damage, and should be further investigated. Unfortunately, no proposals were found in previous research for other or new measurement techniques in the search for early NIVL.

It should not be neglected that there was an unequal distribution in terms of gender and age. Only two noise-exposed females signed up for participation, which makes it unequal compared to the 18 male participants. This distribution however, is in line with the gender division in industrial work environments, mainly comprising male employees. Moreover, several females dropped out of the recruiting process because of child-related issues. Considering age, the majority of participants was 50 years or older. An important reason for this unequal distribution lies in the convenience and chain-referral sampling method. Due to this method, results cannot be generalized to the entire population of NE-employees as the sample was probably not representative for this whole population (Van Borsel, 2019). Furthermore, the current sample mainly comprised NE-employees from industrial work environments. Nevertheless, also other professions create a considerable risk for excessive noise exposure such as: dentistry, musicians, public safety, and the military

(Al-Omoush et al., 2020; Basner et al., 2014; Davis & Clavier, 2017; Pouryaghoub, Mehrdad, & Pourhosein, 2017). In order to protect individuals practicing these professions as well from NIHL and NIVL, it should be explored what effects noise sources other than continuous noise, such as impulse noise and music may have on the cochlear and vestibular functioning.

Lastly, recreational noise exposure might have been a confounding factor within this study. Since recreational noise exposure is unavoidable in both young and older individuals, it would be of high value in future research to determine the effects of recreational noise exposure to the vestibular organ before attributing deleterious noise-effects to the vestibular organ solely to occupational noise exposure.

CONCLUSION

The current study was set up as a pilot study that showed small-scale, yet promising results regarding the detection of NIVL in NE-employees and made novel recommendations for necessary screening programs. Occupational noise exposure might result in saccular damage and damage to the semicircular canals. For young NE-individuals, the cVEMP can distinguish noise-induced saccular insults. Additionally, this study proved that the vHIT might be of added value in screening for NIVL, especially in older NE-participants whose saccular sensitivity decreases with increasing age. No evidence could be found for noise-induced utricular damage. However, seeing the current small-scale study design, oVEMP measurements should be implemented as well in future attempts towards NIVL diagnosis.

No vestibular symptoms could be directly linked to NIVL, therefore a cautious statement could be made about NIHVL in terms of measurable damage with absent symptoms due to central compensation. Nevertheless, the existence of possible noise-induced vestibular symptoms (both motor and cognitive) cannot be ruled out and it is up to future research to define any symptoms and explore possible more sensitive vestibular tests.

Whether or not existing, a possible relationship between NIVL and NIHL remains unclear. Yet, some statements within this study tend to early NIVL before measurable NIHL. This matter should be further explored, but could be an onset of the development of hearing and balance conservation programs and a fundamental base for counseling and education for all stakeholders in the prevention and protection of noise-induced hearing and vestibular loss.

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Prof. Dr. Leen Maes
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Ons kenmerk	**Uw kenmerk**	**datum**	**pagina**
BC-10113	NVT	14/07/2021	1/3

Betreft : Advies voor monocentrische studie met als titel:

"Het effect van lawaaiblootstelling op de audiovestibulaire functie bij volwassenen. Scriptie Lena Van den Boscche"

B.U.N.: B6702021000470

* Adviesaanvraagformulier dd. 28/4/2021 Document D (volledig ontvangen dd. 05/05/2021)
* Begeleidende brief dd. 5/5/2021
* Patiëntenmateriaal: Versie 4 dd. 26/4/2021
  Flyer voor studie- en controlepersonen
  Oproep voor deelnemers sociale media
* Rekruteringsmateriaal: Begeleidende brief voor de deelnemers Versie 3 dd. 10/2/2021
* Vragenlijsten: voor deelnemers Versie 9 dd. 27/4/2021
* CV: Lena Van den Bossche
* Antwoord onderzoeker ontvangen. dd. 30/6/2021

BOVENVERMELDE DOCUMENTEN WERDEN DOOR HET ETHISCH COMITÉ BEOORDEELD. ER WERD EEN POSITIEF ADVIES GEGEVEN OVER DIT PROTOCOL OP 13/07/2021 . INDIEN DE STUDIE NIET WORDT OPGESTART VOOR 13/07/2022, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INGEDIEND WORDEN.

Vooraleer het onderzoek te starten dient contact te worden genomen met HIRUZ CTU (09/332 05 00).

THE ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE.A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 13/07/2021. IN CASE THIS STUDY IS NOT STARTED BY 13/07/2022, THIS ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.

Before initiating the study, please contact HIRUZ CTU (09/332 05 00).

° *Het Ethisch Comité werkt volgens 'ICH Good Clinical Practice' - regels*
° *Het Ethisch Comité beklemtoont dat een gunstig advies niet betekent dat het Comité de verantwoordelijkheid voor het onderzoek op zich neemt. Bovendien dient U er over te waken dat Uw mening als betrokken onderzoeker wordt weergegeven in publicaties, rapporten voor de overheid enz., die het resultaat zijn van dit onderzoek.*
° *In het kader van 'Good Clinical Practice' moet de mogelijkheid bestaan dat het farmaceutisch bedrijf en de autoriteiten inzage krijgen van de originele data. In dit verband dienen de onderzoekers erover te waken dat dit gebeurt zonder schending van de privacy van de proefpersonen.*
° *Het Ethisch Comité benadrukt dat het de promotor is die garant dient te staan voor de conformiteit van de anderstalige informatie- en toestemmingsformulieren met de nederlandstalige documenten.*

ALGEMENE DIRECTIE
Commissie voor Medische Ethiek

VOORZITTER:
Prof.dr. P. Deron

SECRETARIS
Prof.dr. R. Peleman

INGANG 75
ROUTE 7522

° *Geen enkele onderzoeker betrokken bij deze studie is lid van het Ethisch Comité.*
° *Alle effectieve leden van het Ethisch Comité, of hun plaatsvervangers,hebben dit project beoordeeld. (De ledenlijst is bijgevoegd)*
° *The Ethics Committee is organized and operates according to the 'ICH Good Clinical Practice' rules.*
° *The Ethics Committee stresses that approval of a study does not mean that the Committee accepts responsibility for it. Moreover, please keep in mind that your opinion as investigator is presented in the publications, reports to the government, etc., that are a result of this research.*
° *In the framework of 'Good Clinical Practice', the pharmaceutical company and the authorities have the right to inspect the original data. The investigators have to assure that the privacy of the subjects is respected.*
° *The Ethics Committee stresses that it is the responsibility of the promotor to guarantee the conformity of the non-dutch informed consent forms with the dutch documents.*
° *None of the investigators involved in this study is a member of the Ethics Committee.*
° *All effective members of the Ethics Committee, or their representatieves, have reviewed this project. (The list of the members is enclosed)*

Namens het Ethisch Comité / On behalf of the Ethics Committee

Prof. dr. P. Deron
Voorzitter / Chairman

CC: UZ Gent – HIRUZ CTU
FAGG - Research & Development; Victor Hortaplein 40, postbus 40 1060 Brussel

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Ledenlijst op 13/07/2021

Voorzitter: Prof. dr. P. Deron
Secretaris: Prof. Dr. R. Peleman

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De beoordeling gebeurt door de effectieve leden. Indien een effectief lid niet kan beoordelen, gebeurt de beoordeling door zijn/haar plaatsvervangend lid.

Leden van de commissie die actief betrokken zijn bij een onderzoeksprotocol, werden d'office uitgesloten van beoordeling.

GHENT UNIVERSITY

VERTROUWELIJKHEID & OVERDRACHT VAN RECHT EENZIJDIGE VERKLARING

NDA-EV

Deze Verklaring wordt afgelegd ten aanzien van

Universiteit Gent, openbare instelling met rechtspersoonlijkheid, waarvan de bestuurszetel gevestigd is te 9000 Gent, Sint-Pietersnieuwstraat 25, gekend onder ondernemingsnummer 0248.015.142 voor wie optreedt bij delegatie ingevolge het besluit van de Raad van Bestuur, prof. dr. Rik Van de Walle, rector ("UGent")

Door:

Van den Bossche Lena

Student, ingeschreven aan UGent in de richting:	Master of science in de logopedische en audiologische wetenschappen: audiologie
Project: Omschrijving / titel onderzoeksproject	Het effect van tawaai-blootstelling op de audiovestibulaire functie bij volwassenen.

In het kader van zijn/haar opleiding aan UGent, zal ondergetekende kennis krijgen van bepaalde vertrouwelijke informatie toebehorend aan UGent of door derden toevertrouwd aan UGent.

Ondergetekende verbindt er zich toe om de aan hem/haar in het kader van het Project ter beschikking gestelde informatie op geen enkele manier publiek bekend te maken zonder voorafgaande uitdrukkelijke schriftelijke toelating van UGent. Deze verbintenis geldt voor een duur van **tien (10) jaar** te rekenen vanaf de datum van deze Eenzijdige Verklaring.

Ondergetekende draagt eveneens al zijn/haar rechten op onderzoeksresultaten behaald in het kader van het Project over aan UGent.

Ondergetekende garandeert de mensenrechten te zullen respecteren.

Deze Eenzijdige Verklaring vervangt alle schriftelijke en mondelinge overeenkomsten die de partijen eerder zijn aangegaan met betrekking tot haar voorwerp en omvat de enige en volledige overeenkomst ter zake tussen de partijen.

Aldus verklaart en tekent voor akkoord:

Naam	Van den Bossche Lena
Handtekening	*Voorafgegaan door handgeschreven vermelding "gelezen en goedgekeurd"* gelezen en goedgekeurd
Datum:	14/11/2021

APPENDICES

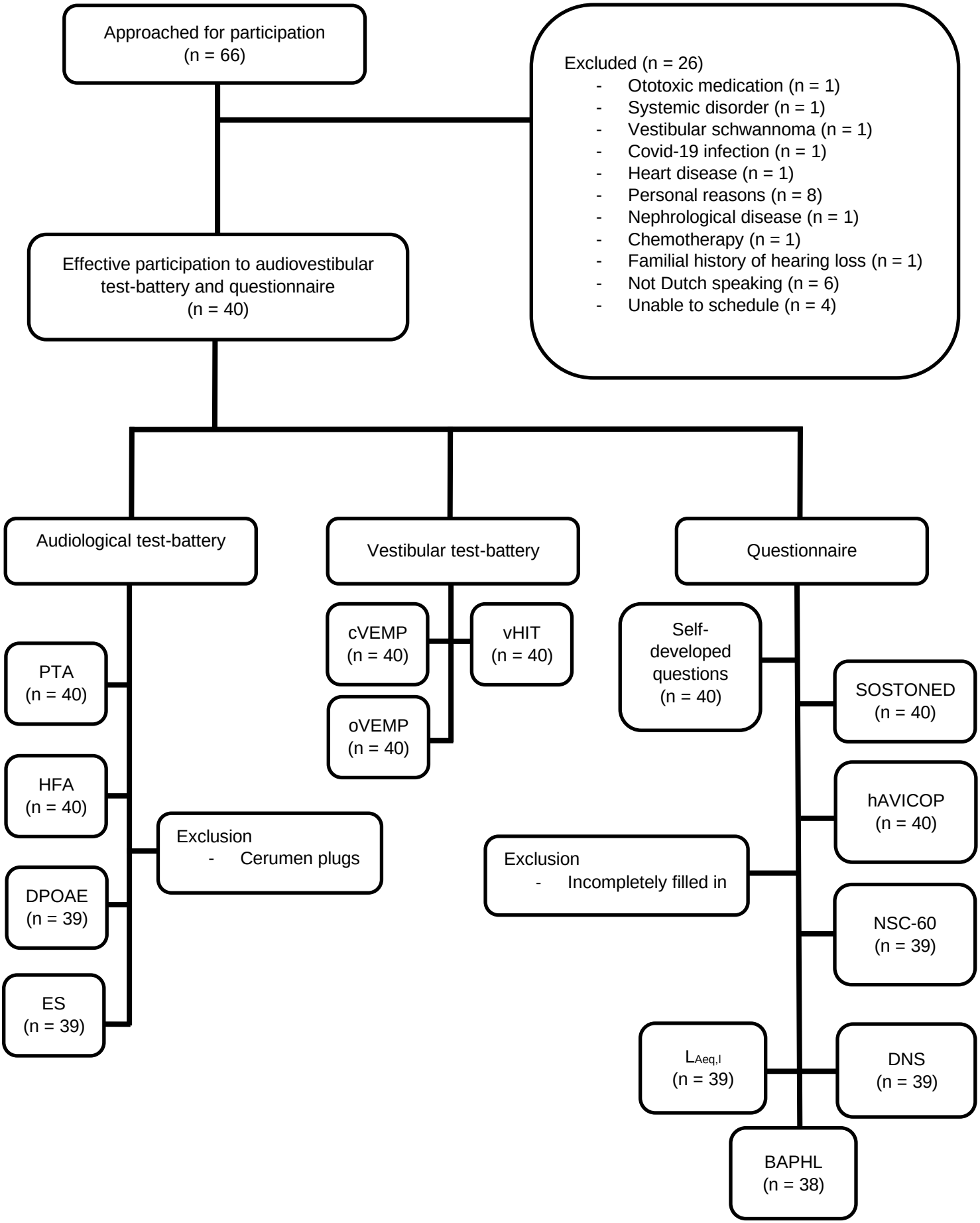
APPENDIX 1: DEMOGRAPHIC FEATURES

Table 8: Overview of demographic features (i.e. gender, age, sector and amount of work years) for each participant with occupational noise exposure (NE) and its matched control (C).

Matched pair	Gender	Age Years (months)		Sector		Work years		Age-category	Age per category (years) Mean (SD)	
		NE	C	NE	C	NE	C		NE	C
1	M	26 (8)	24 (5)	industry	others[1]	1-5	N.A.			
2	M	25 (4)	24 (11)	industry	industry	1-5	1-5			
3	M	24 (1)	24 (4)	industry	health care	1-5	1-5			
4	M	23 (4)	22 (11)	industry	health care	1-5	1-5	18-33 years	23,5 (2,00)	23,0 (1,58)
5	M	22 (3)	21 (8)	industry	education	1-5	1-5			
6	M	21 (9)	22 (1)	industry	others[1]	1-5	N.A.			
7	M	20 (8)	20 (6)	industry	others[1]	<1	N.A.			
8	M	48 (8)	48 (5)	industry	trade and service	>10	5-10			
9	M	45 (8)	45 (2)	industry	industry	5-10	1-5	34-49 years	45,2 (3,32)	45,2 (2,91)
10	M	41 (3)	41 (11)	industry	education	>10	>10			
11	M	60 (0)	62 (5)	industry	education	>10	>10			
12	M	57 (8)	57 (6)	industry	industry	>10	>10			
13	M	55 (5)	56 (5)	industry	education	>10	>10			
14	M	54 (10)	56 (4)	industry	trade and service	>10	>10			
15	M	54 (2)	53 (10)	industry	public administration	>10	>10	50 years	54,8	55,1
16	M	54 (1)	53 (9)	industry	industry	>10	>10	and older	(2,32)	(3,33)
17	M	53 (7)	52 (2)	trade and service	education	>10	>10			
18	M	53 (6)	52 (11)	industry	trade and service	>10	>10			
19	F	53 (7)	55 (6)	industry	health care	>10	>10			
20	F	51 (7)	50 (0)	health care	health care	>10	>10			

NE, noise exposure group; C, control group; SD, standard deviation; L, left ear; R, right ear; M, male; F, female; N.A. not applicable because participant is still a student; others[1], student.

APPENDIX 2: SUBJECT FLOW DIAGRAM



APPENDIX 3: OVERVIEW OF TEST RESULTS

PURE TONE AUDIOMETRY

Table 9: Overview of the hearing thresholds of all separately tested frequencies and the pure tone average computed with both the value of the Fletcher Index (FI) and *Bureau International d'Audiophonologie* (BIAP) for both the noise-exposed (NE) (n=40 ears) and control (C) group (n=40 ears).

	Compared groups	Hearing threshold (dB HL) Mean (SD)			
		NE		C	
		L	R	L	R
250 Hz	All participants	6,5 (6,71)	7,3 (7,34)	7,0 (8,94)	7,5 (10,58)
	18-33 years	4,3 (7,32)	9,3 (8,38)	0,7 (4,50)	1,4 (6,27)
	34-49 years	5,0 (8,66)	3,3 (7,64)	8,3 (2,89)	8,3 (2,89)
	50+ years	8,5 (5,80)	7,0 (6,75)	11,0 (10,22)	11,5 (12,70)
500 Hz	All participants	4,3 (4,94)	4,8 (6,58)	6,0 (7,18)	6,5 (10,14)
	18-33 years	3,6 (4,76)	5,7 (7,32)	1,4 (3,78)	2,1 (5,67)
	34-49 years	3,3 (5,77)	3,3 (5,77)	6,7 (2,89)	10,0 (5,00)
	50+ years	5,0 (5,27)	4,5 (6,85)	9,0 (8,43)	8,5 (12,92)
1000 Hz	All participants	4,3 (7,12)	5,5 (7,59)	2,3 (4,72)	5,3 (7,69)
	18-33 years	2,1 (8,59)	5,0 (11,55)	0,7 (3,45)	1,4 (3,78)
	34-49 years	1,7 (2,89)	5,0 (5,00)	3,3 (7,64)	1,7 (5,77)
	50+ years	6,5 (6,69)	6,0 (5,16)	3,0 (4,83)	9,0 (8,76)
2000 Hz	All participants	5,8 (6,93)	8,5 (8,29)	4,5 (6,26)	5,3 (6,17)
	18-33 years	2,9 (8,59)	5,7 (11,34)	1,4 (4,76)	2,1 (2,67)
	34-49 years	6,7 (2,89)	10,0 (5,00)	1,7 (2,89)	1,7 (2,89)
	50+ years	7,5 (6,35)	10,0 (6,67)	7,5 (6,77)	8,5 (7,09)
3000 Hz	All participants	12,8 (14,82)	14,8 (17,73)	10,8 (8,78)	7,0 (9,51)
	18-33 years	2,9 (9,94)	5,7 (12,05)	7,9 (7,56)	0,0 (5,77)
	34-49 years	11,7 (7,64)	16,7 (12,58)	6,7 (2,89)	3,3 (5,77)
	50+ years	20,0 (15,81)	20,5 (20,74)	14,0 (9,94)	13,0 (8,88)
4000 Hz	All participants	21,5 (21,71)	20,5 (23,56)	12,3 (12,51)	9,8 (11,53)
	18-33 years	7,1 (10,75)	7,9 (17,04)	2,9 (9,06)	-0,7 (5,35)
	34-49 years	21,7 (23,09)	28,3 (20,21)	13,3 (7,64)	11,7 (5,77)
	50+ years	31,5 (22,98)	27,0 (26,37)	18,5 (12,26)	16,5 (10,81)
6000 Hz	All participants	26,5 (21,47)	26,0 (19,30)	18,8 (16,29)	17,0 (14,18)
	18-33 years	14,3 (16,44)	13,6 (15,47)	3,6 (4,76)	2,9 (6,36)
	34-49 years	15,0 (8,66)	26,7 (7,64)	25,0 (13,23)	16,7 (5,77)
	50+ years	38,5 (21,35)	34,5 (20,34)	27,5 (15,14)	27,0 (11,11)
8000 Hz	All participants	21,8 (19,42)	21,5 (18,22)	16,6 (14,93)	20,5 (21,88)
	18-33 years	11,4 (17,73)	10,0 (12,91)	5,7 (10,97)	6,4 (9,00)
	34-49 years	25,0 (8,66)	28,3 (10,41)	7,3 (4,04)	13,3 (2,89)
	50+ years	28,0 (20,98)	27,5 (20,17)	27,0 (12,06)	32,5 (24,97)
PTA FI	All participants	4,8 (5,49)	6,4 (6,52)	4,3 (4,82)	5,7 (6,60)
	18-33 years	2,8 (6,94)	5,6 (9,78)	1,1 (3,39)	2,0 (3,56)
	34-49 years	4,0 (3,46)	6,3 (4,04)	4,0 (1,73)	4,3 (1,15)
	50+ years	6,3 (4,81)	6,9 (4,63)	6,6 (5,21)	8,6 (7,90)
PTA BIAP	All participants	8,9 (8,05)	9,8 (9,59)	6 (6,1)	6,3 (6,11)
	18-33 years	3,9 (7,05)	6,1 (11,31)	1,6 (4,19)	1,3 (3,31)
	34-49 years	8,3 (7,64)	11,7 (8,04)	6,3 (3,31)	6,3 (2,17)
	50+ years	12,6 (7,49)	11,9 (8,82)	9,5 (6,02)	10,6 (7,55)

NE, noise exposure group; C, control group; L, left ear; R, right ear; SD, standard deviation.

HIGH FREQUENCY AUDIOMETRY (HFA)

Table 10: Overview of the high-frequency hearing thresholds for both the noise-exposed (NE) and control (C) group.

	Compared groups	Hearing threshold (dB HL) Mean (SD)			
		NE		C	
		L	R	L	R
10000 Hz	All participants	29,8 (22,27)	24,5 (20,58)	19,5 (19,05)	21,8 (21,48)
	18-33 years	15,7 (18,80)	12,1 (18,22)	2,9 (13,18)	6,4 (6,90)
	34-49 years	25,0 (5,00)	30,0 (13,23)	15,0 (5,00)	18,3 (2,89)
	50+ years	41,0 (22,46)	31,5 (21,22)	32,5 (15,32)	33,5 (24,50)
12500 Hz	All participants	41,5 (31,67)	35,5 (24,97)	32,8 (29,13)	30,0 (30,04)
	18-33 years	10,7 (22,63)	10,0 (19,36)	5,0 (13?84)	1,4 (10,69)
	34-49 years	38,3 (12,58)	40,0 (15,00)	26,7 (11,55)	15,0 (10,00)
	50+ years	64,0 (20,92)	52,0 (14,18)	54,0 (22,83)	54,5 (20,74)
14000 Hz	All participants	44,5 (33,20)	37,5 (28,45)	37,5 (30,72)	36,5 (33,49)
	18-33 years	7,9 (24,30)	5,0 (18,26)	2,1 (16,04)	-2,9 (9,06)
	34-49 years	51,7 (25,66)	50,0 (13,23)	40,0 (0,00)	36,7 (15,28)
	50+ years	68,0 (10,59)	56,5 (13,13)	61,5 (14,35)	64,0 (14,68)
16000 Hz	All participants	44,3 (26,47)	41,0 (24,04)	35,0 (28,24)	32,8 (29,09)
	18-33 years	15,0 (26,14)	14,3 (22,25)	2,1 (15,77)	-4,3 (9,76)
	34-49 years	60,0 (0,00)	56,7 (5,77)	46,7 (15,28)	48,3 (10,41)
	50+ years	60,0 (0,00)	55,0 (5,27)	54,5 (12,57)	54,0 (6,99)

NE, noise exposure group; C, control group; L, left ear; R, right ear; SD, standard deviation.

DISTORTION PRODUCT OTOACOUSTIC EMISSIONS (DPOAE)

Table 11: Overview of the response amplitude (dB SPL) of the DPOAE measurements for the left and right ear from both the noise-exposed (NE) and control (C) group and the number of usable pairs for between-group comparisons.

Frequency (Hz)	Amplitude (dB SPL) Mean (SD) [n]				Usable pairs	
	NE		C			
	L	R	L	R	L	R
1000	9 (5,2) [14]	9 (4,7) [14]	10 (5,6) [17]	12 (5,2) [17]	11	12
1500	11 (5,4) [17]	10 (4,1) [17]	12 (5,9) [18]	13 (6,5) [18]	16	15
2000	8 (5,0) [16]	8 (3,5) [16]	10 (6,3) [15]	12 (5,5) [16]	13	13
3000	5 (4,5) [11]	5 (4,5) [13]	6 (5,2) [17]	5 (5,9) [15]	10	11
4000	8 (3,3) [10]	5 (5,1) [11]	5 (4,8) [14]	5 (3,9) [13]	8	8
6000	5 (7,3) [11]	5 (6,3) [9]	7 (4,7) [12]	5 (4,9) [12]	8	8
8000	4 (8,2) [4]	1 (5,8) [6]	4 (5,6) [6]	1 (2,3) [6]	2	3
10000	14 (3,6) [3]	6 (7,8) [4]	4 (5,1) [7]	4 (6,9) [5]	1	2

NE, noise exposure group; C, control group; L, left ear; R, right ear; SD, standard deviation.

EFFERENT SUPPRESSION (ES)

Table 12: Overview of the raw (dB) and normalized (%) index of the ES measurements for the left and right ear from both the noise-exposed (NE) and control (C) group and the number of usable pairs for between-group comparisons.

	Frequency (Hz)	NE		C		Usable pairs	
		L	R	L	R	L	R
Raw index (dB) Mean (SD) [n]	1000	2 (1,5) [8]	2 (1,5) [9]	1 (1,4) [12]	1 (1,2) [10]	6	5
	1500	2 (1,1) [10]	2 (1,5) [10]	2 (2,0) [15]	2 (1,2) [14]	7	7
	2000	1 (/) [1]	1 (1,6) [8]	2 (1,0) [9]	1 (1,1) [13]	n.v.c.	6
	3000	1 (1,1) [2]	1 (0,8) [3]	1 (0,7) [7]	1 (1,0) [6]	n.v.c	1
	4000	0 (/) [1]	1 (0,4) [4]	1 (0,4) [7]	2 (1,3) [6]	n.v.c.	1
Normalized index (%) Mean (SD) [n]	1000	18 (13,2) [7]	16 (13,4) [9]	13 (14,3) [12]	13 (12,1) [10]	5	5
	1500	16 (10,7) [10]	18 (13,2) [10]	16 (17,5) [15]	17 (11,4) [14]	7	7
	2000	15 (/) [1]	13 (14,4) [8]	20 (8,9) [9]	14 (10,6) [13]	n.v.c	6
	3000	6 (12,2) [2]	7 (8,0) [3]	9 (6,9) [7]	8 (10,4) [6]	n.v.c.	1
	4000	0 (/) [1]	6 (4,2) [4]	10 (6,0) [7]	21 (10,9) [6]	n.v.c.	1

NE, noise exposure group; C, control group; L, left ear; R, right ear; n.v.c., no valid cases.

CERVICAL VESTIBULAR EVOKED MYOGENIC POTENTIALS (CVEMP)

Table 1: Overview of the cVEMP outcome measures for both the noise-exposed (NE) and control (C) group.

Outcome measures	Compared groups	NE		C	
		L	R	L	R
Amplitude Mean (SD)	All participants	1,0 (0,47)	0,9 (0,36)	0,8 (0,58)	0,7 (0,53)
	18-33 years	1,3 (0,26)	1,1 (0,44)	1,9 (0,76)	0,7 (0,68)
	34-49 years	0,7 (0,95)	0,8 (0,05)	1,0 (0,40)	0,8 (0,68)
	50+ years	0,8 (0,27)	0,9 (0,31)	0,6 (0,23)	0,6 (0,31)
Latency P (ms) Mean (SD)	All participants	14 (1,9)	13 (2,4)	14 (2,3)	14 (2,1)
	18-33 years	14 (2,6)	13 (2,2)	13 (0,4)	14 (2,4)
	34-49 years	13 (1,7)	14 (4,2)	16 (2,8)	16 (3,3)
	50+ years	14 (0,9)	13 (1,6)	15 (3,0)	14 (1,0)
Latency N (ms) Mean (SD)	All participants	23 (2,2)	22 (2,2)	23 (1,9)	23 (1,5)
	18-33 years	23 (2,7)	22 (1,8)	22 (1,4)	23 (1,3)
	34-49 years	23 (1,8)	25 (2,8)	23 (1,2)	23 (1,7)
	50+ years	22 (1,8)	22 (1,2)	23 (2,7)	22 (1,6)
Threshold (dB nHL) Mean (SD)	All participants	90 (3,9)	90 (3,4)	90 (7,0)	90 (6,7)
	18-33 years	85 (3,9)	90 (2,9)	85 (8,6)	84 (5,3)
	34-49 years	95 (2,9)	92 (2,9)	90 (5,0)	87 (90)
	50+ years	90 (3,5)	91 (4,8)	90 (4,1)	94 (2,5)

NE, noise exposure group; C, control group; L, left; R, right; SD, standard deviation.

OCULAR VESTIBULAR EVOKED MYOGENIC POTENTIALS (OVEMP)

Table 2: Overview of the oVEMP outcome measures for both the noise-exposed (NE) and control (C) group.

Outcome measures	Compared groups	NE		C	
		L	R	L	R
Amplitude (µV) Mean (SD)	All participants	14,6 (9,39)	12,9 (12,87)	11,8 (7,71)	15,6 (8,84)
	18-33 years	20,7 (6,85)	22,9 (12,62)	15,3 (11,09)	16,0 (9,67)
	34-49 years	16,0 (3,89)	10,9 (14,58)	11,1 (7,45)	17,8 (6,89)
	50+ years	8,2 (11,51)	8,7 (12,98)	11,8 (5,12)	15,4 (9,29)
Latency N (ms) Mean (SD)	All participants	12 (1,9)	11 (1,8)	12 (1,6)	12 (1,7)
	18-33 years	11 (1,9)	11 (1,7)	11 (1,3)	11 (1,4)
	34-49 years	11 (0,3)	11 (1,3)	13 (2,6)	12 (2,3)
	50+ years	12 (1,9)	12 (2,1)	12 (1,3)	12 (1,6)
Latency P (ms) Mean (SD)	All participants	16 (2,1)	16 (2,2)	16 (1,8)	16 (1,9)
	18-33 years	14 (1,7)	16 (2,9)	15 (2,2)	16 (1,9)
	34-49 years	14 (1,2)	16 (0,9)	19 (1,4)	18 (1,8)
	50+ years	16 (2,0)	16 (2,0)	16 (1,5)	16 (2,0)

NE, noise exposure group; C, control group; L, left; R, right; SD, standard deviation.

VIDEO HEAD IMPULSE TEST (VHIT)

Table 15: Overview of the vHIT outcome measures for both the noise-exposed (NE) and control (C) group

Tested SCC	Outcome measures	Compared groups	NE		C	
			L	R	L	R
Horizontal	Gain Mean (SD)	All participants	0,95 (0,106)	1,01 (0,108)	0,89 (0,142)	1,02 (0,129)
		18-33 years	1,03 (0,151)	1,09 (0,143)	0,90 (0,035)	0,97 (0,044)
		34-49 years	0,92 (0,153)	1,02 (0,079)	0,98 (0,225)	1,07 (0,245)
		50+ years	0,90 (0,034)	0,96 (0,034)	0,98 (0,132)	1,04 (0,132)
	Overt saccades (%) Mean (SD)	All participants	11 (13,7)	18 (21,2)	2 (3,2)	6 (6,1)
		18-33 years	5 (14,0)	15 (27,9)	1 (1,5)	2 (3,4)
		34-49 years	22 (16,2)	8 (3,1)	2 (2,9)	3 (5,2)
		50+ years	12 (11,7)	24 (18,6)	9 (16,8)	9 (6,7)
	Covert saccades (%) Mean (SD)	All participants	3 (5,0)	3 (6,2)	5 (12,4)	4 (7,3)
		18-33 years	3 (3,5)	1 (2,0)	0 (0,0)	2 (4,9)
		34-49 years	4 (3,2)	1 (1,7)	4 (6,4)	6 (6,7)
		50+ years	3 (6,6)	5 (8,2)	2 (2,1)	6 (8,8)
Anterior	Gain Mean (SD)	All participants	0,90 (0,139)	1,06 (1,89)	0,89 (0,142)	1,01 (0,124)
		18-33 years	0,99 (0,131)	1,20 (0,210)	0,86 (0,063)	1,00 (0,867)
		34-49 years	0,86 (0,061)	1,05 (0,114)	1,03 (0,210)	1,06 (0,052)
		50+ years	0,86 (0,137)	0,97 (0,140)	0,88 (0,152)	1,00 (0,995)
	Overt saccades (%) Mean (SD)	All participants	3 (9,2)	3 (6,5)	0 (0,9)	0 (1,2)
		18-33 years	8 (14,8)	6 (10,0)	1 (1,9)	1 (1,5)
		34-49 years	0 (0,0)	0 (0,0)	0 (0,0)	1 (2,3)
		50+ years	0 (0,9)	1 (3,0)	1 (0,9)	0 (0,0)
	Covert saccades (%) Mean (SD)	All participants	3 (6,4)	9 (11,3)	0 (1,3)	7 (8,6)
		18-33 years	7 (9,3)	12 (12,8)	1 (1,5)	12 (8,2)
		34-49 years	0 (0,0)	10 (11,1)	1 (2,3)	10 (16,7)
		50+ years	2 (3,8)	6 (10,9)	3 (4,1)	3 (3,2)

Table 15 (continued)

Tested SCC	Outcome measures	Compared groups	NE		C	
			L	R	L	R
Posterior	Gain Mean (SD)	All participants	0,91 (0,115)	0,98 (0,132)	0,88 (0,162)	1,01 (0,180)
		18-33 years	0,95 (0,083)	1,05 (0,135)	0,79 (0,189)	0,94 (0,096)
		34-49 years	0,87 (0,015)	0,91 (0,055)	1,01 (0,127)	1,23 (0,323)
		50+ years	0,88 (0,145)	0,95 (0,135)	0,90 (0,131)	0,99 (0,138)
	Overt saccades (%) Mean (SD)	All participants	1 (2,8)	4 (7,3)	1 (2,9)	1 (3,0)
		18-33 years	0 (0,0)	2 (4,9)	0 (0,0)	1 (1,5)
		34-49 years	0 (0,0)	6 (6,6)	4 (7,5)	2 (2,9)
		50+ years	2 (2,1)	6 (8,8)	0 (0,0)	2 (3,9)
	Covert saccades (%) Mean (SD)	All participants	4 (10,0)	7 (13,0)	0 (0,9)	9 (9,0)
		18-33 years	9 (16,0)	10 (19,9)	0 (0,0)	8 (13,1)
		34-49 years	0 (0,0)	3 (3,1)	0 (0,0)	2 (2,9)
		50+ years	1 (1,9)	7 (9,1)	0 (1,3)	3 (6,4)

SCC, semicirular canal; NE, noise exposure group; C, control group; L, left; R, right; SD, standard deviation.

APPENDIX 4: STATISTICALLY SIGNIFICANT DIFFERENCES FROM BETWEEN-GROUP COMPARISONS

Table 16: Overview of obtained statistically significant differences from comparisons between the noise-exposed (NE) and control (C) group.

Obtained statistically significant difference	Statistical test	*p*-value	Df	Mean difference	95% *CI*		t	X^2	*Z*
					Upper	Lower			
The right audiometric notch is more often present in the NE-group compared to the C-group	McNemar	0.012	20					0,0220	
The left 16000 Hz pure tone threshold was more often absent in the NE-group compared to the C-group	McNemar	0.039	20					0,92	
The left 16000 Hz pure tone threshold was higher in the NE-group compared to the C-group	Paired Student T test	0.038	19	9,25	0,58 dB HL	17,92 dB HL	2,234		
The right 16000 Hz pure tone threshold in the 18-33 years age-category was higher in the NE-group compared to the C-group	Paired Student T test	0,023	19	8,25	1,28 dB HL	15,23 dB HL	2,477		
The right 16000 Hz pure tone threshold was higher in the NE-group compared to the C-group	Paired Student T test	0.029	6	18,57	2,62 dB HL	34,53 dB HL	2,848		
The right 1500 Hz DPOAE response amplitude was lower in the NE-group compared to the C-group	Paired Student T test	0.042	14	5 dB SPL	0,18 dB SPL	9,14 dB SPL	2,233		
The right 2000 Hz DPOAE response amplitude was lower in the NE-group compared to the C-group	Paired Student T test	0.008	12	5 dB SPL	1,40 dB SPL	7,67 dB SPL	3,151		
The right cVEMP threshold in the 18-33 years age-category is higher in the NE-group compared to the C-group	Paired Student T test	0.015	6	6 dB nHL	1,55 dB nHL	9,88 dB nHL	3,361		
The right horizontal vHIT gain in the 18-33 years age category was higher in the NE-group compared to the C-group	Paired Student T test	0.029	6	0,13	0,02	0,23	2,849		
The right anterior vHIT gain in the 18-33 years age category was higher in the NE-group compared to the C-group	Paired Student T test	0.010	6	0,20	0,07	0,34	3,695		

Table 16 (continued).

Obtained statistically significant difference	Statistical test	*p*-value	Df	Mean difference	95% *CI*		t	X^2	*Z*
					Upper	Upper			
The left anterior vHIT gain in the 18-33 years age category was higher in the NE-group compared to the C-group	Paired Student T test	0.016	6	0,14	0,04	0,24	3,301		
The right horizontal vHIT overt saccades were more often recorded in the complete NE-group compared to the C-group	Paired Student T test	0.015	19	13%	2,841%	22,859%	2,687		
The right horizontal vHIT overt saccades in the 50+ years age-category were more often recorded in the NE-group compared to the C-group	Paired Student T test	0.043	9	15%	0,606%	29,794%	2,356		
The professional $L_{Aeq,l}$-value was higher for all NE participants compared to the C-group	Paired Student T test	0.025	9	16 dB	2,53 dB	29,70 dB	2,683		
The professional $L_{Aeq,l}$-value in the 50+ years age-category was higher in the NE-group compared to the C-group	Paired Student T test	0.013	4	22 dB	7,87 dB	37,02 dB	4,275		
Vestibular symptoms were less often present in the NE-group compared to the C-group	McNemar	0.031	20					4,314	
NE-participants scored themselves lower on the speech intelligibility in quiet subscore of the hAVICOP questionnaire compared to the C-group	Paired Wilcoxon	0.025							-2,244

NE, noise-exposed; C, control, Df, Degrees of Freedom; CI, confidence interval.

APPENDIX 5: QUESTIONNAIRE CALCULATIONS

NEUROTOXIC SYMPTOMS CHECKLIST 60 (NSC-60)

Responses of the NSC-60 were obtained through the comprehensive questionnaire (**Appendix 6**; question 14). The subcategory calculation was based on the recommendations by Hooisma and Emmen (1992).

Responses on all 60 questions were scored with “never” 1 (Dutch: nooit); seldom 2 (Dutch: zelden); “sometimes” 3 (Dutch: soms); “often” 4 (Dutch: vaak).

All nine subcategories comprised the mean of scores from different questions of the NSC-60 and to each subcategory a limit value was added. Exceeding limit values could be alarming for neurological problems.

Table 17: subcategories, used questions per category and limit values from the NSC-60 questionnaire as described by Hooisma & Emmen (1992).

Subcategory	Used NSC-60 questions	Limit value
Memory difficulties	11, 15, 23, 28, 30, 38, 51	2,9
Chest complaints	12, 45, 46, 52	2,1
Equilibrium	37, 39, 50	2,0
Sleeping difficulties	1, 7, 19	2,7
Neurotoxicity	3, 4, 5, 8, 9, 10, 11, 13, 16, 17, 21, 23, 26, 27, 29, 30, 36, 38, 39, 48, 50, 51	2,6
Mood changes	5, 14, 17, 21, 24, 29, 34, 36, 44, 48, 55	2,8
Sensorimotor complaints	3, 8, 25, 27, 31, 35, 41	2,5
Somatic complaints	6, 9, 32, 43, 49	3,1
Fatigue	16, 26, 33, 42	2,9

HEARING-RELATED QUALITY OF LIFE QUESTIONNAIRE FOR AUDITORY-VISUAL, COGNITIVE AND PSYCHOSOCIAL FUNCTIONING (HAVICOP)

Responses of the hAVICOP were obtained through the comprehensive questionnaire (**Appendix 6**; questions 36 to 57), based on questions 1 to 27 as designed by Ceuleers et al. (2022). Because of an error, questions 4 to 8 of the questionnaire by Ceuleers et al. (2022) were excluded in the comprehensive questionnaire, making some subcategory calculations impossible (**Table 18** in *italic*).

Responses were obtained by a visual analog scale of which the value was inverted for questions 9, 10, 11, 15, 16, 19, 20, 21, 22, 22, 23, 24, 26, and 27 because of the negative form of these questions.

Within three domains (i.e. Auditory-visual, Cognitive, and Psychological functioning), five, four, and two subcategories were calculated respectively based on the mean score from different questions of the hAVICOP questionnaire.

Table 18: Domains, subcategories, and used questions per subcategory from the hAVICOP questionnaire as described by Ceuleers et al. (2022).

Domain	Subcategory	Used hAVICOP questions
Auditory-visual functioning	Speech intelligibility in quiet	36, 37, 38
	Speech intelligibility in noise	*/ (missing question 4 to 6 from Ceuleers et al. (2022))*
	Music perception	42, 43, 44
	Localisation	47, 48
	Audiovisual functioning	55
Cognitive functioning	Working memory	45, 46
	Processing speed	56, 57
	Selective attention	49
	Listening effort	41
Psychosocial functioning	Psychological functioning	50, 51, 52, 53, 54
	Social functioning	*/ (missing question 7 and 8 from Ceuleers et al. (2022))* *39, 40*

LIFETIME EQUIVALENT NOISE EXPOSURE ($L_{AEQ,L}$)

Each participant's occupational and recreational $L_{Aeq,l}$ value was obtained in the comprehensive questionnaire (**Appendix 6**, question 71) based a set of questions by Jokitulppo et al. (2006) and adapted in the context of recent research by De Poortere et al. (2022; *in preparation*). For every given activity, a participant had to fill in if and how often they take part in it, how many hours per session it contains, for how many years they have been doing it, how loud they estimate that specific activity, and whether or not they used HPDs during that activity.

First, based on the reported frequency (never, annually, monthly, weekly, daily; Dutch: nooit, jaarlijks, maandelijks, wekelijks en dagelijks), the weekly average for all activities separately were calculated. When responses were missing from incompletely filling in the questionnaire, these values were replaced by the median of the whole group (NE or C). Second, the loudness scale per activity was converted as shown in **Table 19**. If participants did wear HPDs for certain activities, a correction was implemented in the estimated loudness.

Table 19: Estimated loudness, the corresponding decibel level (dB) and the implemented correction when HPDs were used as obtained though the $L_{Aeq,l}$ questionnaire.

Estimated loudness	Corresponding decibel level (dB)	Correction when using HPDs (dB)
1	50	50
2	60	50
3	60	60
4	70	60
5	80	70
6	90	80
7	100	90

With the corrected loudness values, the $L_{Aeq,l}$ value for every activity separately was calculated as the following sum:

$$\text{Weekly LAeq value (LAeq, w)} = \text{corrected loudness value} + 10 \times \text{LOG(weekly average/40)}$$

$$\text{Lifetime LAeq value (LAeq, l)} = \text{LAeq, w} + 10 \times \text{LOG(annual frequency)}$$

The four last questioned activities corresponded to occupational noise exposure, the cumulative occupational $L_{Aeq,l}$ was calculated as the mean of these four computed $L_{Aeq,l}$ values. All others were related to recreational noise exposure.

BELIEFS ABOUT HEARING PROTECTION AND HEARING LOSS (BAHPHL)

Responses of the BAHPHL were obtained through the comprehensive questionnaire (**Appendix 6**; question 74), and based on the work of Keppler (2010). For every given statement in the questionnaire, participants could choose between “totally agree”, “partly agree”, “neutral”, “partly disagree”, or “totally disagree” (Dutch: volledig mee eens, gedeeltelijk mee eens, neutraal, gedeeltelijk mee oneens en volledig mee oneens). The responses of questions 1, 3, 4, 7, 8, 9, 11, 14, 16, 17, 19, and 21 were inverted considering the negative form of them. Based on the mean of different questions together, seven subcategories were distinguished (**Table 20**).

Table 20: Subcategories, and used questions per subcategory from the BAHPHL questionnaire as described by Keppler (2010).

Subcategory	Used BAHPHL questions
Susceptibility to hearing loss	4, 11, 13, 15, 21, 22
Severity of hearing loss	10, 17, 23
Benefits of preventive action	5 ,14, 18
Behavioural intentions	1, 7, 16, 19
Social norms	3, 6, 24
Self-efficacy	8, 20
Barriers to preventive action	2, 9, 12

APPENDIX 6: QUESTIONNAIRE

DEEL 1: ALGEMENE INFORMATIE

1. **E-mailadres**

   ……

   ☐ Ik wens de resultaten van deze masterproef te ontvangen.

   ☐ Ik wens gecontacteerd te worden om deel te nemen aan toekomstig onderzoek binnen dit onderwerp.

2. **Geboortedatum (dd/mm/jjjj)**

   ...../..…../…..…..

3. **Geslacht**

   M / V / X

4. **In welke sector bent u tewerkgesteld?**

   ☐ Gezondheids- en welzijnssector

   ☐ Handel en dienstverlening

   ☐ ICT

   ☐ Justitie, veiligheid en openbaar bestuur

   ☐ Landbouw, natuur en visserij

   ☐ Media en communicatie

   ☐ Onderwijs, cultuur en wetenschap

   ☐ Industrie, techniek, productie en bouw

   ☐ Toerisme, recreatie en horeca

   ☐ Transport en logistiek

   ☐ Anders: ……..

5. **Hoelang werkt u reeds in deze sector?**

   ☐ < 1 jaar

   ☐ 1-5 jaar

   ☐ 5-10 jaar

   ☐ > 10 jaar

6. **Wordt u tijdens uw werk aan onderstaande factoren blootgesteld? (Meerdere antwoorden zijn mogelijk).**

   ☐ Lawaai

   ☐ Chemicaliën (oplosmiddelen, metalen, pesticiden…)

☐ Zware lasten (tillen, verslepen…)

☐ Andere: ……..

☐ Ik word aan geen van bovenstaande factoren blootgesteld tijdens mijn werk.

7. Neemt u medicatie?

☐ Ja

☐ Neen (ga naar vraag 9)

8. Indien u medicatie neemt, vul aan over welke medicatie het gaat, hoe frequent u deze neemt en in welke dosis.

Medicatie	Frequentie	Dosis
	☐ Dagelijks ☐ Wekelijks ☐ Maandelijks	
	☐ Dagelijks ☐ Wekelijks ☐ Maandelijks	
	☐ Dagelijks ☐ Wekelijks ☐ Maandelijks	
	☐ Dagelijks ☐ Wekelijks ☐ Maandelijks	
	☐ Dagelijks ☐ Wekelijks ☐ Maandelijks	
	☐ Dagelijks ☐ Wekelijks ☐ Maandelijks	
	☐ Dagelijks ☐ Wekelijks ☐ Maandelijks	

9. Had u afgelopen maanden één of meerdere van volgende klachten? (Meerdere antwoorden zijn mogelijk).

- ☐ Hoofdpijn
- ☐ Koorts
- ☐ Spierpijn
- ☐ Stijve spieren
- ☐ Zwakke spieren
- ☐ Hartklachten
- ☐ Tekenbeet
- ☐ Covid-19
- ☐ Longontsteking of een andere luchtweg infectie
- ☐ Andere: ……..
- ☐ Ik heb geen last gehad van één van bovenstaande klachten.

10. Heeft of had u één of meerdere van volgende aandoeningen?

- ☐ Hypertensie (verhoogde bloeddruk)
- ☐ Diabetes Mellitus (suikerziekte)
- ☐ Auto-immuunziekte
- ☐ Verhoogde cholesterol
- ☐ Hart- en vaatproblematiek
- ☐ Nierfunctieproblematiek
- ☐ Schildklierproblematiek
- ☐ Neurologische problematiek
- ☐ Hoofdletsel
- ☐ Nekproblematiek (nekhernia, nekletsel, whiplash…)
- ☐ Tuberculose
- ☐ Andere: ……..
- ☐ Ik heb geen last (gehad) van één van bovenstaande aandoeningen.

11. Hoe vaak drinkt u gemiddeld alcohol?

- ☐ > 4 maal per week
- ☐ 1 – 3 maal per week
- ☐ 2 – 3 maal per maand
- ☐ Maandelijks of minder
- ☐ Nooit (ga naar vraag 13)

12. Wanneer u alcohol drinkt, hoeveel standaardglazen drinkt u dan?

- ☐ 1 à 2 glazen
- ☐ 3 à 4 glazen
- ☐ 5 à 6 glazen
- ☐ 7 à 9 glazen
- ☐ > 9 glazen

13. Rookt u (klassieke sigaret of e-sigaret)?

- ☐ Nooit
- ☐ Dagelijks
- ☐ Wekelijks
- ☐ Occasioneel
- ☐ Ik heb gerookt, maar ben nu gestopt.

a. Indien u bent gestopt, hoe lang geleden bent u dan gestopt?
……..

b. Hoeveel jaar hebt u voordien gerookt? ……..

14. Gelieve het meest passende antwoord aan te duiden.

	Nooit	**Zelden**	**Soms**	**Dikwijls**
Valt u moeilijk in slaap?				
Vindt u het moeilijk om de inhoud van kranten of boeken te begrijpen?				
Heeft u krachtverlies in de benen?				
Bent u duizelig?				
Voelt u zich terneergeslagen?				
Heeft u last van uw maag?				
Heeft u last van nachtmerries?				
Heeft u moeilijkheden bij het bewegen van uw handen als uw werk nauwkeurigheid vraagt?				
Bent u wel eens misselijk?				
Voelt u zich ’s morgens abnormaal moe?				
Bent u vergeetachtig?				
Heeft u last van hartkloppingen?				
Vindt u het moeilijk om u te concentreren?				
Bent u ongeduldig?				
Gebruikt u spiekbriefjes om dingen te onthouden?				
Valt u wel eens in slaap terwijl u niet in bed ligt?				
Verandert uw stemming wel eens zonder directe aanleiding?				
Heeft u last van trillende handen?				
Wordt u vaak wakker uit uw slaap?				
Heeft u een verdoofd of tintelend gevoel in uw handen?				
Voelt u zich rusteloos?				
Bent u soms plotseling angstig, zonder dat daarvoor een reden is?				

Gebeurt het dat als u iets wil zeggen of doen, dat u vergeten bent wat u wilde?				
Ziet u het wel eens niet meer zitten?				
Heeft u krachtverlies in uw handen en armen?				
Voelt u zich ’s avonds abnormaal moe?				
Laat u wel eens dingen uit uw handen vallen?				
Moet u wel eens teruggaan om te controleren of u bijvoorbeeld het gas heeft uitgedaan of de deur heeft gesloten?				
Voelt u zich lusteloos?				
Droomt u weleens in gedachten weg?				
Heeft u moeilijkheden bij het bewegen van uw handen als uw werk kracht vraagt?				
Heeft u last van oorsuizingen?				
Bent u slaperig?				
Bent u zenuwachtig als u zich moet haasten?				
Heeft u een verdoofd of tintelend gevoel uw benen?				
Voelt u zich geïrriteerd?				
Heeft u last van evenwichtsstoornissen?				
Hebben anderen geklaagd over uw geheugen?				
Merkt u veranderingen in uw reukvermogen?				
Vindt u zichzelf nu eens vol energie en dan weer lui?				
Heeft u pijnlijke tintelingen ergens in uw lichaam?				
Zweet u abnormaal vaak?				
Heeft u hoofdpijn?				
Voelt u zich ongelukkig?				
Heeft u het gevoel iets in uw keel te hebben, waardoor u moeilijk kan slikken?				
Heeft u last van ademhalingsproblemen?				
Bent u gevoelig voor lawaai?				
Vermoeit het u als u in een groep mensen bent?				
Heeft u het steeds koud?				
Voelt u zich soms dronken, zonder dat u alcohol heeft gedronken?				
Bent u wel eens ‘afwezig’?				
Voelt u wel eens druk op uw borst?				
Als u een onbekende ontmoet, vindt u het dan moeilijk om een gesprek te beginnen?				
Vindt u het moeilijk om snel te werken?				
Vindt u zichzelf neerslachtig?				
Vindt u het onplezierig om onbekenden te ontmoeten?				
Vindt u het moeilijk om vrienden te maken?				
Voelt u zich geremd bij vreemden?				
Vindt u het vervelend als men u opjaagt?				
Vindt u het moeilijk om beslissingen te nemen?				
	Ja		**Neen**	
Voelt u zich onzeker bij het lopen? (U kunt goed zien, maar u moet toch kijken waar u uw voeten zet, u loopt onzeker in het donker, u hebt een dronkenmansgang)				
Hebt u last van een brandende, zeurende pijn of een pijnlijk gevoel in uw voeten of onderbenen? (Deze klachten treden op in rust of ’s nachts in bed maar niet bij inspanning)				

Hebt u last van dove plekken in uw voeten of onderbenen? (U hebt plekken die slapen of dood aanvoelen)		
Heeft u last van een vreemde smaak in de mond?		

15. Mocht u zelf nog zaken willen toevoegen die u relevant acht, mag u dit hier noteren.

……
……
……

DEEL 2: ZICHT (VISUELE INFORMATIE)

16. Draagt u een bril en/of lenzen?

- ☐ Ja
- ☐ Neen (ga naar vraag 18)

17. Zijn deze voldoende om uw zicht te corrigeren?

- ☐ Ja
- ☐ Neen

18. Ziet u beter met het ene oog dan met het andere?

- ☐ Ja
- ☐ Neen (ga naar vraag 20)

19. Met welk oog ziet u beter?

- ☐ Linkeroog
- ☐ Rechteroog
- ☐ Dit is variabel

20. Heeft u soms last van dubbelzicht?

- ☐ Ja
- ☐ Neen (ga naar vraag 22)

21. Wanneer heeft u hier last van?

- ☐ Bij het kijken met één oog
- ☐ Bij het kijken met beide ogen
- ☐ Dit is variabel

22. Indien u bijkomende problemen of opmerkingen heeft met betrekking tot uw zicht mag u dit hier noteren.

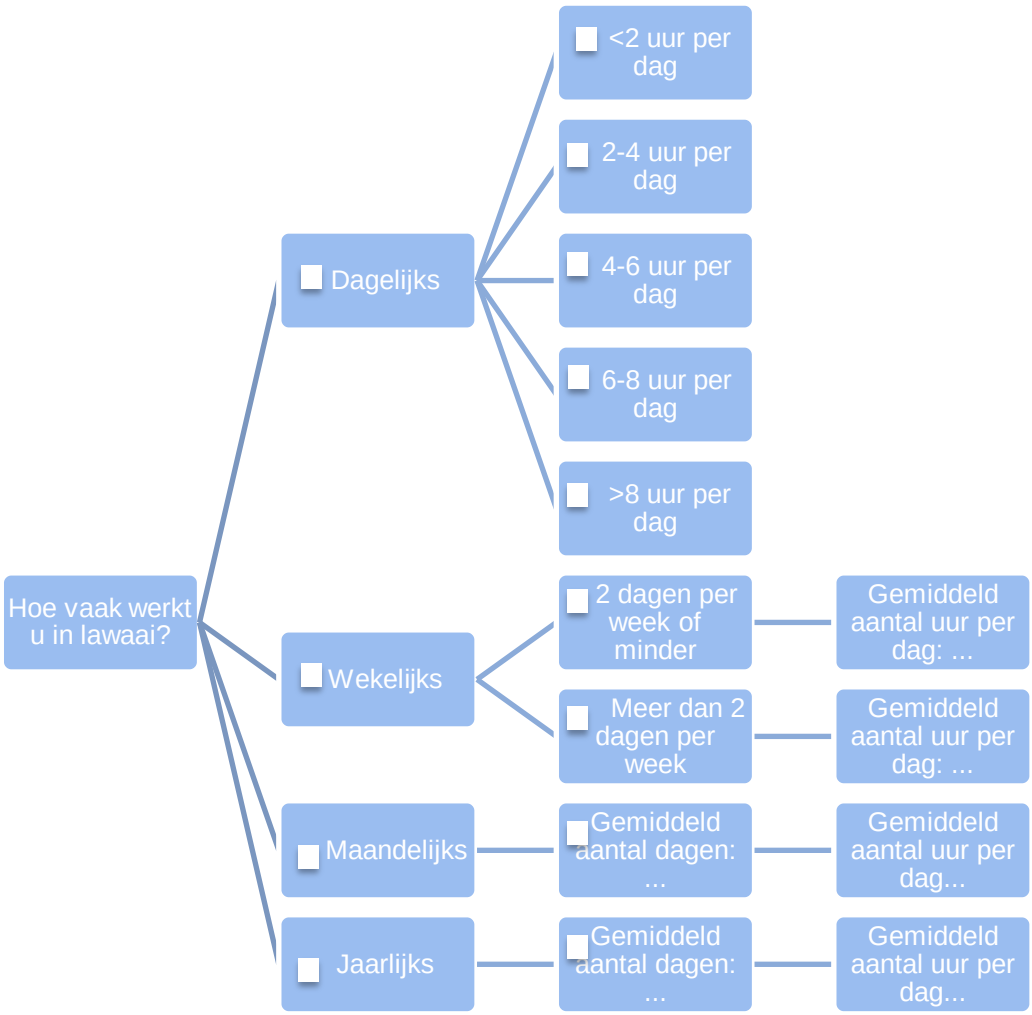
……
……
……
……
……
……
……

DEEL 3: GEHOOR EN LAWAAIBLOOTSTELLING

23. Welke stelling past het best bij het geluidsniveau op uw werkplaats?

- ☐ Communicatie is perfect mogelijk, u hoeft hiervoor niet te roepen (ga naar vraag 25).
- ☐ U moet roepen om over een afstand van meer dan 1 meter gehoord te kunnen worden.
- ☐ U moet roepen om over een afstand van minder dan 1 meter gehoord te kunnen worden.
- ☐ Communicatie is onmogelijk.

24. Duid aan wat voor u van toepassing is. Vul op de stippellijntjes een antwoord in waar nodig.



25. Werd u tijdens één van uw voorgaande jobs blootgesteld aan lawaai?

- ☐ Ja
- ☐ Neen (ga naar vraag 29)

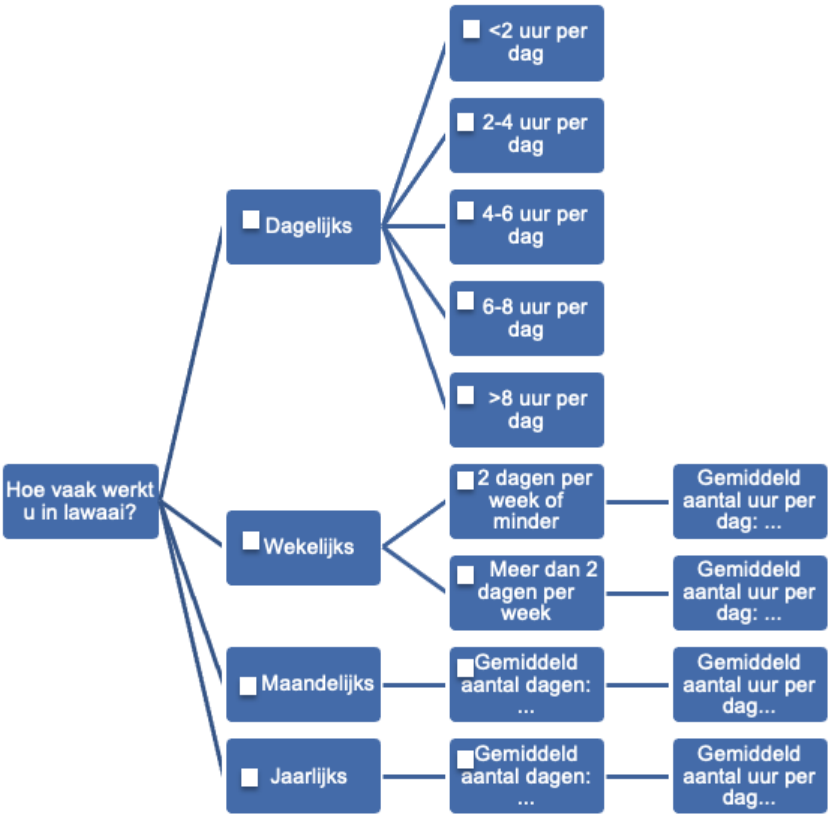
26. Hoe lang heeft u deze job beoefend?

- ☐ < 1 jaar
- ☐ 1-5 jaar
- ☐ 5-10 jaar
- ☐ > 10 jaar

27. Welke stelling past het best bij het geluidsniveau op uw voorgaande job?

- ☐ Communicatie is perfect mogelijk, u hoeft hiervoor niet te roepen.
- ☐ U moet roepen om over een afstand van meer dan 1 meter gehoord te kunnen worden.
- ☐ U moet roepen om over een afstand van minder dan 1 meter gehoord te kunnen worden.
- ☐ Communicatie is onmogelijk.

28. Duid aan wat voor u van toepassing is (lawaaiblootstelling voorgaande job). Vul op de stippellijntjes een antwoord in waar nodig.



29. Heeft iemand in uw familie een gehoorverlies?

☐ Ja

☐ Neen (ga naar vraag 30)

a. Indien ja, over wie gaat het? (broer, zus, oma, tante…). Gelieve dit in te vullen onder 'persoon'.
b. Indien ja, kent u de oorzaak? Gelieve het corresponderende nummer naast het corresponderende familielid te plaatsen.

1 = aangeboren
2 = niet aangeboren ziekte
3 = ouderdom
4 = lawaaiblootstelling
5 = trauma (bv. een hoofdwonde, breuk, verkeersongeval…)
6 = luid geluid (bv. een geweerschot)
7 = medicatie
8 = ik weet het niet

Persoon	Oorzaak

30. Heeft u ooit een gehoorvermindering (= het gevoel dat u plots minder hoort dan vroeger) van uw gehoor opgemerkt (uitgezonderd verminderd gehoor tijdens een verkoudheid)

☐ Ja

☐ Neen (ga naar vraag 34)

31. In welk oor merkte u deze vermindering op?

☐ Linkeroor

☐ Rechteroor

☐ Beide oren, met een beter gehoor links

☐ Beide oren, met een bete gehoor rechts

☐ Beide oren gelijk

32. Wanneer merkte u deze gehoorvermindering op?

☐ Mijn gehoor is altijd minder

☐ Ik heb dit sinds enkele dagen

☐ Dit is meer dan een week geleden

☐ Dit is meer dan een maand geleden

☐ Ik heb dit lang geleden (> 1 jaar) ervaren

33. Hoelang duurt deze gehoorvermindering gemiddeld?

☐ < 24 uur

☐ 24 – 48 uur

☐ Ze is nooit verdwenen

34. Heeft u ooit een gehoorvermindering opgemerkt tijdens of na het werk?

☐ Ja, ik heb al een gehoorvermindering ervaren **tijdens** het werk

☐ Ja, ik heb al een gehoorvermindering ervaren **na** het werk

☐ Neen, ik heb nog nooit een gehoordaling gerelateerd aan mijn werk ervaren (ga naar vraag 36).

35. Hoelang duurde deze gehoorvermindering, gerelateerd aan uw werk, gemiddeld?

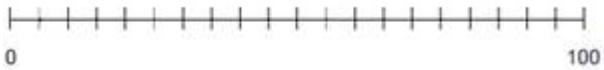
☐ < 24 uur

☐ 24 – 48 uur

☐ Ze is nooit verdwenen

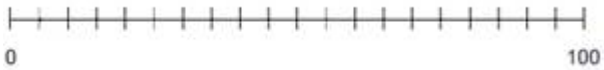
Lees onderstaande stellingen bij vraag 36 t.e.m. 57 zorgvuldig en duidt vervolgens aan op het lijnstuk hoe vaak dit voor u van toepassing is. Een score van 0 komt overeen met 'Zelden tot nooit' en een score 100 komt overeen met '(Bijna) altijd'

36. Ik kan in een rustige omgeving een gesprek voeren met 1 persoon.

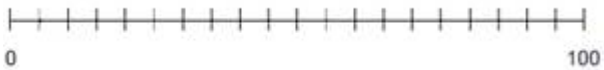


37. Ik kan in een rustige omgeving een gesprek voeren met meer dan 2 personen (als ze beurtelings aan het woord zijn).

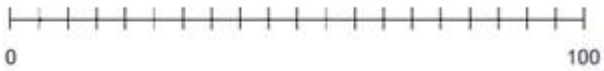
38. Ik kan in een rustige omgeving een kort telefoongesprek voeren.



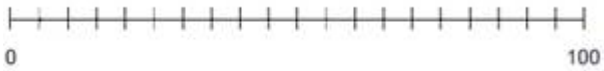
39. Mijn gehoorprobleem vormt een belemmering bij het regelen van belangrijke zaken (bv. notaris, bank, dokter, gemeentehuis, verzekeringen,...).



40. Ik heb het gevoel dat mijn gehoor mijn sociale activiteiten en persoonlijke leven hindert.



41. Het gebeurt dat ik afhaak tijdens een gesprek omdat het me te veel inspanning kost om alles te verstaan.



42. Ik kan ervan genieten naar muziek te luisteren

43. **Ik versta de tekst van een Nederlandstalig lied (gezongen in het Algemeen Nederlands, afgespeeld op een normale luidheid).**

44. **Ik herken de melodie van liedjes van vroeger die ik goed heb gekend.**

45. **Ik heb moeite met het volgen van een lang verhaal/gesprek.**

46. **Het gebeurt dat ik vergeten ben wat iemand me gevraagd heeft, vooraleer ik heb kunnen antwoorden.**

47. **In een rustige straat kan ik op basis van het geluid inschatten waar een auto vandaan komt.**

48. **Als ergens in huis een deur dichtslaat of iets op de grond valt, kan ik onmiddellijk in de juiste richting kijken.**

49. **Ik vind het moeilijk mijn aandacht bij een gesprek te houden en ben snel afgeleid.**

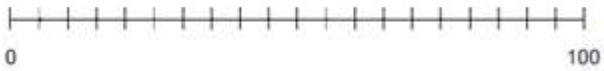
50. **Ik heb er moeite mee dat ik slechthorend ben.**

51. **Ik heb minder zelfvertrouwen door mijn gehoorprobleem.**

52. **Ik maak me zorgen over mijn gehoor.**

53. **Ik voel me eenzaam ten gevolge van mijn gehoorprobleem.**

54. **Ik probeer mijn gehoorprobleem te verbergen voor anderen.**



55. **Ik kan verstaan wat iemand tegen me zegt zonder die persoon aan te kijken.**

56. **In een alledaags gesprek heb ik tijd nodig om te verwerken wat gezegd werd, alvorens ik kan antwoorden.**

57. In een gesprek heb ik het gevoel dat ik langer dan anderen moet nadenken vooraleer ik een vraag kan beantwoorden.

58. Bent u overgevoelig voor lawaai?

☐ Ja

☐ Neen (ga naar vraag 61)

59. Indien u overgevoeligheid ervaart, in welk oor heeft u hier dan last van?

☐ Linkeroor

☐ Rechteroor

☐ Beide oren

☐ Beide oren, maar mijn linkeroor is erger

☐ Beide oren, maar mijn rechteroor is erger

☐ Dit is variabel

60. Hoe vaak heeft u tijdens of na een werkdag last van overgevoeligheid voor lawaai?

☐ Altijd na het werk

☐ Enkel tijdens het werk

☐ Enkel tijdens mijn pauzes of vrije tijd

☐ Zelden

61. Heeft u last van oorsuizen (het horen van een fluit, piepen, bromtoon…)?

☐ Ja

☐ Neen (ga naar vraag 65)

62. Indien u oorsuizen ervaart, in welk oor heeft u hier dan last van?

☐ Linkeroor

☐ Rechteroor

☐ Beide oren

☐ Beide oren, maar mijn linkeroor is erger

☐ Beide oren, maar mijn rechteroor is erger

☐ Dit is variabel

63. Hoe vaak heeft u tijdens of na een werkdag last van oorsuizen (het horen van een fluit, piepen, bromtoon…)?

☐ Altijd na het werk

☐ Enkel tijdens het werk

☐ Enkel tijdens mijn pauzes of vrije tijd

☐ Zelden

☐ Nooit (ga naar vraag 65)

64. Indien u oorsuizen ervaart tijdens of na het werk, hoe zou u uw oorsuizen beschrijven?

☐ Tijdelijk (ze is binnen de 24 uur verdwenen)

☐ Schommelend (ze is de ene keer beter dan de andere keer)

☐ Permanent

☐ Ze is te overstemmen met andere geluiden

65. Ervaart u soms een drukgevoel/volgevoel in uw oren (uitgezonderd indien u een verkoudheid heeft of het gevoel wanneer u een hoogteverschil doormaakt).

☐ Ja

☐ Neen (ga naar vraag 69)

66. Indien u een drukgevoel/volgevoel ervaart, in welk oor heeft u hier last van?

☐ Linkeroor

☐ Rechteroor

☐ Beide oren

☐ Beide oren, maar mijn linkeroor is erger

☐ Beide oren, maar mijn rechteroor is erger

☐ Dit is variabel

67. Hoe vaak heeft u tijdens een werkdag last van een drukgevoel/volgevoel in uw oren?

☐ Altijd na het werk

☐ Enkel tijdens het werk

☐ Enkel tijdens mijn pauzes of vrije tijd

☐ Zelden

☐ Nooit (ga naar vraag 69)

68. Indien u een drukgevoel/volgevoel in uw oren ervaart tijdens of na het werk, hoe zou u deze beschrijven?

☐ Tijdelijk (dit is binnen de 24 uur verdwenen)

☐ Schommelend (het is soms beter, soms slechter)

☐ Permanent

69. Draagt u één of meerdere hoorapparaten?

☐ Ja

☐ Neen (ga naar vraag 71)

70. Indien u hoorapparaten draagt, draagt u één of twee hoorapparaten?

☐ Ik draag één hoorapparaat **links**

☐ Ik draag één hoorapparaat **rechts**

☐ Ik draag twee hoorapparaten

71. In volgende tabel staan een aantal activiteiten opgesomd.

- ***a.*** **Geef aan hoe vaak u deelneemt aan deze activiteiten. Indien u 'jaarlijks', 'maandelijks' of 'wekelijks' aanduidt, geeft u ook weer hoeveel keer per jaar, per maand of per week u gemiddeld deelneemt aan de activiteit. Indien u 'nooit' aanduidt, hoeft u de volgende kolommen niet in te vullen.**
- ***b.*** **Geef in de kolom 'uren per sessie' hoelang u per keer gemiddeld spendeert aan de activiteit.**
- ***c.*** **Geef in de kolom 'totaal aantal jaren' het aantal jaren in dat u deze activiteit reeds uitvoert.**
- ***d.*** **Geef in de kolom 'geschatte luidheid' aan hoe luid u deze activiteit schat. Kies het best passende cijfer:**
  - **1 = geluidsniveau van een normale conversatie**
  - **2 = geluidsniveau waarbij u uw stem moet verheffen**
  - **3 = geluidsniveau van een luide conversatie**
  - **4 = geluidsniveau van een zeer luide conversatie**
  - **5 = geluidsniveau waarbij u moet roepen over 1 meter om gehoord te worden**
  - **6 = geluidsniveau waarbij u moet roepen over een kleine afstand om gehoord te worden**
  - **7 = geluidsniveau dat communicatie onmogelijk maakt**
- **e. In deze kolom geeft u aan of u tijdens het uitvoeren van deze activiteit gehoorbescherming draagt.**

Een voorbeeld:

Activiteit	a. Frequentie								b. uren per sessie	c. Totaal aantal jaren	d. Geschatte luidheid					e. Gehoor-bescherming		
	Nooit	jaarlijks (+hoeveel		Maandelijks (+ hoeveel)		Wekelijks (+ hoeveel)		Dagelijks			1	2	3	4	5	Ja	Soms	Nee
Spelen in band, orkest, fanfare	☐	☐		☒	3x	☐		☐	3	5	☐	☐	☐	☒	☐	☑	☐	☐

Activiteit	a. Frequentie								b. uren per sessie	c. Totaal aantal jaren	d. Geschatte luidheid							e. Gehoor-bescherming		
	Nooit	jaarlijks (+hoeveel)		Maandelijks (+ hoeveel)		Wekelijks (+ hoeveel)		Dagelijks			1	2	3	4	5	6	7	Ja	Soms	Nee
Spelen in band, orkest, fanfare	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Muziek beluisteren via oortjes of oordopjes (computer, smartphone, iPhone…)	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Muziek beluisteren via luidsprekers (thuis, in de wagen…)	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sportlessen met muziek (aerobics, dansles, spinning…)	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Naar cinema gaan	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Uitgaan in discotheek, danscafé of fuif	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Naar praatcafé gaan	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bijwonen van festivals	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Activiteit	a. Frequentie							b. uren per sessie	c. Totaal aantal jaren	d. Geschatte luidheid							e. Gehoor-bescherming		
	Nooit	jaarlijks (+hoeveel)		Maandelijks (+ hoeveel)		Wekelijks (+ hoeveel)		Dagelijks			1	2	3	4	5	6	7	Ja	Soms	nee
Bijwonen van concerten en optredens	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bijwonen van sportevenementen (voetbalwedstrijd, basketbal, …)	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Gebruik van luidruchtig gereedschap in de vrije tijd	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Motorrijden	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bespelen van een muziekinstrument	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Gaming met hoofdtelefoon of oordopjes (via PC, PlayStation, Xbox…)	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Gaming met luidsprekers (via PC, PlayStation, Xbox…)	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Televisie kijken	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Andere lawaaierige activiteiten in de vrije tijd	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Activiteit	a. Frequentie							b. uren per sessie	c. Totaal aantal jaren	d. Geschatte luidheid							e. Gehoor-bescherming		
	Nooit	jaarlijks (+hoeveel)		Maandelijks (+ hoeveel)		Wekelijks (+ hoeveel)		Dagelijks			1	2	3	4	5	6	7	Ja	Soms	Nee
Lawaai op het werk / vakantiejob: gebruik van luidruchtig gereedschap	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lawaai op het werk / vakantiejob: rumoerige omgeving	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lawaai op het werk / vakantiejob: werken in luide muziek	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lawaai op het werk / vakantiejob: werken met kinderen (bv. onderwijs, zorginstellingen...)	☐	☐		☐		☐		☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

72. Draagt u gehoorbescherming op het werk?

☐ Ja

☐ Neen (ga naar vraag 74)

☐ Soms

73. Welk type gehoorbescherming draagt u op het werk?

☐ Op maat gemaakte oordoppen (a)

☐ Kneedbare wegwerpdoppen (b)

☐ Universele oordoppen (c)

☐ Oorkappen (d)

☐ Andere: …..

 a	 b	 c	 d

74. Beoordeel volgende stellingen. Duid telkens één antwoord aan.

	Volledig mee eens	Gedeeltelijk mee eens	Neutraal	Gedeeltelijk mee oneens	Volledig mee oneens
Ik denk dat gehoorbeschermers teveel druk op mijn oren zetten.	☐	☐	☐	☐	☐
Ik geloof dat ik weet hoe ik gehoorbeschermers moet inbrengen en dragen.	☐	☐	☐	☐	☐
Ik heb niet de intentie om gehoorbescherming te dragen wanneer ik in lawaaierige omstandigheden ben.	☐	☐	☐	☐	☐
Ik geloof dat ik in een lawaaierige omgeving kan vertoeven zonder mijn gehoor te schaden.	☐	☐	☐	☐	☐
Ik denk dat het dragen van gehoorbescherming elke keer ik in lawaai vertoef belangrijk is.	☐	☐	☐	☐	☐
Ik draag gehoorbeschermers wanneer ik in lawaai ben.	☐	☐	☐	☐	☐
Ik vind gehoorbescherming dragen oncomfortabel.	☐	☐	☐	☐	☐
Mijn collega's dragen nooit gehoorbescherming.	☐	☐	☐	☐	☐
Ik weet niet zeker wanneer gehoorbeschermers aan vervanging toe zijn.	☐	☐	☐	☐	☐
Mijn gehoor verliezen maakt het voor anderen moeilijk om met mij te praten.	☐	☐	☐	☐	☐
Ik geloof dat mijn oren uiteindelijk aanpassen aan lawaai zodat er minder risico is op beschadiging.	☐	☐	☐	☐	☐
Ik weet wanneer ik gehoorbeschermers zou moeten dragen.	☐	☐	☐	☐	☐
Ik geloof dat blootstelling aan lawaai mijn gehoor kan schaden.	☐	☐	☐	☐	☐
Ik ben ervan overtuigd dat ik gehoorverlies kan voorkomen wanneer ik in lawaaierige omstandigheden gehoorbeschermers draag.	☐	☐	☐	☐	☐
Ik denk dat mijn gehoor geschaad wordt door blootstelling aan lawaai.	☐	☐	☐	☐	☐
Gehoorbeschermers beperken mijn mogelijkheden om met anderen te communiceren.	☐	☐	☐	☐	☐
Ik geloof niet dat een deel van mijn gehoor verliezen een grote handicap zou zijn.	☐	☐	☐	☐	☐
Als ik gehoorbeschermers draag, bescherm ik mijn gehoor.	☐	☐	☐	☐	☐
Gehoorbescherming dragen is vervelend.	☐	☐	☐	☐	☐
Mijn collega's vinden het een goed idee om gehoorbeschermers te dragen.	☐	☐	☐	☐	☐
Ik denk niet dat het nodig is elke keer ik in lawaai vertoef gehoorbeschermers te dragen.	☐	☐	☐	☐	☐
Ik denk dat dagelijkse blootstelling aan lawaai mijn gehoor uiteindelijk kan schaden.	☐	☐	☐	☐	☐
Ik denk dat het een groot probleem zou zijn als ik mijn gehoor zou verliezen.	☐	☐	☐	☐	☐
Ik ben van plan gehoorbescherming te dragen.	☐	☐	☐	☐	☐

75. Bent u ooit geopereerd aan één van beide oren?

☐ Ja, het linkeroor

☐ Ja, het rechteroor

☐ Ja, beide oren

☐ Neen (ga naar vraag 78)

76. Wat was de reden voor de operatie?

……
……
……
……

77. Indien u bijkomende gehoorklachten of opmerkingen heeft mag u dit hier noteren.

……
……
……
……
……
……
……
……

DEEL 4: EVENWICHT

78. Heeft u last van één of meer van volgende symptomen (meerdere antwoorden mogelijk)?

- ☐ Duizeligheid
- ☐ Vallen zonder bewustzijnsverlies
- ☐ Vallen met bewustzijnsverlies
- ☐ Misselijkheid
- ☐ Draaierigheid
- ☐ Oscillopsie (= instabiel beeld van de omgeving wanneer u hoofdbewegingen maakt)
- ☐ Dronken gevoel
- ☐ Ruimtelijke oriëntatie of navigatieproblemen
- ☐ Instabiliteit
- ☐ Braken
- ☐ IJlhoofdigheid
- ☐ Gevoel op een schip/op wolken te zitten
- ☐ Lateropulsie (= onvrijwillige, zijwaartse beweging van lichaam of een lichaamsdeel, gevoel van opzij geduwd te worden).
- ☐ Ik heb geen van bovenstaande symptomen. **U mag de vragenlijst hier beëindigen.**

79. Hoe vaak heeft u last van deze klachten?

- ☐ Dagelijks (1 keer)
- ☐ Dagelijks (meerdere keren)
- ☐ Om de paar dagen tot wekelijks
- ☐ Om de paar weken tot maandelijks
- ☐ Om de paar maanden
- ☐ Onregelmatig
- ☐ Continu
- ☐ Slechts één keer
- ☐ Slechts bij een trigger

80. Wanneer zijn deze klachten begonnen?

- ☐ Enkele dagen geleden (< 7 dagen)
- ☐ Vorige week
- ☐ Deze maand
- ☐ Een aantal maanden geleden
- ☐ Ik heb deze klachten al jaren

81. Ervaart u deze klachten aanvalsgewijs of continu?

- ☐ Aanvallen
- ☐ Continu

82. Hoelang zijn deze klachten gemiddeld aanwezig?

- ☐ < 1 minuut
- ☐ 1 – 5 minuten
- ☐ 5 – 20 minuten
- ☐ 20 minuten – enkele uren
- ☐ > 24 uur – enkele dagen
- ☐ Weken – maanden
- ☐ Continu
- ☐ Variabel

83. Hoe evolueren de klachten?

- ☐ Aanhoudende klachten
- ☐ Verbetering van de klachten
- ☐ Verslechtering van de klachten
- ☐ Variabel (schommelend)

84. Kunnen één van volgende triggers uw symptomen uitlokken/verergeren?

- ☐ Snelle hoofdbewegingen
- ☐ Draaien in bed
- ☐ Omhoog kijken
- ☐ Voorover buigen, achterover buigen
- ☐ Gaan liggen

☐ Rechtop staan

☐ Inspanning

☐ In het schemerduister/donker lopen

☐ Op een oneffen ondergrond lopen

☐ Auto- of vliegreis

☐ Hoesten, niezen, iets opheffen

☐ Geluiden

☐ Vermoeidheid

☐ Emoties

☐ Stress

☐ Medicatie

☐ Alcoholgebruik

☐ Visueel (bv. door te veel licht of drukke visuele patronen zoals voorbijrijdende trein)

☐ Andere:…..

☐ Mijn symptomen worden niet uitgelokt/erger door een trigger.

85. Ervaart u één van volgende gehoorgerelateerde klachten voor, tijdens of net na het optreden van uw symptomen uit vraag 84? Indien u één van de klachten aankruist, vul dan de bijhorende gedetailleerde bevraging in. (Meerdere antwoorden mogelijk).

☐ Gehoorverlies

☐ Oorsuizen (tinnitus)

☐ Drukgevoel/volgevoel in de oren

☐ Overgevoeligheid aan geluid

☐ Autofonie (versterkt horen van lichaamseigen geluiden)

☐ Ik ervaar geen gehoorgerelateerde klachten (ga naar vraag 86).

Gedetailleerde bevraging gehoorverlies

a) Gehoorverlies en evenwichtsklachten, duid aan wat past

☐ Mijn gehoorverlies gaat **altijd** gepaard met mijn evenwichtsklachten

☐ Mijn gehoorverlies komt ook los van mijn evenwichtsklachten voor

☐ Tijdens mijn evenwichtsklachten treedt het gehoorverlies soms op, soms niet

b) Duur van uw gehoorverlies, duid aan wat past

☐ Mijn gehoorverlies is tijdelijk (het gaat weer voorbij)

☐ Mijn gehoorverlies is permanent

f) Evolutie van uw gehoorverlies, duid aan wat past

☐ De ernst van mijn gehoorverlies is constant

☐ Mijn gehoorverlies wordt erger

☐ Mijn gehoorverlies wordt beter

☐ Mijn gehoorverlies is de ene keer beter, de andere keer erger

Gedetailleerde bevraging oorsuizen (tinnitus)

a) Mijn tinnitus klinkt als…

☐ Een toon

☐ Ruis, gezoem, gesis

☐ Beide: zowel een toon als ruis

b) Mijn tinnitus is…

☐ Een hoge toon, pieptoon, scherp, metaalachtig…

☐ Een lage toon, gebrom, dof, zwaar…

☐ Een middentoon

☐ Ruis (er is geen onderscheid te maken tussen hoog, midden of laag).

c) In welk oor ervaart u tinnitus?

☐ Linkeroor

☐ Rechteroor

☐ In beide oren, zonder onderscheid

☐ In beide oren maar verschillend (bijvoorbeeld een ruis in het linkeroor, een toon in het rechteroor)

d) Mijn tinnitus treedt op…

☐ Tijdens het werk

☐ Na het werk

☐ Tijdens mijn pauzes (op het werk)

☐ In mijn vrije tijd

e) Tinnitus en evenwichtsklachten, duid aan wat past

☐ Mijn tinnitus gaat **altijd** gepaard met mijn evenwichtsklachten

☐ Mijn tinnitus komt ook los van mijn evenwichtsklachten voor

☐ Tijdens mijn evenwichtsklachten treedt mijn tinnitus soms op, soms niet

f) Duur van uw tinnitus, duid aan wat past

☐ Mijn tinnitus is tijdelijk (het gaat weer voorbij)

☐ Mijn tinnitus is permanent

g) Evolutie van uw tinnitus, duid aan wat past

☐ De ernst van mijn tinnitus is constant

☐ Mijn tinnitus wordt erger

☐ Mijn tinnitus wordt beter

☐ Mijn tinnitus is de ene keer beter, de andere keer erger

☐ Drukgevoel/volgevoel in de oren

Gedetailleerde bevraging drukgevoel/vol gevoel in de oren

a) In welk oor ervaart u een drukgevoel/volgevoel?

☐ Linkeroor

☐ Rechteroor

☐ In beide oren

b) Het drukgevoel/volgevoel treedt op…

☐ Tijdens het werk

☐ Na het werk

☐ Tijdens mijn pauzes (op het werk)

☐ In mijn vrije tijd

c) Drukgevoel/volgevoel en evenwichtsklachten, duid aan wat past

☐ Het drukgevoel/volgevoel gaat **altijd** gepaard met mijn evenwichtsklachten

☐ Het drukgevoel/volgevoel komt ook los van mijn evenwichtsklachten voor

☐ Tijdens mijn evenwichtsklachten treedt het drukgevoel/volgevoel soms op, soms niet

d) Duur van het drukgevoel/volgevoel, duid aan wat past

☐ Het drukgevoel/volgevoel is tijdelijk (het gaat weer voorbij)

☐ Het drukgevoel/volgevoel is permanent

e) Evolutie van het drukgevoel/volgevoel, duid aan wat past

☐ De ernst van het drukgevoel/volgevoel is constant

☐ Het drukgevoel/volgevoel wordt erger

☐ Het drukgevoel/volgevoel wordt beter

☐ Het drukgevoel/volgevoel is de ene keer beter, de andere keer erger

☐ Overgevoeligheid aan geluid

Gedetailleerde bevraging overgevoeligheid aan geluid

a) In welk oor ervaart u de overgevoeligheid?

☐ Linkeroor

☐ Rechteroor

☐ In beide oren

b) De overgevoeligheid treedt op…

☐ Tijdens het werk

☐ Na het werk

☐ Tijdens mijn pauzes (op het werk)

☐ In mijn vrije tijd

c) Overgevoeligheid en evenwichtsklachten, duid aan wat past

☐ De overgevoeligheid gaat **altijd** gepaard met mijn evenwichtsklachten

☐ De overgevoeligheid komt ook los van mijn evenwichtsklachten voor

☐ Tijdens mijn evenwichtsklachten treedt de overgevoeligheid soms op, soms niet

d) Duur van de overgevoeligheid, duid aan wat past

☐ De overgevoeligheid is tijdelijk (het gaat weer voorbij)

☐ De overgevoeligheid is permanent

e) Evolutie van de overgevoeligheid, duid aan wat past

☐ De ernst van de overgevoeligheid is constant

☐ De overgevoeligheid wordt erger

☐ De overgevoeligheid wordt beter

☐ De overgevoeligheid is de ene keer beter, de andere keer erger

☐ Versterkt horen van lichaamseigen geluiden (bijvoorbeeld uw hartslag) = autofonie.

Gedetailleerde bevraging versterkt horen van lichaamseigen geluiden (= autofonie)

a) Ik ervaar autofonie

☐ Tijdens het werk

☐ Na het werk

☐ Tijdens mijn pauzes (op het werk)

☐ In mijn vrije tijd

b) Autofonie en evenwichtsklachten, duid aan wat past

☐ Deze sensatie gaat **altijd** gepaard met mijn evenwichtsklachten

☐ Deze sensatie komt ook los van mijn evenwichtsklachten voor

☐ Tijdens mijn evenwichtsklachten treedt deze sensatie soms op, soms niet

c) Duur van de autofonie, duid aan wat past

☐ Deze sensatie is tijdelijk (het gaat weer voorbij)

☐ Deze sensatie is permanent

d) Evolutie van de autofonie, duid aan wat past

☐ De ernst van deze sensatie is constant

☐ Deze sensatie wordt erger

☐ Deze sensatie wordt beter

☐ Deze sensatie is de ene keer beter, de andere keer erger

86. Worden de klachten vergezeld, voorafgegaan of gevolgd door één van volgende zaken? (Meerdere antwoorden mogelijk).

☐ Nekpijn

☐ Hoofdpijn

☐ Dubbelzien

☐ Spraakproblemen

☐ Bewustzijnsverlies

☐ Gevoeligheid voor licht

☐ Gevoeligheid voor geluid

☐ Tintelingen

☐ Vlekken voor de ogen

☐ Hyperventilatie

☐ Paniekaanvallen

☐ Depressie

87. Heeft een arts reeds een diagnose gesteld rond een mogelijke oorzaak?

- ☐ Ja
- ☐ Neen (ga naar vraag 89)

88. Welke oorzaak heeft de arts gesteld?

- ☐ Hoofdletsel
- ☐ Medicatie
- ☐ Operatie
- ☐ Tumor
- ☐ Infectie van de evenwichtszenuw (neuritis)
- ☐ Herseninfarct
- ☐ Vermoeidheid
- ☐ Ziekte van Ménière
- ☐ Benigne paroxysmale positioneringsvertigo (de steentjes in uw evenwichtsorgaan zijn losgekomen)
- ☐ Ik weet het niet meer.
- ☐ Andere: …

89. Heeft iemand in uw familie een evenwichtsprobleem?

f. Indien ja, over wie gaat het? (broer, zus, oma, tante…). Gelieve dit in te vullen onder 'persoon'.

g. Indien ja, kent u de oorzaak? Gelieve het corresponderende nummer naast het corresponderende familielid te plaatsen.

1 = hoofdletsel
2 = medicatie
3 = operatie
4 = tumor
5 = infectie
6 = herseninfarct
7 = geen duidelijke oorzaak
8 = ik weet het niet

Persoon	Oorzaak

90. Eventuele bijkomende evenwichtsklachten of opmerkingen mag u hier noteren.

……
……
……
……
……
……