PREVENTION OF HEARING LOSS IN YOUNG ADULTS

A COST-BENEFIT ANALYSIS

Report

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Contents

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Executive Summary

Context: In the past few decades, noise induced hearing loss (NIHL) has become an increasing problem, especially in children and young adults between 12 and 25 years old. Due to improved sound experience and increased accessibility to music since the 1980's, the exposure to noise has increased significantly and thus the incidence of NIHL has risen. This increased incidence has a large impact on society, due to the socioeconomic and psychological consequences of NIHL, which in turn influence the health related quality of life.

Problem statement: Due to the absence of accurate data, the impact of NIHL on society is greatly underestimated, which is one of the main reasons that various stakeholders, like (local) governments are reluctant to invest in the prevention of NIHL. This problem is recognized by the Netherlands Hearing foundation, who are actively involved in raising national awareness and developing preventive interventions. However, due to a lack of involvement of various stakeholders, there are not enough resources available to reduce the amount of individuals that develops NIHL.

Research question: To stimulate various stakeholders to invest in prevention of NIHL in young adults between 12 and 25 years old, an overview is needed of the costs and benefits that are related to investing in preventive interventions for NIHL. Therefore, this study aimed to answer the following research question: *What are the health-economic benefits of investing in prevention of NIHL in young adults between 12 and 25 from a health care perspective?*

Methods: For this study, a model was used that was based on the methods that were used in the Assessing Cost-Effectiveness (ACE)-prevention study and the WHO-CHOICE program by the World Health Organization (WHO). The model was made to compare various alternative scenarios to a base case scenario (null scenario). In the null scenario, two interventions were included that were already active in the Netherlands and targeted at young adults between the age of 12 and 25 years. For the alternative scenarios, a total of four interventions were included: two interventions from abroad, along with one intervention that was developed and tested in the Netherlands but not active and one intervention which the Netherlands Hearing Foundation is planning to implement in the near future.

The input parameters that were needed for the cost-benefit analysis were coverage, adherence, effect, cost-offsets and program costs of each interventions, along with the amount of people between 12 and 25 years old at risk of developing NIHL and the Willingness to Pay for each avoided case of NIHL. Values for these input parameters were obtained by an extensive literature reviews, expert opinions through questionnaires and interviews. Approximations and estimations were used to fill data gaps that remained. All obtained input parameters were inserted into the model and a total of 10 alternative scenarios were constructed. Each alternative scenario was compared to the null scenario in a best, middle and worst case situation, which refers to the ranges of the obtained parameters that were obtained during data gathering. Subsequent primary and secondary outcome measures were saved and compared to each other to provide answers to the sub-questions.

Results: A large amount of results came from the cost-benefit analyses. Therefore, only the results with the largest and smallest difference between alternative and null scenarios are presented, to illustrate the scope of the possible costs and benefits. The amount of young adults between the age of 12 and 25 years that are currently at risk of developing NIHL is approximately 828.000, which is 28.6% of the total number of young adults between the age of 12 and 25 years in the Netherlands. Each alternative scenario that was analyzed entailed higher net-benefits than the null scenario. The incremental net-benefits were positive for each alternative scenario. The alternative scenario in which only

“Iets minder is de max” was added to the currently active interventions yielded the lowest incremental net-benefits, while the alternative scenarios in which Oorcheck JGZ, Sonic Silence Exhibit, Sound Effects and “Iets minder is de max” were added to the currently active interventions yielded the highest incremental net-benefits: approximately €20.000.000. The alternative scenario with the highest mean for each invested euro and the lowest cost-benefit ratio turned out to be the scenario in which only Oorcheck JGZ was added, to the currently available interventions, in the best case situation. Oorcheck JGZ had relatively low costs and high benefits, which led to the highest mean ROI (in the best case situation) and therefore had the largest difference compared to the mean ROI of the null scenario.

Discussion and conclusion: Although some alternative scenarios had higher ROIs and net-benefits than others, each alternative scenario turned out to generate more benefits for relatively less costs than the null scenario, which suggest that investing in these scenarios would be beneficial. However, it should be taken into account that, due to data scarcity, we often had to rely on assumptions and approximations for our analysis, which resulted in high uncertainty of the results. This was partly compensated for by performing Monte Carlo uncertainty analysis, but the obtained outcome ranges are very broad and the outcomes remain highly speculative. Therefore no firm conclusions can be drawn from the analyses.

Furthermore, the used model leaves room for improvement, since the socioeconomic and psychological consequences were not taken into account in the analysis, due to insufficient information of these aspects. If these aspects are taken into account, the model could provide a more holistic view of the costs and benefits of investing in the prevention of NIHL.

Even though robust conclusions cannot be drawn from the our analyses, this study did provide a health-economic simulation tool that can prove to be valuable in the future, especially when more data on interventions and consequences of NIHL become available.

Recommendations: In terms of directions for future research, the focus should be on determining the coverage, adherence and effects of various preventive interventions for NIHL to provide input data for the simulation tool. When data becomes available and is inserted into the health-economic simulation tool, the outcomes will be more specific and provide a more realistic view on the actual costs and benefits of the preventive interventions.

1. Introduction

Hearing impairments are a growing public health concern in the Netherlands costing society over 900 million Euros in 2011. A total of 1% of the yearly healthcare costs in the Netherlands is spend on hearing impairments, and this number is only increasing (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2014).

Noise pollution is one of the main causes of hearing loss and tinnitus. Tinnitus is a condition in which an individual hears sounds that are not really there, for example a constant beep. Even though several new techniques made it possible to reduce the noise exposure in the industrial sector, hearing loss is still in the top 10 of most common burdens of disease worldwide and is only expected to become more common in the future (Hasson, Theorell, Westerlund, & Canlon, 2010; Helvik, Krokstad, & Tambs, 2009).

In the Netherlands, the percentage of workers that is exposed to excessive noise during their work is stable at around 7% (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013). However, the incidence of noise induced hearing loss (NIHL) only increased in the past decades, especially in children and young adults between 12 and 25 years old. This increase is presumably due to increased exposure to music since the early 1980's, when the first Walkmans came on the market (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013; Kahari, Åslund, & Olsson, 2011). Due to developments that took place in the past few decades, it became possible to listen to higher levels of sound, without compromising the quality of music. In addition to a better sound quality, personal audio devices where brought on the market. These developments had an enormous impact on sound experience but also on accessibility of music (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013). As a consequence, noise exposure is not only prolonged, but the noise intensity is also increased.

Both duration and noise intensity determine whether hearing loss occurs or not. Sounds that are above 80 dB(A) can cause hearing loss in case of prolonged exposure. For example, if the average noise level is 85 dB(A), hearing loss starts to occur after 8 hours of exposure to that sound level. If the noise level increases, the time until onset of hearing loss will decrease (Taneja, 2014). Any preventive measures should therefore focus on reducing exposure time, intensity or both.

Hearing loss can have serious economic, psychological and social consequences. In most cases, these consequences also influence each other. For example, children with hearing impairments incurred at a young age are likely to have difficulties with their speech and language development. These difficulties often have consequences for their further education and career prospects, but also on their social and emotional development (Shargorodsky, Curhan, Curhan, & Eavey, 2010). How prominent these difficulties are, depends greatly on the age of onset. Individuals who develop hearing loss at an older age often experience difficulties at work and in their social lives due to communication barriers, a lack of understanding and so on. This often leads to a decrease in productivity and, according to a study in Denmark, even in 30% of the cases to unemployment (Parving & Christensen, 1993). In addition, these individuals get socially isolated which in turn can lead to psychological issues (Kramer, 2008). All these factors have an impact on the health related quality of life (HRQoL).

Although some research was carried out on the costs of hearing impairment in general, no data is available on the costs of NIHL in the Netherlands (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013), which is mainly caused by a lack of information on the exact incidence of NIHL. Numbers about hearing impairments in general are available, but these numbers also include individuals with hearing loss that is not caused by excessive noise exposure, but for example by a genetic disorder or an infectious disease.

Unfortunately, the absence of accurate information leads to an underestimation of the seriousness of the problem, which is one of the main obstacles to get stakeholders like (local) governments and employers to invest in preventive interventions for NIHL.

If the Netherlands Hearing Health Foundation (Nationale Hoorstichting) wants to prevent a large part of the current generation from being deaf before the age of 40, it is important that measures are taken to decrease noise exposure, especially from recreational sources like music, in young adults between 12 and 25. The difficulty lies in the fact that hearing damage is not directly recognized as such. The onset is very slow and it can take years before an individual experiences serious hearing impairments and the impact on the Health Related Quality of Life (HRQoL). Therefore, hearing loss is often not taken seriously, especially by children and adolescents, because the effects are mostly noticeable on the long-term. However, hearing loss is irreversible and will therefore have a permanent impact on the HRQoL (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013; Taneja, 2014). This research shows that an effective solution to prevent a decreasing HRQoL due to NIHL would be to focus the preventive interventions on educating individuals about hearing loss and the importance of hearing protection. In addition, resources should be provided by various involved stakeholders to facilitate individuals in protecting their hearing.

Another disadvantage of the slow onset of NIHL is that various stakeholders, to whom NIHL should be of concern, are not motivated enough to invest in prevention or they are not aware of the extent in which NIHL can become a problem for them. Examples of involved stakeholders are insurance companies, educational institutes and employers. The Netherlands Hearing Health Foundation recognizes this issue and aims to stimulate involved parties by providing them with arguments why they should invest in NIHL prevention interventions. To achieve this, an overview is needed of the costs that are related to these preventive interventions and the health benefits of these investments.

Therefore, the main research question is: *What are the health-economic benefits of investing in prevention of NIHL in young adults between 12 and 25 from a health care perspective?* The research objective is to provide the Netherlands Hearing Health Foundation insight in the health-economic benefits of preventive interventions for NIHL from a healthcare perspective by making an assessment of the impact of investments in preventive interventions for NIHL on the health related quality of life and NIHL related health-care costs. In addition, a conceptual exploration is provided of the economic benefits of investment for various stakeholders.

2. Background

This section starts with a short overview of what hearing loss is and how it occurs, what the pitfalls are in recognition of NIHL and what the adverse effects of NIHL are. This will be followed up by a description of the current situation in the Netherlands, why prevention is important, which stakeholders are involved in preventing NIHL, and an overview of the preventive interventions that are taken into account in this research.

2.1 Hearing loss

There are two types of hearing loss, namely conductive and sensorineural hearing loss. Conductive hearing loss is caused by a defect that prevents sound vibrations from reaching the part of the ear that perceives sound. Sensory hearing loss is age related or caused by excessive noise. The latter is also called Noise Induced Hearing Loss (NIHL), which is a 100% preventable and therefore will be the main focus of the report (Taneja, 2014).

In NIHL, the hair cells in the inner ear are damaged due to overstimulation. Hair cells detect sound vibrations that come from our environment. These cells are very sensitive and therefore very vulnerable for loud noise. (Fligor). Overstimulation of the hair cells due to excessive noise leads to mechanical injury of the hair cells but also to big chemical changes that will damage the hair cells and the surrounding supporting cells. The degree in which the hair cells are damaged depends for the largest part on the level of noise and the duration of the exposure (Taneja, 2014). However, once a hair cell is damaged or dead, it will not regenerate, so any damage to the hair cell means permanent hearing loss (Fligor). It should be taken into account that other factors, like genetics, also determine how sensitive the ear is to noise. Nevertheless, these other factors have very little to do with NIHL and therefore will not be elaborated on. For this report, NIHL is defined as any hearing impairment due to damage to the hair cells, caused by excessive noise.

NIHL starts to occur at around 80 dB(A), which is as loud as a flushing toilet. However, for hearing loss to occur at 80 dB(A), there has to be more than 8 hours of exposure before damage occurs. If the amount of decibels increases by 3, the time of exposure until damage occurs decreases by 50%, as shown in Table 1 (Taneja, 2014; Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013).

Sound level in dB(A)	**Maximum exposure time until damage**
80	8 hours
83	4 hours
90	48 minutes
100	5 minutes
110	30 seconds

Table 1: Maximum exposure time before damage occurs at various sound levels: derived from RIVM (2013)

In general, the safe sound level is 75 dB(A), at which no hearing loss occurs in most people (Perenboom, Blankespoor, Kateman, & Quak, 2003). However, in various countries, the maximum sound level at work is set at 85 dB(A) (Passchier-Vermeer & Passchier, 2000). Taking Table 1 in consideration, this sound level would still lead to a hearing impairment after years of working. However, the severity of hearing loss can vary per person, since not everybody is equally sensitive to noise (Passchier-Vermeer & Passchier, 2000). In the

Netherlands however, the maximum sound level at work is set at 80 dB(A), which is a lot safer than 85 dB(A), but still a sound level at which hair cells can be damaged if the duration of exposure is long enough (Perenboom, Blankespoor, Kateman, & Quak, 2003). In the nightlife, visitors and employees of clubs and discotheques are always exposed to sound levels above 90 dB(A). On the dancefloor, the sound levels are even higher and can reach up to 110 dB(A).

Depending on how long and how much noise an individual is exposed to, different types of NIHL can occur. The main types are (Appendix I:C. Effects of Excessive Exposure):

- *Acoustic trauma* is caused by a single exposure to noise of more than 100 dB(A). Due to the intensity of the sound, immediate hearing loss will occur. This can be temporary or permanent.
- *Noise induced permanent threshold shifts (NIPTS)* is a permanent loss of hearing, which is caused by destruction of hair cells within the cochlea due to long-term noise exposure or acoustic trauma.
- *Noise induced temporary threshold shift (NITTS)* is a temporary type of NIHL, caused by short-term exposure, fatigue of the inner ear or an acoustic reflex.
- *Tinnitus* is described as hearing a constant hum or buzz, which is produced by the inner ear. Tinnitus is caused by long-term exposure to high noise levels or a single exposure to extremely high noise levels. This can also be caused by certain types of health issues or injuries.

In this report, the term NIHL will be used to refer to the above mentioned types of NIHL.

To determine the severity of hearing loss, an audiometry is performed at the frequencies 250, 500, 1000, 2000 and 4000 Herz (Hz). An audiometry is a test that determines the sensitivity of the ears for tones at various frequencies (van Son, 2012). The higher the frequency, the higher pitched the tone is. The amount of dB Hearing Loss (HL) at these frequencies then determines the severity of the hearing loss, as shown in Table 2. At mild severity, individuals already experience difficulties in understanding speech. Therefore, the term NIHL will be used in this report if the hearing loss is greater than 20 dB HL.

dB HL	**Severity**
0-20	No hearing loss
20-40	Mild hearing loss
40-60	Moderate hearing loss
60-80	Severe hearing loss
80-90	Profound hearing loss
>90	Deaf

Table 2: Classification of hearing loss severity by db HL: derived from RIVM (2013)

Hearing loss in individuals due to exposure to excessive noise is recognizable by a dip in the audiogram at 4000 Hz. 4000 Hz is the frequency where hearing loss starts in most cases. After prolonged exposure, the hearing loss will also occur for other high-pitched frequencies between 3000 and 6000 Hz (Perenboom, Blankespoor, Kateman, & Quak, 2003). Therefore, although NIHL has the largest effect at 4000 Hz, audiometric measurements have their limitations, since they only measure how good speech or certain tones are detected at predetermined frequencies (Passchier-Vermeer & Passchier, 2000; van Son, 2012). How sounds are perceived and processed by the individual cannot be measured

(Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013; Commission on Hearing Loss, 2014).

Another difficulty in the recognition of NIHL, is that it often starts with not being able to hear high pitched tones. High-pitched tones do not often occur in daily life, which makes it difficult to recognize NIHL in early stages (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013). In addition to that, hearing loss has a slow onset and it can take up to 10 years before the first signs of hearing loss are recognized as such (Commission on Hearing Loss, 2014).

2.2 Adverse effects

When an individual starts to notice a hearing impairment that is caused by noise exposure, the damage is already done. However, these individuals are often not aware of the further consequences of their impairment on the rest of their life. NIHL can have profound economic, social and psychological consequences, which in turn influence an individual's well-being and therefore the perceived quality of life (QoL). In the case of NIHL, the QoL of the individual is influenced by his health status and will therefore be referred to as Health Related Quality of Life (HRQoL).

Work and education are important aspects of an individual's daily life, not only from an economic point of view but also from a social point of view (Stam, Kostense, Festen, & Kramer, 2012). Therefore, aspects of education, income and occupation are often referred to as an individual's socioeconomic status (Winkleby, Jatulis, Frank, & Fortmann, 1992). NIHL has a major influence on the socioeconomic status of an individual. How the socioeconomic status of an individual is affected by NIHL, depends for a large part on the age of onset but also on the environment in which the individual grows up and how the individual is brought up by his parents. If NIHL develops when the individual is still in school, this could have a negative influence on the educational and social development of the individual (Shargorodsky, Curhan, Curhan, & Eavey, 2010). If the individual reaches a lower level of education because of the NIHL, this will have a direct effect on all aspects of socioeconomic status, namely on education, future occupation and income. When NIHL develops in a later stage, when the individual already finished his education, the effects will be limited to the occupation and income aspects of the socioeconomic status (Stam, Kostense, Festen, & Kramer, 2012). It should be taken into account that the causal relationship between NIHL and socioeconomic status may not be a one-way relationship. There is some evidence that a low socioeconomic may increase the risk of developing NIHL. Stam et al. (2012) suggests that this could be due to a lower level of education that increases the probability of an individual to work in noisy industries, for example in construction.

Another important aspect that is influenced by NIHL is psychological wellbeing. NIHL restricts an individual's ability to perceive speech and therefore also his ability to communicate. The communication issues that arise due to NIHL have a great impact on an individual's social life and will often lead to social restriction (Kerr & Cowie, 1997). These social restrictions can be imposed by the individuals with NIHL themselves, because they are ashamed of their condition, have the feeling of being stigmatized or feel like they are being left out. Another possibility is that the individual with NIHL is trying to stay socially involved, but his colleagues or family and friends are excluding and stigmatizing him. In most cases, social restriction is caused by an interplay of these factors (Kerr & Cowie, 1997). Social restriction often causes an individual to feel negative emotions like loneliness, anxiety and sadness (Commission on Hearing Loss, 2014). If these negative emotions persist, they can lead to the development of anxiety disorders, depression, burnout or even suicide in the case of tinnitus (Thomas & Herbst, 1980; Vogel, van de Looij-Jansen, Mieloo, Burdorf, & de Waart, 2014). Another common consequence of communication difficulties is fatigue, caused by the amount of energy that is spend by an individual with NIHL to make out what is said in conversations. This in turn could also lead to social restriction due to a lack of energy (Kramer & Gussenhoven, 2013).

To assess the impact of hearing loss on the HRQoL of an individual, the term disability weight is used in this study. Disability weight is given a value between 0 and 1, in which 0 is equivalent to a state of perfect health, while 1 is equivalent to death. Table 3 shows the disability weights of hearing loss in the Netherlands according to Stouthard et al. (1997). These disability weights are specifically for the Netherlands and are also used in other recent health studies (Hasson, Theorell, Westerlund, & Canlon, 2010; Wittchen, et al., 2011; Smit, van Laar, Croes, & Busschbach, 2008). It should be noted that the disability weights for hearing loss are much lower according to Salomon et al. (2012). Why these disability weights are so different is not clear, but it is possible that the large variation originates form a difference in used methods. However, the disability weights according to Salomon et al. (2012) are worldwide disability rates. Therefore, the disability weights in Table 3, which are specific for the Netherlands, will be used in this research.

Severity	**Disability weight**
mild, untreated	0.000
moderate, untreated	0.120
severe – profound, untreated	0.333
moderate, with hearing aid	0.040
severe – profound, with hearing aid	0.120

Table 3: Disability weights for each level of severity of NIHL: derived from Mathers, Smith and Concha (2003).

2.3 NIHL in the Netherlands

Worldwide, hearing impairment is in the top 10 of most common burdens of disease (Hasson, Theorell, Westerlund, & Canlon, 2010). In the Netherlands, hearing impairments are even within the top 5. Unfortunately there are not much statistics on the prevalence and incidence of hearing loss in the Netherlands. The statistics that are available do not distinct between noise induced hearing loss and hearing loss caused by other factors. According to a study performed by Passchier-Vermeer (1989), 21.500 (young) adults up to the age of 30 were at risk of NIHL every year. However, in 1989, personal audio devices were not as popular and advanced as they are now. In addition to that, sound levels at concerts and festivals have presumably increased due to better sound quality at higher sound levels. The current incidence is therefore probably even higher than 21.500 every year.

To prevent NIHL from taking on epidemic forms in the Netherlands, effective prevention is needed. If preventive measures are not taken soon, the subsequent future burden to Dutch society will only increase. However, for effective prevention to be possible, investment is needed from various stakeholders who all have different perspectives on the utility of prevention and the extent of the problem.

The Netherlands Hearing Health Foundation is committed to protect the hearing of the Dutch population and is involved in many projects to achieve this. Their main activities are aimed at raising awareness and providing education concerning hearing and hearing loss by providing online tools to gain insight and knowledge about hearing loss, initiating research and contributing to measures that are taken to decrease risky behavior by various stakeholders (Nationale Hoorstichting, 2015). However, not enough funding is available to them to make the impact they desire. This research is aimed to help them by providing tools to gain more funding for their projects and thereby enabling them to make a larger impact concerning the prevention of hearing loss in the Dutch population.

2.4 Importance of prevention

NIHL is a major public health problem, not only in the Netherlands, but worldwide. Although no exact numbers are known, it is clear that the incidence of NIHL is rising, especially in young adults (Werkgroep geluid, vakgroep Milieu en Gezondheid, 2013; Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013; Passchier-Vermeer, Steenbekker, & Vos, 1998). A recent study of the World Health Organization (WHO) indicated that at least 40% of the young adults between 12 and 25 years old worldwide are at risk of developing NIHL (World Health Organization, 2015). This leads to an increasing concern that soon, a large part of the current generation will suffer from hearing impairments before the age of 40.

Damage to the hair cells is permanent and there is no cure for NIHL. Although there are several hearing aids available for individuals with hearing impairments, none of these aids are without disadvantages. Some of these disadvantages are high costs and potential discomfort. Another option for some individuals would be a cochlear implant. However, this option also has some disadvantages: the implant is very sensitive and could for example interfere with certain devices or signals in the individual’s environment. Taken this into consideration, prevention is the best option.

In theory, NIHL is a 100% preventable. However, most young adults are not even aware of their risk of NIHL (Nationale Hoorstichting, 2012). It is therefore important that young adults are educated about the causes and consequences of prolonged noise exposure and about the available options to prevent NIHL. In addition, resources should be made available by various stakeholders to facilitate prevention, like provision of earplugs at locations where there is excessive noise exposure.

2.5 Involved stakeholders

The consequences of NIHL are not limited to the individual with the impairment. In fact, various other stakeholders experience the consequences of an individual that develops NIHL due to various costs that are imposed om them. These stakeholders can therefore benefit from investing in preventive interventions. The benefits of preventive interventions against NIHL mainly consist of avoided costs that are related to NIHL. Both benefits and costs of preventive interventions can be monetary or non-monetary and vary for each stakeholder. Involved stakeholders are the individual at risk, the parents of the individual at risk, schools/educational institutes that the individual at risk attends, employers of the individual at risk, insurance companies of the individual at risk and (local) governments.

For the individual at risk, the benefits of the prevention of NIHL are mainly non-monetary due to the avoided adverse effects (chapter 1.2) and will contribute to an increased HRQoL when compared to the HRQoL in absence of the preventive intervention (Healthy People 2020, 2010). However, the individual at risk will also avoid healthcare costs that are related to NIHL if NIHL is prevented, which is a monetary benefit.

	Individual	Parents	Schools/educ. Inst.	Employers	(Local) governments	Insurance companies
Monetary costs	Health care costs (+) Travel expenses (+) Income (-)	Health care costs (+) Travel expenses (+) Income (-)	Personnel costs (+)	Replacement costs (+) Sick pay (+) Productivity (-) Performance (-) Hiring costs (+) Instruction costs (+)	Received taxes (-) Work guidance (+) Productivity (-) Benefit payments (+) Special education (+) Social services (+)	Coverage costs (+)
Non-monetary costs	Stress (+) Social interactions (-) Performance (-) Leasure time (-) Productivity (-)	Leasure time (-)	Performance (-) Social interactions (-)			

Table 4: Monetary and non-monetary costs of NIHL for each involved stakeholder. When these costs are avoided by preventing NIHL, the costs will turn into benefits.

The benefits of preventing NIHL are both monetary and non-monetary for the parents of an individual at risk that still lives at home. The monetary benefits consist of the healthcare costs that are avoided and income that otherwise would be missed out on by the parents. Non-monetary benefits arise from leisure time that otherwise would be occupied by providing for the individual's additional care needs. Other involved stakeholders, like employers and (local) governments can only achieve monetary benefits when NIHL is prevented.

Table 4 provides an overview of the different types of monetary and non-monetary costs of NIHL for each stakeholder. A detailed description of these costs and where they originate from can be found in Appendix I.

2.6 Preventive interventions

Currently, there are four national intervention programs available in the Netherlands for the prevention of NIHL in young adults between the age of 12 and 25 years (RIVM, 2012). Three of these programs are still active: Oorcheck.nl, the covenant for the prevention of hearing loss in the music sector and the hearing module at TestJeLeefstijl.nu. The fourth program, that is available but is not actively provided at the moment, is Sound Effects (RIVM, 2012). Each of these four available interventions is briefly explained in the upcoming section. Following the four available interventions in the Netherlands, five evidence-based interventions from abroad are briefly summarized: 'Iets minder is de Max', 'Help ze niet naar de tuut', Dangerous Decibels and the Sonic Silence Exhibit. A more extensive explanation of the interventions can be found in Appendix II.

Oorcheck.nl is a website that is developed by the Netherlands Hearing Health foundation. Their aim is to raise public awareness, specifically in young adults between 12 and 25 years old, about risks of listening to loud music and how to decrease their risk for developing NIHL. One of the components on Oorcheck.nl is the speech-in-noise hearing test. At the end of this test, an advice is given based on the results of the test. One of the aims of the Netherlands Hearing Health Foundation is to implement the hearing test into the Youth Health (Jeugdgezondheidszorg, JGZ) contact moments in school-aged children (van Deelen, 2014).

Another preventive intervention that is available and active in the Netherlands is the covenant for the prevention of hearing loss in the music sector. This covenant consists of an agreement between the Ministry of Health, Welfare and Sport, the Association of Dutch Music Venues and Festivals (De Vereniging Nederlandse Poppodia en Festivals, VNPF) and the Association for Eventmakers (de Vereniging van EvenementenMakers, VVEM), with the aim to reduce noise exposure during musical events (Ministerie van Volksgezondheid, Welzijn en Sport, 2014).

The third active intervention program in the Netherlands is TestJeLeefstijl.nu, which is provided by the TestJeLeefstijl Foundation. This program is a lifestyle intervention program that contains a hearing health module that is specifically aimed at students from participating schools between 16 and 20 years old. The aim of the program is to raise awareness and to provide the participating schools insight into various aspects of their student's lifestyles so that the school can anticipate on their student's needs (RIVM, 2012; Testjeleefstijl.nu; Stichting TestJeLeefstijl, 2013).

The last available program in the Netherlands, although not currently active, is Sound Effects. This program contains multiple trajectories and was tested succesfully during as pilot in Amsterdam en surrounding regions. The material of this program can be retrieved online (Bouman, 2012; van Empelen, 2009).

In Flanders, two large public campaigns are available for the prevention of hearing loss. These campaigns are called 'Iets minder is de max' and 'Help ze niet naar de tuut' and are similar to Oorcheck.nl. However, the Flemish campaigns were supported by the government, which is not the case with Oorcheck.nl. As a consequence, the Flemish campaigns were funded and promoted more extensively than Oorcheck.nl.

The largest evidence-based intervention taken into account in this study is called Dangerous Decibels. This intervention program is currently available and used in 50 states and 37 countries all over the world and this number is only increasing. The program focuses on education, exhibition and research (O'Sullivan, 2015).

Another preventive intervention that is based on education is the university course on preventing hearing loss at the Pennsylvania State University. The course is called CSD 101: Preventing Hearing Loss and is primarily focused on hearing loss caused by noise. The course can be chosen by undergraduate students to meet their General Education requirements and is mainly based online (Blood & Blood, 2008).

The last intervention that is included in this research is the Sonic Silence Exhibit in Western Australia. This intervention consists of a simulation game as part of an exhibit in the science museum in which hearing loss is simulated in different real-life situations, specifically designed for school-aged children (Chang, 2013).

3. Conceptual Framework

In this section, the origin of the model that is used during this study, why this model is used and the components of the model are explained and elaborated on. To evaluate if an intervention or a combination of interventions from abroad to prevent NIHL is beneficial in comparison to the already available interventions and combinations of interventions in the Netherlands, a cost-benefit analysis will be conducted. In this study, different scenarios will be evaluated in comparison with the current situation regarding the prevention of NIHL. Therefore, the framework of Schmidhauser et al. (2009) is adjusted to depict this comparison. This model is chosen due to a lack of other available visual models that represented the method that is used during this study. To represent the used method, the concepts coverage, adherence and effect are added to the model, which is in accordance with the methods used in the Assessing Cost-Effectiveness (ACE)-prevention study and the WHO-CHOICE program by the World Health Organization (WHO) (Vos, et al., 2010; Edejer, et al., 2012). The framework that will be used for this study is shown in figure 1 and the concepts within the framework will be further explained in the upcoming sections.

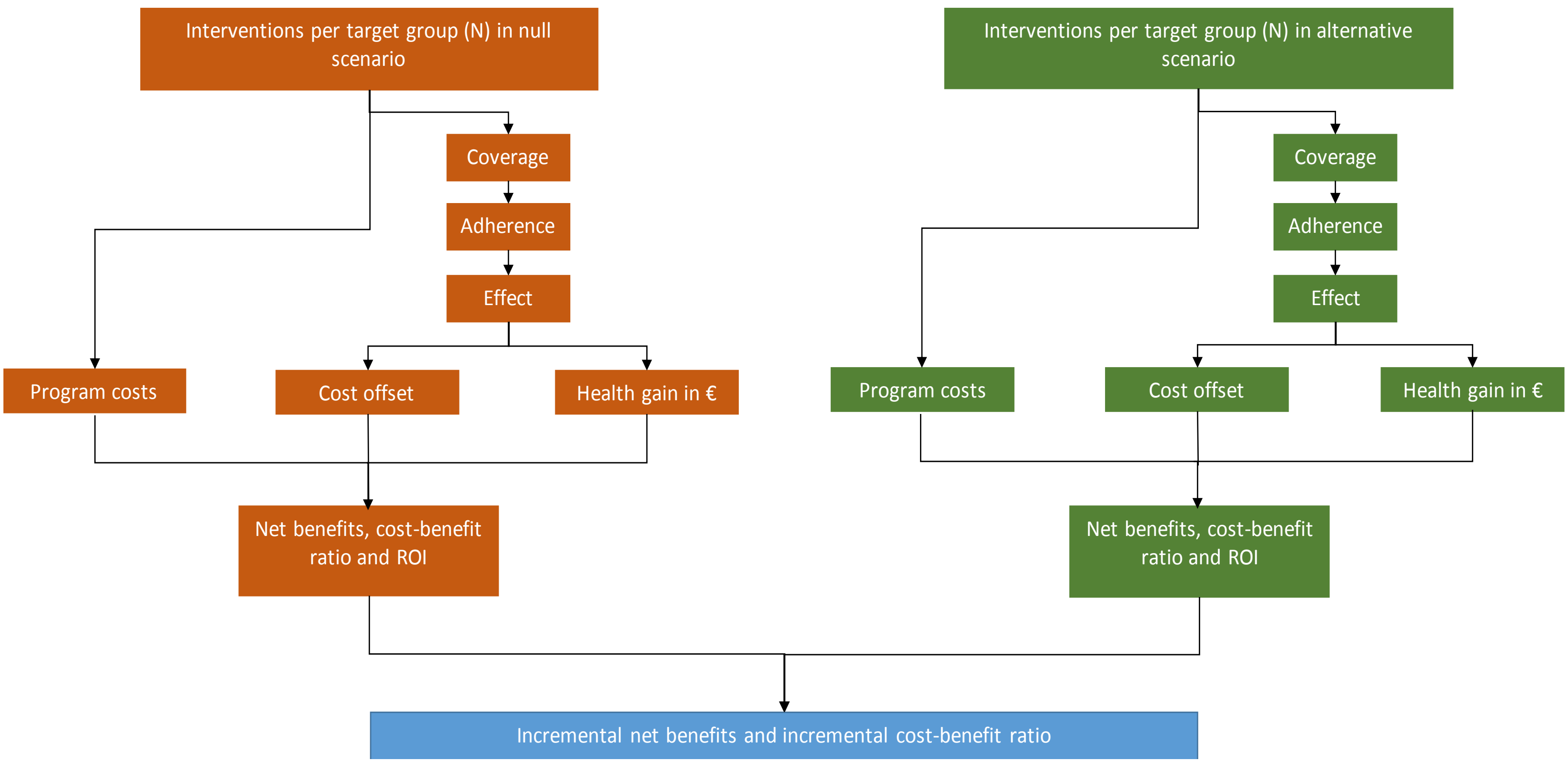

Figure 1 Conceptual framework for cost-benefit analysis of preventive interventions for NIHL. Derived from Schmidhauser et al. (2009).

3.1 Interventions per target group

The conceptual framework is used to analyze the costs and benefits of different combinations of interventions for different target group. Therefore, the interventions need to be divided by target group and grouped together in various combinations of interventions for each target group. For each target group the N has to be known, which is the amount of people within a specific target group. The N of each target group will be the 100% value, which is necessary to enable the calculation of health gains in euros after accounting for coverage, adherence and effect and to calculate Program costs. However, N only influences the Program costs if these costs are on a per person basis.

3.2 Null scenario and alternative scenarios

According to the conceptual framework (figure 1), interventions or combinations of interventions are analyzed for different target groups between the age of 12 and 25. In the null scenario (orange in figure 1), the current situation remains the same for the target groups regarding preventive interventions for NIHL. The null scenario functions as a baseline scenario to compare alternative scenarios (green in figure 1) against. Alternative scenarios are scenarios in which, for each target group, new interventions or new combinations of interventions are implemented in addition to the already active interventions in the null scenario. These are hypothetical scenarios that are compared to the null scenario. The advantage of using different scenarios, is that inefficiencies of the current situation are easily identified in comparison with the alternative situations (Hutubessy, Chisholm, & Edejer, 2003). Moreover, multiple alternative scenarios can be compared to the null scenario, but also to each other to identify which interventions or combination of interventions are most beneficial.

3.3 Coverage, adherence and effect

Coverage, adherence and effect determine how many cases of NIHL are avoided due to the intervention and therefore affect the amount of health gain in euros and cost-offsets as shown in figure 1. The first important variable that influences the impact of the intervention is coverage. In this study, coverage is defined as the percentage of individuals at risk to which the intervention or combination of interventions is available, which is in accordance with the definition of the WHO (Murray & Evans, 2003). After determining or estimating the coverage of an intervention, the adherence needs to be determined or estimated. Adherence is the extent to which individuals at risk utilize the preventive interventions that are available to them, which will also be expressed in percentages in this study.

Due to the use of behavioral models in the development and evaluation of some preventive interventions, intention is a frequently encountered measure that is taken in these studies (Chang, 2013; Gilles & van der Heyning, 2014; van Empelen, 2009). According to Sheeran (2002), intention on average leads to actual behavior in 52% of the cases (43%-61%). In theory, if the ears are protected, NIHL should be 100% preventable (Taneja, 2014). Therefore, if intention leads to behavior, the adherence can also be estimated by using measures for intention if data on adherence is not available.

Lastly, the effect of the intervention needs to be determined or estimated in the population at risk to whom the intervention is available and utilized. Effect describes to what extend the intervention prevents NIHL in the covered and adherent target population. This will be expressed in risk ratios.

When coverage, adherence and effect are known, it can be calculated how many cases of NIHL are avoided within the target population. An additional advantage of using these variables in the analysis, is that they show which aspects of an intervention can be improved to increase the impact and what the subsequent consequences are on the amount of health gain in euros and cost-offsets when these variables are adjusted during sensitivity analyses (Vos, et al., 2010; Edejer, et al., 2012; Lokkerbol, et al., 2014; Smit, et al., 2011).

3.4 Program costs, cost-offsets and health gains in euros

The implementation of an intervention always entails certain costs, which are called program costs in the conceptual framework (figure 1). These program costs are the costs of providing the intervention and consist of costs for planning, implementation, monitoring, administration, salaries, etcetera. Depending on the type of intervention, the program costs are often also influenced by the level of implementation, unless the intervention consists of a national campaign.

Cost-offsets represents the health care expenses that would have been made if an individual developed NIHL, but are avoided because the individual is prevented from developing NIHL. These costs are calculated by looking at various aspects of the average healthcare trajectory of an individual that develops NIHL and the subsequent costs of each aspect in the healthcare trajectory. Cost-offsets is therefore categorized as a benefit, due to the avoided costs.

Health gains in euros is a way to express the increase of the HRQOL in a monetary value. HRQOL can be expressed in Quality Adjusted Life Years (QALYs) or Disability Adjusted Life Years (DALYs). In this study, the aim is to identify how much the HRQOL can be increased by a certain intervention or combination of intervention. When using QALYs to measure the HRQOL, the increase in HRQOL is not specifically linked to NIHL but more to the general health state of the individual. Therefore, QALYs are unsuitable as a measure for HRQOL in this study. DALYs on the other hand can be linked to a specific disease and measure a decrease in HRQOL by looking at years lost due to bad health, disability or death (Lajoie, 2015). The formula for calculating DALYs is:

DALY= Years of Life Lost due to premature mortality (YLL) +
Years Lived with Disability (YLD)

However, NIHL is not a fatal illness, so the dimension YLL that is included in DALYs is not applicable to this research and is therefore removed from the formula from this research. What remains is YLD, which will be used as a measure of the HRQOL in this research (Lajoie, 2015). YLD can be calculated by using the following formula:

YLD= I x DW x L

In the formula, I is the number of incident cases of NIHL, DW is the disability weight of NIHL and L is the average duration of NIHL, which is calculated by subtracting average age of onset of NIHL from average life expectancy (Lajoie, 2015).

When the number of avoided cases due to a specific intervention or combination of interventions is known from the calculations with coverage, adherence and effect and this number is inserted for I in the formula for YLD, it can be calculated how many YLD are avoided by that intervention or combination of interventions. The last step is to determine a value for each YLD that is avoided and multiply this value by YLD avoided, calculating the health gain in euros. It should be taken into account that, although YLD is given a monetary value, no actual money can be earned by avoiding YLD. The value that is given to an avoided YLD is determined by the price that an individual is willing to pay for an avoided YLD. This method is chosen to be able to compare costs (program costs) and benefits (health gain and cost-offsets) in a common unit (Stein, 2006).

3.5 Incremental net-benefits, (incremental) cost-benefit ratio and Return on Investment

When using the simulation tool, coverage, adherence, effect, program costs and cost-offsets are required inputs for the cost-benefit analysis. The primary output of the cost-benefit analysis consists of net-benefits, cost-benefit ratio and the Return on Investment (ROI) for each scenario which is then used as input to compare scenarios by calculating the secondary output measures: incremental net-benefits and incremental cost-benefit ratio. These secondary outputs are chosen for this research as they illustrate which scenario yields the highest benefits in an absolute manner (net-benefits) and a relative manner (cost-benefit ratio).

In the conceptual framework, net-benefits are defined as health benefits (health gain valued in euros by multiplying the health gain by the willingness to pay) and cost-offsets (health care savings) minus the program costs (intervention costs). Thus, net-benefits = (Effect * WTP – Cost-offsets) – Program costs. When the net-benefits are calculated for the null scenario and the alternative scenarios, the incremental net-benefits can be calculated. Calculation of this secondary outcome is done by subtracting the net-benefits of the null scenario from the net-benefits of the alternative scenario. If the benefits of the alternative scenario exceed the benefits of the null scenario, the incremental net-benefits will have a positive value. If the benefits of the null scenario exceed the benefits of the alternative scenario, the incremental net-benefits will have a negative value.

The cost-benefit ratio illustrates what the costs for each euro in health gain are. This ratio is calculated by dividing the costs (program costs) of a scenario by the benefits (health gain in euros + cost-offsets) of the same scenario. The outcome shows if the costs exceed the benefits or the other way around. When the outcome is 1, the costs are equal to the benefits: 1 euro in benefits costs 1 euro. If the outcome is bigger than 1, the benefits are exceeded by the costs: 1 euro in benefits costs more than 1 euro. Conversely, if the outcome is smaller than 1, the benefits exceed the costs: 1 euro in benefits costs less than 1 euro. To calculate the incremental cost-benefit ratio, the incremental costs are divided by the incremental benefits.

The ROI is the inverse of the cost-benefit ratio. ROI is calculated by dividing benefits (health gain in euros and cost-offsets) of a scenario by the costs (program costs) of the same scenario. The outcome shows how many euros in benefits can be gained by investing 1 euro. The higher the outcome, the higher the profitability of the investment will be.

3.6 Sub-questions

The aim of this study is to answer the research question: *What are the health-economic benefits of investing in prevention of NIHL in young adults between 12 and 25 from a heath care perspective?* To provide an answer to this question, the following sub-questions that are derived from the conceptual framework (figure 1) are answered:

1. How many people are within each target group (N)?
2. What are the coverage, adherence and effect of each intervention?

3. What are the program costs of each intervention?
4. What is the typical healthcare trajectory of an individual that develops NIHL and what are the associated cost-offsets?
5. What are the mean program costs during a period of a year of each scenario, using a steady state model?
6. What are the mean health gains in euros during a period of a year of each scenario, using a steady state model?
7. What are the mean cost-offsets in euros during a period of a year of each scenario, using a steady state model?
8. What are the net-benefits, cost-benefit ratio and mean ROI of each scenario, using a steady state model?
9. Which combination of interventions yields the highest incremental net-benefits and the lowest incremental cost-benefit ratio?

Sub-question 1 to 7 need to be answered in order to obtain the information that is needed to answer the key questions 8 and 9. The focus of sub-question 8 is on the primary outcomes of each scenario, whereas sub-question 9 focusses on comparison of the alternative scenarios with the null scenario, which can be useful in strategic decision making.

4. Methods

In this section the methods are explained that were used in order to conduct the cost-benefit analysis. This process started with a selection of interventions based on several criteria, followed by a literature review to obtain information about NIHL in the Netherlands and to explore the selected interventions. Based on the gathered data from the literature review, questionnaires were send to experts to obtain expert opinions about data that was not found during the literature review. Filled out questionnaires were followed up by semi-structured interviews. After the data collection, the data was inserted into the cost-benefit analysis model and additional analyses were conducted to come to a worst-case, middle-case and best-case scenario.

4.1 Selection of interventions

For this study, different search strategies were used to identify relevant preventive interventions for the null scenario and the alternative scenarios. The database that was used for identification of preventive interventions in the Netherlands was the I-database of "Loket gezond leven". Interventions from the I-database were only included in the null scenario if they were specifically focused on preventing NIHL or contained a subcomponent specifically focused on prevention of NIHL and if they were targeted at young adults within an age range of 12-25 years.

In order to identify preventive interventions to include in the alternative scenarios, search terms related to "prevention of NIHL" and "hearing foundation" were inserted in Google Scholar and Google. In addition, the website of Audiology Online, American Journal of Audiology, International Commission on Biological Effects of Noise and the Better Hearing Institute were scanned for preventive interventions. Each found preventive intervention was screened to determine if the inclusion criteria were met. Inclusion criteria for the interventions for the alternative scenarios were that they were targeted at young adults between the age of 12-25 years, they are not available in the Netherlands and that research was conducted to develop the preventive intervention.

4.2 Literature review

The first part of the literature review consisted of a search of available statistics on the size of the target population between the age of 12-25 years, the percentage of young adults that are at risk of NIHL, the amount of young adults between the age of 12-25 years that does and does not go to school, prevalence and incidence of NIHL, the disability weight of NIHL, and YLD. Databases that were used included the Central Bureau for Statistics (Centraal Bureau voor de Statistiek, CBS), National Institute for Public Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu, RIVM), the Netherlands Hearing Health Foundation (Nationale Hoorstichting), and the World Health Organization (WHO).

The second part of the literature review was performed using Google Scholar along with relevant citations in articles that were found to explore the available data for each selected intervention. The used search terms were the names of the selected interventions. Extracted data included: description of the intervention, exact target group, coverage, adherence, effect, intention increase, behavioral models used for development of the intervention, program costs, providing parties and involved researchers and/or authorities that could be contacted for expert opinions. Additionally, the NOAH 4 protocol, the website of the Dutch Healthcare Authority (Nederlandse Zorgautoriteit, NZA) and the DBC

Information database were used to identify possible healthcare trajectories and the price rates of healthcare professionals within the healthcare trajectories to calculate the cost-offsets (Nederlandse Zorgautoriteit, 2014; Nederlandse Zorgautoriteit; Veldnorm Hoortoestelverstrekking, 2013).

4.3 Questionnaires

A total of 14 respondents were selected based on their involvement in the development and/or evaluation of the preventive intervention. It was assumed that the researchers and/or authorities that were involved in the development and/or evaluation of the intervention were most likely to have access to the information that was needed to answer the questions in the questionnaire. Respondents were contacted primarily by e-mail and by phone if no response was given to the e-mail to ask if they were willing to participate.

Questionnaires were developed based on the data that could not be retrieved during the literature review. A basic questionnaire was developed in Dutch and English that functioned as a template, consisting of 11 questions (Appendix III). The first part of the questionnaire consisted of questions that requested estimations of age of onset, incidence and prevalence of NIHL in the Netherlands. The second part inquired intervention specific information and estimations about the input measures for the cost-benefit analysis: target group, age of target group, coverage, adherence, effect and program costs. It was requested to accompany given estimations with a safe upper and lower limit. In the final part of the questionnaire, respondents were asked for recommendations for additional respondents. For each respondent the questionnaire was adapted by removing the questions about data that was already found during the literature review. In addition, the first part of the basic questionnaire was only included when send to Dutch respondents with an audiology background to prevent random guesses.

4.4 Interviews

The respondents for the questionnaire were contacted for a follow up interview when the filled out questionnaire was received. Interviews with the Dutch respondents were preferably face to face. However, respondents with a busy schedule were interviewed by phone or by Skype. International respondents were interviewed by Skype or by phone. Interview designs were prepared by checking the filled out questionnaire for any vagueness, questions that were not answered and answers that led to additional questions. In addition, interview guides for respondents with an audiology background included a question regarding the healthcare trajectory that an individual with NIHL follows when he suspects hearing loss. Interviews were semi-structured and guided by the questions in the interview design (Appendix IV). The semi-structured approach was used because it leaves room for exploring additional topics that might emerge from the interview, while still being able to ask the prepared questions (Longhurst, 2010). Interviews were not transcribed since the main goal of the interviews was to eliminate any misunderstandings regarding the filled out questionnaire. Any additional information that was included in the research was written down during the interview, summarized, checked and confirmed by the respondent after the interview to avoid misinterpretation of the answers that were given by the respondents.

4.5 Cost-benefit analysis: conceptual model

The model that was used for the analysis is an adapted version a costing tool that was developed by the Trimbos Institute and PricewaterhouseCoopers to make health economical calculations in different scenarios regarding the prevention of mental disorders like depression or addiction (Lokkerbol, et al., 2014; Smit, et al., 2011). Adaptation of the model was done by the developers of the costing tool.

For the analysis, various alternative scenarios were compared to the null scenario. The null scenario was constructed based on the already active interventions for target groups 12-18 years and 19-25 years. Only interventions of which data was acquired or educated assumptions could be made were included in the null scenario. After constructing a null scenario, alternative scenarios were constructed in a pyramidal manner by adding interventions to the null scenario to create an alternative scenario and continue to the next alternative scenario with the most favorable option, as illustrated in figure 2. The green blocks indicate the most favorable alternative scenario compared to the null scenario. On the left side of the figure, only one intervention (A, B, C or D) is added to an alternative scenario and compared to the null scenario. If intervention A is most favorable, A is added to each upcoming alternative scenario, along with one of the other, less favorable interventions. In the next step, the most favorable combination of interventions is selected to be added to each next alternative scenario, and so on, until all interventions are combined in one alternative scenario.

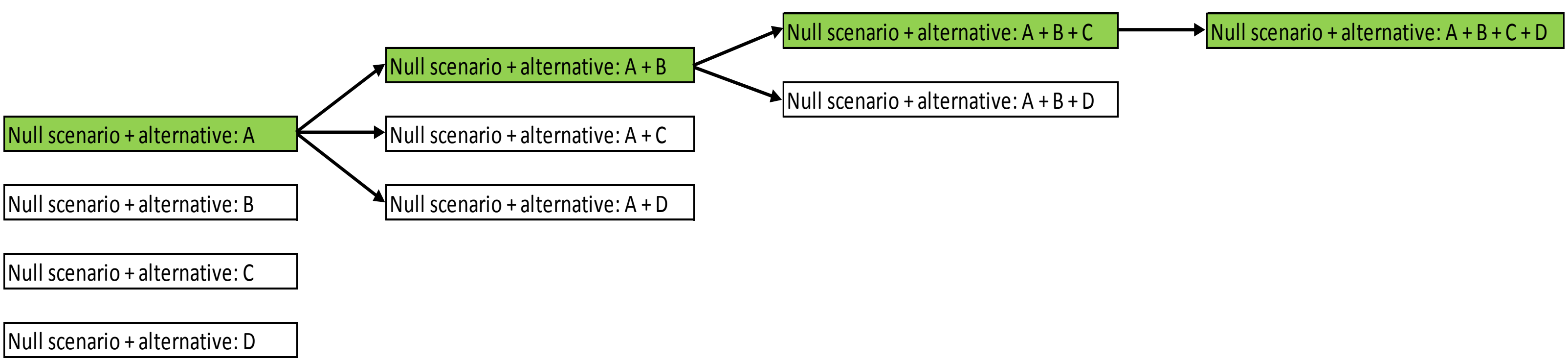

Figure 2: Construction of alternative scenarios to compare to the null scenario.

For each scenario the model calculated the amount of people from the target population at risk that is effectively prevented from developing NIHL by an intervention or combination of interventions after inserting the input parameters. The initial approach was to calculate the YLDs and multiply these by €20.000 (conservative value of a YLD) to generate a monetary value that represents the benefits of an intervention or combination of interventions. To achieve this, risk ratios were needed as measures for effect size. However, due to a lack of data on risk ratios and effect sizes in general, this method could not be used in the analysis. Therefore, an approach was chosen in which a percentage was used to indicate in how many cases an intervention could prevent a covered and adherent individual from developing NIHL, which was then multiplied by the estimated amount that society is willing to pay each year for each avoided case of NIHL to obtain a monetary value for the health gains(benefits). Estimations of the willingness to pay (WTP) were made by multiplying disability weights by the conservative value of an YLD (€20.000). The lowest average value of WTP (€2350) was used in the analysis. In addition, program costs and cost-offsets were inserted into the model and outcome measures were generated.

For the analysis of the costs and benefits of the intervention in which the hearing test from Oorcheck.nl is integrated into the Youth Health contact moments for school-aged children, hypothetical values were used since the intervention is not yet available and the parameters are unknown. Estimations were made for the target population at risk, coverage, adherence, effect and program costs. Coverage, adherence and effect were then altered in various alternative scenarios to provide insight in the impact of an adjustment on the secondary outcomes.

Both costs and benefits were discounted for at a rate of 4% for the costs and 1,5% for the benefits, which is in accordance with the manual for cost-research by CVZ (CVZ, 2010). Additionally, sensitivity analyses were performed to account for parameter uncertainty (Pomp, Schoemaker, & Polder, 2014). In the sensitivity analyses the upper and lower limits were used that were acquired from the literature review, questionnaires and interviews.

The analyses are performed over a period of 1 year, assuming a steady state model. This method was chosen because the dynamics of incidence of NIHL due to certain interventions cannot be predicted accurately with the available data and the uncertainty of the long-term effects of the preventive interventions.

4.6 Outcome measures of cost-benefit analysis

After inserting the input parameters into the model, discounting the costs and benefits (as to compute the "net present value of both costs and benefits") and performing the sensitivity analyses, the primary outcome measures that resulted were ranges of net-benefits, cost-benefit ratios and ROIs for each scenario. The primary outcomes of each individual alternative scenario were compared to a worst, middle and best case null scenario, which resulted in the secondary outcomes: incremental net-benefits and incremental cost-benefit ratios. Due to estimations and assumptions that were inserted into the model to generate future scenarios, Monte Carlo uncertainty analyses were performed to account for the uncertainty of the inserted input parameters, which resulted in upper and lower uncertainty limits for the primary and secondary outcomes (Pomp, Schoemaker, & Polder, 2014; Stæhr, 2006).

5. Results

In this section, the results from the selection of interventions are briefly summarized. In addition, the input parameters that were gained from the literature review, the questionnaires and the interviews are presented. Finally, an overview of the primary and secondary outcome measures is given of the best case null scenario compared to the worst case alternative scenario and the worst case null scenario compared to the best case alternative scenario to illustrate the (simulated) health-economic impacts of implementing one or the other scenario.

5.1 Selection of interventions

The primary selection of interventions was based on the inclusion criteria, as mentioned in subsection 4.1, and resulted in 4 preventive interventions for the null-scenario and 5 preventive interventions for the alternative scenarios. In addition to the 4 preventive interventions for the alternative scenarios an adapted version of Oorcheck.nl, in which JGZ contact moments was taken into account for future application, was also included at the request of the Netherlands Hearing Health Foundation in the alternative scenarios. An overview of the primary selection of interventions is provided in Table 5 and elaborated on in Appendix II.

Intervention	**Abbreviation (if applicable)**
Null scenario	
Oorcheck.nl	-
Convenant	-
TestjeLeefstijl.nu	-
Sound Effects	SE
Alternative scenario	
CSD 101: Preventing hearing loss	-
Iets minder is de max	IMIDM
Help ze niet naar de tuut	HZNNDT
Sonic Silence Exhibit	SSE
Oorcheck in JGZ contact moments	JGZ

Table 5: Primary selection of interventions, with used abbreviations.

5.2 Literature review

The first part of the literature review was aimed on gaining statistics to answer the first sub-question regarding the amount of people within the target groups within the age range of 12-25 years (sub-question 1). Since double-counting had to be avoided, 2 divisions were chosen: young adults between 12-18 and 19-25 (Table 6), and school going young adults and non-school going young adults (Table 7). Statistics were obtained from the Central Bureau for Statistics (CBS):

	Absolute amount
Young adults on 1-1-2015 (12-18 years)	1.413.660
Young adults on 1-1-2015 (19-25 years)	1.482.771
Total young adults on 1-1-2015 (12-25 years)	2.896.431

Table 6: Derived from Centraal Bureau voor de Statistiek, 2015. Target groups devided by age.

	Absolute amount
Schoolgoing young adults in 2014 (12-25 years)*	2.390.431
Non-school going in 2014 (12-25 years)*	506.000

Table 7: Derived from Centraal Bureau voor de Statistiek, 2015.
*: Statistics were only available starting from age 15. Therefore, the assumption was made that every young adult between 12-15 years was school-going.

Additionally, it was found during the literature review that 28,6% of the high school students in the Netherlands were at risk of developing NIHL (Vogel, Brug, van der Ploeg, & Raat, 2011). Table 8 illustrates the number of individuals at risk in each target group, assuming that the risk percentage of 28.6% is equally distributed across age groups.

	Absolute amount
Young adults on 1-1-2015 (12-18 years)	404.307
Young adults on 1-1-2015 (19-25 years)	424.073
Schoolgoing young adults in 2014 (12-25 years)*	683.663
Non-school going in 2014 (12-25 years)*	144.716

Table 8: Amount of individuals at risk in each target group

The second part of the literature review aimed at answering the sub-questions on coverage, adherence, effect size and program costs of each included preventive intervention (sub-questions 2 and 3). Intention (i.e. preparedness or willingness to change) was also included, as it could function as an alternative way to estimate adherence. Elsewhere it was found that in 53% (43%-61%) of the cases, intention to change led to actual change in behavior (Sheeran, 2002). It should be noted that this percentage illustrates a general relation between intention and behavior and is not specifically applicable to prevention or hearing protection. Table 9 and 10 give an overview of the parameters that were found during the literature review for each intervention for respectively the null scenario and the alternative scenarios.

Intervention	Coverage	Intention	Adherence	Effect	Program costs
Sound effects	13,5% (12% - 15%) [1]	-	16,2% [1]	-	€60.000 - €75.000 [2]
Oorcheck.nl	5,9% (5,7% - 6,2%) [3]	46% [4]	24% (20% - 28%) [5]	-	
Covenant	-	-	-	-	-
Testjeleefstijl.nu	-	-	-	-	-

Table 9: Found data for null scenario

1: Derived from van Empelen (2009)

2: Derived from Loket Gezond Leven: Sound Effects

3: Derived from Sheikh Rashid, Leensen, & Dreschler (2015)

4: Not directly related to hearing test, but to risk awareness and intention to wear earplugs (Chung, Des Roches, Meunier, & Eavey, 2005). Used as estimation for intention increase as result of Oorcheck.nl.

5: Calculated by multiplying intention by the percentage of cases in which intention leads to behavior.

Intervention	Coverage	Intention	Adherence	Effect	Program costs
CSD 101: Preventing Hearing Loss	-	-	-	-	-
Iets minder is de Max	9,1%* [1]	-	7.2% (3,7% -10,7%) [1]	-	€136.189 [2]
Help ze niet naar de tuut	50% [3]	-	-	-	
Sonic Silence Exhibit	32% [5]	40% [6]	17% (14%-20%) [7]	-	-
Dangerous Decibels	-	-	-	-	-
Oorcheck in JGZ	-	-	-	-	-

Table 10: Found data for alternative scenarios

1: Derived from Gilles & van der Heyning (2014)

2: Derived from Vlaams Agentschap Zorg en Gezondheid (2011)

3: Derived from Var (2012): Listening figures of young adults to popular Flemish radio stations

4: Derived from Martin, Sobel, Griest, Howarth, & Yongbing (2006)

5: Derived from Chang (2013)

6: Calculated by multiplying intention by the percentage of cases in which intention leads to behavior.

The final sub-question that was answered during the literature review was the question regarding the usual healthcare trajectory after onset of NIHL and its associated costs (sub-question 4). However, there was no single (and "average") healthcare trajectory; instead there are multiple pathways, depending on the severity and complexity of the hearing problem. Of these, the shortest and the longest trajectories are illustrated in Figure 3 and 4, respectively. In almost all instances, the individual visits a general practitioner first, who makes an initial diagnosis and refers the individual to a specialist. In the shortest trajectory (figure 3), the individual is referred to an E.N.T. specialist, who runs additional tests and confirms or adjusts the general practitioner's diagnosis, which leads to an advice on an appropriate hearing aid for the individual. The individual then visits a hearing care professional for hearing aid fitting, based on the advice of the E.N.T. specialist. The hearing care professional also provides the hearing aid, while the check-ups to see if the hearing aid is working properly are done by the E.N.T. specialist. When the longest trajectory is applicable (figure 4), the individual is referred to an audiological center by the general practitioner. At the audiological center, several hearing tests are performed to determine the severity of hearing loss that the individual experiences. In addition, the E.N.T. specialist examines the individual for any physical obstructions or visible damage to the E.N.T. tract that may cause the hearing impairments. After the examination by the E.N.T. specialist, the individual returns to the audiological center where a definitive diagnosis is made based on the hearing tests and the E.N.T. examination. An advice is given to the individual which hearing aid is most appropriate for the individual's situation and, if needed, what type of

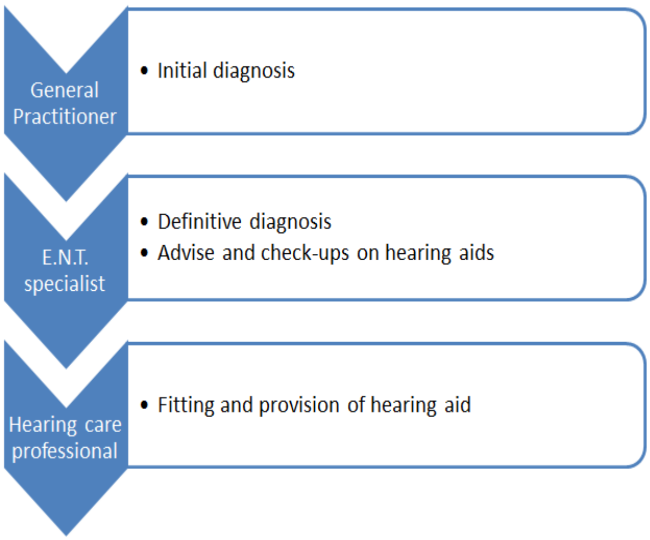

Figure 3: Shortest healthcare trajectory: derived from the NOAH-4 protocol (Veldnorm Hoortoestelverstrekking, 2013).

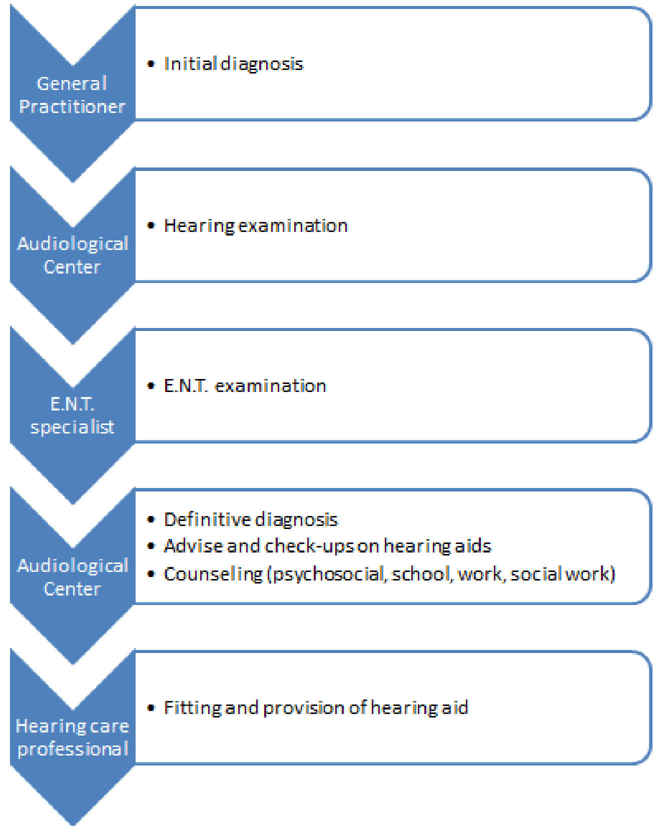

Figure 4: Longest healthcare trajectory: derived from the NOAH-4 protocol (Veldnorm Hoortoestelverstrekking, 2013).

counseling the individual could benefit from. For hearing aid fitting and provision, the individual visits the hearing care professional, while check-ups are done by the audiological center (Veldnorm Hoortoestelverstrekking, 2013). Costs for these trajectories were not fixed due to varying healthcare rates and costs for hearing aids. These differences were caused by variation in contracts and agreed prices between health insurance companies and healthcare professionals. Therefore, lowest costs were calculated for the shortest healthcare trajectory and highest costs for the longest healthcare trajectory to determine the range of the possible costs associated with the healthcare trajectory. Calculation of the lowest costs for the shortest healthcare trajectory resulted in a total rate of €683,10 per patient per year and the calculation for the highest costs resulted in a total rate of €3697,50 per patient per year.

5.3 Questionnaires

A total of 23 researchers and authorities were *contacted* for participation in the study. 11 of them *completed* the questionnaire and sent it back, of which 7 provided answers that could be *included* in the analysis. Table 11 shows the amount of contacted respondents, completed questionnaires and included questionnaires per intervention.

Questionnaires were used to obtain data for the analyses that were not acquired during the literature review and therefore provided answers to the same sub-questions as the literature review (sub-question 1,2 and 3).

Intervention	Contacted	Completed	Included
Sound effects	3	2	2
Oorcheck.nl	3	2	2
Covenant	4	1	0
Testjeleefstijl.nu	2	1	1
CSD 101: Preventing Hearing Loss	2	0	0
Iets minder is de Max	1	0	0
Help ze niet naar de tuut	2	1	1
Sonic Silence Exhibit	1	1	1
Dangerous Decibels	2	2	0
Oorcheck in JGZ	2	0	0
General information	1	1	0
Total	**23**	**11**	**7**

Table 11: Amount of contacted respondents, completed questionnaires and included questionnaires for each intervention.

The estimations that were obtained from the questionnaires for each intervention are summarized for the null scenario and alternative scenarios in Table 12 and Table 13.

Intervention	Coverage *	Adherence	Intention	Effect	Program costs
Sound effects	14%	-	-	-	€65000(€60000-€750000)
Oorcheck.nl	2,4%-24%	-	-	10% (1%-20%)	€ 100.000
Covenant [1]	-	-	-	-	-
Testjeleefstijl.nu	30% (25%-35%)	-	-	-	€3,50 per student

Table 12: Estimations and data obtained from the questionnaires for the null scenario.
*: Coverage was given in absolute numbers in questionnaire. Calculated to percentage from the target group at risk.
1: Contacted respondents were not willing and/or able to give estimations.

Intervention	Coverage *	Adherence	Intention	Effect	Program costs
CSD 101: Preventing Hearing Loss [1]	-	-	-	-	-
Iets minder is de Max [2]	-	-	-	-	-
Help ze niet naar de tuut [3]	-	-	-	-	-
Sonic Silence Exhibit	38% (30%-39%)	-	-	-	€ 65.500
Dangerous Decibels [4]	-	-	-	-	-
Oorcheck in JGZ [5]	-	-	-	-	-

Table 13: Estimations and data obtained from the questionnaires for the alternative scenarios.
*: Coverage was given in absolute numbers in questionnaire. Calculated to percentage from the target group at risk.
1: Respondents were not willing to participate.
2: Respondent was not able to participate within timeframe.
3: Questionnaire was completed, answers were not usable.
4: Questionnaire was completed, answers were for a different target population. Could not be used.
5: No respondents willing or able to make predictions and/or estimations.

The respondents for the CSD 101: Preventing Hearing Loss intervention were not willing to fill out the questionnaire, because the intervention was being revised. Additionally, no data was available in the literature that could be used in the analysis. Therefore, CSD 101: Preventing Hearing Loss was excluded from the analysis.

Another intervention that was excluded after sending out the questionnaires was the covenant. Reasons for exclusion were misinterpretation of the questions in the questionnaire and the respondent's professional reluctance to offer educated estimations of the requested data.

The last intervention that was excluded from the analysis based on the questionnaire was Dangerous Decibels. Reason for exclusion of this intervention was that the age of the Dangerous Decibels target group was changed recently to children between 8 and 11 years old, which is younger than the target group of this study.

Although no information was acquired for the use of the Oorcheck in the Youth Health contact moments for school-aged children (JGZ contactmoment), the intervention was not excluded from the analysis, due to the importance of this intervention for the future of strategies of the Netherlands Hearing Health Foundation. Assumptions were made based on data that was used for the regular, already active Oorcheck.nl and CBS statistics on the amount of children aged 12 and 14.

5.4 Interviews

The interviews with the respondents that filled out the questionnaire functioned as a check of respondent's understanding of the questions in the questionnaire and of the interviewer's understanding of the answers that were provided by the respondents. In addition, the interviews gave the respondents the opportunity to give background information on the intervention that they helped develop.

The interview with the respondent for 'Help ze niet naar de tuut' provided information on the coverage of the intervention which was not acquired from the filled out questionnaire. The respondent explained that the largest radio stations in Flanders participated in the campaign. By looking up the listening figures in 2012 of these radio stations, an estimation of the coverage could be made that was used in the analysis. However, no figures were acquired during the literature review, questionnaire or interview regarding adherence or effect. Consequently, 'Help ze niet naar de tuut' had to be excluded from the study.

During the other interviews, no additional information was acquired that could be used in the analysis.

5.5 Cost-benefit analysis model

To perform the analyses, data gained from the literature review, questionnaires and interviews were combined and adjusted to be applicable to age groups 12-18 and 19-25 years. Target group division was chosen based on age instead of school-going or not, due to a lack of data for each intervention to be able to use the last division. Cost-offsets and WTP were set at the conservative values €683,10 and €2350,-, respectively. Table 14 and 15 are overviews of the combined and adjusted data that was used in the analyses for age group 12-18 and 19-25, respectively. No data was found on the effect of the interventions, except for an estimation of one of the respondents for Oorcheck.nl. This estimation was used as assumption for the effect of the other interventions.

Interventions	Coverage	Adherence	Effect	Program costs
Oorcheck.nl	9,6% (9,2% - 10%)	8%(6%-10%)	10% (1-20%)	€ 100.000
Testjeleefstijl.nu	4% (3,7% - 4,3%)	4%(3%-5%)	10% (1-20%)	€ 3,50 per student
Oorcheck JGZ	28,8% (25%-32,6%)	24% (20%-28%)	10% (1-20%)	€ 150.000 (€ 100.000-€ 200.000)
Sound Effects	5,7% (5,1%-6,3%)	16,2%	10% (1-20%)	€ 65000(€ 60000-€ 75000)
Iets minder is de max	6,5%	7.2% (3,7% -10,7%)	10% (1-20%)	€ 136.189,20
Sonic Silence Exhibit	24,9% (21,6%-28,1%)	17% (14%-20%)	10% (1-20%)	€ 65.500

Table 14: Data for the interventions for the target group aged 12-18 years. The null scenario consists of the upper two interventions. Alternative scenarios were constructed by adding one of the four interventions below the line.

Interventions	Coverage	Adherence	Effect	Program costs
Oorcheck.nl	2,20%	8%(6%-10%)	10% (1-20%)	€ 100.000
Testjeleefstijl.nu	4% (3,7% - 4,3%)	4%(3%-5%)	10% (1-20%)	€ 3,50 per student
Oorcheck JGZ	-	-	-	-
Sound Effects	13,5% (12%-15%)	16,2%	10% (1-20%)	€ 65000(€ 60000-€ 75000)
Iets minder is de max	-	-	-	-
Sonic Silence Exhibit	-	-	-	-

Table 15: Data for the interventions for the target group aged 19-25 years. The null scenario consists of the upper two interventions. Alternative scenarios were constructed by adding one of the four interventions below the line.

Sizes of the analyzed target groups (N) were based on the amount of individuals at risk for NIHL. Table 16 shows the N that was used for each target group in the analyses.

	N
Young adults on 1-1-2015 (12-18 years)	404.307
Young adults on 1-1-2015 (19-25 years)	424.073

Table 16: Individuals at risk for each target group (N).

5.6 Primary outcome measures of cost-benefit analysis

Due to the large amount of analyses and outcome measures, results are presented for two situations: a worst case situation in which the difference between the null scenario and alternative scenarios are smallest and a best case situation in which the difference between de null scenario and alternative scenario are largest.

The *worst case situation* is simulated by using the highest values for coverage, adherence and effect and the lowest values for the program costs for the null scenario. For the alternative scenarios in the worst case situation, the lowest values were used for the coverage, adherence and effect and the highest values were used for the program costs.

For the *best case situation* simulation, the lowest values of coverage, adherence and effect and the highest values for program costs for the null scenario. The highest values for coverage, adherence and effect and the lowest values for program costs were used for the alternative scenarios in the best case situation. The secondary outcomes are presented in a similar method.

The mean program costs, mean health gains and mean cost-offsets of each scenario (sub-question 5, 6 and 7) in the worst and best case situation are illustrated in Figure 5,6 and 7.

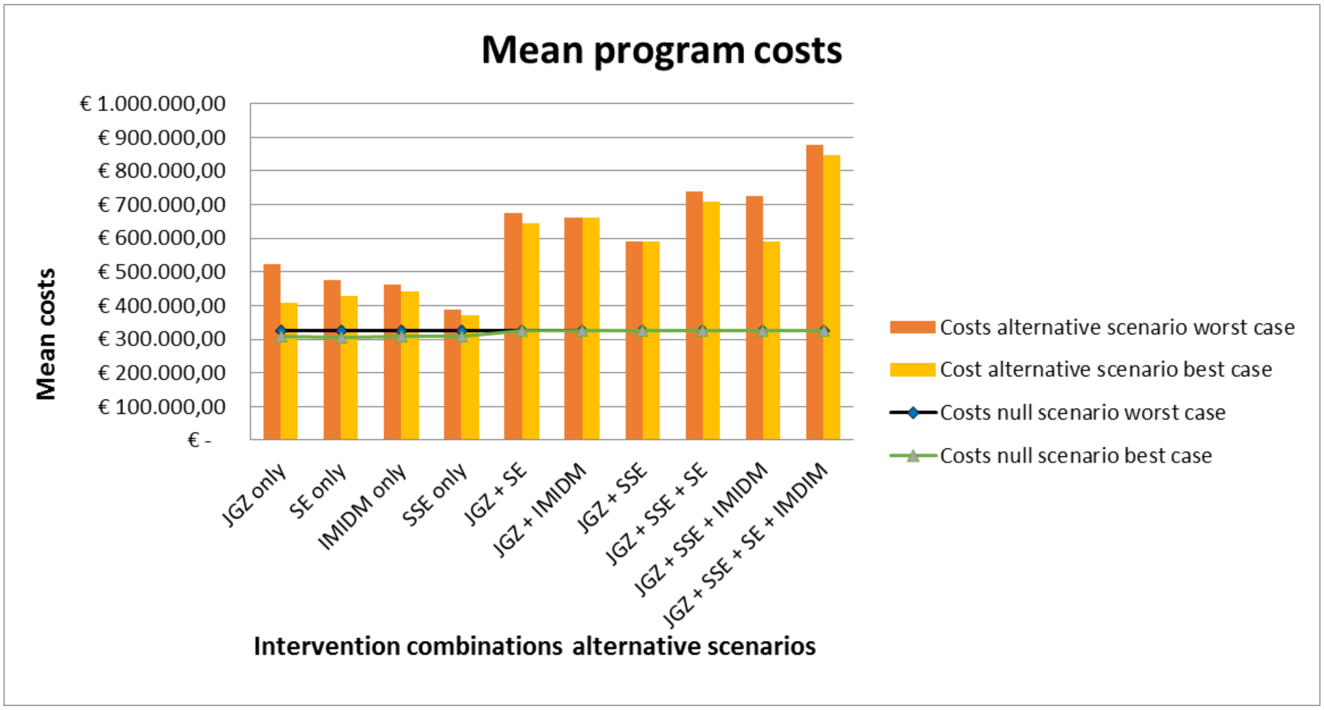

Figure 5: Mean program costs of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

The most expensive scenario in both the best and worst case situation is the alternative scenario that adds Oorcheck JGZ, the Sonic Silence Exhibit, Sound Effects and "Iets minder is de max" to the null scenario, as shown in figure 5. In the worst case situation, the costs for this alternative scenario turned out to be 2.7 times higher than the costs of the alternative scenario. In the best case situation the costs for the most extensive alternative scenario are 2.61 times higher than the costs for the alternative scenario. The alternative scenario with the lowest costs compared to the null scenario is the alternative scenario in which only the Sonic Silence Exhibit is added to the already available interventions. The costs for this alternative scenario are 1.2 times higher in the worst case scenario and 1.21 times higher in the best case scenario.

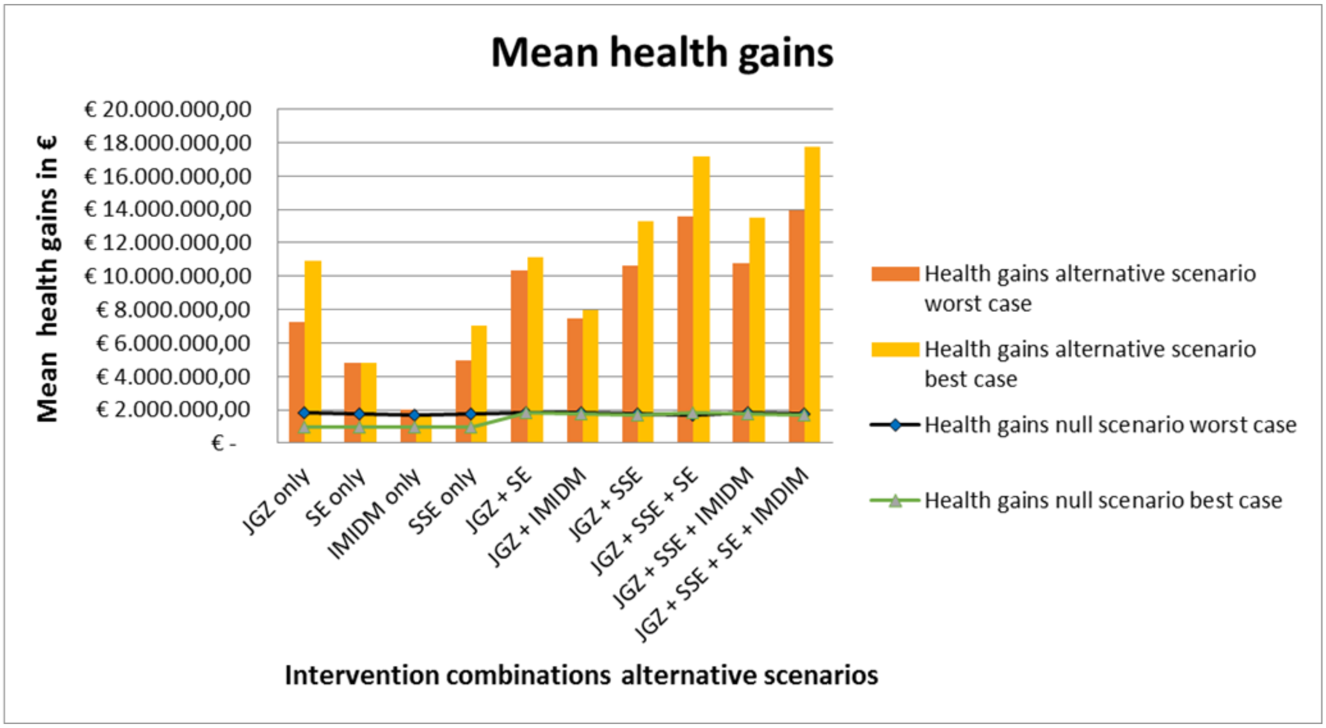

Figure 6: Mean health gains of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

Figure 6 shows that the alternative scenario with the largest increase in health gains in both the best and worst case situation is the alternative scenario in which Oorcheck JGZ, the Sonic Silence Exhibit, Sound Effects and "Iets minder is de max" are added to the interventions in the null scenario. The increase in health gains ranges from 7.8 times the health gains in the null scenario to 10.3 times the health gains in the null scenario.

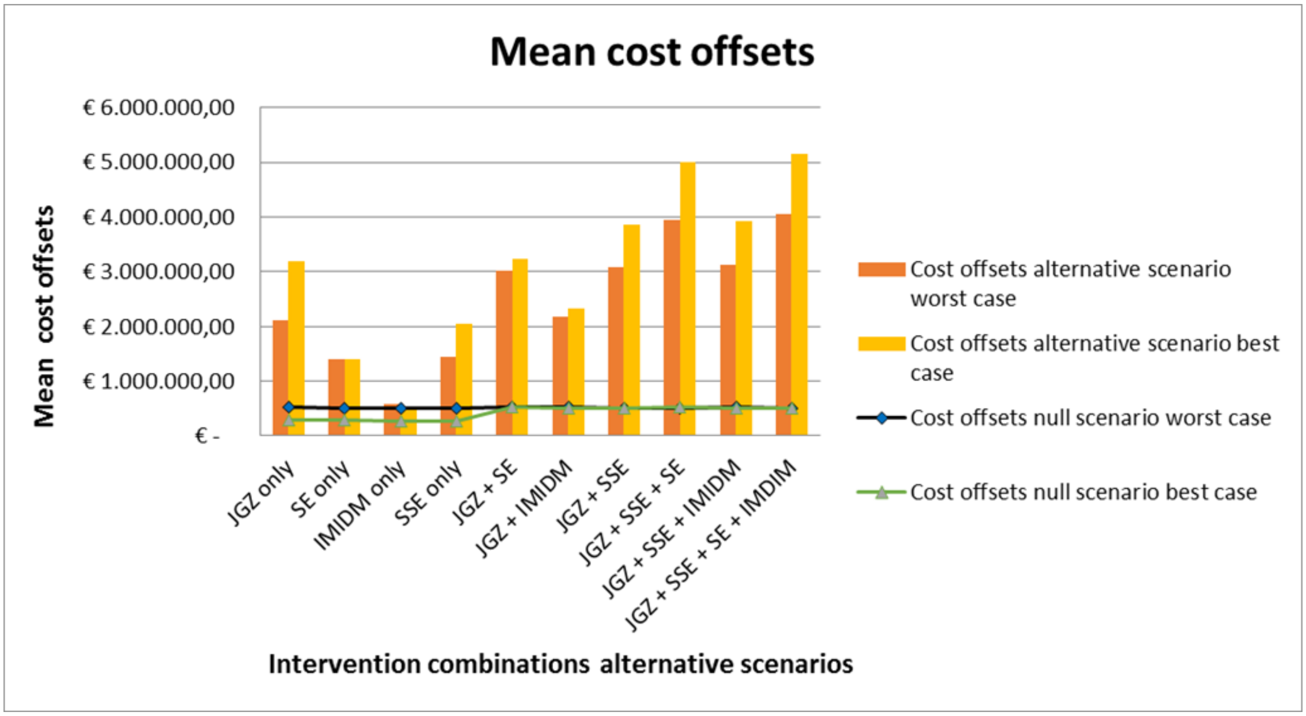

Figure 7: Mean cost-offsets of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

The same alternative scenario that yield the highest mean costs and the highest mean health gains, also yields the highest mean cost-offsets. The cost-offsets for the alternative scenario are between 7.8 and 10.3 times bigger than the null scenario.

It should be noted that the fluctuation of the null scenario lines in figures 5, 6 and 7 is caused by the Monte Carlo uncertainty analysis, in which simulations where done to gain mean values, which resulted in small discrepancies every time a simulation for the null scenario was performed.

The primary outcomes of the analysis consist of the net-benefits, the cost-(net) benefit ratios and the mean ROI of each scenario (sub-question 8). These outcomes are summarized in figure 8, 9 and 10, respectively.

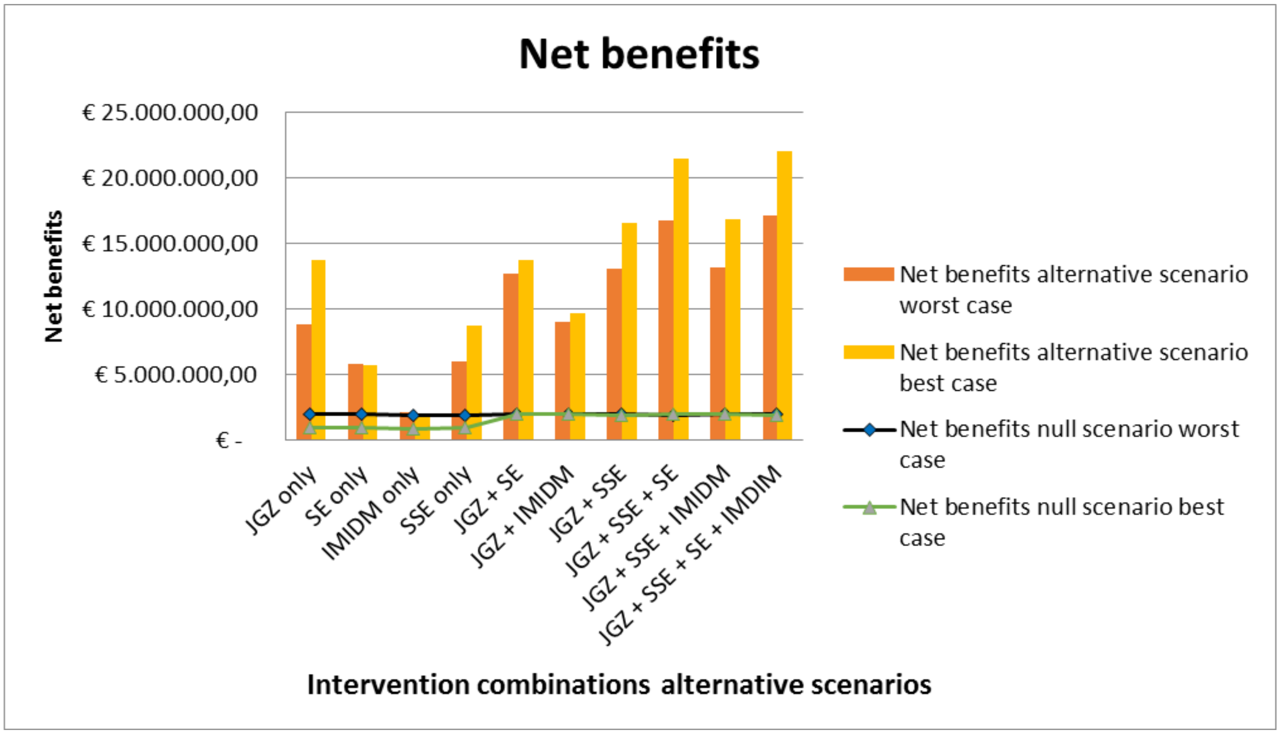

Figure 8: Net-benefits of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

The mean net-benefits consists of the mean health gains and the mean cost-offsets of each scenario minus the costs. As illustrated in figure 8, the highest net-benefits come from the alternative scenario that also yielded the highest health gains and cost-offsets compared to the null scenario. The net-benefits for the alternative scenario in which Oorcheck JGZ, the Sonic Silence Exhibit, Sound Effects and "Iets minder is de max" are included range from €17.120.200,- to €22.069.854,-.

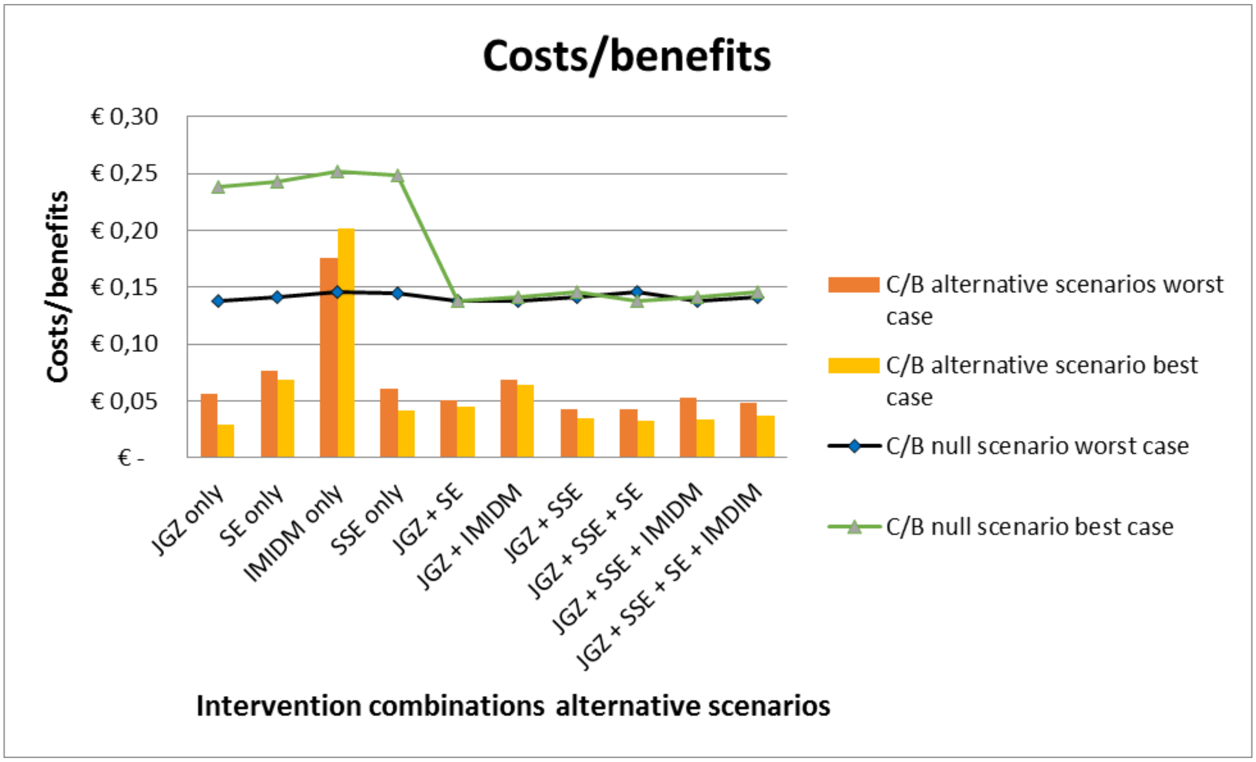

Figure 9: Cost-benefit ratio of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

Figure 9 illustrates what the costs are for each euro in benefits for each scenario. The most expensive scenario is the null scenario in the best case situation, where the price of each euro in benefits exceeds the price each euro in benefits of all alternative scenarios. The most expensive alternative scenario is the scenario with "Iets minder is de max" added to the already available interventions. The price for each euro in benefits with this scenario is €0,25.

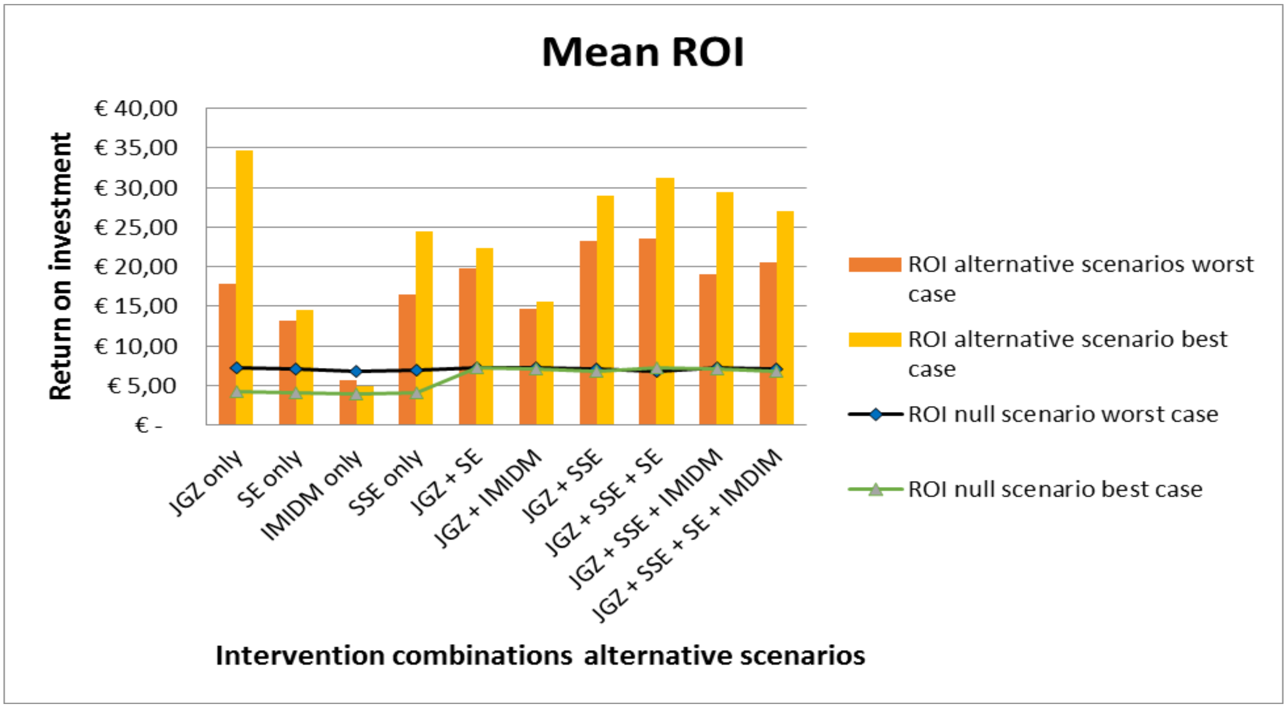

Figure 10: Mean ROI of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

Figure 10 shows the mean ROI for each alternative scenario, which was calculated by dividing the mean net-benefits by the mean costs. The mean ROI depicts the average net-benefits that can be gained per €1-, investment.

The answer to the question which alternative scenario has the highest mean ROI (sub-question 8) can be derived from figure 10. The alternative scenario with the highest ROI (ROI = €23,64 for each invested euro) in the worst case situation is the scenario in which Oorcheck JGZ, Sonic Silence Exhibit and Sound effects are added to the currently available interventions. In the best case situation, the alternative scenario with the highest ROI of €34,76 is the scenario in which only Oorcheck JGZ is added to the already active interventions of the null scenario.

5.7 Secondary outcome measures

The difference between the net-benefits and cost-benefit ratios of the null scenario compared to each alternative scenario are illustrated in figure 11 and 12 as incremental net-benefits and incremental cost-benefit ratios. These figures provide an answer to sub-question 9.

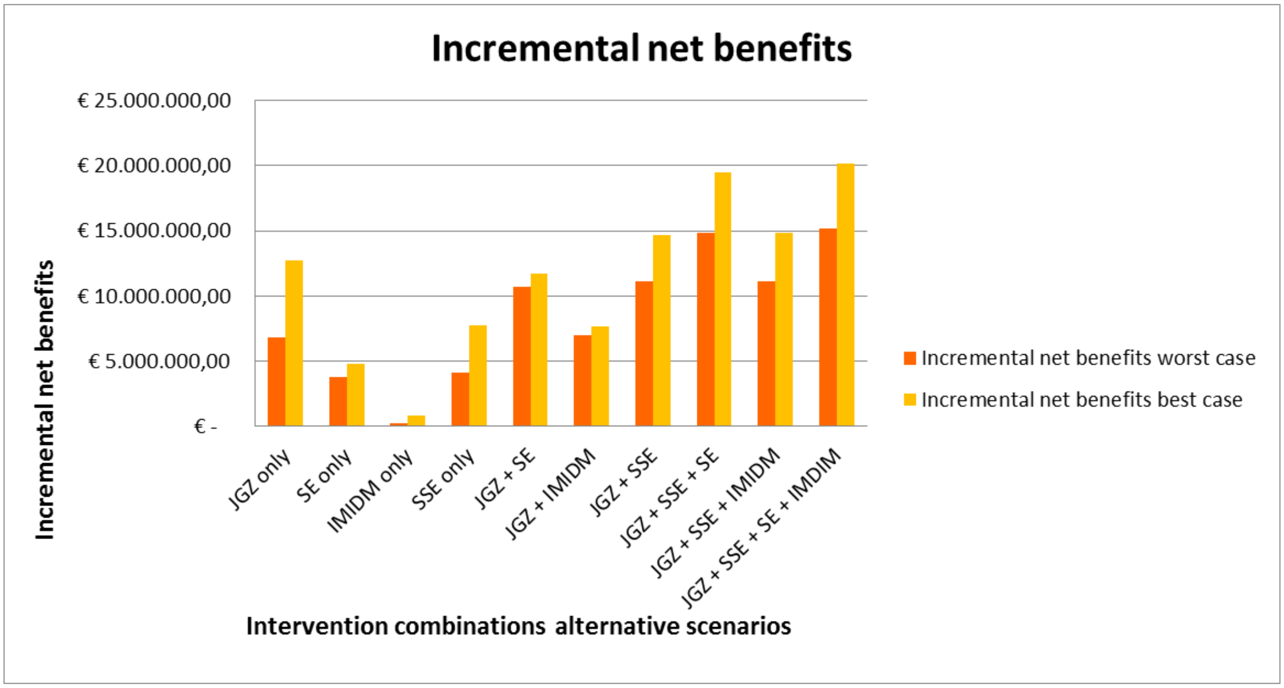

Figure 11: Incremental net-benefits of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

Figure 11 illustrates the incremental net benefits, which were calculated by subtracting the net benefits of the null scenario from the net benefits of the alternative scenario. The highest incremental net-benefits, as shown in figure 11, are generated by the alternative that includes Oorcheck JGZ, the Sonic Silence Exhibit, Sound Effects and "Iets minder is de max" and the alternative with the interventions Oorcheck JGZ, the Sonic Silence Exhibit and Sound Effects. Addition of "Iets minder is de max" to the alternative scenario leads to an increase in incremental net-benefits of 2% in the worst case scenario and 2,5% in the best case scenario.

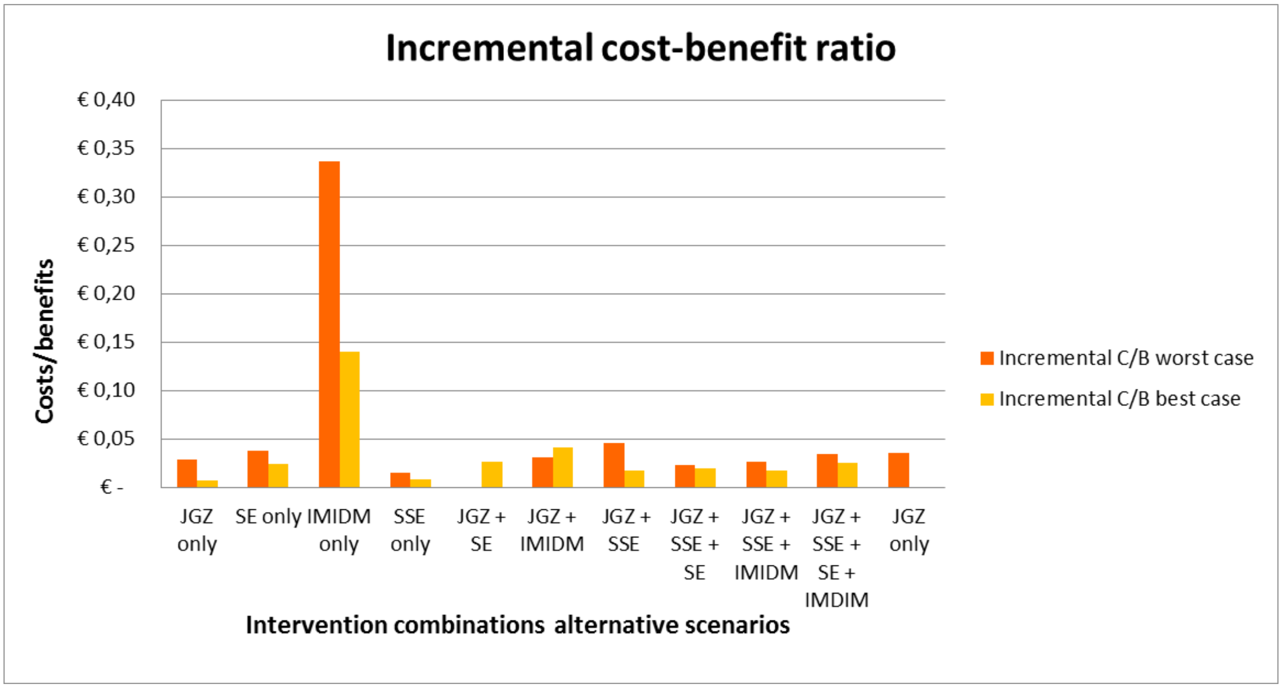

Figure 12: Incremental cost-benefit ratio of each alternative scenario in the worst and best case situation, over a period of one year. Abbreviations: JGZ = Oorcheck integration into Youth Health contact moments, SE = Sound Effects, IMIDM = Iets minder is de max, SSE = Sonic Silence Exhibit.

As can be seen from Figure 12, "Iets minder is de max" is the intervention with the highest costs for €1-, gain in the net-benefits. What is interesting is that each alternative scenario have an incremental cost-benefit ratio below €1-, which translates in a positive ROI, as shown in figure 12.

Figure 11 and 12 provide an answer to sub-question 9: which scenario yields the highest incremental net-benefits, lowest incremental cost-benefit ratio and the highest mean ROI. Figure 11 illustrates that the alternative scenario that includes the Oorcheck JGZ, the Sonic Silence Exhibit, Sound Effects and "Iets minder is de max" yields the highest net-benefits, but the interventions that contribute most to these net-benefits are Oorcheck JGZ and the Sonic Silence Exhibit, while "Iets minder is de max" has the lowest contribution . This is confirmed figure 10 and 12, in which both Oorcheck JGZ and the Sonic Silence exhibit yield the lowest incremental cost-benefit ratio and the highest mean ROI (both separately and combined).

6. Discussion

6.1 Main findings

The aim of this study was to identify the health-economic costs and benefits of investing in the prevention of NIHL in young adults between 12 and 25 years and what the health-economic consequences of investing in prevention would be.

Individuals at risk (sub-question 1)

A total of 828.379 young adults between 12 and 25 years old turned out to be currently at risk in the Netherlands.

Coverage, adherence and effect (sub-question 2)

An answer to sub-question 2 resulted in the following numbers for the current scenario (null scenario), which included only the interventions Oorcheck.nl and TestjeLeefstijl.nu: the coverage ranged between 12,9% and 14,3%, the adherence between 9% and 15% and the effects between 2% and 40%. For the alternative scenarios, the coverage ranged between 18% and 87.8%, the adherence between 12.7% and 89.9% and the effects between 3% and 100. In each case, the alternative scenario was modelled to have a higher, but realistic, coverage, adherence and effect than the null scenario which translated into greater benefits, but the alternative scenarios also entailed higher program costs than the null scenario.

(Mean) Program costs (sub-questions 3 and 5)

The size of the program costs for each intervention were addressed by answering sub-question 3, which were then translated into the mean program costs for each scenario (sub-question 5). Program costs for the null scenario varied from approximately €305.000 to €325.000, while the program costs for the alternative scenarios varied from approximately €400.000 to €875.000.

Typical healthcare trajectory and associated cost-offsets (sub-question 4)

To answer sub-question 4, the most common healthcare trajectories were identified and associated costs were calculated. These costs were defined as cost-offsets and ranged between approximately €680 and €3700 per individual with NIHL, which are avoided if an individual is prevented from developing NIHL and therefore categorized as benefits. Numbers regarding coverage, adherence, effect, program costs and cost-offsets were primarily obtained from literature and estimations from experts to provide answers to sub-questions 1,2,4 and 5. If no data was obtained during literature or from experts, more general literature was used to obtain approximate answers for these sub-questions.

Mean health gains in euros and mean cost-offsets (sub-question 6 and 7)

The answers to sub-questions 1 to 5 provided the means to answer sub-question 6 and 7: what are the mean health gains and the mean cost-offsets? The mean health gains varied from approximately €950.000 to €1.800.000 in the null scenario. In the alternative scenario the health gains were much higher, even in the worst case, and varied from €2.000.000 to €17.800.000. If only the health gains were taken into account, each alternative scenario would yield more benefits at any time than the null scenario. In addition to the health gains, cost-offsets were also counted as benefits. The mean cost-offsets of the null scenario varied from approximately €275.000 to €530.000, while the cost-offsets of the alternative scenario ranged between €590.000 and €5.000.000, which is significantly higher than the cost-offsets of the null scenario.

Net benefits, cost-benefit ratio and ROI (sub-question 8)

To provide an answer to sub-question 8, net benefits, cost-benefit ratios and ROIs were calculated using the answers that were given for sub-question 5, 6 and 7. The net benefits of the null scenario ranged from circa €900.000 to €2.000.000, compared to a range between approximately €1.750.000 and €22.000.000 for the net benefits of the alternative scenarios. The cost-benefit ratios, which represent the costs for each euro gained in benefit, ranged between €0,16 and €0,34 for the null scenario and between €0,03 and €0,25 for the alternative scenarios.

Lastly, the ROIs of the null scenario ranged between €2,98 and €6,23 for each invested euro and for the alternative scenarios this range was between €3,95 and €33,76 for each invested euro. Although there was some overlap between the net benefits, cost-benefit ratios and mean ROIs of the null and alternative scenarios, the benefits of the alternative scenarios exceeded the benefits of the null scenario greatly in most cases, especially when Oorcheck JGZ and the Sonic Silence Exhibit were included in the alternative scenario.

Incremental net-benefits and incremental cost-benefit ratio (sub-question 9)

For the last sub-question, the incremental values of the net-benefits and cost-benefit ratios were computed (sub-question 9). The combination of interventions with the highest incremental net-benefits was the alternative scenario in which Oorcheck JGZ, the Sonic Silence Exhibit, Sound Effects and "Iets minder is de max" are added to the already active interventions of the null scenario. Finally, the combination of interventions with the lowest incremental cost-benefit ratio was the alternative scenario in which only Oorcheck JGZ was added to the currently active interventions. This is not surprising, since this intervention had relatively low program costs but high benefits and therefore a high ROI.

6.2 Limitations

We must be clear that the findings of this study need to be interpreted with utmost caution, since the largest share of the input data was based on expert opinions, approximations and assumptions because the literature does not report robust evidence in support of our analysis, a problem that was also encountered by the RIVM (2013). That said, uncertainty in the input parameters was partly compensated for by running 500 uncertainty (Monte Carlo) analyses to assess the width and depth of the uncertainty in the simulation model.

To illustrate, all respondents who were approached to obtain estimates were reluctant to make educated guesses based on their experience. Only one of the respondents was willing to provide estimates that were mainly based on experience. This shows the sometimes very poor quality of the data on which the simulations were based.

By way of further illustration, the data gaps that remained were filled mainly by using approximations based on general literature, if available. These approximations are likely to have led to more uncertainty in the outcomes and a decrease in the model's internal validity. In addition, the assumption was made that the effect size was equal for all interventions. This assumption was based on the only estimation that was provided during the questionnaires on effect size, which also affected the internal validity negatively.

Another difficulty that arose during the study was the problem of double counting. With the data that was available, it was not possible to form mutually excluding target groups for the interventions. Therefore, an individual in one target group could benefit from multiple interventions, which was not accounted for and likely led to an overestimation of benefits of the scenarios. On the other hand, measure were taken to prevent overestimation of the outcome measures of the analyses by using conservative values for the WTP and the cost-offsets. However, it is not known how large the effects are and it could therefore not be determined if the double counting problem and the conservative values for WTP and cost-offsets outweigh each other.

In addition to the data problems, the model that was used for the analysis did not account for the possible consequences if interventions are combined. Combination of interventions could lead to changes in parameters used in the analysis that are more complicated than just adding or subtracting these parameters from each other. Combined interventions could enhance each other in a synergetic way or counteract each other.

Furthermore, this study only took into account the health gains, cost-offsets and the program costs. However, an individual who develops NIHL also experiences socioeconomic and psychological consequences (Appendix I). Future studies should take this into account and add these consequences as costs to the model as more data becomes available to create a more holistic view on the consequences of NIHL on society and the benefits of investing in prevention.

Unfortunately, it is unknown what the impact of the data uncertainty is on the obtained outcomes measures and therefore, no conclusions can be drawn from the results of this study. However, we did provide the Netherlands Hearing Health Foundation with a conceptual framework and a health-economic simulation model that have the potential to contribute to their cause by showing (local) governments and other potential investors what the health-economic consequences and benefits of their investments are. To achieve this, more research is needed so that more input data for the costing tool will become available and thus the results from the cost-benefit analyses will become more accurate as more specific data is inserted.

The findings of this research may not have provided a conclusive answer to the research question, but they did provide some tools and starting points for future studies that aim to contribute to the prevention of the "Silent Epidemic".

6.3 Conclusions

Our findings suggest that investing in prevention of NIHL is beneficial from a health-economical perspective. Although there are large differences in the costs and benefits of each intervention and combinations of interventions, each new (alternative) scenario yielded a positive mean ROI, which means that every invested euro will generate more benefits in euros than what was invested and more so under the new (alternative) scenario than under the old (null) scenario of current levels of NIHL prevention – even when taking into account worst and best case versions of the null and alternative scenarios.

No conclusive answers can be drawn from this study due to the large amount of assumptions and approximations that were used for the input parameters, which led to great uncertainty in the modeled outcomes. Nevertheless, it is clear that investing in effective preventive interventions for NIHL that are aimed at raising awareness and educating young adults is beneficial from a health care perspective if an effort is made to cover as many individuals who are at risk as possible and stimulate them to utilize the available preventive measures.

Despite a lack of reliable outcome measures, this study offers a simulation model for health-economic evaluation that can be used and complemented as more data becomes available to provide insights into the costs and benefits of the prevention of NIHL and therefore this tool could contribute in persuading various stakeholders to invest in prevention of NIHL.

6.4 Recommendations

Main recommendations

One of the main difficulties in this study was to obtain the data that was needed for the analyses. Because NIHL is a disease with an onset that can take several years, longitudinal studies need to be done to measure the adherence and effectiveness of interventions. Since the budgets of the preventive interventions are often limited and longitudinal studies are expensive, there is a scarcity in effect studies of these interventions and thus scarcity of data that can be found in literature. As a consequence of the lack of data, no previous quantitative studies where performed on the subject of NIHL in the Netherlands, except for a study by the RIVM (2013), who had to conclude that there was not enough data available to draw conclusions about the trends regarding NIHL and the size of the problem (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013).

Therefore, additional research is needed to obtain data on coverage, adherence and effect of various preventive interventions and combinations of interventions, but also on socioeconomic and psychological consequences of NIHL to get a clear and complete view on the costs and benefits of NIHL in the Netherlands.

Another issue that arose during the study was the scarcity of expert opinions to fill the data gaps. A probable cause for this issue could be the low amount of respondents that participated in this study. A possible cause for the reluctance of the respondents to provide estimations could be insufficient and/or unclear provision of information, prior to the questionnaires, on the purpose of the study and on how the given estimations would be used. A possible solution would be to perform focus groups instead of one on one interviews, so that more respondents from the same intervention can participate in the study and estimations are more likely to be obtained due to group discussions and decision making.

Additional recommendations

Some additional issues arose from the interviews that did not provide answers to the research question of this study, but did provide material for additional recommendations. One of these issues was the lack of legislation concerning a noise limit in the Netherlands, which came up during an interview. This type of legislation is already active in Flanders and, according to the respondent, very effective. However, the same respondent commented that for the legislation to be effective, the compliance to the legislation should be actively monitored and thus governmental involvement in the prevention of NIHL is necessary.

Another topic that arose during the interviews was the age of the target groups for the preventive interventions. Multiple respondents were of opinion that education on the risks and ways to protect hearing should start at primary school in order to prevent NIHL effectively because, according to these respondents, behavioral adaptations are easier to achieve in primary school-aged kids than in young adults. Additional research should be done to confirm this statement.

Appendix I: Conceptual stakeholder analysis

The effectiveness of preventive interventions depends largely on which stakeholders are actively involved and how they are involved. This is influenced by the benefits and costs that preventive interventions hold for a particular stakeholder. In addition, interventions that are offered by one stakeholder can lead to additional costs or benefits for other stakeholders. Figure 2 is an actor map that illustrates which stakeholders are involved in the prevention of NIHL and how they influence each other directly by adopting preventive measures against NIHL and if this influence provides benefits or imposes costs for the other stakeholders. The figure is based on the separate analysis of each stakeholder, which is elaborated on in the upcoming sections. Benefits of preventive interventions against NIHL mainly consist of avoided costs that are related to NIHL. Both benefits and costs of preventive interventions can be monetary or non-monetary and vary for each stakeholder. Non-monetary costs and benefits influence an individual's well-being and therefore the perceived quality of life (QoL). If the perceived QoL is influenced by the individuals health status, the non-monetary costs and benefits are referred to as Health Related Quality of Life (HRQoL) (Healthy People 2020, 2010).

In this section, the costs as a consequence of NIHL will be elaborated on for each stakeholder separately to illustrate how each stakeholder could benefit from investing in preventive interventions.

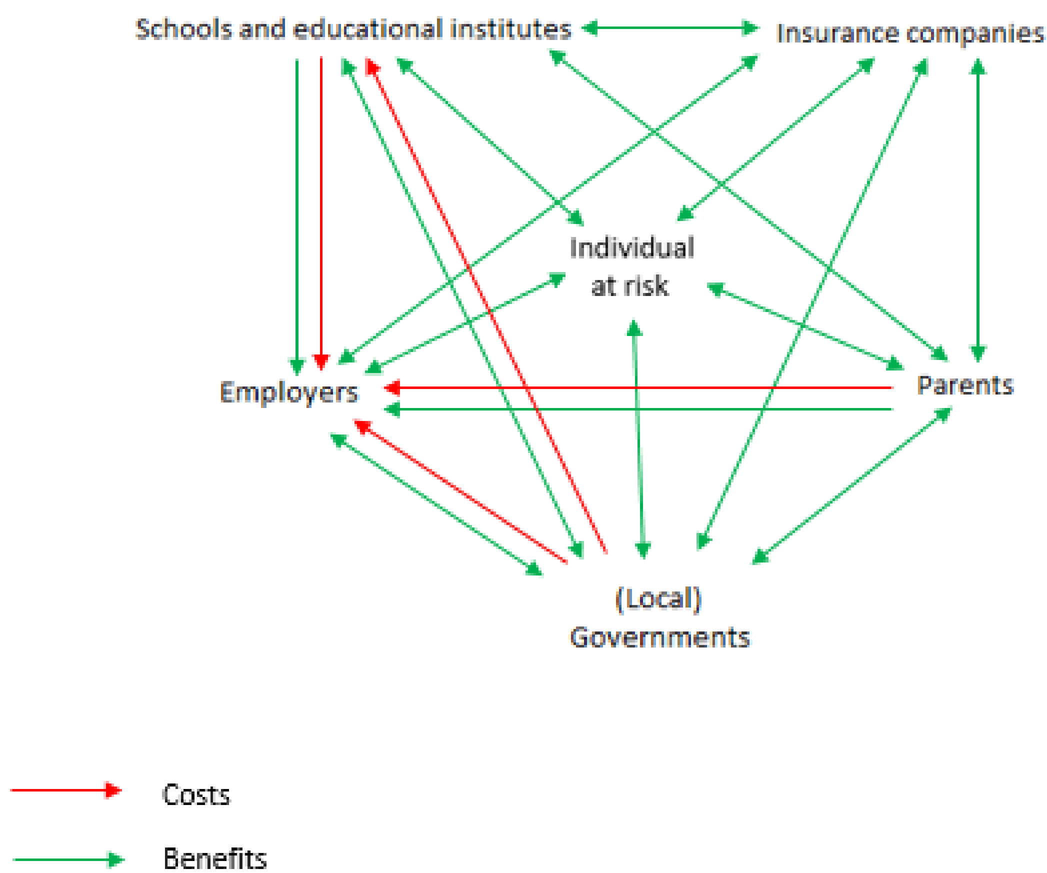

Figure 1 Actor map

Individual at risk

The target for preventive interventions are the individuals that are at risk for NIHL and they are therefore placed in the center of the actor map. As shown in Figure 2, preventive interventions of any involved stakeholder benefit the individual at risk. This is due to the avoidance of the costs that are shown in Figure 3. Figure 3 illustrates how different domains are affected when an individual develops NIHL and which costs are imposed on the individual due to these affected domains. It should be noted that this is an oversimplification and that several domains and costs often also influence each other.

The most obvious domain that is affected by NIHL is communication. An individual with NIHL has to put a lot of effort in following conversations and in understanding what is said (Kramer, 2008; Kramer & Gussenhoven, 2013; Nederlands Centrum voor Beroepsziekten, 2014). This often leads to fatigue, stress and avoidance of social interactions (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013; Commission on Hearing Loss, 2014; Li, et al., 2014). In addition, a lack of understanding from the individual's surroundings may also lead to avoidance of social interactions and an increased stress level (Kramer & Gussenhoven, 2013). Decreased social interactions have an negative impact on the HRQOL. In addition, chronic stress can have a serious impact on a person his health and therefore on the HRQOL due to an increased risk of developing several diseases like depression, obesity and cardiovascular diseases (Mcewen, 2004; Healthy People 2020, 2010).

Decreased social interactions and stress can also influence each other. Loneliness can lead to increased stress levels and increased stress levels can lead to a decrease in social interactions (Deberard & Kleinknecht, 1995; Commission on Hearing Loss, 2014). Finally, communication has an effect on the performance of an individual, whether it is at school or at work (Blood & Blood, 2008; Shargorodsky, Curhan, Curhan, & Eavey, 2010). Due to decreased communication, difficulties mainly arise in teamwork and the understanding of instructions that are given which affects a person his performance. Additionally, performance can also be affected negatively by the increased stress levels (Kramer, 2008).

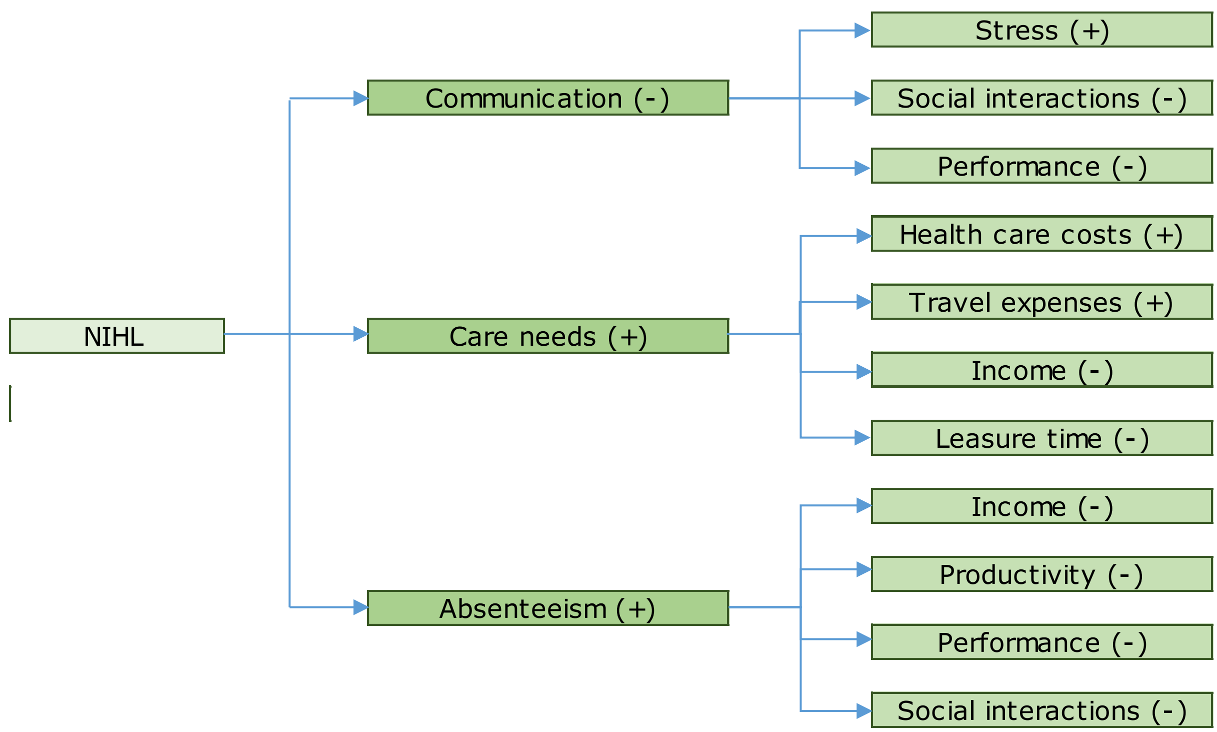

Figure 3 Costs as a consequence of NIHL from the perspective of the individual with NIHL.

Individuals with NIHL require more healthcare than healthy individuals. Healthcare is partly covered by health insurance companies. However, not every treatment is fully covered by health insurance and in addition to that, individuals have obligatory deductible excess. Therefore, the healthcare costs for the individual increase when he develops NIHL. To receive healthcare, an individual has to travel to the location where the healthcare professional his situated. This will increase the travel expenses that the individual has to make. Additionally, healthcare professionals are often only available during business hours. Therefore, an increased need for healthcare can lead to less income, since business hours have to be sacrificed to visit a healthcare professional. If this is not the case, for example for individuals who work part-time, visiting a healthcare professional will decrease the amount of leisure time. This in turn can lead to stress, due to a decreased amount of social interactions and will lead to a decreased HRQOL.

Finally, NIHL influences how often an individual is absent from work or school. Reasons why an individual with NIHL is absent can differ from appointments with healthcare professionals to stress or fatigue related sick-leave (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013; Hasson, Theorell, Westerlund, & Canlon, 2010; Kramer, 2008; Kramer & Gussenhoven, 2013; Nachtegaal, et al., 2009). When an individual is frequently absent from work, this will have a direct influence on his income. The individual will still get paid by his employer, but less than he would get when he is present. The minimum that an employer has to pay to a sick employee is 70% of his regular salary. In addition, absenteeism leads to a reduced output and therefore the individuals suffers from productivity loss (Kramer & Gussenhoven, 2013). School-going children will miss out on education and the development of skills when they are absent from school. Therefore, their performance will be affected negatively by increased absenteeism (Shargorodsky, Curhan, Curhan, & Eavey, 2010).

Another factor that is influenced by absenteeism is the HRQOL due to the decreased amount of social interactions that an individual has. Both school and work are large parts of an individual's life, where a lot of social interactions take place. When an individual is absent, either from work or school, he will miss out on all these social interactions which in turn can have consequences on its own (Shargorodsky, Curhan, Curhan, & Eavey, 2010; Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013).

Schools and educational institutes

When a school going individual develops NIHL, this has an influence on the school or educational institute that the individual attends to. As shown in Figure 2, schools and educational institutes also benefit from preventive interventions that are supplied by all involved stakeholders, except for interventions from employers. The assumption is made that school going individuals are not exposed to excessive noise during any side jobs that they may have. Therefore, no preventive interventions will be provided by employers of school going children of which schools or educational institutes can benefit from. Figure 4 illustrates which domains are influenced by students with NIHL and to which costs this leads for the school or educational institute that the individual attends to.

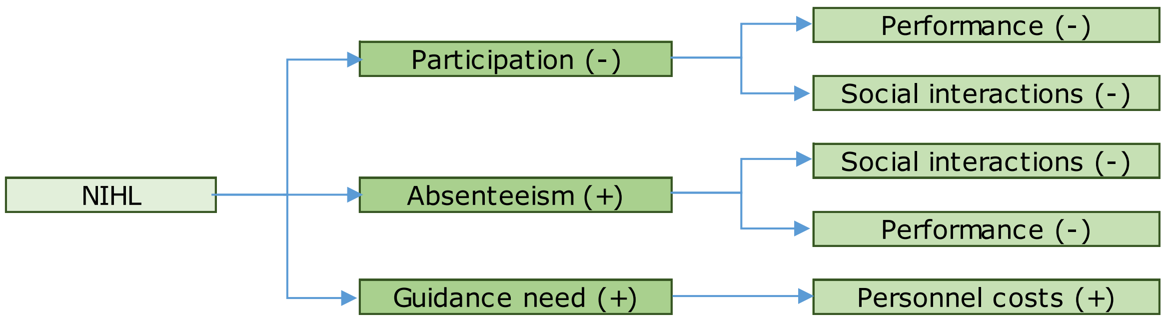

Figure 4 Costs as a consequence of NIHL from the perspective of schools and educational institutes.

Individuals with NIHL have to put more effort into understanding what is said during class. This can cost a lot of energy and will have a negative influence on the individuals participation during class. As a consequence, the individuals performance at school is likely to be affected negatively (Shargorodsky, Curhan, Curhan, & Eavey, 2010). However, participation does not only consists of paying attention in class. Participation also involves activities outside of the class-room. An individual with NIHL is often inclined to retract from such activities due to his disability and will therefore have less social interactions and a decreased HRQOL (Li, et al., 2014; Commission on Hearing Loss, 2014).

Social interactions at school are especially important for the development of social skills. A decrease in social interactions could therefore affect the social development of the individual with NIHL and his behavior. In addition, decreased social interactions may also lead to bullying from other kids. These issues are a burden for the school or educational institute, because it will cause individuals with NIHL to need additional guidance or special education (Shargorodsky, Curhan, Curhan, & Eavey, 2010). This imposed additional costs on schools and on (local) governments.

Decreased participation, both on social as on educational level, often leads to individuals that drop out of school at a young age. This can have a significant effect on the end qualification and future income of the individual (in 't Veld, Korving, Hamdan, & van der Steen, 2006). According to in 't Veld et al. (2006), each completed school year is equal to a rise of 7% in future income.

When an individual with NIHL has appointments with healthcare professionals, this is often during business hours when the individual should actually be at school. Additionally, individuals with NIHL report sick more often due to emotional exhaustion. Therefore, the absenteeism rate for individuals with NIHL is higher than individuals who do not suffer from NIHL. The consequences of being absent more often are similar to the consequences of decreased participation.

Schools often offer additional guidance after school for individuals who need it. Individuals with NIHL are likely to need additional guidance for things like bullying or incurred delays and will therefore impose additional personnel costs for the school or educational institute.

When an involved stakeholder provides an effective preventive intervention for the students, this will benefit the school or institute because they avoid the costs that are made. However, a preventive intervention that requires schools to educate their students about hearing loss is likely to have an effect on the schools budget. These costs come from hiring additional personnel, training the personnel or paying for overtime.

Employers

When an individual at risk of NIHL is at working age, his employer becomes an involved stakeholder in the prevention of NIHL. Figure 5 shows which domains are affected if more employees develop NIHL and on which costs this has an influence.

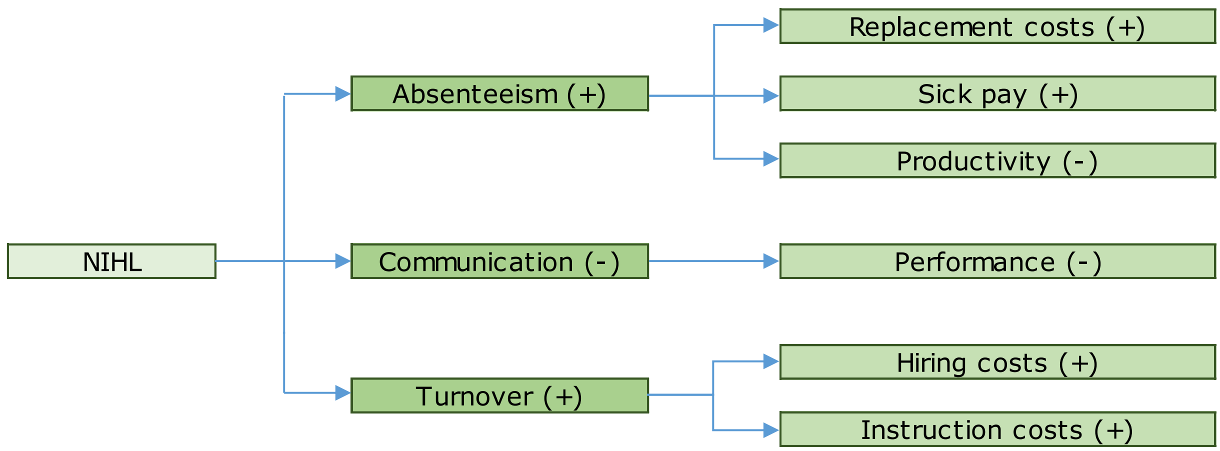

Figure 5 Costs as a consequence of NIHL from the perspective of employers.

Individuals with NIHL are absent from work 22% more often than individuals without NIHL (Jellema, 2014). The reasons for absenteeism from work are similar to the reasons for absenteeism from school. When an individual is absent from work, the employer needs someone to replace the individual, which causes a rise in replacement costs. At the same time, the employer has to pay the employee that is absent a sick pay of at least 70% of his normal salary. Finally, absenteeism leads to a decrease in productivity if a replacement cannot be found in time, or when the replacement is less productive. The amount of time that productivity is lost because replacement is not found yet is called the friction period. Currently, the average friction period is 6 months, which leads to significant productivity loss. It should be noted that the duration of the friction period varies for each sector (Hakkaart- van Roijen, Tan, & Bouwmans, 2010).

In most working environments, communication is important to perform the job well. However, individuals with NIHL have more difficulties communicating. When teamwork is important, the communication difficulties are likely to result in decreased performance, not only by the individual with NIHL but also by other employees in the team. Decreased performance often leads to decreased productivity and will therefore impose cost on the employer (Hasson, Theorell, Westerlund, & Canlon, 2010; Kramer, 2008).

For some jobs, sufficient hearing is essential to perform the job. If NIHL occurs often in such companies, the turnover rate will be high. This in turn will lead to increased hiring costs and costs for instructing the new personnel.

The involvement of employers in the prevention of NIHL varies per sector. Employers that offer jobs in which sufficient hearing is important have a larger stake in preventing NIHL than employers who offer jobs in which hearing is not that important. Therefore, the willingness to invest in preventive interventions can vary strongly among employers.

When the initiative for preventive measures does not come from the employer himself, other stakeholders may still impose costs for preventive measures on them. Parents and schools can do this by educating future employees about hearing loss and hearing protection, which may lead to a higher demand from employees for sufficient hearing protection at work. In addition, (local) governments may impose stricter regulations and inspections concerning hearing protection at work, which obligates employers to invest in preventive interventions for their employees.

(Local) governments

Starting in 2015, (local) governments became responsible for youth care, work and income and healthcare for the elderly (Rijksoverheid). Therefore, they are important stakeholders in the prevention of NIHL in young adults. Figure 6 illustrates how the domains of youth care and work force are affected if no preventive interventions for NIHL take place.

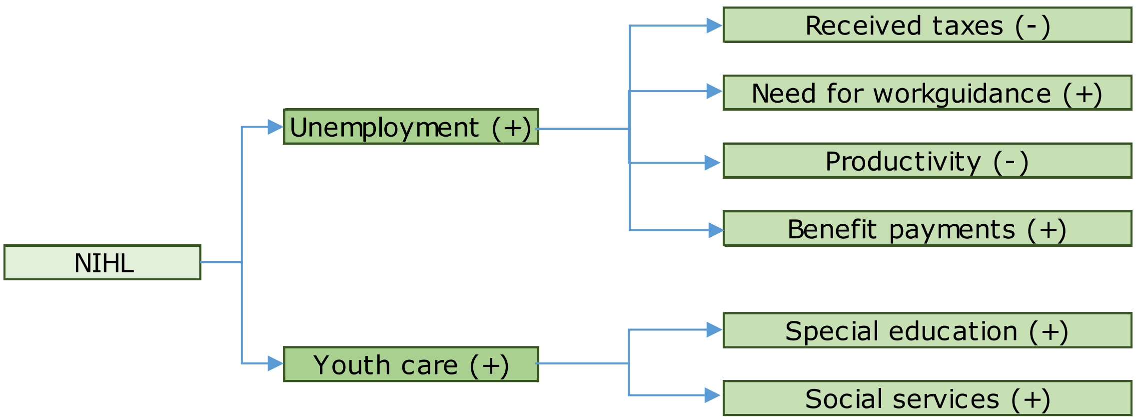

Figure 6 Costs as a consequence of NIHL from the perspective of (local) governments.

According to a study in Denmark, individuals with NIHL that are at working age have a 18% higher chance of being unemployed than individuals that do not have NIHL (Kramer & Gussenhoven, 2013). Unemployed individuals receive social benefits and are eligible for tax exemption. As a consequence, (local) governments receive fewer taxes and have to pay more benefits when unemployment rises in their region. Another consequence of unemployment is a loss of output, or productivity loss as seen from the perspective of the local government in its role as an employer (Kramer & Gussenhoven, Vocational Issues for Persons With Hearing Loss, 2013). Due to the significant effects of unemployment on the budget of (local) governments, they offer work guidance to help people get a job. Therefore, when unemployment rises, the need for work guidance rises to.

School going individuals with NIHL impact the costs that are made by (local) governments in a different way. However, it should be noted that an individual that develops NIHL at a school going age, will be of working age in the future. The influence of this individual will then switch from the youth care domain to the unemployment domain. Individuals who develop NIHL on a school going age, need more guidance to ensure sufficient development. However, not every regular school is able to provide these individuals with enough means to develop skills and knowledge sufficiently. Therefore, some individuals qualify for special education (Shargorodsky, Curhan, Curhan, & Eavey, 2010; Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2013). This brings additional costs, which are covered by the municipality of the region where the individual with NIHL lives. In addition, some of the individuals with NIHL develop behavioral problems or experience problems at home (van Eldik, 2005). These individuals may need the help of a social worker, which is also paid by (local) governments.

(local) governments can benefit greatly from preventive interventions that are provided by involved stakeholders. A big difference between (local) governments and other stakeholders, is that (local) governments can impose rules on other stakeholders. They can obligate schools and educational institutes or employers to provide their students or employers with preventive measures for NIHL, which imposes costs on these stakeholders while (local) governments only benefit from it.

Parents

When an individual with NIHL still lives with his parents, the parents are also important stakeholders that can benefit from preventive interventions of any other involved stakeholder. Figure 7 illustrates the domains that are affected if their child has NIHL and the subsequent costs.

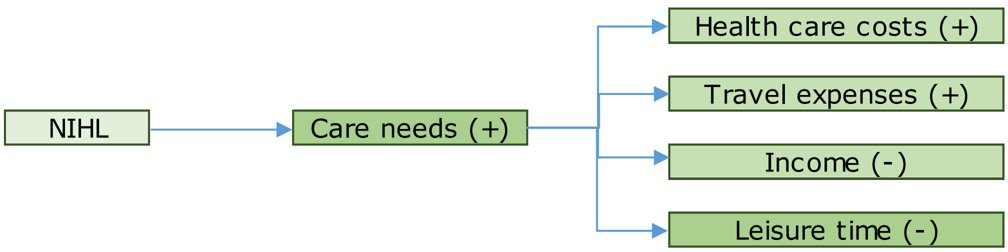

Figure 7 Costs as a consequence of NIHL from the perspective of parents of an individual with NIHL that still lives at home.

The care needs of an individual with NIHL are higher than the care needs of an healthy individual. If the individual still lives at home, parents are often involved in meeting those needs (Gregory, 1998). This causes their healthcare and travel expenses to rise, due to visits to healthcare professionals with their child, but it will also have an effect on their time. As mentioned previously, most healthcare professionals can only be visited during business hours. Therefore, if the parents join the child when visiting his healthcare professional, they have to take a day off from work. This leads to decreased income due to missed hours at work. If the parents work part-time or the healthcare professional can be visited outside of business hours, visiting the healthcare professional will not necessarily have an impact on the income of the parents but it will have an impact on their leisure time. Both a decreased income and decreased leisure time can lead to higher stress levels and a decrease of social interactions which in turn affects the QoL of the parents (About Families, 2012).

When preventive interventions are provided by other involved stakeholders, the parents of the individual at risk benefit by avoiding the costs that are illustrated in Figure 7. They may however be confronted with some costs for purchasing proper hearing protection for their child, but these are one-time costs that are relatively low and are therefore not shown in Figure 2.

Insurance companies

If the incidence of NIHL rises it affects only one domain that is relevant for insurance companies, as shown in Figure 8.

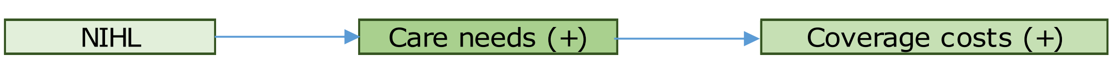

Figure 8 Costs as a consequence of NIHL from the perspective of insurance companies

Health insurance companies mainly profit from the preventive interventions of other stakeholders without providing any preventive means for NIHL themselves. Figure 8 illustrates that a higher incidence of NIHL leads to increased care needs and will therefore lead to higher coverage costs. Nevertheless, health insurance companies do not often invest in preventive interventions due to the so called prevention paradox: insurance companies are not guaranteed to benefit from their preventive measures, because customers are free to change health insurance company every year (van den Berg, 2008). Another reason that health insurance companies are often reluctant to invest in prevention, is that investments often lead to a rise in premium and this may lead to a loss in customers (van Klaveren, Poortvliet, & van Free, 2011). These companies could however stimulate the use of preventive interventions by other stakeholders by offering them economic incentives that are in accordance with their preventive efforts.

Offering incentives to other companies for their efforts in preventing NIHL can potentially be even more useful for *income insurance companies*. Income insurance companies have clients who work independently and pay premium every month for coverage of income in case they are not able to perform their jobs anymore. These companies can benefit greatly if their clients are prevented from developing hearing loss, especially when good hearing is necessary for performing their jobs. When these companies provide incentives to stakeholders who provide their clients with preventive interventions, both parties can benefit greatly by helping each other. This may even stimulate other stakeholders to participate in similar collaborations.

Appendix II: Description of interventions

Oorcheck.nl is an initiative of the Netherlands Hearing Health Foundation. Their goal is to raise awareness in young adults between the age of 12 and 25 years about hearing protection and the risks of loud music. The website contains information about the function of the ear, what the causes of NIHL are and how NIHL can be prevented. The website also provides a popquiz, a hearing test in which you can check your ability to understand words in a noisy environment, which is called a speech-in-noise test, a test to check what the maximum frequency is that you are able to hear, and the possibility to check if the volume on your personal audio player is causing damage to your ears. At the end of each test, an advice is given based on your results. One of the aims of the Netherlands Hearing Health Foundation is to implement the hearing test into the Youth Health (Jeugdgezondheidszorg, JGZ) contact moments in school-aged children (van Deelen, 2014). In addition to the tests and pop quizes, the website has a section in which teaching material can be downloaded for grade 1 and 2 of secondary schools (RIVM, 2012; Nationale Hoorstichting).

Another preventive intervention that is available and active in the Netherlands is the covenant for the prevention of hearing loss in the music sector. This covenant is an agreement between the Ministry of Health, Welfare and Sport, the Association of Dutch Music Venues and Festivals (De Vereniging Nederlandse Poppodia en Festivals, VNPF) and the Association for Eventmakers (de Vereniging van EvenementenMakers, VVEM). In the covenant the three parties agree to take measures to reduce excessive noise exposure by noise mitigation, measuring noise and providing hearing protection at the music events that VNPF and VVEM are responsible for. The ministry of Health, Welfare and Sports supports the VNPF and VVEM financially to develop and implement the measures that they agree upon concerning the communication to the public. This intervention is targeted at the visitors of music venues and festivals that are organized by the VNPF and VVEM (Ministerie van Volksgezondheid, Welzijn en Sport, 2014).

The third active intervention program in the Netherlands is TestJeLeefstijl.nu, which is provided by the TestJeLeefstijl Foundation. This program differs from the previous two, due to the multidisciplinary character of this intervention. TestJeLeefstijl.nu is a website that provides a range of lifestyle tests concerning various lifestyle themes like alcohol, drugs and also hearing (RIVM, 2012). The program is a mandatory part of the educational program in participating schools. Each aspect of lifestyle has its own module that contains a test that is followed by an advice. The students need to complete each of the lifestyle modules in order to graduate. The aim of this program is to support intermediate vocational education students between the age of 16 and 20 years in making healthy lifestyle choices. The program also provides participating schools with insight into the lifestyle of their students and the aspects of their lifestyle that need improvement so the school can adapt their health policy according to the needs of their students (RIVM, 2012; Testjeleefstijl.nu; Stichting TestJeLeefstijl, 2013).

The last available program in the Netherlands, although not currently active, is Sound Effects. This program ran a pilot from 2008 to 2009 in Amsterdam and surrounding region which was created and evaluated by the Centre Media and Health (Centrum Media en Gezondheid) (van Empelen, 2009; Bouman, 2012). The pilot served as a basis to develop a toolkit to prevent NIHL that is acquired in the nightlife, which can be ordered at the Centre

Media and Health (Centrum Media en Gezondheid) (van Empelen, 2009; Loket Gezond Leven). The program consists of three trajectories. The first is focused on young adults between the age of 16 and 30 years who visit night clubs and bars on a regular basis. The main goal of this trajectory is to raise awareness and educate the target group about the risks and how they can prevent NIHL. The second trajectory is focused on the owners of nightclubs and bars and associations that organize events, to stimulate them to take measures to decrease excessive noise exposure. The last trajectory is focused on raising public awareness using local and national media for several campaigns concerning NIHL (Bouman, 2012). Due to the multiple trajectories, a variety of material was used to provide this pilot intervention. The provided material consisted of media campaigns, a website, an internet soap with a website, a Sound Check test, a Sound Check test, manuals for educatory purposes and several printed materials (Bouman, 2012).

In Flanders, two large public campaigns are available for the prevention of hearing loss. These campaigns are called 'Iets minder is de max' and 'Help ze niet naar de tuut'. Both campaigns are provided by the Flemish government and both are very similar to Oorcheck.nl in the Netherlands. All three interventions consist of websites containing information, several hearing tests and advice on how to protect your hearing. However, the most prominent difference lays in the fact that Oorcheck.nl is provided by the Netherlands Hearing Health Foundation, while the Belgian campaigns are provided and funded by the Belgian government. In addition, the campaigns in Belgium are supported by national policies that are implemented to reduce excessive noise exposure, which is not the case in the Netherlands. Another difference is that the Belgian campaigns are promoted more extensively through various media channels than Oorcheck.nl in the Netherlands (Gilles & van der Heyning, 2014; Vlaamse overheid, 2012; Departement Leefmilieu, Natuur & Energie).

The largest evidence-based intervention is called Dangerous Decibels. This intervention program is currently available and used in 50 states and 37 countries all over the world and this number is only increasing (O'Sullivan, 2015). The Dangerous Decibels program focusses on three components: education, exhibitory and research. For the educational component, Dangerous Decibels provides classroom materials, classroom programs and workshops to train teachers in how to educate their students on hearing loss. In addition, they provide several in-class interactive tools to educate the students in a playful manner. The exhibitory component of Dangerous Decibels refers to an exhibit at the Oregon Museum of Science and Industry in Portland, Oregon and a Virtual Exhibit that is based on the exhibit in the museum and can be provided at any location. Both exhibits consist of visualizations on how the ear works, interactive games to test your hearing and knowledge about hearing and hearing loss, games to interactively learn how to protect your hearing, a simulation to experience how it is to have hearing loss and several animations of the ear. The last component refers to research that the team of Dangerous Decibels does to test their program and improve the program accordingly. The team also works together with several communities to develop a preventive program for Indian communities (O'Sullivan, 2015; Meinke, et al., 2008).

Another preventive intervention that is based on education is the university course on preventing hearing loss at the Pennsylvania State University. The course is called CSD 101: Preventing Hearing Loss and is primarily focused on hearing loss caused by noise. At the Penn State University, undergraduate students are required to choose a selection of courses concerning General Education of which at least one course should be from Health Science or Physical activity. The CSD 101 course is one of the courses that can be followed to meet the General Education Requirements and a total of 1,5 ECs can be obtained by following the course. The course was based online and aimed to increase the knowledge about NIHL and about the measures that can be taken to prevent NIHL (Blood & Blood, 2008).

The last intervention that is included in this research is the Sonic Silence Exhibit in Western Australia. This intervention is developed by the science museum SciTech and the National Acoustics Laboratory in Western Australia and is funded was funded by the government. The exhibit consists of a simulation game involving real-life activities in which individuals can experience how it is to have hearing loss in various situations by sitting in a booth that is part of a giant headphone. The exhibit is available to people of all ages but is specifically designed for school aged children and their parents to learn in a playful way what the consequences are of excessive noise exposure (Chang, 2013).

Onderzoek preventie gehoorschade bij jongeren

Beste heer/mevrouw,

Vanuit het Trimbos-instituut en de Vrije Universiteit van Amsterdam doen wij een onderzoek in opdracht van de Nationale Hoorstichting naar de preventie van gehoorschade bij jongeren. Wij streven er naar om aan de hand van de resultaten uit dit onderzoek het belang van preventie van gehoorschade bij jongeren onder de aandacht te brengen.

Graag willen wij u vragen om de bijgevoegde vragenlijst zo nauwkeurig mogelijk in te vullen, zodat wij deze gegevens kunnen gebruiken in ons onderzoek. De vragenlijst bestaat uit 11 vragen. De gegevens die worden gevraagd zijn een aantal algemene schattingen over gehoorschade binnen de Nederlandse populatie en een aantal gegevens over de interventie X. Omdat het hier om schattingen gaat vragen wij u om een gemiddelde in te vullen, aangevuld met een veilige onder- en bovengrens.

Wij verzoeken u om de vragen zo goed mogelijk te beantwoorden en moedigen het dan ook aan om eventueel bronnen te raadplegen als er wordt gevraagd naar een schatting. Indien u gebruik maakt van bronnen, stellen wij het zeer op prijs als u de geraadpleegde bronnen toevoegt aan uw ingevulde vragenlijst. De titels, auteurs en het jaar waarin de publicaties hebben plaatsgevonden zijn hiervoor voldoende. De ingevulde vragenlijst kunt u terugsturen naar het e-mailadres onderaan deze pagina.

De vragenlijst zal worden opgevolgd met een kort mondeling interview waarin nog een aantal aanvullende vragen zullen worden gesteld en waarin u de kans krijgt om uw antwoorden eventueel toe te lichten en/of aan te vullen. Wij zullen contact met u opnemen over een afspraak voor het interview nadat wij de ingevulde vragenlijst van u hebben ontvangen. Indien u in het uiteindelijke rapport van dit onderzoek anoniem wenst te blijven, dan kunt u dit aangeven in het opmerkingenveld aan het einde van de vragenlijst. Hier kunt u ook aangeven of u het rapport wenst te ontvangen als het onderzoek is afgerond.

Wij willen u alvast hartelijk bedanken voor uw bijdrage aan dit onderzoek. Indien uw vragen heeft, kunt u contact opnemen met Latoya Vermaas aan de hand van de volgende contactgegevens:

Latoya Vermaas
Telefoonnummer (kantoor): 030 29 71 111
Telefoonnummer (mobiel): 06 46 79 12 56
E-mailadres: l.t.vermaas@student.vu.nl

Vragenlijst preventie gehoorschade

Naam: Tel:

Functie: Mail:

Deel 1: Algemene vragen

Vraag 1: Op welke **leeftijd** denkt u dat vermijdbare gehoorschade door geluid gemiddeld ontstaat en welke veilige onder- en bovengrens horen daar volgens u bij?

Gemiddeld:

Ondergrens:

Bovengrens:

Geraadpleegde bronnen:

Vraag 2: Hoeveel jongeren tussen 12 en 25 jaar met vermijdbare gehoorschade door geluid denkt u dat er *jaarlijks* bij komen in Nederland *(1-jaars incidentie)* en welke veilige onder- en bovengrens horen daar volgens u bij?

Gemiddeld:

Ondergrens:

Bovengrens:

Geraadpleegde bronnen:

Vraag 3: Hoeveel jongeren tussen 12 en 25 jaar met vermijdbare gehoorschade door geluid denkt u dat er *binnen een gegeven jaar* zijn in Nederland *(1-jaars prevalentie)* en welke veilige onder- en bovengrens horen daar volgens u bij?

Gemiddeld:

Ondergrens:

Bovengrens:

Geraadpleegde bronnen:

Vraag 4: Op welke **doelgroep(en)** is Interventie gericht?

Antwoord:

Geraadpleegde bronnen:

Vraag 5: Binnen welke **leeftijdscategorie**(ën) valt de doelgroep waar Interventie voor is bedoeld?

Antwoord:

Geraadpleegde bronnen:

Vraag 6: Hoeveel mensen uit de beoogde doelgroepen worden *jaarlijks* gemiddeld met Interventie **bereikt** en welke veilige onder- en bovengrens horen daar volgens u bij?

Gemiddeld:

Ondergrens:

Bovengrens:

Geraadpleegde bronnen:

Vraag 7: Welk **percentage** van de bereikte doelgroep maakt **daadwerkelijk gebruik** van de interventie en welke veilige onder- en bovengrens horen daar volgens u bij?

Gemiddeld:

Ondergrens:

Bovengrens:

Geraadpleegde bronnen:

Vraag 8: Hoe **effectief** is Interventie in het voorkomen van gehoorschade bij de mensen *die gebruik maken van* Interventie, uitgedrukt in een percentage en welke veilige onder- en bovengrens horen daar volgens u bij?

Gemiddeld:

Ondergrens:

Bovengrens:

Geraadpleegde bronnen:

Vraag 9: Wat zijn de **aanbiedingskosten** van Interventie? Geeft u hierbij aan of het om de kosten per persoon, *per jaar* of een andere eenheid gaat.

Antwoord:

Geraadpleegde bronnen:

Mocht u naar aanleiding van het beantwoorden van de vragen nog suggesties of aanbevelingen hebben voor personen die ons wellicht van meer informatie kunnen voorzien voor het onderzoek, dan willen wij u vragen om hieronder de contactgegevens van de betreffende personen in te vullen.

Vraag 10: Suggesties voor contactpersonen voor het beantwoorden van vraag 1 t/m 3 (algemeen):

Naam:

Functie:

Telefoonnummer:

E-mailadres:

Vraag 11: Suggesties voor contactpersonen voor het beantwoorden van vraag 4 t/m 9 (interventie specifiek):

Naam:

Functie:

Telefoonnummer:

E-mailadres:

Eventuele opmerkingen:

Bedankt voor uw medewerking.

Appendix IV: Basic interview design (Dutch)

Naam respondent: Datum interview:
Functie respondent: Locatie Interview:

Introductie

- Naam + opleiding
- Onderzoek + opdrachtgevers
- Graag zo uitgebreid mogelijk antwoorden.
- Als u geen idee heeft, graag dit aangeven.
- Toestemming voor geluidsopname.
- Wens anonimiteit checken
- Op of aanmerkingen voor interviewer: graag aan het einde van het interview.

Vragen

1. Antwoorden vragenlijst nalopen, interpretatie checken van de antwoorden.
2. Vragen nalopen die niet zijn beantwoord: Reden, mogelijkheden om toch aan een antwoord te komen, verwijzingen indien deze nog niet was gegeven.
3. Waren er onduidelijkheden?
4. Wenst respondent bepaalde antwoorden nog verder toe te lichten?
5. Controleren of er vragen zijn naar aanleiding van de vragenlijst bij respondent?
6. (vraag enkel voor audioloog): Welk zorgtraject doorloopt een persoon die gehoorschade blijkt te hebben?

Afsluiting

- Wilt u nog iets aanvullen?
- Heeft u verder nog vragen?
- Wat vond u van het interview? Eventueel nog tips?
- Verzekeren dat respondent contactgegevens heeft
- Bedanken voor deelname

References

About Families. (2012). *Parenting on a low income.* Edinburgh: About Families.

Appendix I:C. Effects of Excessive Exposure. (n.d.). Retrieved February 24, 2015, from United States Departement of Labor: https://www.osha.gov/dts/osta/otm/noise/health_effects/effects.html

Blood, I. M., & Blood, G. W. (2008). A university course on preventing hearing loss. Foxwoods: 9th International Congress on Noise as a Public Health Problem.

Bouman, M. (2012, September). *Databank effectieve jeugdinterventies: beschrijving 'Sound Effects'.* Retrieved from Nederlands Jeugdinstituut: www.nji.nl/jeugdinterventies

Centraal Bureau voor de Statistiek. (2015, February 4). *Bevolking per maand; leeftijd, geslacht, herkomst, generatie.* Retrieved from CBS Statline: http://statline.cbs.nl/Statweb/publication/?VW=T&DM=SLNL&PA=71090NED&D1=0&D2=0&D3=13-26&D4=0&D5=0&D6=l&HD=150616-1539&HDR=T,G3,G1&STB=G2,G4,G5

Chang, P. (2013). *Sonic Silence Exhibit: Demonstrating the Consequences of Noise-Induced Hearing Loss and Tinnitus.* Joondalup: Edith Cowan University: Faculty of Computing, Health and Science.

Chung, J. H., Des Roches, C. M., Meunier, J., & Eavey, R. D. (2005). Evaluation of Noise-Induced Hearing Loss in Young People Using a Web-Based Survey Technique. *Pediatrics, 115*(4), 861-867. doi:10.1542/peds.2004-0173

Commission on Hearing Loss. (2014). *Final Report.* London: ILC-UK.

Cuijpers, M., & Lautenbach, H. (2006). *Disabled employees.* Den Haag: Dutch Ministry of Social Affairs and Employment.

CVZ. (2010). *Handleiding voor kostenonderzoek, geactualiseerde versie 2010.* Diemen: College voor Zorgverzekeringen.

Deberard, M. S., & Kleinknecht, R. A. (1995). Loneliness, duration of loneliness, and reported stress symptomatology. *Psychological Reports, 76*(3c), 1363-1369. doi:10.2466/pr0.1995.76.3c.1363

Departement Leefmilieu, Natuur & Energie. (n.d.). *Help ze niet naar de tuut: Over de campagne*. Retrieved June 11, 2015, from Departement Leefmilieu, Natuur & Energie: http://www.lne.be/campagnes/help-ze-niet-naar-de-tuut/help-ze-niet-naar-de-tuut/over

Edejer, T. T., Baltussen, R., Adam, T., Hutubessy, R., Acharya, A., Evans, D. B., & Murray, C. J. (2012). *Making choices in health: WHO guide to cost-effectiveness analysis.* Geneva: World Health Organization.

Fligor, B. (n.d.). *Your Guide to Prevention of Hearing Loss From Noise.* Retrieved Februari 24, 2015, from Better Hearing Institute: http://www.betterhearing.org/hearingpedia/hearing-loss-prevention/noise-induced-hearing-loss

Gilles, A., & van der Heyning, P. (2014). Effectiveness of a preventive campaign for noise-induced hearing damage in adolescents. *International Journal of Pediatric Otorhinolaryngology, 78*(4), 604-609. doi:10.1016/j.ijporl.2014.01.009

Gregory, S. (1998). Deaf young people: aspects of family and social life. In M. Marschark, & M. D. Clark, *Psychological Perspectives on Deafness* (pp. 159-170). Mahwah: Lawrence Erlbaum Associates.

Hakkaart- van Roijen, L., Tan, S. S., & Bouwmans, C. A. (2010). *Handleiding voor kostenonderzoek: Methoden en standaard kostprijzen voor economische evaluaties in de gezondheidszorg.* Erasmus Universiteit Rotterdam, Instituut voor Medical Technology Assessment. Diemen: College voor zorgverzekeringen.
Hallberg, L. R. (1996). Occupational hearing loss: coping and family life. *Scandinavian Audiology, 43*, 25-33.
Hasson, D., Theorell, T., Westerlund, H., & Canlon, B. (2010). Prevalence and characteristics of hearing problems in a working and non-working Swedisch population. *The Journal of Epidemiology and Community Health, 64*(5), 453-460. doi:10.1136/jech.2009.095430
Healthy People 2020. (2010). *Health-Related Quality of Life and Well-Being.* Healthy People 2020.
Helvik, A., Krokstad, S., & Tambs, K. (2009). Socioeconomic Inequalities in Hearing Loss: The HUNT study. *American Journal of Public Health*, 1376-1378.
HOorzaken.nl. (n.d.). *Het oor*. Retrieved March 26, 2015, from Hoorzaken: http://www.hoorzaken.nl/het-oor/geluid/
Hutubessy, R., Chisholm, D., & Edejer, T. T. (2003). Generalized cost-effectiveness analysis for national-level priority-setting in the health sector. *Cost Effectiveness and Resource Allocation, 1*(1), 8. doi:10.1186/1478-7547-1-8
in 't Veld, R., Korving, W., Hamdan, Y., & van der Steen, M. (2006). *Eindrapport: Kosten en Baten van Voortijdig Schoolverlaten.* Rotterdam: Rebel Group.
Jellema, I. J. (2014). *Preventie van gehoorschade op de werkvloer.* Nationale Hoorstichting.
Kahari, K., Åslund, T., & Olsson, J. (2011). Preferred sound levels of portable music players and listening habits among adults: A field study. *Noise and Health, 13*, 9-15.
Kerr, P., & Cowie, R. (1997). Acquired deafness: a multidimensional experience. *British Journal of Audiology, 31*(3), 177-188. doi:10.3109/03005364000000020
Kramer, S. E. (2008). Hearing impairment, work, and vocational enablement. *International Journal of Audiology, 47*(1), 124-130. doi:10.1080/14992020802310887
Kramer, S. E., & Gussenhoven, A. H. (2013). Vocational Issues for Persons With Hearing Loss. In J. J. Montano, & J. B. Spitzer, *Adult Audiologic Rehabilitation, Second Edition* (pp. 435-451). San Diego: Plural Publishing.
Lajoie, J. (2015). *Understanding the Measurement of Global Burden of Disease.* Winnipeg: National Collaborating Centre for Infectious Diseasea.
Li, C. M., Zhang, X., Hoffman, H. J., Cotch, M. F., Themann, C. L., & Wilson, M. R. (2014). Hearing Impairment Associated With Depression in US Adults, National Health and Nutrition Examination Survey 2005-2010. *JAMA Otolaryngology Head Neck Surgery, 140*(4), 293-302. doi:10.1001/jamaoto.2014.42
Loket Gezond Leven. (n.d.). *Sound Effects*. Retrieved June 11, 2015, from Loket Gezond Leven: http://toolkits.loketgezondleven.nl/toolkits/?page_id=1798
Lokkerbol, J., Adema, D., Cuijpers, P., Reynolds, C. F., Schulz, R., Weehuizen, R., & Smit, F. (2014). Improving the Cost-Effectiveness of a Healthcare System for Depressive Disorders by Implementing Telemedicine: A Health Economic Modeling Study. *American Association for Geriatric Psychiatry, 22*(3), 253-262. doi:10.1016/j.jagp.2013.01.058

Longhurst, R. (2010). Semi-structured interviews and focus groups. In N. Clifford, S. French, & G. Valentine, *Key Methods in Geography* (pp. 103-113). London: SAGE Publications Ltd.
Martin, W. H., Sobel, J., Griest, S. E., Howarth, L., & Yongbing, S. (2006). Noise Induced Hearing Loss in Children: Preventing the Silent Epidemic. *Journal of Otology, 1*(1), 11-21.
Mathers, C., Smith, A., & Concha, M. (2003). *Global burden of hearing loss in the year 2000.* Geneva: World Health Organization.
Mcewen, B. S. (2004). Protection and Damage from Acute and Chronic Stress: Allostasis and Allostatic Overload and Relevance to the Pathophysiology of Psychiatric Disorders. *Annals of the New York Academy of Sciences, 1032*, 1-7. doi:10.1196/annals.1314.001
Meinke, D. K., Martin, W. H., Griest, S. E., Howarth, L., Sobel, J. L., & Scarlotta, T. (2008). Dangerous Decibels® I: Noise induced hearing loss and tinnitus prevention in children. Noise exposures, epidemiology, detection, interventions and resources. *Hearing loss: 9th International Congress on Noise as a Public Health Problem.* Foxwoods, Connecticut: ICBEN.
Miles, J., & Gilbert, P. (2005). *A Handbook of Research Methods for Clinical and Health Psychology.* New York: Oxford University Press Inc.
Ministerie van Volksgezondheid, Welzijn en Sport. (2014). *Convenant preventie gehoorschade muzieksector.* Ministerie van Binnenlandse Zaken.
Murray, C. J., & Evans, D. B. (2003). *Health Systems Performance Assessment: Debates, Methods and Empiricism.* Geneva: World Health Organization.
Nachtegaal, J., Kuik, D. J., Anema, J. R., Goverts, S. T., Festen, J. M., & Kramer, S. E. (2009). Hearing status, need for recovery after work, and psychosocial work characteristics: Results from an internet-based national survey on hearing. *International Journal of Audiology, 48*(10), 684-691.
Nationale Hoorstichting. (n.d.). Retrieved June 6, 2015, from Oorcheck.nl: http://www.oorcheck.nl
Nationale Hoorstichting. (2012). *Gehoorschade als gevolg van harde muziek: risicogedrag en misconcepties onder uitgaanspubliek.* Leiden: Nationale Hoorstichting.
Nationale Hoorstichting. (2015). *Visie & missie.* Retrieved March 26, 2015, from Nationale Hoorstichting: http://www.hoorstichting.nl/over-ons/visie---missie
Nederlands Centrum voor Beroepsziekten. (2014). *Beroepsziekten in Cijfers 2014.* Amsterdam: Nederlands Centrum voor Beroepsziekten.
Nederlandse Zorgautoriteit. (2014). *Bijlage bij TB/CU-7089-01 Tarievenlijst huisartsenzorg en multidisciplinaire zorg.* Utrecht: NZa.
Nederlandse Zorgautoriteit. (n.d.). *Open data van de Nederlandse Zorgautoriteit*. Retrieved June 15, 2015, from Open DIS data: http://www.opendisdata.nl
O'Sullivan, D. (2015). Prevention of NIHL and Tinnitus is Possible: Dangerous Decibels® Update. *Canadian Audiologist, 2*(3).
Parving, A., & Christensen, B. (1993). Training and employment in hearing-impaired subjects at 20-35 years of age. *Scandinavian audiology, 22*(2), 133-139.
Passchier-Vermeer, W. (1989). *Het gehoor van jongeren en blootstelling aan geluid.* Nederlands lnstituut voor Praeventieve Gezondheidszorg. Leiden: TNO.

Passchier-Vermeer, W., & Passchier, W. F. (2000). Noise Exposure and Public Health. *Environmental Health Perspectives, 108*, 123-131.

Passchier-Vermeer, W., Steenbekker, J. H., & Vos, H. (1998). *Popmuziek via hoofdtelefoons en gehoorverlies bij jongeren.* Leiden: TNO Preventie en Gezondheid.

Perenboom, R., Blankespoor, M., Kateman, H., & Quak, A. (2003). *Slechthorendheid door lawaai: stand van zaken.* Nationale Hoorstichting. Leiden: TNO.

Pomp, M., Schoemaker, C. G., & Polder, J. J. (2014). *Op weg naar maatschappelijke kosten-batenanalyses voor preventie en zorg.* Bilthoven: RIVM.

Rijksinstituut voor Volksgezondheid en Milieu (RIVM). (2013). *Gehoorschade en geluidsblootstelling in Nederland – inventarisatie van cijfers.* Rijksinstituut voor Volksgezondheid en Milieu (RIVM).

Rijksinstituut voor Volksgezondheid en Milieu (RIVM). (2014). *Gehoorstoornissen samengevat.* Bilthoven: Rijksinstituut voor Volksgezondheid en Milieu (RIVM).

Rijksoverheid. (n.d.). *Decentralisatie van overheidstaken naar gemeenten*. Retrieved March 16, 2015, from Rijksoverheid: http://www.rijksoverheid.nl/onderwerpen/gemeenten/decentralisatie-van-overheidstaken-naar-gemeenten

RIVM. (2012, March 28). *Zoeken in I-database*, 2.30. Retrieved June 10, 2015, from Loketgezondleven.nl: http://www.loketgezondleven.nl/interventies/i-database/zoeken-in-i-database/zoeken/default.aspx?zoekterm=gehoorschade&option=literal&sort=0&&searched=true&javascriptEnabled=1

Salomon, J. A., Vos, T., Hogan, D. R., Naghavi, M., Mokdad, A., Begum, N., . . . Díaz-Torné, C. (2012). Common values in assessing health outcomes from disease and injury: disability weights measurement study for the Global Burden of Disease Study 2010. *Lancet, 380*(9859), 2129-2143. doi:10.1016/S0140-6736(12)61680-8

Sataloff, R., & Sataloff, J. (2006). *Occupational Hearing Loss.* Boca Raton, Florida: Taylor & Francis Group.

Schmidhauser, S., Wieser, S., Kauer, L., & Brügger, U. (2009). *Returns on Investment in Prevention and Health Promotion Measures in Switzerland: Review of methodological literature on economic evaluation of health promotion and prevention with focus on cost-benefit analysis.* Winterthur: Federal Office of Public Health.

Schmidhauser, S., Wieser, S., Kauer, L., & Brügger, U. Framework of cost-benefit analysis. *Returns on Investment in Prevention and Health Promotion Measures in Switzerland.* Federal Office of Public Health, Winterthur.

Shargorodsky, J., Curhan, S. G., Curhan, G. C., & Eavey, R. (2010). Change in Prevalence of Hearing Loss in US adolescents. *The Journal of the American Medical Association, 304*(7), 772-778. doi:10.1001/jama.2010.1124

Sheeran, P. (2002). Intention—Behavior Relations: A Conceptual and Empirical Review. *European Review of Social Psychology, 12*(1), 1-36. doi:10.1080/14792772143000003

Sheikh Rashid, M., Leensen, M. C., & Dreschler, W. A. (2015). *Report online hearing tests 2010-2014: Five years of Oorcheck & Hoorscan.* Nationale Hoorstichting.

Smit, F., Lokkerbol, J., Riper, H., Majo, M. C., Boon, B., & Blankers, M. (2011). Modeling the Cost-Effectiveness of Health Care Systems for Alcohol Use Disorders: How

Implementation of eHealth Interventions Improves Cost-Effectiveness. *Journal of Medical Internet Research, 13*(3), 1-14. doi:10.2196/jmir.1694
Smit, F., van Laar, M., Croes, E., & Busschbach, J. (2008). *Ziektelastgewichten voor misbruik, schadelijke gebruik en afhankelijkheid van alcohol en drugs.* Utrecht: Trimbos-Instituut.
Stæhr, K. (2006). *Risk and uncertainty in cost benefit analysis.* Copenhagen: Environmental Assessment Institute.
Stam, M., Kostense, P. J., Festen, J. M., & Kramer, S. E. (2012). The relationship between hearing status and work. *A Journal of Prevention, Assessment and Rehabilitation, 46*(2), 207-219. doi:10.3233/WOR-131747
Stein, A. J. (2006). *Micronutrient Malnutrition and the Impact of Modern Plant Breeding on Public Health in India: How cost-effective is biofortification?* Göttingen, Germany: Cullivier Verlag.
Stichting TestJeLeefstijl. (2013, September 2). *Gehoor & Muziek onderdeel van Testjeleefstijl*. Retrieved from Testjeleefstijl: http://www.testjeleefstijl.nl/nieuws/gehoor-muziek-onderdeel-van-testjeleefstijl
Stouthard, M. E., Essink-Bot, M. L., Bonsel, G. L., Barendregt, J. J., Kramers, P. G., van de Water, H. P., . . . van der Maas, P. J. (1997). *Disability weights for diseases in the Netherlands.* Rotterdam: Department of Public Health, Erasmus University.
Taneja, M. (2014). Noise-induced hearing loss. *Indian Journal of Otology, 20*(4), 151-154. doi:10.4103/0971-7749.146928
Testjeleefstijl.nu. (n.d.). Retrieved June 6, 2015, from Platform Bewegen en Sport: http://www.platformbewegenensport.nl/Theme/5/Testjeleefstijl-nu
Thomas, A., & Herbst, K. G. (1980). Social and psychological implications of acquired. *British Journal of Audiology, 14*(3), 76-85.
Thurston, F. (2013). The worker's ear: a history of noise-induced hearing loss. *American Journal of Industrial Medicine, 56*(3), 367-377. doi:10.1002/ajim.22095
Trade, foreign policy, diplomacy and health. (n.d.). Retrieved March 12, 2015, from World Health Organization: http://www.who.int/trade/glossary/story049/en/
University of Northern Colorado. (2008). Dangerous Decibels® I: Noise induced hearing loss and tinnitus prevention in children. Noise exposures, epidemiology, detection, interventions and resources. *Hearing loss: 9th International Congress on Noise as a Public Health Problem.* Foxwoods, Connecticut: ICBEN. Retrieved June 11, 2015, from Dangerous Decibels: http://www.dangerousdecibels.org/
van Deelen, L. D. (2014, November). De preventie van gehoorschade en de online 'Oorcheck'. *De preventie van gehoorschade en de online 'Oorcheck', 46*(5/6), p. 120. doi:10.1007/s12452-014-0038-7
van den Berg, M. (2008, December 12). *Preventie in het basispakket.* Retrieved from Nationaal Kompas Volksgezondheid: http://www.nationaalkompas.nl/preventie/thema-s/zorgverzekeraars/preventie-in-het-basispakket/
van Eldik, T. (2005). Mental Health Problems of Dutch Youth With Hearing Loss as Shown on the Youth Self Report. *American Annals of the Deaf, 150*(1), 11-16. doi:10.1353/aad.2005.0024
van Empelen, P. (2009). *Deelrapport 7: Evaluatie van de pilotcampagne Sound Effects ter preventie van gehoorschade onder uitgaande jongeren.* Rotterdam: Erasmus MC.

van Klaveren, S. M., Poortvliet, E. P., & van Free, F. M. (2011). *Samenwerking gemeenten en zorgverzekeraars rond preventie: Motievenmatrix.* Panteia. Zoetermeer: Research voor Beleid.

van Son, N. (2012). *101 vragen over horen.* Utrecht/Antwerpen: Kosmo Uitgevers.

Var. (2012). *CIM Radio 2012W3.* Sint-Stevens-Waluwe: Var.

Veldnorm Hoortoestelverstrekking. (2013). *Voorwaarden voor kwaliteit*. Utrecht.

Vlaams Agentschap Zorg en Gezondheid. (2011). *Jongerenbewustmakingscampagne Iets minder is de max.* Retrieved April 10, 2015, from Communicatiejaarverslag 2011 Vlaamse Regering: http://communicatiejaarverslag-2011.vlaanderen.be/jaarverslag/vlaams-agentschap-zorg-en-gezondheid-z-en-g/jongerenbewustmakingscampagne-iets-minder-de

Vlaamse overheid. (2012, April 9). *Help ze niet naar de tuut.* Retrieved from Geluidnieuws: http://www.geluidnieuws.nl/2012/mei2012/tuut.html

Vogel, I., Brug, J., van der Ploeg, C. P., & Raat, H. (2011). Adolescents risky MP3-player listening and its psychosocial correlates. *Health Education Research, 26*(2), 254-264. doi:10.1093/her/cyq091

Vogel, I., van de Looij-Jansen, P. M., Mieloo, C. L., Burdorf, A., & de Waart, F. (2014). Risky Music Listening, Permanent Tinnitus and Depression, Anxiety, Thoughts about Suicide and Adverse General Health. *PLoS ONE, 9*(6). doi:10.1371/journal.pone.0098912

Vos, T., Carter, R., Barendregt, J., Mihalopoulos, C., Veerman, J. L., Magnus, A., . . . Wallace, A. L. (2010). *Assessing Cost-Effectiveness in Prevention (ACE–Prevention): Final Report.* ACE–Prevention Team. Melbourne: University of Queensland, Brisbane and Deakin University.

Werkgroep geluid, vakgroep Milieu en Gezondheid. (2013). *Handreiking gehoorschade jongeren bij festival- en uitgaansbezoek.*

Winkleby, M. A., Jatulis, D. E., Frank, E., & Fortmann, S. P. (1992). Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health, 82*(6), 816-820. doi:10.2105/AJPH.82.6.816

Wittchen, H. U., Jacobi, F., Rehm, J., Gustavsson, A., Svensson, M., Jönsson, B., . . . Steinhausen, H. c. (2011). The size and burden of mental disorders and other disorders of the brain in Europe 2010. *European Neuropsychopharmacology, 21*(9), 655-679. doi:10.1016/j.euroneuro.2011.07.018

World Health Organization. (2015, February 27). 1.1 billion people at risk of hearing loss. Geneva, Switzerland.