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Societal costs of severe-to-profound hearing loss among adults without cochlear implants

– A health economic evaluation using a Markov model

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– A health economic evaluation using a Markov model

Summary

Severe-to-profound hearing loss (STPHL) forms a large burden of disease and is among others in Sweden a growing public health concern due to an aging society. Cochlear implants (CI) form a safe and useful treatment for STPHL, but despite its benefits, only 13 percent of the adults with STPHL that are eligible for CI receive this treatment. To underpin the need for better treatment, a health economic evaluation has been conducted on the societal costs of STPHL among Swedish adults when not treated with CI. A better understanding of these costs might give a better insight into the need for improved treatment and can be used for discussions regarding policymaking for the treatment of STPHL.

In this project, a Markov model has been created that enables the calculation of the societal costs of STPHL among adults who might be eligible for CI who do not receive this treatment. These costs are being compared to the costs of a similar group of adults without hearing loss. Next to a calculation of the costs for the Swedish society, the model can even be used for similar calculations in other Nordic countries. This report describes how the Markov model has been created, how the calculations have been conducted, and how the model can be used.

As the model forms a simplified simulation of reality, several aspects of STPHL that appear in real life are missed. For the most part, this leads to an underestimation of the societal costs of STPHL when not treated with CI, which makes this model conservative. A shortage of studies regarding some of the parameters of the model leads to uncertainty in the values of these parameters and thus the calculations. More research on the topic is needed to be able to make more secure calculations.

Over a period of 23 years, the additional costs of STPHL for the simulated cohort are expected to be 23,9 billion SEK, which equals approximately 1,2 million SEK per person. However, due to the uncertainties in the model one should be careful with the usage of a single number. Instead, it is highly recommended to look at how the results may change based on changing values of parameters which is possible by use of a sensitivity analysis. Most of the costs are caused by fall accidents and paid by municipalities, due to the costs for home care after fall accidents.

Next to the calculations presented in this report, it would be valuable to know how high the calculated societal costs are compared to the costs of a similar cohort that does receive CI treatment. Despite that this comparison is not possible to make today due to a lack of research, it is possible to describe how the current model can be used to make the comparison between receivers and non-receivers of CI, in case the needed studies are available in the future.

One of the aims of the project was to enable a similar analysis within the other Nordic countries. For this, a description of such usage has been provided at the end of this report. As the calculations only apply to the Swedish society and are based on the Swedish population, usage of the model in other Nordic countries requires changes in the values of some of the parameters in the model. Usage of the model in other countries requires more, major changes as these have different systems for health governance and funding of health care.

Background

Severe-to-profound hearing loss

In Sweden, the prevalence of adults with severe-to-profound hearing loss (STPHL) is estimated to be 0,28 percent, which corresponds to 22,298 persons (Löfvenberg et al., 2022) and is expected to increase in the upcoming years due to an aging population. Hearing loss can, especially in a severe condition, have a negative effect on people's social, emotional, physical, and cognitive wellbeing. Next to this, it can lead to difficulties to understand speech in noisy environments which in its turn can lead to more social isolation and loneliness, and reduced quality of life (Lin et al., 2013; Wick et al., 2020). There is evidence for associations between hearing loss and healthy hearing and healthy aging (Salomon et al., 2015). Several studies indicate an increased risk of developing moderate to severe depression, accelerated cognitive decline, or dementia in older adults, as well as for fall accidents compared to people with no hearing impairment (Livingston et al., 2020). STPHL is associated with high-ranking scores in the burden of disease disability weights. According to the World Health Organization (WHO) (Institute for Health Metrics and Evaluation, 2017) hearing impairment is globally the fourth most common cause of disability in all ages and the leading cause of disability among people above 70 years of age. For the Swedish population hearing impairment is the ninth most likely cause of more years lived with disability in all ages and for people above 70, hearing impairment is the third most likely cause of developing a disability. Furthermore, studies (e.g. Salomon et al., 2015) show that for the relatively few people with STPHL their disability is extreme. A visualization of the most common potential adverse health consequences of hearing loss is presented in Figure 1.

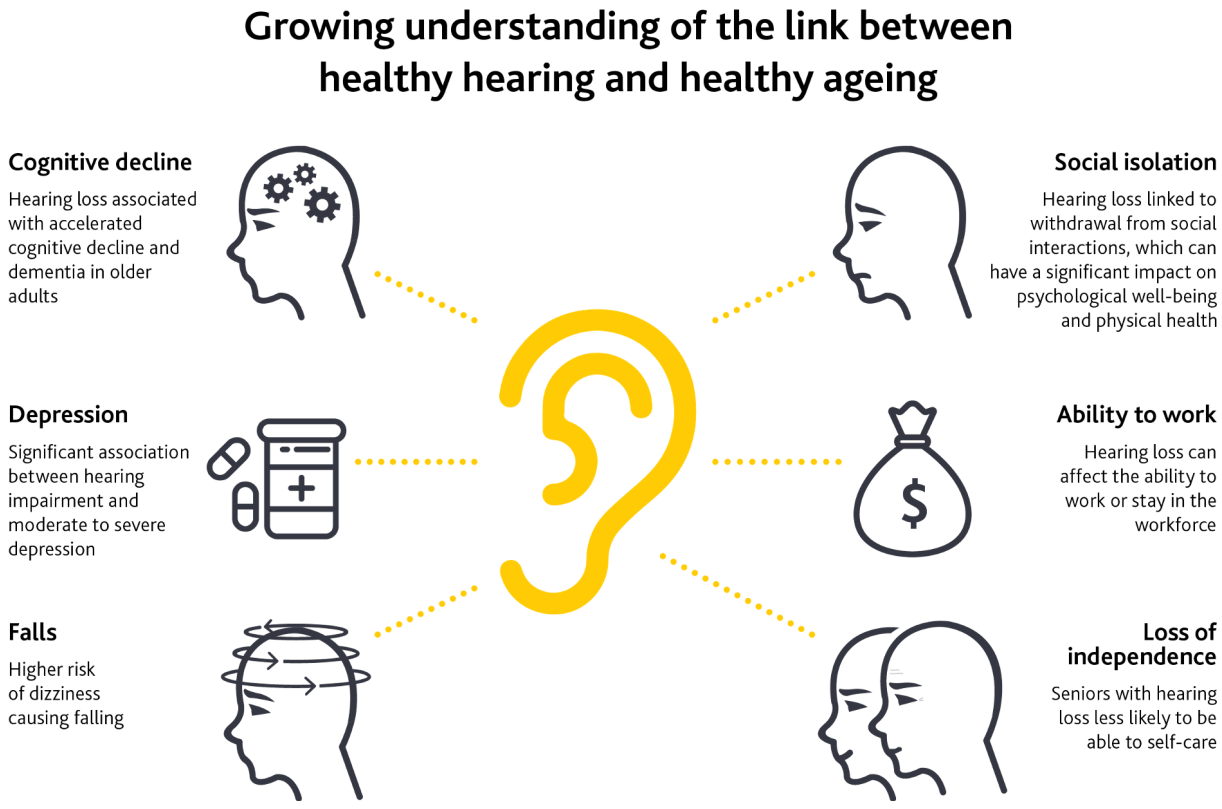


Figure 1. potential adverse health consequences of hearing loss (Cochlear, 2022)

Cochlear implants

High and increasing prevalence of hearing loss and its impact on people's health and wellbeing highlights the need for appropriate hearing rehabilitation.

Cochlear implants (CI) are developed to mimic the function of a healthy inner ear. The implants replace the function of damaged sensory hair cells inside the inner ear to help provide clearer sound than what hearing aids can provide (Cochlear, 2022) .CI implantation is both safe and useful for older people and age does not influence CI outcomes (Turunen-Taheri et al., 2019). Studies show that persons with STPHL who have a CI report among others better quality of life and have better results on speech recognition tests (Crawford & Henry, 2003, 2003; Lin et al., 2012; McRackan et al., 2018; Olze et al., 2011). CI users have also been found to get more independent and improve their social life more than patients with no CI (Mäki-Torkko et al., 2015) as well as having better cognitive functioning (Mosnier et al., 2018). Despite the lack of studies on the causality between the usage of CI and the prevention of adverse health consequences such as dementia, depression, and fall accidents, the available findings show promising outcomes for further usage of CI.

To be eligible for a CI in Sweden, a patient must have STPHL (Pure Tone Average cut-off threshold of 0.5, 1, 2 and 4 kHz ≥70 dB HL or a score of 50 percent or less on monosyllabic-words test on the better hearing ear) and not receive adequate benefit from using optimal fitted hearing aids (aided threshold with pure tone audiometry of 50 dB HL or less at 4 kHz, or a score of 50 percent or less on monosyllabic-words test in sound field) and not have any comorbidities that may affect the intervention (Mäki-Torkko et al., 2011).

Despite its reported clinical benefits (Turunen-Taheri et al., 2019) only 13 percent (2 624 adults) of the estimated eligible Swedish adults use a unilateral CI (Nationellt kvalitetsregister för öron-, näs- och halssjukvård, 2017). This low utilization of CIs is also seen in other developed countries and has been attributed to several factors including a lack of screening for hearing loss in adults as well as a lack of awareness of CI candidacy criteria and outcomes among physicians and audiologists (Sorkin & Buchman, 2016). Due to this, adults with STPHL may miss out on potential benefits from CIs and thus better health and wellbeing. To create a better understanding of the need for investment in more appropriate hearing rehabilitation, more knowledge is needed on the adverse effects of not providing a better treatment.

Societal costs and future potential

As hearing loss is associated with several adverse health consequences such as accelerated cognitive decline and a higher risk of fall accidents or depression, it also comes with additional costs (Estimating the Cost of Untreated Hearing Loss, 2019). Given the economic implications of untreated hearing loss, there is a strong argument for making this impairment a more prioritized public health concern. Not adequately addressing hearing loss can lead to negative consequences for the individual as well as significant economic and social consequences.

Objective

The primary aim of this project is to develop a health economic model that enables an assessment and estimation of the societal costs of STPHL among adults in Sweden when not treated with CI. The secondary aim of the project is to enable an analysis of the societal costs of STPHL among adults without CI, within the Nordic countries. The aims are met by developing a health economic model that is applicable in health systems where the Beveridge model (Lameire et al., 1999) for healthcare is used, as well as using the model with Swedish data and relevant estimates.

Method

Markov model

Due to the chronic nature of STPHL and potential complications, a Markov cohort model with corresponding health states was chosen to simulate how a cohort of adults with STPHL could transition between different health states over time. The Markov model is a statistical and mathematical model that represents a system, in this case, the health state of adults with STPHL and without CI. The model forms an abstract representation of reality and consists of a structure that defines dependencies among the various health states and parameters related to STPHL.

In this case, the parameters applied to the model are represented by so-called transition probabilities, which are the risks of individuals moving from one health state to the other, before simulations end when the entire cohort has died. The Markov chain is further described by a transition matrix (see *Appendices* and the section *Model specification* for instructions). Each cycle in the model is equivalent to one year. The health states in the model are mutually exclusive, which means that it is not possible for an individual to be in more than one health state during a cycle.

By running the model over a series of discrete-time periods (cycles), aspects of time are incorporated into the model. The time horizon has been set for a lifetime perspective, which is 23 years given the average age when adults in Sweden receive CI (61 years) (Gumbie et al., 2021) and the average life expectancy in Sweden (82,4 years) (Folkhälsomyndigheten, 2022). In this model, all participants were considered dead after 23 years of simulation. Next to this, health states presented in the model are collectively exhaustive, which means that probabilities calculated for every cycle always add up to 100 percent of the cohort.

In the sections below the Markov model and the different parts that constitute the model will be presented. The pathway in the model was developed through consultation with Cochlear experts and risk numbers and unit costs were derived from different Swedish registries and authorities as well as scientific papers. The data and the sources that we use in the study are presented in section Data and in the Appendices.

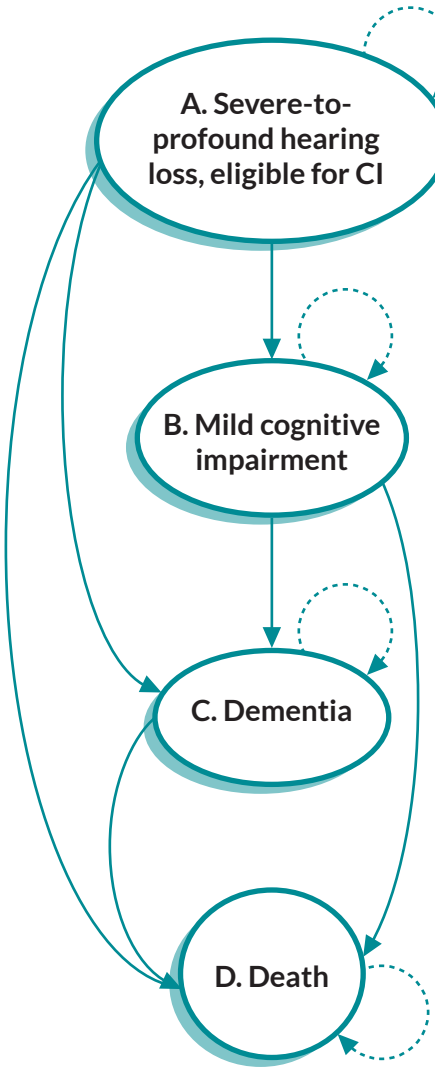


Figure 2. Markov Model

Model specification

In this section, we present the Markov model, assumptions underpinning the study, and an explanation of how the model works. The model is illustrated in Figure 2, where the arrows indicate the possibility of transitioning from one state to the other. The circles above the health states illustrate the possibility to remain in the current state.

Health states

STPHL may be associated with several health consequences, which are illustrated in Figure 1 and depicted as health states in Figure 2. The health states that are included in the Markov model are the following:

Severe to profound hearing loss, eligible for a CI (state A): The initial health state in the system is STPHL without cognitive decline and where the person might be eligible for CI, according to the Swedish criteria (Mäki-Torkko et al., 2011). From state A, patients can either remain here, transfer to state B (mild cognitive impairment), state C (dementia), or state D (death).

Mild cognitive impairment (MCI) (state B): From state B the patient can remain, develop dementia, or die.

Dementia (state C): If the patient has developed dementia and is currently in state C, the patient can remain, or die.

Death (state D): The death state (D) is absorbing, indicating that all patients will end up here during a lifetime.

In the model, the health states are mutually exclusive. That means it is not possible for a patient to reside in more than one state during one cycle. Moreover, as explained above, probabilities always sum up to one. Accordingly, the probabilities of the transition states in every cycle also add up to 100 percent of the cohort and are thus collectively exhaustive.

Another property of the Markov model is that the states in the Markov model are classified as either recurrent or transient. A state is recurrent if you start from state i and from wherever you can go there is a way of returning to state i. If not recurrent the state is transient, namely starting from i, there is a way you can go which you cannot return to i from. In the presented model all health states are transient, due to the lack of research on the effect of recurrence on different risks.

From the mutually exclusive states A, B and C people can develop two additional health states that can be influenced by hearing loss. These states, fall accidents and depression, lead to additional costs that occur for one year. The connections between A, B, C and fall accidents and depression are illustrated in figure 3.

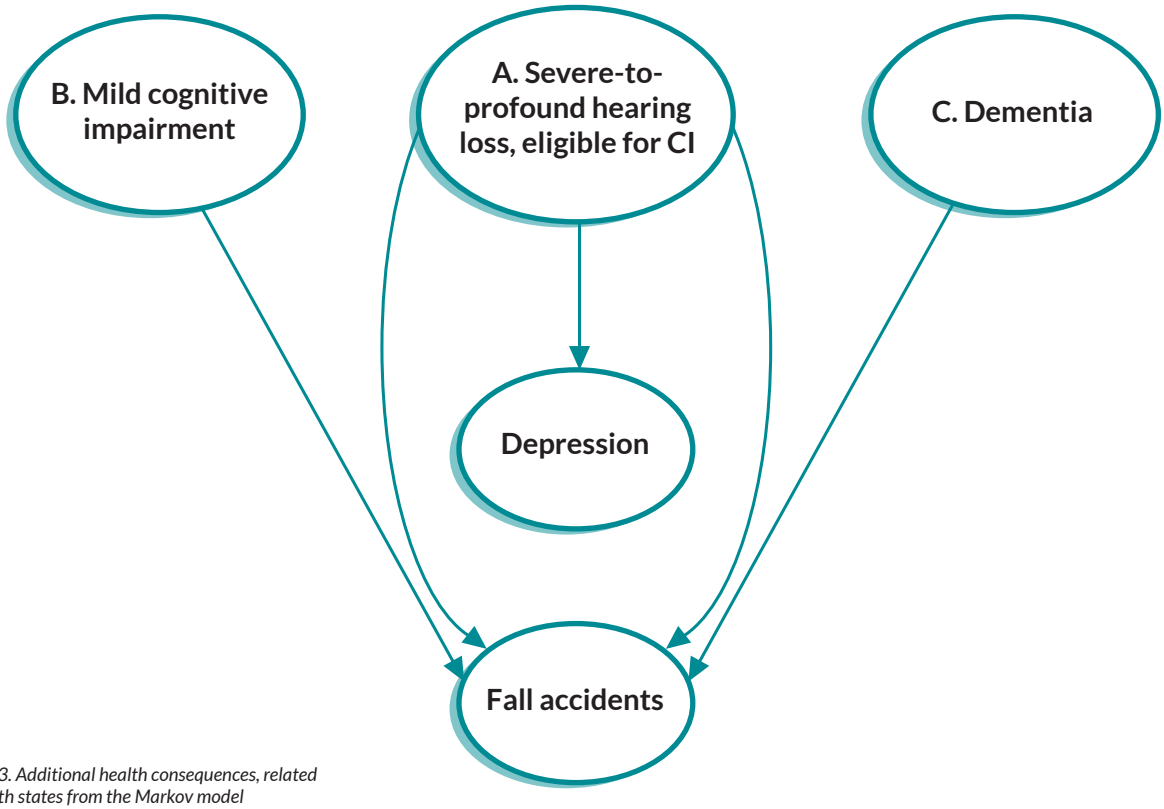


Figure 3. Additional health consequences, related to health states from the Markov model

Despite the possibility to develop depression when having MCI or dementia we do not include these additional cases in the calculation due to multiple uncertainties regarding the risks of these transitions.

Transition probabilities

As described above the transition probabilities refer to the probability of a patient moving from one health state to another. As mentioned, according to research there exist an increased risk for adverse health consequences given STPHL. Although more research is needed to determine a potential causal relationship, we can use data on associations when we calculate the transition probabilities. The model is, however, developed in a way that when new research is available the old data can be substituted for the new research. It is important to be aware of the implications of using associations rather than a causal relationship in the model and thus to be careful with the interpretation and hence the generalization of the result. Furthermore, as discussed in section Data, more research is also needed to identify potential associations or correlations between the different consequences. For some of the transition probabilities, data needed regarding the specific transitions was not available at the time of the project. For these transitions, values were calculated based on the outcomes of other studies, which leads to uncertainties in the outcomes.

Since risks for adverse health outcomes might vary between different sexes, the model considers whether the person with hearing impairment is female or male, which is done by presenting two separate calculations. The corresponding transition probabilities are presented in the Appendices.

Assumptions

When using a Markov model, several assumptions are made regarding how the model relates to reality. This influences the outcome of the calculations and has, therefore, to be considered when interpreting the results Within this project we make the following assumptions when making the calculations:

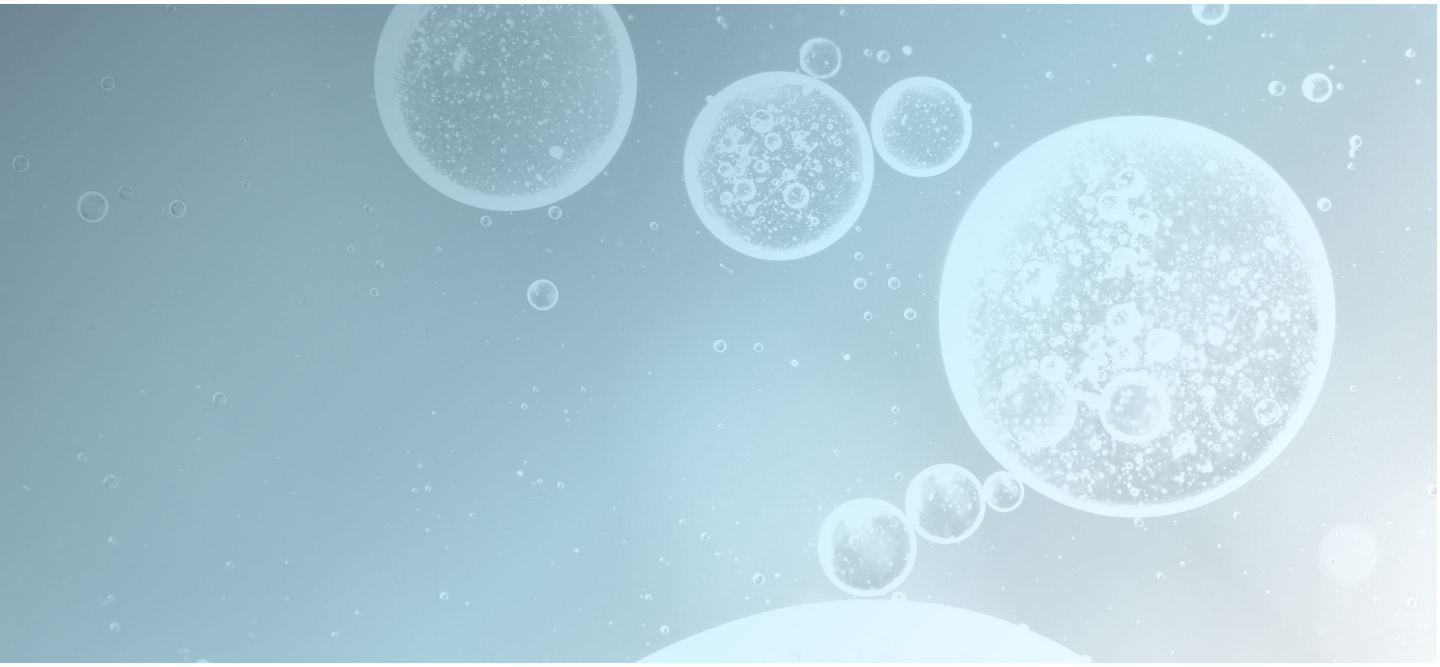
1. At the start of the simulations, all patients that are eligible for CI are 61 years, which is based on the average age when adults receive a CI (based on data from Gumbie et al, 2021. This means that the model does not consider all CI-eligible adults that are younger, and that some of the actual costs could be missed.)
2. Before age 61 we assume all other variables are equal (e.g. education and demographics). In reality, such variables can have an influence on the risk of developing certain health states, but in this case, we only account for the differences between men and women. Other factors do not affect the transition probabilities in the model.
3. The retirement age is 65, which means that we do not calculate productivity loss after this age.
4. The average life expectancy is approximately 83 years, even though people might live longer in reality. This means that costs for those who in reality would live longer than 83 years are missed in the model.
5. We assume that all patients starting at stage A do not have any other health issues besides STPHL that might influence the risk of transitioning to any of the other health states.
6. In Sweden 7902 women and 9658 men are eligible for a CI, without receiving this treatment (Nationellt kvalitetsregister för öron-, näs- och halssjukvård, 2017). We use these numbers for the cohort of the Markov model, even though some of the actual people in this group might be younger than 61 or older than 83 years. Since the actual prevalence is higher than registries account for, due to undiagnosed cases, we use the total numbers of registered, for CI-eligible adults.

Furthermore, regarding the transition probabilities in the model, we make the following assumptions:

1. In the simulations we assume that patients receive treatment as usual, which means that no treatment with CI is provided. However, there still might be a difference between what other treatment patients might receive. In case people are using another type of hearing aid, this could have an influence on the transition probabilities. However, it is hard to say how many people have hearing aids and how many are using them. Due to this, the transition probabilities are assumed to be the same, irrespective of hearing aid use or not.
2. When it comes to additional productivity loss, we only calculate those additional costs that occur from people with STPHL and MCI having a fall injury, as depression and dementia already lead to productivity loss and we don't have information on how the severity of productivity loss would change in case multiple adverse health events occur at the same time. By doing so, these conservative adjustments give a better insight in the costs that would occur in reality, even though they are most likely higher in real life.

Other aspects that might influence the calculations and outcome

- Some data are based on subjective self-perceived hearing handicap, instead of objectively measured hearing impairment.
- Some data is based on patients with hearing impairment, but not necessarily patients with STPHL.
- As the model creates a simplified simulation of reality, not all aspects regarding STPHL can be included. For this reason, other factors, such as social isolation and loss of independence, are exogeneous in the model and therefore not included. There might also exist a correlation between social isolation and loss of independence, but above all these factors there might be a risk of developing dementia, depression, and fall accidents. Reverse causation is hence possible but, in the model, we treat that possibility as exogeneous.
- The relationship and thus the identified probabilities between hearing impairment and the health consequences are based on associations mostly. More research is needed to determine a potential causal relationship.



Data

Cost health outcomes

Costs regarding the health states in the model have been derived from different Swedish sources. In some cases, these costs were applicable to previous years. To adjust for the differences in price levels, all costs have been calculated as if they were at the price levels of December 2022 (SCB, 2022b). To give a better insight in where the different costs come from, these are split up into the following categories:

- Regional costs of medical treatment, these are the costs associated with medical treatment by regional health care providers.
- Other care costs, exist mainly of costs associated with care provided by municipalities, but also care provided by relatives of the patient.
- Productivity loss (absence from work), are the costs of the loss of labor due to illness.
- Other costs, are in this model associated with fall accidents and exist of costs for social security and insurance.
- Discounting, as people tend to value things more if they occur in the present than when they occur in the future, future events lose some of their value. In health economic evaluations it is common to adjust the outcomes by use of so-called discounting (Smith & Gravelle, 2001). In this model, a discount rate of 3% per (future) year is used.

Cost general productivity loss

Next to the productivity loss due to adverse health states related to STPHL, hearing loss itself is associated with productivity loss as well. Patients with hearing loss have been found to be more likely to be unemployed, as well as to be on sick leave compared to people without hearing loss (Jung & Bhattacharyya, 2012; Kramer et al., 2006). The following steps are included in the model to enable the calculation of the costs of these types of productivity loss:

- Calculation of the numbers of patients who are unemployed or on sick leave within the cohort during years 1 to 5 (61 to 65 years of age). This is done by multiplying the number of patients alive in the cohort with the risk of being unemployed or on sick leave in Sweden (*Arbetslöshet - internationellt*, n.d.) as well as adjusting these numbers by the added risk for these outcomes due to hearing loss (Jung & Bhattacharyya, 2012; Kramer et al., 2006).
- Calculation of the costs for unemployment or sick leave among the abovementioned group of patients. This is done by multiplying the number of patients that are on sick leave or unemployed with the costs for these outcomes in Sweden (Försäkringskassan, 2022; Ljunggren, n.d.)

Since there is a difference in the mean income of men and women in Sweden, the costs of unemployment are adjusted for this difference (SCB, 2022a). Next to this, all costs are presented both with and without discounting.

Transition probabilities

The transition probabilities in the model are derived from different studies and combined with Swedish data on the incidence of developing one of the health outcomes in the model and the risk of developing the outcome given STPHL without CI treatment. The numbers are based on the incidence of the health states as well as the increased risk due to (severe-to-profound) hearing loss, since no studies are available on the specific incidence for hearing loss.

Results

The simulations and calculations enabled by the Markov model as well as the available data have resulted in an overview of costs for adults with STPHL who do not receive CI treatment. The costs have been calculated separately for women and men as well as the different types of costs. Next to this, both discounted and undiscounted results are presented. These calculation outcomes are summarized below in tables 1, 1a and 1b.

By separating the different costs, better insight is provided into which part is paying the most for the treatment of consequences of STPHL. One thing that stands out in the results summarized below, is that the largest part of the costs is categorized as "costs others" (municipalities and relatives of patients). When comparing these outcomes to the costs of each of the health states, we can see that it is especially fall accidents that lead to high costs for municipalities, which is due to that this adverse health event leads to a higher need of home care services (in Sweden mainly provided by municipalities). As women have a higher risk of fall accidents than men, their costs for others and total costs are higher than these costs are for men. At the same time, regional health care costs are higher among the male cohort, which can be mainly attributed to the fact that the male cohort is larger.

Data colors:

Table 1. Results treatment as usual, costs in thousand SEK (combined population of 17560 adults)

	Costs per patient discounted	Costs total population discounted
Total costs	3 499	66 790 110
Costs region	241	4 101 945
Care costs others	2 913	50 722 743
Other costs others	0,5	8 827
Productivity loss	13	224 874
Productivity loss general	334	5 865 861

Table 1a (women). Results treatment as usual, costs in thousand SEK (population of 7902 women)

	Costs per patient discounted	Costs total population discounted
Total costs	3 795	32 401 167
Costs region	313	2 474 315
Care costs others	3 160	24 972 342
Other costs others	0,6	4 730
Productivity loss	16	123 210
Productivity loss general	305	2 413 285

Table 1b (men). Results treatment as usual, costs in thousand SEK (population of 9658 men)

	Costs per patient discounted	Costs total population discounted
Total costs	3 203	34 388 943
Costs region	169	1 627 630
Care costs others	2 666	25 750 401
Other costs others	0,4	4 098
Productivity loss	11	101 664
Productivity loss general	357	3 452 575

Comparison to a healthy cohort

As of today, no research is available regarding the effect of CI on the development of the selected health states, which makes it impossible to calculate the differences in costs between the outcomes of treatment with or without CI. If such studies will be available in the future, adjustment this will only require minor changes in the risks documented in the Excel-model.

However, it is possible to calculate the differences in costs between a cohort with and without STPHL This can give an insight into the additional costs of STPHL compared to a healthy state.

The only differences in the simulations among a cohort with and without STPHL are the risks for developing the selected health states and general productivity loss. The adjustment for this difference is made by taking the general risks for the development of these conditions, without the additional risks from STPHL. Comparing these results to those of a cohort with STPHL shows us that STPHL leads to the following additional costs for society.

Table 2. Additional costs of STPHL, costs in thousand SEK (combined population of 17560 adults)

	Costs per patient discounted	Costs total population discounted
Total costs	1 236	23 987 874
Costs region	123	2 046 373
Care costs others	962	16 659 003
Other costs others	0,2	4 276
Productivity loss	6	97 380
Productivity loss general	148	2 590 422

Table 2a (women). Additional costs of STPHL, costs in thousand SEK (population of 7902 women)

	Costs per patient discounted	Costs total population discounted
Total costs	1 413	12 181 544
Costs region	184	1 453 192
Care costs others	1 093	8 640 163
Other costs others	0,3	2 292
Productivity loss	7	52 737
Productivity loss general	129	1 016 580

Table 2b (men). Additional costs of STPHL, costs in thousand SEK (population of 9658 men)

	Costs per patient discounted	Costs total population discounted
Total costs	1 059	11 806 330
Costs region	61	593 181
Care costs others	830	8 018 839
Other costs others	0,2	1 984
Productivity loss	5	44 643
Productivity loss general	163	1 573 842

To create an understanding of how much the different health states cost, an overview of the costs of the three major health states is shown in table 3. We can see that the largest part of the additional costs of STPHL is caused by fall accidents.

Table 3 Additional costs of STPHL per health state, costs in thousand SEK

	Dementia	Depression	Fall accidents
Total population (women)	2 973 631	41 200	6 485 242
Per person (women)	376	5	821
Total population (men)	5 172 983	14 904	7 633 592
Per person (men)	562	2	825
Total population (combined)	8 146 615	56 104	14 118 834
Per person (combined)	469	3	823

Discussion

Assumptions and uncertainties

As the model and the results from its calculations are based on a simplified simulation of reality, we must be aware of the discrepancies between the outcomes of the calculations presented and the costs for adults with STPHL without CI treatment in real life. The main factors that must be taken into consideration when interpreting the results of the calculations are mentioned in previous sections of the report and are summarized below:

-Since the model only represents a limited number of health outcomes that are related to STPHL, and the simulations are run over a limited period of time, certain health outcomes and their costs are missed in the results.

-Since the presented calculations are based on a cohort from 61 to 83 years of age, societal costs for younger or older adults with STPHL and without CI treatment are missed in the results.

-Most studies that are used describe the risks for adverse health outcomes given hearing loss in general, instead of STPHL. Given that STPHL is a more severe state we can assume that the risks are probably higher than calculated in the model.

-The limited number of studies regarding the incidence and increased risks of the included health states given STPHL, leads to insecurity in the calculations. More research is needed to get a better insight into the exact risks of STPHL.

The limited number of health outcomes, time range, and the fact that risks of less severe hearing loss are included lead to an underestimation of the costs. It is most likely that the societal costs of STPHL among adults without CI treatment are higher than accounted for in this calculation, which makes the model conservative.

Uncertainties and sensitivity analysis

To limit the mentioned uncertainties, more research within the area of STPHL is needed. However, it might take several years before this is in place. To deal with uncertainty before new studies are published, an option for a sensitivity analysis (Briggs et al., 2006) has been created in the model. Conduction of a sensitivity analysis is increasingly valued, and the outcome can play an important role in decision-making (Adalsteinsson & Toumi, 2013).

A so called deterministic sensitivity analysis (DSA) shows how the outcome of the analysis will change with a given increase or decrease of one specific parameter (Briggs et al., 2006). A one-way sensitivity analysis can give insight into how a change in certain parameters affect the outcomes of the calculations. To conduct such an analysis, the parameter of choice can be manually changed to obtain alternative results. In the first sheet of the Excel-file values of the parameters “Regional medical treatment fall accidents”, “Other costs fall accidents”, “Risks fall accidents”, “Risks MCI” and “Risks MCI to dementia” can be changed with +/- 20%. This will show how these changes affect the outcomes of the calculations. The parameters for the DSA have been chosen based on the impact of fall accidents on the outcomes of the calculations as well as research that has shown that CI could have a positive impact on the cognitive functions of those with profound hearing loss (Mosnier et al., 2018). An alternative to a DSA is a probabilistic sensitivity analysis (PSA) that is based on computer simulations of random combinations of parameter changes by use of a so-called Monte Carlo simulation. In the current model, no options are included for such an analysis. However, it would be possible to add this to the model in future steps of its development.

Usage in other countries

Next to the development of a health economic model that enables an assessment and estimation of the societal costs of STPHL among adults in Sweden when not treated with CI, the secondary aim of this project was to enable a similar analysis within the other Nordic countries. As the presented calculations only apply to the Swedish society and as they are based on the Swedish population, usage of the model in other Nordic countries requires changes in the values of some of the parameters in the model. An explanation of which parameters must be changed and how this can be done is provided in Appendix 4. The model can only be applied to other Nordic countries, as these have a health care system based on the Beveridge model that is similar to the Swedish system. Usage of the model in other countries would require more, major changes as these have different systems for health governance and funding of health care.

Conclusion and recommendations

This report presents the construction and usage of a Markov model that gives an insight into the societal costs of STPHL among adults who do not receive CI treatment. As the model is based on a simplified simulation of reality, users must be aware of the discrepancies between the outcomes of the calculations presented and the costs for adults with STPHL without CI treatment in real life.

The calculations show us that adults with STPHL who do not receive cochlear implants generate more costs for the society than a similar cohort without this condition. Over a period of 23 years, the additional costs for the simulated cohort with STPHL are expected to be 23,9 billion SEK, which equals approximately 1,2 million SEK per person. However, due to the many uncertainties in the model one should be careful with the usage of a single number. Instead, it is highly recommended to look at how the results may change based on changing values of parameters which is possible with a sensitivity analysis.

A valuable insight that the calculations give us is that the largest part of the additional costs of STPHL is caused by fall accidents and that most of these costs are paid by municipalities, as these are the main providers of care facilities after fall accidents. It is however important to mention that one also must look at the total costs for society instead of only at which part is paying most. Both municipalities and regions have key roles in the delivery of health care in Sweden and are financed through taxes, which indirectly means that costs and benefits of one part directly or indirectly will affect the other. This must be considered when new decisions regarding the treatment of STPHL are being made. If, for example, the risk and medical- and care costs of fall accidents increase by 20%, then this would lead to the additional costs for the simulated cohort with STPHL reaching 29 billion SEK (or 1,5 million SEK per person). A 20% reduction in these parameters would in turn lead to total additional costs of 19,5 billion SEK (or 979 thousand SEK per person). When comparing these costs to those of CI (443 thousand SEK per person (Gumbie et al., 2021), we see that the additional costs of STPHL are much higher.

In this report, calculations have been made for a Swedish cohort, but the model can be used for evaluations in other Nordic countries as well. Further analysis and discussion regarding these outcomes are recommended. An additional value can be created when an analysis can be conducted on the costs among the same cohort given CI treatment. Due to limited research, such a comparison is not possible today. In case this will be available in the future, similar health economic evaluations can improve the understanding of the costs and benefits of CI treatment.

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Appendices

Appendix 1. Input values: disease costs in SEK with corresponding +/- 20 % input variance

Unit	Cost	Variation of values for DSA		Reference
Regional costs medical treatment	Base case	-20%	20%	
MCI	0	0	0	Socialstyrelsen, 2007
Dementia	23 162	18 530	27 795	Socialstyrelsen, 2014
Depression	24 099	19 280	28 919	Ekman et al., 2014
Fall accidents	113 800	91 040	136 560	Socialstyrelsen, 2022
Other care costs	Base case	-20%	20%	
MCI	0	0	0	Socialstyrelsen, 2007
Dementia	537 639	430 112	645 167	Socialstyrelsen, 2014
Depression	0	0	0	-
Fall accidents	1 242 900	994 320	1 491 480	Socialstyrelsen, 2022
Productivity loss (absence from work)	Base case	-20%	20%	
MCI	0	0	0	Socialstyrelsen, 2007
Dementia	941	753	1 129	Socialstyrelsen, 2014
Depression	110 778	88 622	132 933	Ekman et al., 2014
Fall accidents	33 960	27 168	40 752	Myndigheten för samhällsskydd och beredskap, 2010
Other costs	Base case	-20%	20%	
Fall accidents	492	393	590	Myndigheten för samhällsskydd och beredskap, 2010
General productivity loss	Base case	-20%	20%	
Social insurance costs sick leave per day women	75	60	90	Försäkringskassan, 2022 ; SCB, 2022b
Social insurance costs sick leave per day men	83	66	100	Försäkringskassan, 2022 ; SCB, 2022b
Employers' costs for sick leave per hour (day 1) women	59	47	71	SCB, 2022b; Försäkringskassan, 2022
Employers' costs for sick leave per hour (day 2-14) women	235	188	282	SCB, 2022b; Försäkringskassan, 2022
Employers' costs for sick leave per hour (day 1) men	72	58	86	SCB, 2022b; Försäkringskassan, 2022
Employers' costs for sick leave per hour (day 2-14) men	282	226	338	SCB, 2022b; Försäkringskassan, 2022

Continued

Continued 'Appendix 1. Input values: disease costs in SEK with corresponding +/- 20 % input variance'

Unit	Cost	Variation of values for DSA		Reference
Annual unemployment costs women	314 940	251 952	377 928	Ljungren & Ljungren, n.d. ; SCB, 2022c
Annual unemployment costs men	409 060	327 248	490 872	Ljungren & Ljungren, n.d. ; SCB, 2022c
Total cost per person per health state (Societal perspective)		-20%	20%	
MCI	0	0	0	
Dementia	561 743	449 394	674 092	
Depression	171 429	137 143	205 714	
Fall accidents	1 560 052	1 248 041	1 872 062	

Appendix 2. Transition probabilities and Matrix

A = Severe-to-profound hearing loss, eligible for CI

B = Fall accidents

C = mild cognitive impairment

D = Depression

E = Dementia

F = Death from complications

G = Death from other causes

Table 1. Transition matrix usual treatment women

	A.	B.	C.	D.	Total
A.	0,8837	0,0840	0,02756	0,00	1,000
B.	-	0,7563	0,2390	0,00	1,000
C.	-	-	0,9953	0,00	1,000
D.	-	-	-	1,0000	1,000

Table 2a. Time varying transition matrix women

Year	Age	STPHL, eligible for CI	Mild cognitive impairment	Dementia	Death	Check
1	61	7902				
2	62	7631	218	16	37	7902
3	63	7370	375	83	75	7902
4	64	7117	487	186	112	7902
5	65	6873	564	316	148	7902
6	66	6591	614	486	211	7902
7	67	6320	644	664	273	7902
8	68	6061	659	847	335	7902
9	69	5812	663	1031	396	7902
10	70	5573	660	1213	457	7902
11	71	5223	676	1441	562	7902
12	72	4894	677	1665	666	7902
13	73	4587	666	1880	768	7902
14	74	4299	648	2086	869	7902
15	75	4028	626	2279	969	7902
16	76	3633	593	2535	1141	7902
17	77	3276	556	2761	1309	7902
18	78	2954	517	2958	1472	7902
19	79	2664	478	3128	1632	7902
20	80	2402	439	3273	1788	7902
21	81	2031	373	3413	2086	7902
22	82	1717	316	3500	2370	7902
23	83	1451	268	3543	2640	7902

Table 2b. Time varying transition matrix women, additional health consequences

Year	Age	STPHL, eligible for CI > fall accidents	Mild cognitive impairment > fall accidents	Dementia > fall accidents	STPHL, eligible for CI > depression
1	61				
2	62	664	18	1	104
3	63	641	32	7	101
4	64	619	41	16	97
5	65	598	47	27	94
6	66	577	52	41	91
7	67	554	54	56	87
8	68	531	55	71	83
9	69	509	56	87	80
10	70	488	55	102	77
11	71	468	57	121	74
12	72	439	57	140	69
13	73	411	56	158	65
14	74	385	54	175	61
15	75	361	53	191	57
16	76	338	50	213	53

Continued

Continued 'Table 2b. Time varying transition matrix women, additional health consequences'

Year	Age	STPHL, eligible for CI > fall accidents	Mild cognitive impairment > fall accidents	Dementia > fall accidents	STPHL, eligible for CI > depression
17	77	305	47	232	48
18	78	275	43	248	43
19	79	248	40	263	39
20	80	224	37	275	35
21	81	202	31	287	32
22	82	171	27	294	27
23	83	144	22	298	23

Table 3. Transition matrix usual treatment men

	A.	B.	C.	D.	Total
A.	0,8991	0,0624	0,03081	0,01	1,000
B.	-	0,9904	0,0020	0,01	1,000
C.	-	-	0,9924	0,01	1,000
D.	-	-	-	1,0000	1,000

Table 4a. Time-varying transition matrix men

Year	Age	STPHL, eligible for CI	Mild cognitive impairment	Dementia	Death	Check
1	61	9658				
2	62	9268	298	19	74	9658
3	63	8893	510	108	147	9658
4	64	8534	658	247	219	9658
5	65	8189	759	419	291	9658
6	66	7785	820	640	413	9658
7	67	7402	853	869	534	9658
8	68	7037	866	1102	653	9658
9	69	6690	865	1333	771	9658
10	70	6360	853	1559	887	9658
11	71	5892	864	1830	1071	9658
12	72	5459	855	2091	1252	9658
13	73	5058	833	2338	1429	9658
14	74	4686	802	2568	1603	9658
15	75	4341	765	2779	1772	9658
16	76	3849	714	3037	2059	9658
17	77	3412	658	3253	2335	9658
18	78	3025	602	3431	2600	9658
19	79	2682	547	3573	2857	9658
20	80	2377	495	3682	3104	9658
21	81	1953	408	3736	3561	9658
22	82	1604	336	3731	3987	9658
23	83	1318	277	3681	4383	9658

Table 4b. Time varying transition matrix men, additional health consequences

Year	Age	STPHL, eligible for CI > fall accidents	Mild cognitive impairment > fall accidents	Dementia > fall accidents	STPHL, eligible for CI > depression
1	61				
2	62	603	19	1	68
3	63	579	32	7	65
4	64	555	41	15	63
5	65	533	47	26	60
6	66	511	51	40	58
7	67	486	53	54	55
8	68	462	54	69	52
9	69	439	54	83	50
10	70	418	53	97	47
11	71	397	54	114	45
12	72	368	53	131	42
13	73	341	52	146	39
14	74	316	50	160	36
15	75	293	48	174	33
16	76	271	45	190	31
17	77	240	41	203	27
18	78	213	38	214	24
19	79	189	34	223	21
20	80	167	31	230	19
21	81	148	25	233	17
22	82	122	21	233	14
23	83	100	17	230	11

Appendix 3. Usage of the model in Excel

This appendix presents an explanation of the different sheets in the excel file with the Markov model, as well as guidance regarding how to use them.

Sheet 1, results of the calculations and DSA

The first sheet shows an overview of the results of the calculations. The numbers change automatically when variables in the other sheets are changed. Next to the results of the calculations of the costs of a population with and without STPHL, the differences between these and the additional costs per health consequence, sheet 1 gives an opportunity to conduct a deterministic sensitivity analysis (DSA). This can be done by changing the parameters “Regional medical treatment fall accidents”, “Other care costs fall accidents”, “Risks fall accidents”, “Risks MCI” and “Risks MCI to dementia” with +/- 20%.

Results severe to profound hearing loss

Population	Table 1W (women). Severe to profound hearing loss				
7902		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	5 451 885 SEK	3 794 974 SEK	45 710 455 867 SEK	32 401 167 459 SEK
	Costs region	313 125 SEK	313 125 SEK	2 474 315 236 SEK	2 474 315 236 SEK
	Care costs others	4 787 866 SEK	3 160 256 SEK	37 833 716 884 SEK	24 972 342 093 SEK
	Other costs others	836 SEK	599 SEK	6 606 691 SEK	4 729 661 SEK
	Productivity loss	17 275 SEK	15 592 SEK	136 503 209 SEK	123 210 246 SEK
	Productivity loss general	332 784 SEK	305 402 SEK	2 629 656 924 SEK	2 413 285 111 SEK

Population	Table 1M (men). Severe to profound hearing loss				
9658		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	4 697 107 SEK	3 203 186 SEK	49 124 934 293 SEK	34 388 942 908 SEK
	Costs region	248 520 SEK	168 527 SEK	2 400 201 579 SEK	1 627 629 798 SEK
	Care costs others	4 046 995 SEK	2 666 225 SEK	39 085 881 211 SEK	25 750 400 762 SEK
	Other costs others	587 SEK	424 SEK	5 672 368 SEK	4 097 644 SEK
	Productivity loss	11 662 SEK	10 526 SEK	112 631 079 SEK	101 663 762 SEK
	Productivity loss general	389 343 SEK	357 483 SEK	3 760 274 028 SEK	3 452 575 471 SEK

Population	Results severe to profound hearing loss				
17560		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	5 074 496 SEK	3 499 080 SEK	94 835 390 160 SEK	66 790 110 367 SEK
	Costs region	280 822 SEK	240 826 SEK	4 874 516 815 SEK	4 101 945 034 SEK
	Care costs others	4 417 431 SEK	2 913 240 SEK	76 919 598 095 SEK	50 722 742 855 SEK
	Other costs others	712 SEK	511 SEK	12 279 059 SEK	8 827 305 SEK
	Productivity loss	14 468 SEK	13 059 SEK	249 134 288 SEK	224 874 008 SEK
	Productivity loss general	363 891 SEK	334 047 SEK	6 389 930 951 SEK	5 865 860 583 SEK

Results no hearing loss

Population	Table 1.2W (women). Results no hearing loss				
7902		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	3 558 019 SEK	2 382 045 SEK	29 637 516 463 SEK	20 219 623 202 SEK
	Costs region	192 238 SEK	129 223 SEK	1 519 064 821 SEK	1 021 123 571 SEK
	Care costs others	3 162 854 SEK	2 066 841 SEK	24 992 873 023 SEK	16 332 178 673 SEK
	Other costs others	431 SEK	309 SEK	3 403 374 SEK	2 437 795 SEK
	Productivity loss	9 881 SEK	8 918 SEK	78 077 193 SEK	70 472 877 SEK
	Productivity loss general	192 616 SEK	176 753 SEK	1 522 049 026 SEK	1 396 705 143 SEK

Population	Table 1.2M (men). Results no hearing loss				
9658		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	3 193 170 SEK	2 143 703 SEK	32 886 475 889 SEK	22 582 613 063 SEK
	Costs region	159 952 SEK	107 108 SEK	1 544 819 143 SEK	1 034 448 675 SEK
	Care costs others	2 814 442 SEK	1 835 945 SEK	27 181 879 892 SEK	17 731 561 524 SEK
	Other costs others	303 SEK	219 SEK	2 925 352 SEK	2 114 000 SEK
	Productivity loss	6 541 SEK	5 904 SEK	63 175 936 SEK	57 021 045 SEK
	Productivity loss general	211 932 SEK	194 526 SEK	2 046 837 783 SEK	1 878 733 910 SEK

Population	Results no hearing loss				
17560		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	3 375 595 SEK	2 262 874 SEK	62 523 992 352 SEK	42 802 236 265 SEK
	Costs region	176 095 SEK	118 166 SEK	3 063 883 964 SEK	2 055 572 246 SEK
	Care costs others	2 988 648 SEK	1 951 393 SEK	52 174 752 915 SEK	34 063 740 196 SEK
	Other costs others	367 SEK	264 SEK	6 328 726 SEK	4 551 795 SEK
	Productivity loss	8 211 SEK	7 411 SEK	141 253 129 SEK	127 493 922 SEK
	Productivity loss general	203 240 SEK	186 528 SEK	3 568 886 810 SEK	3 275 439 053 SEK

Additional costs of severe to profound hearing loss

Population	Table 1.3W (women). Additional costs of severe to profound hearing loss				
7902		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	1 893 866 SEK	1 412 929 SEK	16 072 939 404 SEK	12 181 544 257 SEK
	Costs region	120 887 SEK	183 902 SEK	955 250 416 SEK	1 453 191 665 SEK
	Care costs others	1 625 012 SEK	1 093 415 SEK	12 840 843 862 SEK	8 640 163 420 SEK
	Other costs others	405 SEK	290 SEK	3 203 317 SEK	2 291 866 SEK
	Productivity loss	7 394 SEK	6 674 SEK	58 426 016 SEK	52 737 370 SEK
	Productivity loss general	140 168 SEK	128 648 SEK	1 107 607 897 SEK	1 016 579 968 SEK

Population	Table 1.3M (men). Additional costs of severe to profound hearing loss				
9658		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	1 503 937 SEK	1 059 483 SEK	16 238 458 404 SEK	11 806 329 845 SEK
	Costs region	88 567 SEK	61 419 SEK	855 382 436 SEK	593 181 122 SEK
	Care costs others	1 232 553 SEK	830 279 SEK	11 904 001 319 SEK	8 018 839 239 SEK
	Other costs others	284 SEK	205 SEK	2 747 016 SEK	1 983 644 SEK
	Productivity loss	5 121 SEK	4 622 SEK	49 455 144 SEK	44 642 717 SEK
	Productivity loss general	177 411 SEK	162 957 SEK	1 713 436 244 SEK	1 573 841 562 SEK

Population	Additional costs of severe to profound hearing loss				
17560		Costs per patient	Costs per patient discounted	Costs total population	Costs total population discounted
	Total costs	1 698 902 SEK	1 236 206 SEK	32 311 397 808 SEK	23 987 874 102 SEK
	Costs region	104 727 SEK	122 660 SEK	1 810 632 852 SEK	2 046 372 788 SEK
	Care costs others	1 428 783 SEK	961 847 SEK	24 744 845 181 SEK	16 659 002 658 SEK
	Other costs others	345 SEK	248 SEK	5 950 333 SEK	4 275 510 SEK
	Productivity loss	6 257 SEK	5 648 SEK	107 881 159 SEK	97 380 087 SEK
	Productivity loss general	160 652 SEK	147 518 SEK	2 821 044 141 SEK	2 590 421 530 SEK

Regional medical treatment fall accidents	1,00
Other care costs fall accidents	1,00
Risks fall accidents	1,00
Risks MCI	1,00
Risks MCI to dementia	1,00

Deterministic sensitivity analysis (DSA)
Change the following parameters: -20% = 0,8 ; 1= no change; +20% =1,2

Women			
	Dementia	Depression	Fall accidents
Total population	4 946 880 054 SEK	23 344 194 SEK	8 898 500 916 SEK
Per person	626 029 SEK	2 954 SEK	1 126 107 SEK

Men			
	Dementia	Depression	Fall accidents
Total population	5 172 983 288 SEK	14 903 767 SEK	7 633 591 891 SEK
Per person	561 824 SEK	1 614 SEK	825 113 SEK

Combined			
	Dementia	Depression	Fall accidents
Total population	10 119 863 343 SEK	38 247 962 SEK	16 532 092 807 SEK
Per person	593 926 SEK	2 284 SEK	975 610 SEK

Sheet 2, disease costs and index table

Sheet 2 shows an overview of the different costs per health state as well as costs related to general productivity loss (directly related to STPHL). Under the column "base case" you can find the costs for the respective health and employment states based on a Swedish perspective. Under the column "reference" the sources of these values are described, which are documented in more detail in sheet 10. Under the two columns "DSA" you can see the change in these values given a 20% increase or decrease.

Disease costs				
UNIT	COST	DSA		REFERENCE
Regional costs medical treatment	Base case	-20%	20%	
MCI	0 SEK	0 SEK	0 SEK	Socialstyrelsen, 2007
Dementia	23 162 SEK	18 530 SEK	27 795 SEK	Socialstyrelsen, 2014
Depression	24 099 SEK	19 280 SEK	28 919 SEK	Ekman et al., 2014
Fall accidents	113 800 SEK	91 040 SEK	136 560 SEK	Socialstyrelsen, 2022
Other care costs	Base case	-20%	20%	
MCI	0 SEK	0 SEK	0 SEK	Socialstyrelsen, 2007
Dementia	537 639 SEK	430 112 SEK	645 167 SEK	Socialstyrelsen, 2014
Depression	0 SEK	0 SEK	0 SEK	-
Fall accidents	1 242 900 SEK	994 320 SEK	1 491 480 SEK	Socialstyrelsen, 2022
Productivity loss (absence from work)	Base case	-20%	20%	
MCI	0 SEK	0 SEK	0 SEK	Socialstyrelsen, 2007
Dementia	941 SEK	753 SEK	1 129 SEK	Socialstyrelsen, 2014
Depression	110 778 SEK	88 622 SEK	132 933 SEK	Ekman et al., 2014
Fall accidents	33 960 SEK	27 168 SEK	40 752 SEK	Myndigheten för samhällsskydd och beredskap, 2010

Continued

Continued 'Disease costs'

UNIT	COST	DSA		REFERENCE
Other costs	Base case	-20%	20%	
Fall accidents	492 SEK	393 SEK	590 SEK	Myndigheten för samhälls-skydd och beredskap, 2010
General productivity loss	Base case	-20%	20%	
Social insurance costs sick leave per day women	75 SEK	60 SEK	90 SEK	FörsäSEKingskassan, 2022 ; SCB, 2022b
Social insurance costs sick leave per day men	83 SEK	66 SEK	100 SEK	FörsäSEKingskassan, 2022 ; SCB, 2022b
employers costs for sick leave per hour (day 1) women	59 SEK	47 SEK	71 SEK	SCB, 2022b; FörsäSEKingskassan, 2022
employers costs for sick leave per hour (day 2-14) women	235 SEK	188 SEK	282 SEK	SCB, 2022b; FörsäSEKingskassan, 2022
employers costs for sick leave per hour (day 1) men	72 SEK	58 SEK	86 SEK	SCB, 2022b; FörsäSEKingskassan, 2022
employers costs for sick leave per hour (day 2-14) men	282 SEK	226 SEK	338 SEK	SCB, 2022b; FörsäSEKingskassan, 2022
Annual unemployment costs women	314 940 SEK	251 952 SEK	377 928 SEK	Ljungren & Ljungren, n.d. ; SCB, 2022c
Annual unemployment costs men	409 060 SEK	327 248 SEK	490 872 SEK	Ljungren & Ljungren, n.d. ; SCB, 2022c
Total cost per person per health state (Societal perspective)		-20%	20%	
MCI	0 SEK	0 SEK	0 SEK	
Dementia	561 743 SEK	449 394 SEK	674 092 SEK	
Depression	134 877 SEK	107 902 SEK	161 852 SEK	
Fall accidents	1 391 152 SEK	1 112 921 SEK	1 669 382 SEK	

Since some of the costs are based on articles or reports from previous years, we must adjust these for the most recent price levels. The index values for the relevant years are presented in the index table. In case new costs would be added to this sheet that are from different years, index numbers for these years have to be added to the table and used in the calculations. Adjustments for price levels of different years can be made by taking the price from a previous year and multiply this by the number that results from dividing the current index number by the index number of the year that the "old" price comes from.

Index table (SCB, 2022a)	
Index 2022 (December)	395,96
Index 2017	322,11
Index 2016	316,43
Index 2014	313,49
Index 2012	314,20
Index 2005	280,40
Index 2004	279,20
Index 2001	267,10

Old price * indexnumberl time two / indexnumber time one = new price

Sheet 3, model and transition matrixes

In this sheet a visualization of the Markov model is presented together with the model for additional health consequences. It also shows an overview of the probabilities of the transitions in the transition matrixes. The Markov model and the model for additional health consequences show how a patient can move from one state to another, which has been described earlier in this report.

The first transition matrix shows how the probabilities of going from one stage to another are defined. The following two matrixes give an insight in the values of the different transitions for women and men respectively. The values under the column "total" should always add up to 1, since the probabilities of the transition states are collectively exhaustive. These transition matrixes are mainly to be used to see if there are any errors in the reasoning behind the calculations, which is the case when the values under the column "total" are higher or lower than 1. The values in this example are taken from the risks in sheet 4 and based on the first year included in the cohort (61 years of age). The discount rate on the right side of the model is used to calculate the discounted costs.

Transition matrix

	A.	B.	C.	D.	Total
A.	1-A2B-A2C-A2D	A2B	A2C	A2D	1
B.	-	1-B2C-B2D	B2C	B2D	1
C.	-	-	1-C2D	C2D	1
D.	-	-	-	1	1

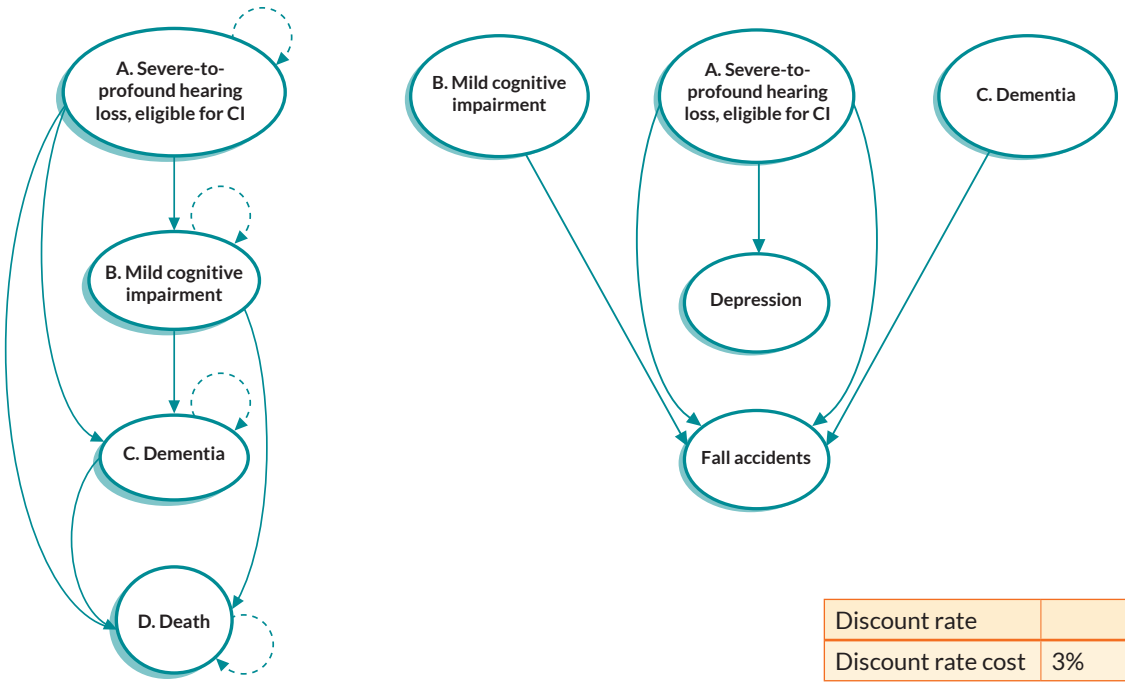
Transition matrix usual treatment women

	A.	B.	C.	D.	Total
A.	0,8837	0,0840	0,02756	0,00	1,000
B.	-	0,7563	0,2390	0,00	1,000
C.	-	-	0,9953	0,00	1,000
D.	-	-	-	1,0000	1,000

Transition matrix usual treatment men

	A.	B.	C.	D.	Total
A.	0,8991	0,0624	0,03081	0,01	1,000
B.	-	0,9904	0,0020	0,01	1,000
C.	-	-	0,9924	0,01	1,000
D.	-	-	-	1,0000	1,000

Figure 1. Markov model



Discount rate	
Discount rate cost	3%

Sheet 4 and 5, risks

Sheet 4 forms a summary of the risks for developing one of the selected health or death states in the model, given STPHL. The risks are based on the risks in the general population and then adjusted for the additional risks that appear due to STPHL. As there might be a difference in risks between men and women as well as between people from different ages, the risks are documented per age and sex. The values are retrieved from scientific articles and Swedish registries. For every risk you can see the source where the value or values are taken from (see "source"). The comments in the sheet show how the risks are calculated. In case new research is available regarding the risks for the selected health outcomes, the values in the sheet have to be updated manually. Sheet 5 forms a summary of the same risks with the difference being that these are probabilities given that one does not have STPHL.

Death risks

	A2D/B2D/C2D: Average death risk	
	Female	Male
61	0,005	0,008
62	0,005	0,008
63	0,005	0,008
64	0,005	0,008
65	0,008	0,013
66	0,008	0,013
67	0,008	0,013
68	0,008	0,013
69	0,008	0,013
70	0,014	0,021
71	0,014	0,021
72	0,014	0,021
73	0,014	0,021
74	0,014	0,021
75	0,025	0,036
76	0,025	0,036
77	0,025	0,036
78	0,025	0,036
79	0,025	0,036
80	0,049	0,070
81	0,049	0,070
82	0,049	0,070
83	0,049	0,070
	Source: Socialstyrelsen, 2022b	

Risks TAU

	STPHL to fall accidents		A2B: STPHL to MCI	
	Female	Male	Female	Male
61	0,08400132	0,06242971	0,02756	0,03081
62	0,08400132	0,06242971	0,02756	0,03081
63	0,08400132	0,06242971	0,02756	0,03081
64	0,08400132	0,06242971	0,02756	0,03081
65	0,08400132	0,06242971	0,02756	0,03081
66	0,08400132	0,06242971	0,02756	0,03081
67	0,08400132	0,06242971	0,02756	0,03081
68	0,08400132	0,06242971	0,02756	0,03081
69	0,08400132	0,06242971	0,02756	0,03081
70	0,08400132	0,06242971	0,03289	0,03666
71	0,08400132	0,06242971	0,03289	0,03666
72	0,08400132	0,06242971	0,03289	0,03666
73	0,08400132	0,06242971	0,03289	0,03666
74	0,08400132	0,06242971	0,03289	0,03666
75	0,08400132	0,06242971	0,03289	0,03666
76	0,08400132	0,06242971	0,03289	0,03666
77	0,08400132	0,06242971	0,03289	0,03666
78	0,08400132	0,06242971	0,03289	0,03666
79	0,08400132	0,06242971	0,03289	0,03666
80	0,08400132	0,06242971	0,02483	0,02769
81	0,08400132	0,06242971	0,02483	0,02769
82	0,08400132	0,06242971	0,02483	0,02769
83	0,08400132	0,06242971	0,02483	0,02769
	Reference: Folkhälsomyndigheten, 2022 ; Gopinath et al., 2016		*Reference: Wei et al., 2017; Overton, Pihlsgård & Elmståhl, 2019*	

Risks TAU						
	STPHL to depression		B2C: MCI to dementia		A2C: STPHL to dementia	
	Female	Male	Female	Male	Female	Male
61	0,0132	0,007056	0,239	0,239	0,0020	0,0020
62	0,0132	0,007056	0,239	0,239	0,0020	0,0020
63	0,0132	0,007056	0,239	0,239	0,0020	0,0020
64	0,0132	0,007056	0,239	0,239	0,0020	0,0020
65	0,0132	0,007056	0,239	0,239	0,0054	0,0054
66	0,0132	0,007056	0,239	0,239	0,0054	0,0054
67	0,0132	0,007056	0,239	0,239	0,0054	0,0054
68	0,0132	0,007056	0,239	0,239	0,0054	0,0054
69	0,0132	0,007056	0,239	0,239	0,0054	0,0054
70	0,0132	0,007056	0,239	0,239	0,0158	0,0158
71	0,0132	0,007056	0,239	0,239	0,0158	0,0158
72	0,0132	0,007056	0,239	0,239	0,0158	0,0158
73	0,0132	0,007056	0,239	0,239	0,0158	0,0158
74	0,0132	0,007056	0,239	0,239	0,0158	0,0158
75	0,0132	0,007056	0,239	0,239	0,0405	0,0405
76	0,0132	0,007056	0,239	0,239	0,0405	0,0405
77	0,0132	0,007056	0,239	0,239	0,0405	0,0405
78	0,0132	0,007056	0,239	0,239	0,0405	0,0405
79	0,0132	0,007056	0,239	0,239	0,0405	0,0405
80	0,0132	0,007056	0,239	0,239	0,0810	0,0810
81	0,0132	0,007056	0,239	0,239	0,0810	0,0810
82	0,0132	0,007056	0,239	0,239	0,0810	0,0810
83	0,0132	0,007056	0,239	0,239	0,0810	0,0810
	Reference: Lejtzén et al., 2014 ; Lawrence et al., 2020		*Reference: Van Maurik et al., 2019*		*Reference: Livingston et al., 2020; Van Bussel et al., 2017*	

Sheet 6 and 7, treatment as usual: transition matrix and calculation of costs

In the sixth and seventh sheet, transition matrixes with the simulated number of patients in each health state are presented. There is one matrix for women (yellow) and one for men (blue). The formulas in this sheet should not be changed. Only the number of patients in the population can be adjusted in case this is needed. If you wish to add more years to the simulation, more rows can be added. However, in this case sheet 4 and 5 have to be adjusted for the new ages of the population as well, which might take more time since the values of the risks for developing certain health states have to be adjusted for older or younger patients. The column “check” should always be equal to the total population and no numbers in the matrixes should be negative. Sheet 6 presents the transition matrixes and calculation of costs given that the cohort STPHL while the cohort in sheet 7 does not have hearing loss.

On the right side of the sheets, results can be found of calculations of the different costs per year, as well as the summarized costs. The results are based on the numbers at the left side of the sheets as well as the costs that are presented in Sheet 2. The discounted costs are calculated by using the discount rate in Sheet 3. Changes to this part of the sheet should only be made if there is a need for calculations over a longer period. In that case, new rows should be added to the tables including an adjustment for the discounted costs.

Transition matrix (women)

Year	Age	STPHL, eligible for CI	Mild cognitive impairment	Dementia	Death	Check		STPHL, eligible for CI > fall accidents	Mild cognitive impairment > fall accidents	Dementia > fall accidents	STPHL, eligible for CI > depression
1	61	7902									
2	62	7631	218	16	37	7902		664	18	1	104
3	63	7370	375	83	75	7902		641	32	7	101
4	64	7117	487	186	112	7902		619	41	16	97
5	65	6873	564	316	148	7902		598	47	27	94
6	66	6591	614	486	211	7902		577	52	41	91
7	67	6320	644	664	273	7902		554	54	56	87
8	68	6061	659	847	335	7902		531	55	71	83
9	69	5812	663	1031	396	7902		509	56	87	80
10	70	5573	660	1213	457	7902		488	55	102	77
11	71	5223	676	1441	562	7902		468	57	121	74
12	72	4894	677	1665	666	7902		439	57	140	69
13	73	4587	666	1880	768	7902		411	56	158	65
14	74	4299	648	2086	869	7902		385	54	175	61
15	75	4028	626	2279	969	7902		361	53	191	57
16	76	3633	593	2535	1141	7902		338	50	213	53
17	77	3276	556	2761	1309	7902		305	47	232	48
18	78	2954	517	2958	1472	7902		275	43	248	43
19	79	2664	478	3128	1632	7902		248	40	263	39
20	80	2402	439	3273	1788	7902		224	37	275	35
21	81	2031	373	3413	2086	7902		202	31	287	32
22	82	1717	316	3500	2370	7902		171	27	294	27
23	83	1451	268	3543	2640	7902		144	22	298	23

Transition matrix (men)

Year	Age	STPHL, eligible for CI	Mild cognitive impairment	Dementia	Death other cause	Check		STPHL, eligible for CI > fall accidents	Mild cognitive impairment > fall accidents	Dementia > fall accidents	STPHL, eligible for CI > depression
1	61	9658									
2	62	9268	298	19	74	9658		603	19	1	68
3	63	8893	510	108	147	9658		579	32	7	65
4	64	8534	658	247	219	9658		555	41	15	63
5	65	8189	759	419	291	9658		533	47	26	60
6	66	7785	820	640	413	9658		511	51	40	58
7	67	7402	853	869	534	9658		486	53	54	55
8	68	7037	866	1102	653	9658		462	54	69	52
9	69	6690	865	1333	771	9658		439	54	83	50
10	70	6360	853	1559	887	9658		418	53	97	47
11	71	5892	864	1830	1071	9658		397	54	114	45
12	72	5459	855	2091	1252	9658		368	53	131	42
13	73	5058	833	2338	1429	9658		341	52	146	39
14	74	4686	802	2568	1603	9658		316	50	160	36
15	75	4341	765	2779	1772	9658		293	48	174	33
16	76	3849	714	3037	2059	9658		271	45	190	31
17	77	3412	658	3253	2335	9658		240	41	203	27
18	78	3025	602	3431	2600	9658		213	38	214	24
19	79	2682	547	3573	2857	9658		189	34	223	21
20	80	2377	495	3682	3104	9658		167	31	230	19
21	81	1953	408	3736	3561	9658		148	25	233	17
22	82	1604	336	3731	3987	9658		122	21	233	14
23	83	1318	277	3681	4383	9658		100	17	230	11

Calculation of costs

(WOMEN)	Regional healthcare costs	Other care costs	Other costs	Productivity loss	Regional healthcare cost w. discounting	Other care costs w.discounting	Other costs w. discounting	Productivity loss w.discounting	Year	Age		Dementia	Depression	Fall accidents
									1	61				
	80 644 462 SEK	857 772 605 SEK	335 971 SEK	34 777 141 SEK	76 015 140 SEK	808 532 948 SEK	316 685 SEK	32 780 791 SEK	2	62		8 771 254 SEK	14 068 539 SEK	950 690 387 SEK
	81 667 088 SEK	888 970 325 SEK	334 051 SEK	34 311 689 SEK	74 736 955 SEK	813 533 779 SEK	305 704 SEK	31 400 056 SEK	3	63		46 438 730 SEK	13 586 451 SEK	945 257 974 SEK
	83 548 508 SEK	939 975 537 SEK	332 152 SEK	33 895 798 SEK	74 231 767 SEK	835 156 090 SEK	295 113 SEK	30 115 977 SEK	4	64		104 747 824 SEK	13 120 883 SEK	939 883 288 SEK
	86 032 843 SEK	1 004 852 593 SEK	330 273 SEK	33 518 581 SEK	74 212 686 SEK	866 794 673 SEK	284 896 SEK	28 913 422 SEK	5	65		177 498 062 SEK	12 671 268 SEK	934 564 959 SEK
	89 653 176 SEK	1 093 533 353 SEK	329 272 SEK		75 083 123 SEK	915 816 967 SEK	275 760 SEK		6	66		272 340 051 SEK	2 186 478 SEK	931 734 152 SEK
	92 997 114 SEK	1 181 904 376 SEK	326 225 SEK		75 615 164 SEK	960 996 415 SEK	265 251 SEK		7	67		372 553 017 SEK	2 096 659 SEK	900 578 039 SEK
	96 451 934 SEK	1 272 648 477 SEK	323 219 SEK		76 140 047 SEK	1 004 640 460 SEK	255 152 SEK		8	68		475 134 661 SEK	2 010 531 SEK	892 278 438 SEK
	99 935 698 SEK	1 363 870 043 SEK	320 252 SEK		76 592 391 SEK	1 045 292 822 SEK	245 446 SEK		9	69		578 110 278 SEK	1 927 940 SEK	884 087 775 SEK
	103 389 085 SEK	1 454 198 166 SEK	317 323 SEK		76 931 189 SEK	1 082 060 007 SEK	236 118 SEK		10	70		680 052 381 SEK	1 848 742 SEK	876 003 452 SEK
	108 666 742 SEK	1 577 739 266 SEK	317 578 SEK		78 503 167 SEK	1 139 792 415 SEK	229 425 SEK		11	71		808 243 838 SEK	1 772 798 SEK	876 706 951 SEK
	112 534 347 SEK	1 684 881 361 SEK	312 382 SEK		78 929 327 SEK	1 181 741 887 SEK	219 098 SEK		12	72		933 704 755 SEK	1 661 391 SEK	862 361 944 SEK
	116 246 453 SEK	1 787 916 548 SEK	307 303 SEK		79 158 178 SEK	1 217 484 169 SEK	209 259 SEK		13	73		1 054 571 292 SEK	1 556 984 SEK	848 342 028 SEK
	119 751 130 SEK	1 885 662 315 SEK	302 338 SEK		79 169 604 SEK	1 246 644 932 SEK	199 881 SEK		14	74		1 169 621 717 SEK	1 459 140 SEK	834 634 927 SEK
	123 015 891 SEK	1 977 386 114 SEK	297 482 SEK		78 959 219 SEK	1 269 208 902 SEK	190 942 SEK		15	75		1 278 103 023 SEK	1 367 443 SEK	821 229 020 SEK
	128 417 744 SEK	2 110 238 176 SEK	295 559 SEK		80 025 692 SEK	1 315 030 665 SEK	184 182 SEK		16	76		1 421 750 354 SEK	1 281 510 SEK	815 919 614 SEK
	131 549 726 SEK	2 210 145 630 SEK	287 021 SEK		79 589 748 SEK	1 337 174 454 SEK	173 653 SEK		17	77		1 548 475 346 SEK	1 155 633 SEK	792 351 398 SEK
	134 100 833 SEK	2 295 344 859 SEK	278 814 SEK		78 770 106 SEK	1 348 273 193 SEK	163 774 SEK		18	78		1 658 988 830 SEK	1 042 121 SEK	769 693 555 SEK
	136 103 854 SEK	2 366 681 377 SEK	270 916 SEK		77 618 126 SEK	1 349 685 319 SEK	154 500 SEK		19	79		1 754 224 854 SEK	939 758 SEK	747 891 535 SEK
	137 597 155 SEK	2 425 122 674 SEK	263 310 SEK		76 184 208 SEK	1 342 731 626 SEK	145 789 SEK		20	80		1 835 240 406 SEK	847 450 SEK	726 895 283 SEK
	138 954 777 SEK	2 480 711 275 SEK	255 527 SEK		74 695 040 SEK	1 333 504 550 SEK	137 358 SEK		21	81		1 913 750 390 SEK	764 209 SEK	705 406 980 SEK
	137 592 711 SEK	2 491 920 968 SEK	241 437 SEK		71 808 604 SEK	1 300 514 866 SEK	126 004 SEK		22	82		1 962 598 277 SEK	646 038 SEK	666 510 801 SEK
	135 463 965 SEK	2 482 240 846 SEK	228 285 SEK		68 638 473 SEK	1 257 730 954 SEK	115 670 SEK		23	83		1 987 181 615 SEK	546 140 SEK	630 205 341 SEK
SUM	2 474 315 236 SEK	37 833 716 884 SEK	6 606 691 SEK	136 503 209 SEK	1 681 607 956 SEK	24 972 342 093 SEK	4 729 661 SEK	123 210 246 SEK				22 042 100 954 SEK	78 558 105 SEK	18 353 227 840 SEK
SUM per person	313 125 SEK	4 787 866 SEK	836 SEK	17 275 SEK	212 808 SEK	3 160 256 SEK	599 SEK	15 592 SEK				2 789 433 SEK	9 942 SEK	2 322 605 SEK

(MEN)	Regional healthcare costs	Other care costs	Other costs	Productivity loss	Regional healthcare costs w. discounting	Other care costs w.discounting	Other costs w. discounting	Productivity loss w.discounting	Year	Age		Dementia	Depression	Fall accidents
									1	61				
	72 949 225 SEK	784 232 066 SEK	306 144 SEK	28 714 410 SEK	68 761 641 SEK	739 213 937 SEK	288 570 SEK	27 066 085 SEK	2	62		10 720 422 SEK	9 191 445 SEK	866 289 977 SEK
	74 319 748 SEK	825 341 695 SEK	303 418 SEK	28 305 029 SEK	68 013 098 SEK	755 304 568 SEK	277 670 SEK	25 903 111 SEK	3	63		60 875 695 SEK	8 820 020 SEK	858 574 175 SEK
	76 842 970 SEK	893 040 855 SEK	300 728 SEK	27 956 893 SEK	68 273 984 SEK	793 455 233 SEK	267 193 SEK	24 839 337 SEK	4	64		138 715 737 SEK	8 463 604 SEK	850 962 104 SEK
	80 157 038 SEK	978 935 488 SEK	298 073 SEK	27 654 748 SEK	69 144 165 SEK	844 438 351 SEK	257 121 SEK	23 855 229 SEK	5	65		235 472 597 SEK	8 121 590 SEK	843 451 159 SEK
	84 751 631 SEK	1 092 482 153 SEK	296 127 SEK		70 978 156 SEK	914 936 604 SEK	248 001 SEK		6	66		358 649 463 SEK	1 392 499 SEK	837 943 267 SEK
	89 009 167 SEK	1 205 169 785 SEK	291 814 SEK		72 372 598 SEK	979 913 322 SEK	237 271 SEK		7	67		487 565 628 SEK	1 323 859 SEK	805 581 278 SEK
	93 354 534 SEK	1 319 594 521 SEK	287 579 SEK		73 694 931 SEK	1 041 700 100 SEK	227 018 SEK		8	68		618 086 955 SEK	1 258 602 SEK	793 891 076 SEK
	97 676 742 SEK	1 433 189 981 SEK	283 421 SEK		74 861 089 SEK	1 098 420 782 SEK	217 218 SEK		9	69		747 542 075 SEK	1 196 563 SEK	782 411 506 SEK
	101 897 569 SEK	1 544 149 947 SEK	279 337 SEK		75 821 361 SEK	1 148 992 579 SEK	207 853 SEK		10	70		874 052 315 SEK	1 137 581 SEK	771 136 956 SEK
	107 797 411 SEK	1 686 488 748 SEK	277 898 SEK		77 875 144 SEK	1 218 355 354 SEK	200 760 SEK		11	71		1 026 316 468 SEK	1 081 507 SEK	767 166 083 SEK
	112 236 318 SEK	1 810 169 058 SEK	271 290 SEK		78 720 295 SEK	1 269 616 157 SEK	190 277 SEK		12	72		1 172 751 951 SEK	1 001 975 SEK	748 922 739 SEK
	116 391 743 SEK	1 926 579 880 SEK	264 876 SEK		79 257 113 SEK	1 311 907 151 SEK	180 368 SEK		13	73		1 311 091 525 SEK	928 292 SEK	731 216 683 SEK
	120 204 699 SEK	2 034 385 207 SEK	258 648 SEK		79 469 467 SEK	1 344 968 284 SEK	170 997 SEK		14	74		1 439 963 177 SEK	860 027 SEK	714 025 350 SEK
	123 642 743 SEK	2 132 863 168 SEK	252 600 SEK		79 361 572 SEK	1 369 003 707 SEK	162 134 SEK		15	75		1 558 634 251 SEK	796 783 SEK	697 327 477 SEK
	128 573 593 SEK	2 260 747 141 SEK	248 357 SEK		80 122 812 SEK	1 408 822 876 SEK	154 768 SEK		16	76		1 703 216 778 SEK	738 189 SEK	685 614 124 SEK
	131 140 556 SEK	2 351 241 390 SEK	238 175 SEK		79 342 193 SEK	1 422 539 709 SEK	144 100 SEK		17	77		1 824 460 674 SEK	654 427 SEK	657 505 020 SEK
	132 935 211 SEK	2 422 160 346 SEK	228 494 SEK		78 085 426 SEK	1 422 763 926 SEK	134 216 SEK		18	78		1 923 962 131 SEK	580 170 SEK	630 781 750 SEK
	134 023 630 SEK	2 475 157 286 SEK	219 283 SEK		76 431 804 SEK	1 411 547 614 SEK	125 054 SEK		19	79		2 003 533 319 SEK	514 339 SEK	605 352 541 SEK
	134 475 916 SEK	2 511 967 863 SEK	210 510 SEK		74 456 054 SEK	1 390 815 701 SEK	116 554 SEK		20	80		2 065 064 656 SEK	455 977 SEK	581 133 655 SEK
	133 270 598 SEK	2 514 663 669 SEK	200 150 SEK		71 639 513 SEK	1 351 755 634 SEK	107 590 SEK		21	81		2 095 196 463 SEK	404 238 SEK	552 533 716 SEK
	129 514 908 SEK	2 472 952 163 SEK	184 757 SEK		67 592 859 SEK	1 290 615 189 SEK	96 423 SEK		22	82		2 092 279 048 SEK	332 067 SEK	510 040 714 SEK
	125 035 630 SEK	2 410 368 803 SEK	170 692 SEK		63 354 522 SEK	1 221 313 983 SEK	86 488 SEK		23	83		2 064 089 382 SEK	272 781 SEK	471 212 961 SEK
SUM	2 400 201 579 SEK	39 085 881 211 SEK	5 672 368 SEK	112 631 079 SEK	1 627 629 798 SEK	25 750 400 762 SEK	4 097 644 SEK	101 663 762 SEK				25 812 240 710 SEK	49 526 534 SEK	15 763 074 312 SEK
SUM per person	248 520 SEK	4 046 995 SEK	587 SEK	11 662 SEK	168 527 SEK	2 666 225 SEK	424 SEK	10 526 SEK				2 785 177 SEK	5 344 SEK	1 700 858 SEK

Sheet 8 and 9, productivity loss

As STPHL even without complications can lead to productivity loss, a summary of this loss is calculated in Sheet 8. Sheet 9 presents the productivity loss among a cohort without STPHL, in this case the calculations are made based on unemployment and sick-leave in the general population while the values in Sheet 8 are adjusted for the increased risk that comes with hearing loss. In case new values (prevalence and/or incidence) are available regarding unemployment or sick leave, these numbers should be adjusted in column J (see comments for more information). If you wish to add more years (below 61 years of age) to the cohort, new rows should be added. Similar to the calculations of the costs in Sheet 6 and 7, the calculations for the discounted costs should be adjusted for the additional years.

Women

Unemployment					
Year	Age	Total alive	Amount unemployed	Annual costs unemployment	Annual costs unemployment discounted
1	61	7902	1339	421 578 306 SEK	409 299 326 SEK
2	62	7865	1332	419 583 777 SEK	395 497 952 SEK
3	63	7557	1280	403 152 418 SEK	368 941 573 SEK
4	64	7258	1230	387 225 483 SEK	344 044 826 SEK
5	65	6969	1180	371 785 963 SEK	320 705 837 SEK
			Total costs unemployment	2 003 325 947 SEK	
			Total costs unemployment dsicounted	1 838 489 514 SEK	

Unemployment rate women STPHL	**Annual unemployment costs (per person)**
0,1694	314 940 SEK
Annual sick leave days	**Annual costs sick leave**
11	20 082 SEK

Sick leave				
Year	Age	Total working (alive, without unemployment)	Sick leave costs	Sick leave costs discounted
1	61	6563	131 804 589 SEK	127 965 620 SEK
2	62	6532	131 181 008 SEK	123 650 681 SEK
3	63	6277	126 043 816 SEK	115 347 947 SEK
4	64	6029	121 064 331 SEK	107 564 090 SEK
5	65	5788	116 237 233 SEK	100 267 258 SEK
		Total costs sick leave	626 330 977 SEK	
		Total costs sick leave discounted	574 795 597 SEK	

Men

Unemployment					
Year	Age	Total alive	Amount unemployed	Annual costs unemployment	Annual costs unemployment discounted
1	61	9658	1636	669 248 831 SEK	649 756 146 SEK
2	62	9584	1624	664 146 545 SEK	626 021 816 SEK
3	63	9121	1545	632 038 879 SEK	578 405 109 SEK
4	64	8674	1469	601 062 674 SEK	534 036 400 SEK
5	65	8243	1396	571 173 471 SEK	492 699 253 SEK
			Total costs unemployment	3 137 670 399 SEK	
			Total costs unemployment dsicounted	2 880 918 725 SEK	

Unemployment rate men STPHL	**Annual unemployment costs (per person)**
0,1694	409 060 SEK
Annual sick leave days	**Annual costs sick leave**
8	16 554 SEK

Sick leave				
Year	Age	Total working (alive, without unemployment)	Sick leave costs	Sick leave costs discounted
1	61	8022	132 798 127 SEK	128 930 220 SEK
2	62	7961	131 785 687 SEK	124 220 649 SEK
3	63	7576	125 414 607 SEK	114 772 132 SEK
4	64	7205	119 268 041 SEK	105 968 110 SEK
5	65	6846	113 337 167 SEK	97 765 636 SEK
		Total costs sick leave	622 603 629 SEK	
		Total costs sick leave discounted	571 656 747 SEK	

Sheet 10, references

References of all sources that have been used in the calculations can be found in Sheet 10. In case new sources will be added to the model, this sheet has to be updated to keep the model as clear and transparent as possible.

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Appendix 4. usage in other Nordic countries

The current model has been created for calculations regarding the societal costs of severe-to-profound hearing loss among adults without CI treatment in Sweden. To be able to use the model in other Nordic countries, the following parameters must be changed:

- The number of patients in the cohort must be adjusted to the countries number of adults with severe-to-profound-hearing loss that are eligible for CI but who don't receive such treatment.
- The costs for the selected health states and general productivity loss must be adjusted to the local prices of these parameters.
- Risks for the development of the selected health states or general productivity loss must be adjusted in case there is research available on these in the relevant country. If this is not the case, numbers from the Swedish cohort can be used as the Nordic countries are similar to each other. However, this would lead to a larger uncertainty in the outcomes.
- The mean life expectancy and age of receiving CI treatment must be adjusted, as well as the retirement age if this one differs from the Swedish society.

In case the model has to be applied to countries outside the Nordics, with another health care system than Beveridge model, more, major adjustments have to be made as there are major differences in how health care is organized and financed.

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