The Effects of Disease Prevention on Health and Health Care Costs: a Socioeconomic Approach

THESIS

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JELLE BETERAMS

STUDENT ID
512606

SUPERVISOR
DR. B. WOUTERSE

READING COMMITTEE
PROF. MR . DR. MAJM BUIJSEN

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Summary

Background
Disease prevention has been claimed to reduce health inequalities and therefore reduce health care costs. However, preventing fatal diseases reduces disease-related costs but increases longevity. These gained years are liven in poorer health and cause an increase in lifetime health care costs. These findings result in a discrepancy on the reducing effect of disease prevention on health care costs. The objective of this study is to investigate the effect of disease prevention on health and health care costs for different socioeconomic groups.

Methods
Standard and cause-deleted life-expectancy at birth (LE) and lifetime health care costs (LHC) were estimated using data on Dutch mortality probabilities and hospital care spending. Cause-deleted scenarios estimate the LE and LHC when all disease-related mortality and health care costs would be prevented. The effects of disease prevention were estimated for a total of five disease categories (three fatal and two non-fatal). All estimates were performed for five socioeconomic groups, based on income.

Results
For all five included disease categories prevention increased LE across all income groups. The highest increase was observed for lung cancer (0.47 – 0.94 years). For the disease category mood disorders the increase in LE was negligible (0.02 – 0.00 years). The LHC were reduced after prevention of all five disease categories. The highest decrease in LHC was observed for ischaemic heart diseases (€4.700 – €6.800). The decrease in LHC for mood disorders was negligible (€0 – €100). Disease prevention decreased inequalities in health and health care for four out of five included diseases.

Conclusion
This study concludes that prevention increases health and decreases health care costs for most included diseases. Additionally, disease prevention could be seen as a measure to reduce socioeconomic inequalities in health and health care. The results of this study are based on hospital care expenses. Previous research on disease prevention shows that most of the cost growth due to longevity is noticeable in other care sectors like nursing home residentials. Future research using this study's methodological design, including health care costs from other care settings, might support the findings of this study.

1.0 Introduction

Lifestyle disease prevention is commonly seen as a possible intervention to counter growing health care costs (Fries et al., 1993; Goortjans- van Kampen et al., 2014; Sociaal-economische Raad, 2020). It is also seen as a measure to decrease health inequalities (M. Marmot & Bell, 2012). There are strong inequalities in health across socioeconomic groups (Chetty et al., 2016; Judge et al., 2006; JP Mackenbach et al., 1999; Murtin et al., 2017). In the Netherlands, men with low-income have a life-expectancy at birth (LE) of 74,8, men with high-income have a LE of 83,1 (CBS, 2021b). As a result of their poor health, people from lower socioeconomic groups also have higher health care costs (Cookson et al., 2016). In the Netherlands, the lowest educated people have 75% percent more health care costs than the highest educated people (Rele & Van der Horst, 2013).

These finding suggest that prevention might lead to a win-win situation: closing the gap in health between different socioeconomic status (SES), by investing in disease prevention also results in a decrease in health care costs. A study by (Asaria et al., 2016) for England indeed finds this. They estimate that when the health and health care costs of lower socioeconomic groups were equalised to the health and health care costs of the highest socioeconomic group, the total health care spending would be reduced. It would result in saving £4.8 billion per year in 2011/2012.

At the same time, studies that have looked at the general effect of lifestyle prevention on health care costs (without differences in SES) have found mixed results. Indeed, complete extermination of smoking and obesity would decrease short-term health care costs (Barendregt et al., 1997; Van Baal et al., 2008). Since the costs of the treatment for the disease have been averted. However, prevention of these diseases will increase long-term health care costs. Measures preventing smoking and obesity will increase longevity, these gained life years will be lived in less than perfect health. This causes people to use more health care and increases the lifetime health care costs (Barendregt et al., 1997; Van Baal et al., 2008).

There is a trade-off between costs saved related to prevented diseases and additional costs of living longer. For disease prevention to be cost decreasing the short-term savings have to outweigh the long-term cost growth (Goortjans- van Kampen et al., 2014). The degree to which disease prevention saves costs is related to the fatality of the prevented disease. Disease prevention of non-fatal diseases result in lower lifetime health care costs. Contrary, disease prevention of fatal diseases leads to increased longevity at the cost of higher lifetime health care costs (Bonneux et al., 1998; Goortjans- van Kampen et al., 2014).

These findings result in a discrepancy. On the one hand, disease prevention is an intervention to reduce health inequality and could therefore decrease health care costs (Asaria et al., 2016). On the other hand, disease prevention of fatal diseases increases longevity and therefore increases health care costs (Goortjans- van Kampen et al., 2014). Up until now, research on disease prevention has focussed on the effect of disease prevention on total population's health and health care costs without looking at the effects on inequality in health and costs across SES groups (Barendregt et al., 1997; Bonneux et al., 1998; Goortjans- van Kampen et al., 2014; Van Baal et al., 2008). Research on socioeconomic inequality has only focused on the effects of diminishing health inequalities on the inequality in health care costs, but not on the effects of preventing diseases on inequalities in health and health care costs (Asaria et al., 2016; Cookson et al., 2016; Kallestrup-lamb & Marin, 2021).

This study combines both approaches and focusses on the effect of prevention of five disease categories on health and health care spending, for different socioeconomic groups. By differentiating for socioeconomic groups, the researcher was able to conclude on the effect of prevention on inequality in health and health care costs, for specific disease categories. It uses similar approaches to the studies of Goortjans- van Kampen and colleagues (2014) and Asaria and colleagues (2016) using up-to-date data on mortality and hospital care costs from the Netherlands. The effects of disease prevention, for different socioeconomic groups, were estimated by calculating LE and lifetime health care costs (LHC) after elimination of disease-specific mortality and health care costs.

1.1 Reader's guide

The recent developments and current standings regarding both health inequality and disease prevention will be discussed in more detail in the 'Background' section of this thesis. A description on the research methods, data collection and extraction and data analysis are presented in the 'Method' section. Followed by the findings resulting from the analyses performed, which are presented in the 'Results' section. Finally, key findings and their implications, the limitations of this study and the recommendations following this study are assessed in the 'Discussion' section. Supplementary findings, information and concepts are provided in the 'Appendices'.

2.0 Background

First off, background information on basic principles of socioeconomic inequalities and disease prevention is provided. In addition, recent developments and discoveries on socioeconomic inequalities and disease prevention are discussed.

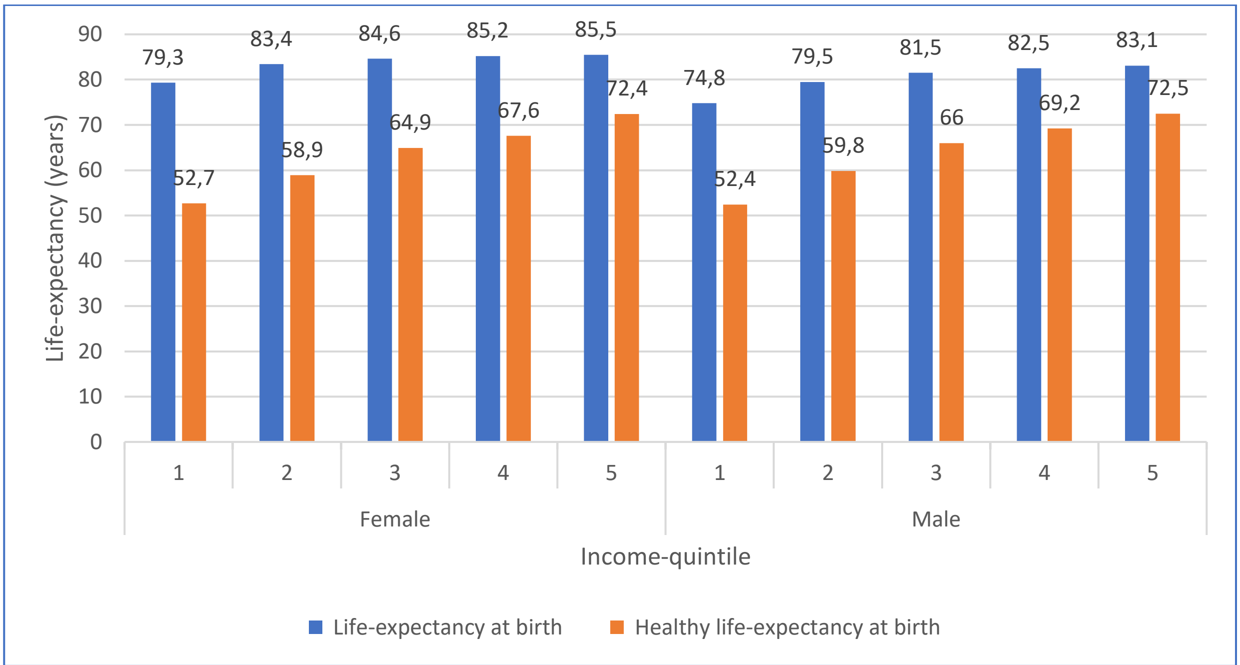
2.1 Socioeconomic inequalities

Countries all over the world are faced with substantial differences in health between socioeconomic groups across countries and within their own population (Michael Marmot, 2005; Murtin et al., 2017; Wagstaff, 2002). Citizens with a lower level of education, a lower social class or a lower level of income are expected to die at younger age, live shorter in optimal health state and face more physical and mental health problems (Johan Mackenbach & de Jong, 2018; JP Mackenbach et al., 1999). Consequently, people from lower socioeconomic groups have higher use of medical services (Van Doorslaer et al., 2000; van Doorslaer & Wagstaff, 1992; Wagstaff et al., 1991).

2.1.1 Inequality in health

The inequality in health is reflected by multiple health outcomes and measurements. In the Netherlands the LE for woman in the lowest income-quintile is 78.8, compared to 85.5 for women in the highest income-quintile. For men, the LE at in the lowest quintile is 73.9, compared to 81.1 for men in the highest income quintile (CBS, 2021b). The differences in healthy LE (expected life years experienced in good health) are even up to 20 years (CBS, 2021b). Figure 1 presents LE and healthy LE for the years 2014-2017 as published by Statistics Netherlands (CBS, 2021b).

Figure 1. *LE at birth and healthy LE in the Netherlands (CBS, 2021b)*



Inequalities in health can be explained by various socioeconomic factors, including living and working conditions (Johan Mackenbach & de Jong, 2018), education (Kreatsoulas & Anand, 2010) , social and psychological factors (Johan Mackenbach & de Jong, 2018), health-related behaviours and healthcare use (Judge et al., 2006; Rosvall et al., 2006). However, evidence for a causal relationship between SES and health has not been substantial. Given the many factors comprised by SES it is challenging to distinguish between the effects of all factors, since most of them interact between themselves. Besides, many other external factors like genetic factors and cognitive ability are likely to cause confounding (Johan Mackenbach & de Jong, 2018).

One of the most concerning problems of health inequalities is that the immoderate health problems of individuals with a lower SES lead to a significant loss in social and economic welfare, both on an individual level as on the population level (Johan Mackenbach & de Jong, 2018). The magnitude of this loss in social and economic welfare is estimated to be €980 billion per year in Europe (JP Mackenbach et al., 2011). This is equal to 9.4% of the Gross Domestic Product (GDP).

2.1.2 Inequality in health care use

People of low SES consume more health care than people of high SES, as a consequence of their lower health status (Cookson et al., 2016). This inequality in health care consumption is reflected by outcomes like health care expenditure. Loef and colleagues (2021) performed a study on Dutch socioeconomic differences in health care expenditure and utilization over the year 2017. They concluded that the health care expenditure of people with a low SES is approximately 50%-150% (depending on age) higher compared to people with a high SES (Loef et al., 2021). Another study was performed by Kelly and colleagues (2016), studying the hospital spending in England over the years 2010-2011 and 2014-2015. They found similar results, but less excessive. They concluded that the most deprived fifth of people have, on average, 15 percent more medical spending than the least deprived fifth of people (Kelly et al., 2016). These higher health care expenses could also be observed when looking at LHC. Asaria and colleagues estimated inpatient lifetime hospital costs of the whole English population by SES, based on data for the year 2011/2012 (Asaria et al., 2016). They found that the most deprived fifth of people of England had approximately 45% more inpatient lifetime hospital costs compared to most affluent fifth of people.

This inequality in health care expenditure and consumption is expected to grow even bigger. In the Netherlands, the increase in health care consumption of citizens of low SES is expected to be higher than for citizens of high SES (Rele & Van der Horst, 2013). This growth in inequality could lead to two potential problems. First, it is a threat for the solidarity of the Dutch health care system (Rele & Van der Horst, 2013; Wouterse et al., 2016). People with high income will have to carry a relative higher economic burden, due to the progressive nature of the Dutch financial health care system (Wouterse et al., 2016). While people with low income will have a relative higher increase in health care expenses and medical use. Secondly, if the Dutch financial health care system would be reformed into a less progressive system. Health care would be financed more from out-of-own pocket spending and higher deductibles. In this scenario, the financial burden from health care expenses as a percentage of income would raise to unpayable levels for people of low SES (Rele & Van der Horst, 2013). This will result into an obstruction for equal access of health care and would not align with the policy goals of the Dutch government, as well as many other governments (Oliver, 2004).

2.2 Disease prevention

2.2.1 Effect on health inequality

Many studies have investigated the causes of death in relation to socioeconomic inequalities in mortality (Howard et al., 2000; Kunst & Groenhof, 1998; Rosvall et al., 2006; Wong et al., 2009). In summary, socioeconomic inequalities in mortality can largely be explained by higher mortality rates in major causes of death like cardiovascular diseases, cancer, diabetes and chronic obstructive pulmonary disease (COPD). Higher morbidity and mortality rates among people with low SES indicate that a part of their health burdens could be prevented or enhanced by public health and health care interventions

(Johan Mackenbach & de Jong, 2018). The OECD estimates that 101 deaths per 100.000 citizens could have been prevented in the Netherlands, in the year 2017 (OECD, 2019). In the Netherlands, the estimated health care costs for diseases caused by smoking, obesity and excessive use of alcohol are €9 billion a year (van Gils et al., 2019). Examples of potential prevention measures to reduce these preventable deaths are restrictions on the disposal of cigarettes, limitations on marketing for alcoholic beverages (VWS, 2018), reducing speed limits in dense populated areas (NICE, 2017) and therapist-guided internet-delivered cognitive behaviour therapy for older adults with symptoms of depression (Titov et al., 2015). Marlies Bär and colleagues found in their research on mortality inequality in the Netherlands, that a decrease in preventable causes of death resulted in lower inequality in mortality (Bär et al., 2021). This indicates the potential positive effect of disease prevention on health and health inequality.

2.2.2 Effect on health care spending

The effect of disease prevention on health care spending is a complex mechanism. Disease prevention decreases disease-related health care costs during middle-ages, but it will increase longevity because disease-related mortality will be prevented. The gained life years are often lived in poorer health, this causes people to use more health care and increases the lifetime health care costs (Goortjans- van Kampen et al., 2014). For disease prevention to be cost decreasing the short-term savings (disease-related costs) have to outweigh the long-term cost (costs of increased longevity) growth.

There are multiple studies that analyse the effect of prevention on health care spending. Barendrecht and colleagues performed a study on the effect of the prevention of smoking on the health care costs for the Netherlands (Barendregt et al., 1997). Van Baal and colleagues performed a similar study on the effect of preventing obesity (Van Baal et al., 2008). Both studies found similar results; Prevention of smoking and obesity would result in major health benefits and it would decrease smoking- and obesity-related costs. However, the non-related costs at older-ages would increase due to longevity. For both, smoking and obesity, the costs of longevity outweigh the disease-related savings.

Goortjans- van Kampen and colleagues aimed to conclude on the differential effects of disease prevention on longevity and lifetime health care costs. They used Dutch mortality and cost data to estimate LE and lifetime health care costs. In total they included 24 different diseases and disease categories and compared the results of elimination of these diseases to the results of the base scenario (all diseases included). They found that the effects of disease prevention on longevity and lifetime health care costs is dependent on the fatality of the disease. Non-fatal diseases have a marginal effect on longevity, but substantially impact annual health care costs. Thereby, resulting in a decrease in lifetime health care costs. Elimination of fatal diseases substantially increases longevity and thereby increases expected annual health care costs at older ages. Lifetime health care costs consequently increase, compared to the base case.

2.2.3 Effect on socioeconomic inequality in lifetime health care use

There are only a few studies that analyse the (potential) effect of prevention on inequality. Asaria and colleagues aimed to measure the costs of socioeconomic inequality to the National Health Service (NHS), by estimating the inpatient lifetime hospital costs of the whole English population by socioeconomic status. They found that the costs of socioeconomic inequality to the NHS was £4.8 billion in 2011/2012 as a result of excess hospital admissions. Following from this, elimination of socioeconomic inequality would spare the NHS £4.8 billion. The study of Asaria and colleagues formed the base for the study of Kallestrup-Lamb & Marin (Kallestrup-lamb & Marin, 2021). They performed a study on the costs of socioeconomic inequality in Denmark, also by estimating lifetime health care costs. They did not only include inpatient hospital costs, but included all health care costs. Kallestrup-

Lamb & Marin (2021) found that differences in lifetime health care spending between socioeconomic groups are only small and insignificant. Socioeconomic differences in average annual health care costs exists across almost all ages, but once accounted for the differences in average lifespan those differences vanished.

3.0 Methods

This chapter discusses the research methods of this study. It is explained how data was gathered, extracted and analysed. This study concludes on two main dependent variables: health and health care costs. These dependent variables are operationalized into life expectancy at birth (health) and lifetime health care costs (health care costs).

First, the research methods of the standard LE and LHC are described. These estimations of LE and LHC included all causes of death. Second, the methods of two simulation scenarios are described. These scenarios were used to indicate the possible effects of increased longevity and decreased health care costs. Tirth, the calculation of cause-deleted LE and LHC are described. Cause-deleted LE and LHC estimated what the LE and LHC would be when a specific disease would be prevented, by complete elimination of all disease-related mortality and health care costs. Forth, the method of comparison between different socioeconomic groups is discussed. Subsequently, the data section describes how income and disease groups were formed, and how relevant data was gathered. To conclude, this chapter discusses the validity and reliability of this study.

3.1 Standard LE and LHC

Standard LE and LHC were calculated to form a base scenario. The outcomes of the base scenario represent the case where no (further) disease prevention measures were taken. This study used, similar to the study of Goortjans- van Kampen and colleagues (2014), life table techniques to calculate the LE. First, the probability that a new-born lives until age *a* was calculated from the annual mortality probabilities in the following manner;

$$S_0^a = \prod_{\mathrm{j=0}}^{\mathrm{a}} (1 - \mathrm{q_a}).$$

Where q_a denotes the mortality probability at age *a*. S_0^a was then used to calculate LE in the following way;

$$LE_0 = \sum_{a=0}^{A} S_0^a$$

This study has calculated lifetime health care costs with a method similar to the study of Asaria et all., (2016). To obtain standard LHC, average annual health care costs at age *a* (h_a) were calculated first. Costs in the last year of life are expected to be higher than in other years of life (Polder et al., 2006). That is why average annual health care costs are a weighted sum of the costs of individuals surviving at age *a* (h_a^s) and individuals dying at age *a* (h_a^d).

$$h_a = q_a h_a^d + (1 - q_a) h_a^s$$

Standard LHC (H_0) were then calculated by the sum of all ages of the multiplication of the average annual costs and the survival probability.

$$H_0 = \sum_{a=0}^{A} S_0^a h_a = \sum_{a=0}^{A} S_0^a [q_a h_a^d + (1 - q_a) h_a^s]$$

Standard LE and LHC were calculated for five income groups individually, based on the income-quintile. This was done by using income-specific mortality probabilities (q_a) and income-specific health care costs (h_a^d and h_a^s). This is explained in more detail under §3.5.

3.2 Simulation scenarios

Two simulation scenarios were calculated to have an indication of the effect of increased longevity and decreased annual health care costs on LHC. To simulate the effect of increased longevity (simulation 1) the standard LHC were calculated using the income-specific annual health care costs (h_a^d and h_a^s), but the mortality probabilities (q_a) of the highest income group were used for all income groups. The highest income group's mortality probabilities cause higher longevity for the lower income groups, while the annual health care costs remain the same for each income group.

To simulate the effect of decreased health care costs (simulation 2) the standard LHC were calculated using the income-specific mortality probabilities (q_a), but the annual health care costs (h_a^d and h_a^s) of the highest income group were used for all income groups. The annual health care costs of the highest income group cause a decrease in annual health care costs for the lower income groups, while the longevity remains the same for each income group.

3.3 Cause-deleted scenarios

To estimate the (potential) effect of disease prevention on LE and LHC, cause-deleted LE and LHC were calculated and compared to the standard LE and LHC. Cause-deleted LE and LHC estimate what the LE and LHC would be when a specific disease would be prevented, by complete elimination of all cause related mortality and health care costs. Although it is almost impossible to eliminate all deaths of a specific disease by prevention, this research assumes that disease prevention will avert all disease related mortality. Therefore, this research will overestimate the effect of disease prevention measures. Nevertheless, mechanisms of disease prevention remain the same, irrelevant to total or partial elimination of mortality. Moreover, this overestimation increases the visibility of disease prevention mechanisms.

Survival probabilities ($S_0^{a,*z}$) and in consequence LE ($LE_{0,*z}$) in the absence of disease *z* were calculated in a similar way as the standard LE. But all disease-specific mortality was eliminated, because the assumption was made that all deaths related to disease *z* were prevented. The annual survival probabilities and the LE in the absence of disease *z* were then calculated in the following way;

$$S_0^{a,*z} = \prod_{\mathrm{j=0}}^{\mathrm{a}} (1 - q_a) - \prod_{\mathrm{j=0}}^{\mathrm{a}} (1 - q_{a,z})$$

$$LE_{0,*z} = \sum_{a=0}^{A} S_0^{a,*z}$$

Where $q_{a,z}$ denotes cause-specific mortality probabilities at age *a* and q_a denotes standard mortality probabilities at age *a*. Similarly, to cause-deleted LE, LHC in the absence of disease *z* were calculated in a similar way as standard LHC. But all disease-specific mortality and health care costs were eliminated. Because the assumption was made that all mortality and health care costs related to disease *z* was prevented. First, average annual health care costs in the absence of disease *z* were calculated in the following manner;

$$h_{a,*z} = q_{a,*z}(h_a^d - h_{a,z}^d) + (1 - q_{a,*z})(h_a^s - h_{a,z}^s)$$

Were $h_a^{d,z}$ and $h_a^{s,z}$ denote annual health care costs of disease *z* for the individuals who die and the individuals who not die at age *a* respectively. $q_{a,*z}$ denotes the mortality probabilities at age *a* in the absence of disease z. At last, the calculation of LHC in the absence of disease *z* was calculated in the following way;

$$H_0^{*z} = \sum_{a=0}^{A} S_0^{a,*z} h_{a,*z} = \sum_{a=0}^{A} S_0^{a,*z} \left[q_{a,*z} h_{a,*z}^{d} + \left(1 - q_{a,*z}\right) h_{a,*z}^{s}\right]$$

3.4 Socioeconomic differences

Due to distinguishing of the effects of disease prevention for different income groups (more information see §3.5), it was possible to compare the effects for low income people with the effects for high income people. This enabled the researcher to conclude on the effects of disease prevention on inequality in health (LE) and health care costs (LHC). The inequality for both was calculated in a different way. First, the level of socioeconomic inequality in health, for each scenario, was calculated with the LE of I5 expressed as a proportion of the LE of I1. A proportion above one means that inequality in health favours I5 (high income). A proportion below one means that inequality in health favours I1 (low income). Second, the level of socioeconomic inequality in LHC, for each scenario, was calculated with the total deviation in LHC for I1 to I4 compared to the LHC of I5. A negative deviation means that the lower income groups have lower LHC than I5, a positive deviation means that lower income groups have higher LHC than I5.

3.5 Data

3.5.1 Income groups

All scenarios were calculated for five socioeconomic groups, based on income. The income groups (I1-I5) were constructed based on the income-quintiles. With income group 1 (I1) representing the households with the lowest 20% of income and income group 5 (I5) representing the households with the highest 20% of income. Income-specific LE and LHC for standard and cause-deleted scenarios were calculated with the use of income-specific mortality probabilities and health care costs. Simulation 1 scenario used income-related health care costs, but used the mortality probabilities of I5 for all income groups. Simulation scenario 2 used income-related mortality probabilities, but used the health care costs of I5 for all income groups. How income-specific data was gathered and/or mutated is described under §3.5.3 and §3.5.4.

3.5.2 Disease groups

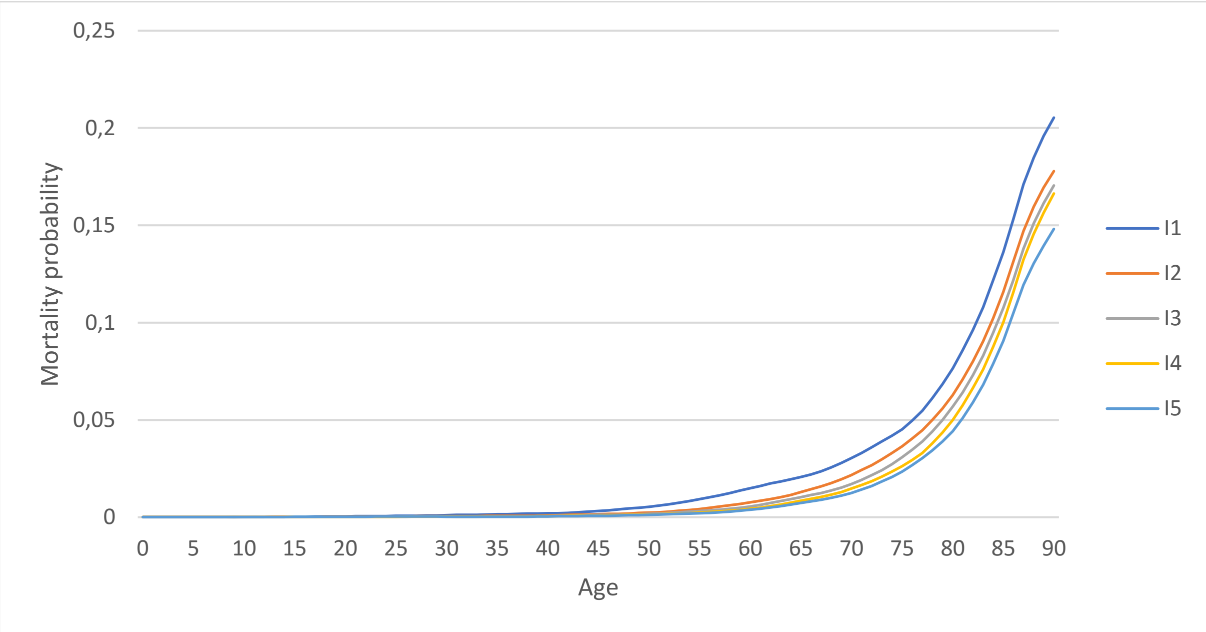
This study includes three fatal and two non-fatal preventable diseases or disease categories. The prevention of fatal diseases seems to have positive influence on LE, while also increasing lifetime health care costs substantially. The influence of prevention of non-fatal diseases on LE is found to be moderate, but it has a positive effect on lifetime health care costs by reducing these costs. (Barendregt et al., 1997; Bonneux et al., 1998; Goortjans- van Kampen et al., 2014; Van Baal et al., 2008). With inclusion of both fatal and non-fatal preventable diseases it is possible to conclude if these different findings are also applicable for different socioeconomic groups.

All included diseases and disease categories were coded following the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), of the World Health Organisation (WHO) (WHO, 2019). The three included preventable diseases and disease categories were lung cancer (ICD-10: C33-C34), ischaemic heart diseases (ICD-10: I20-I25) and chronic lower respiratory diseases (ICD-10: J40-J47). These diseases are among the most preventable causes of mortality according to the OECD (OECD, 2019). The two included non-fatal preventable diseases were mood disorders (ICD-10: F30 & F39) and diabetes (ICD-10: E10-E14). Mood disorders are found to have a major impact on the health care costs according to the research of Goortjans- van Kampen and colleagues (2014). Based on mortality data in the Netherlands diabetes is found to be a disease with high prevalence and low mortality rates. Besides, data on Dutch population's mortality probabilities and health care costs are accessible for these fatal and non-fatal diseases and disease categories.

3.5.3 Data on mortality

Data on income-specific standard and cause-related mortality probabilities (q_a and $q_{a,z}$) was needed to estimate LE. The data was collected from the microdata of the article of Marlies Bär and colleagues (Bär et al., 2021). They estimated age/gender-specific mortality rates by municipal poverty decile on average for the years 2016-2018. The following age groups were followed: 0-4, 5-19, 20-49, 50-64, 65-79 and 80+. In order to construct full life tables, the data had to be converted into single-year mortality probabilities. The r-package 'pspline' was used to fit a polynomial smoothing spline of the data extracted from the article of Marlies Bär and colleagues. This study estimated LE and LHC based on mortality probabilities for the ages 0-90 years. As an example, the smoothed data on mortality probabilities used for the standard scenario are presented in figure 2.

Figure 2. *Standard scenario mortality probabilities*



3.5.4 Data on health care costs

This study focusses only on hospital care costs, because income-specific data on other health care costs (like nursing home facilities) was not attainable at the time of this study. Only medical costs were included, all non-medical costs were excluded. Data on annual heath care costs (h_a^d and h_a^s) and disease-specific annual health care costs ($h_{a,z}^d$ and $h_{a,z}^s$), came from software package PAID 3.0 (Practical Application to Include Disease Costs). PAID is a toolkit that enables researchers to estimate future medical costs by calculating per capita health care costs stratified by disease, age, sex and differentiated by last year of life costs and other years of life costs. PAID was originally constructed from data of the Costs of Illness (COI) study from the Netherlands (van Baal et al., 2011). The original tool has been updated into PAID 3.0, a free accessible web application with data from Dutch COI from 2017 (accessible via https://imta.shinyapps.io/PAID3/). This application enables researchers to select for specific diseases and health care providers.

The data on standard annual health care costs from PAID was not income-specific. In order to estimate the standard LHC, the PAID data on annual health care costs was mutated to become income-specific. This was done by using Dutch data on income-specific annual hospital care spending, obtained from Statline (CBS, 2021a). This data includes all hospital care spending financed in the year 2017, based on data from Vektis. The data was provided for 5-year age intervals and for income-deciles. These deciles where averaged to attain the average spending for income-quintiles. The hospital care spending for each income-quintile was then converted into a proportion of the mean. This resulted in a proportion of hospital care spending for each income group and for each 5-year age interval. The annual health care costs for each income groups, were then multiplied by their related proportion;

$$h_a^d = ph_a^d \ x \ ip_{a,i}$$

$$h_a^s = ph_a^s \ x \ ip_{a,i}$$

Where ph_a^d and ph_a^s denote the annual health care spending of the individuals who not survive at age *a* and the individuals who survive at age *a* as obtained from PAID. $ip_{a,i}$ denotes the income-specific proportion based on the Dutch data on income-specific annual hospital care spending, obtained from Statline (CBS, 2021a). The equation of h_a^d and h_a^s and shows that this study assumes that income interacts the same with costs in the last year of life as it does with costs in other years of life. It may be that that income interacts different with h_a^d than it does with h_a^s. However, this relation is complex and differs per age per and disease. In this research the assumption was made that income interacts the same way with health care costs in the last year of life as in other years of life. To illustrate, figure 3 and figure 4 show the standard annual health care costs (h_a^d and h_a^s), after correction for income.

Figure 3. *Annual health care costs other years of life (h_a^s)*

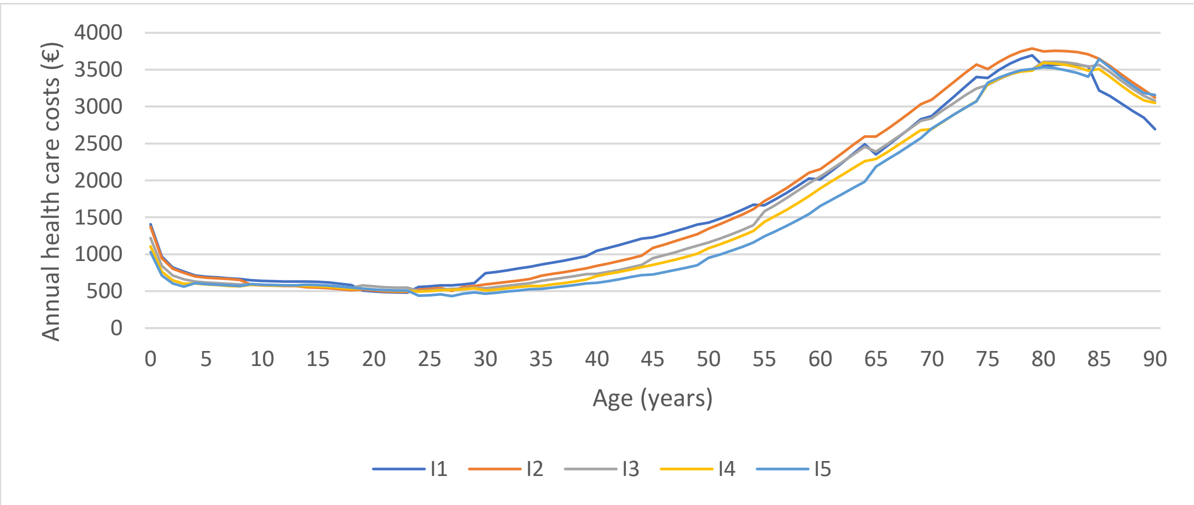
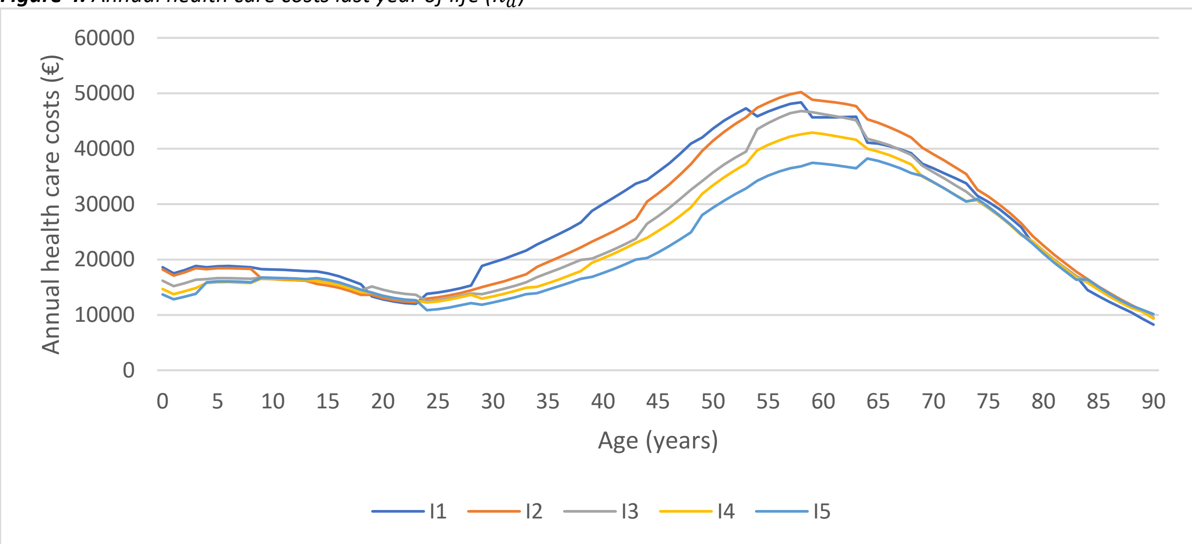


Figure 4. *Annual health care costs last year of life (h_a^d)*



Likewise, PAID data on annual health care costs of a disease had to be converted into income-specific data. This was done by using Dutch income-specific hospitalization data, obtained from Statline (CBS, 2019). This data consists out of the number of hospitalizations per 10.000 citizens for the year 2004, based on the national medical registration (LMR). The data is stratified by gender, 'future public health reconnaissance-diagnoses' (VTV-diagnoses), income-deciles and by 5-year age intervals. Since the VTV-diagnoses are not identical to the ICD-10 diagnoses the following VTV-diagnoses have been selected for the included disease categories: lung cancer (VTV: 2.1.7.), diabetes (VTV: 4.2), mood disorders (5.4.), ischaemic heart diseases (VTV: 7.4), chronic lower respiratory diseases (VTV: 8.5).

Income-delices were averaged to transform the data into data for income-quintiles. The income-specific data on number of hospitalizations was then converted into a proportion from the mean. This resulted in a proportion of hospitalization for each disease, for each income group and for each 5-year age interval. These 5-year interval were then converted into 1-year interval proportions and smoothened, using the r-package: 'pspline'. After smoothening, these proportions still showed very high deviations until the age of 30. This was caused by very low incidence of hospitalizations before the age of 30. To counter these high deviations the annual costs of disease *z* were only applicated from the age of 30 and higher. The annual costs of disease *z*, attained from PAID, were then multiplied by these proportions to attain income-specific annual health care costs of disease *z*;

$$h^d_{a,z} = ph^d_{a,z} \, x \, ip_{a,i,z}$$

$$h^s_{a,z} = ph^s_{a,z} \, x \, ip_{a,i,z}$$

Where $ph^d_{a,z}$ and $ph^s_{a,z}$ denote the annual costs of disease *z* of the individual who not survive at age *a* and the individuals who survive at age *a* as obtained from PAID. $ip_{a,i,z}$ denotes the income-specific proportion based on the Dutch income-specific hospitalization data, obtained from Statline (CBS, 2019). Again, the assumption has been made that income interacts the same way with annual costs of disease *z* for costs in the last year of life as it does with costs in other years of life. To illustrate, figure 5 and figure 6 show the annual health care costs ($h^d_{a,z}$ and $h^s_{a,z}$) of ischaemic heart diseases, after correction for income.

Figure 5. *Annual heath care costs other years of life* ($h^s_{a,z}$)

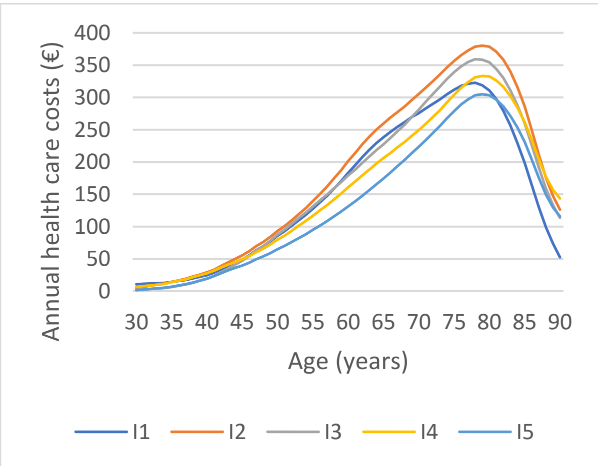
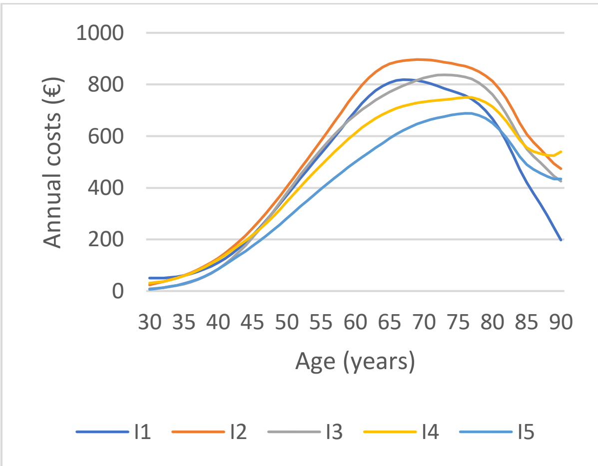


Figure 6. *Annual health care costs last year of life* ($h^d_{a,z}$)



3.6 Validity and reliability

Life table techniques can be distinguished by two types, namely, (i) cohort or generation life table and (ii) current or conventional life table (Lahiri, 2018). In this study conventional life table techniques were used to calculate the effects of disease prevention on inequality in health and health care costs, although cohort life tables are generally speaking more accurate. The data requirements for cohort or generation life table techniques make this method not suitable for this study. This means that data on mortality probabilities from one year were used to predict the Dutch population overall health and lifetime health care costs. Found results on life expectancies are likely to underestimate the actual life expectancy. However, the focus of this study on the effects of disease prevention for the current population make this underestimation irrelevant. Mechanisms and effect of disease prevention for the current Dutch population become visible, independent from the life table techniques used.

The use of life table techniques is heavily dependent on mortality probabilities. Thereby, the reliability of this research is heavily dependent on the accuracy of the data on mortality probabilities. All data on mortality probabilities were obtained from the microdata of the article of Marlies Bär and colleagues (Bär et al., 2021). This data had to be converted into single-year probabilities using using the r-package: 'pspline'. The standard LE resulting from the single-year probabilities have been compared with the calculated LE by Statistics Netherlands. Although the LE found in this study are not equal to those found by statistics Netherlands, they are found to be worthy enough to use in this study.

Income-specific data on the annual health care costs (h_a^d and h_a^s) and annual health care costs for disease z ($h_{a,z}^d$ and $h_{a,z}^s$) was not available. These had to be estimated using proportions $ip_{a,i}$ and $ip_{a,i,z}$. To ensure these proportions were an good estimate, data on income specific annual hospital spending and income-specific hospitalization was used (CBS, 2021a). Preferably data on income-specific annual health care costs would be used. Nevertheless, the use of these proportions is the second-best option for this research to estimate income specific annual health care costs and disease costs.

3.7 Software

All calculations were calculated using RStudio.

4.0 Results

The results in calculated LE and LHC form the base for this chapter. First, the results of the standard scenario is discussed. Following, the results of the two simulation scenarios are described. Third, this chapter describes the results of the cause-deleted scenarios. To conclude this chapter, the results of an additional scenario relevant to the discussion will be elaborated on.

4.1 Standard LE and LHC

To start off with the standard survival probabilities, they are calculated from the mortality probabilities (figure 2) and presented in the standard survival curve in figure 7. This curve shows the survival probability at every age from 0 to 90, for each income group (I1 to I5). Income group one has a strong decline in survival probability from age 50 to age 75. After the age of 75 income group two to five are catching-up and narrow the gap in survival probability until the age of 90. Following, the standard annual average health care costs were calculated by combining the mortality data (figure 2) and annual health care costs of those who survive and those who do not survive (figure 3 and figure 4). The average annual health care costs for the ages 30 to 90 are presented in figure 8. The differences between the income groups for the ages before 30 are negligible. The dark blue line in figure 8 (I1), shows that I1 has the highest annual average health care costs until age 62, at this age I2 becomes the group with the highest annual average health care costs. At the age of 83 all income groups, except I1, have approximately the same annual average health care costs.

Figure 7. *Standard survival curve*

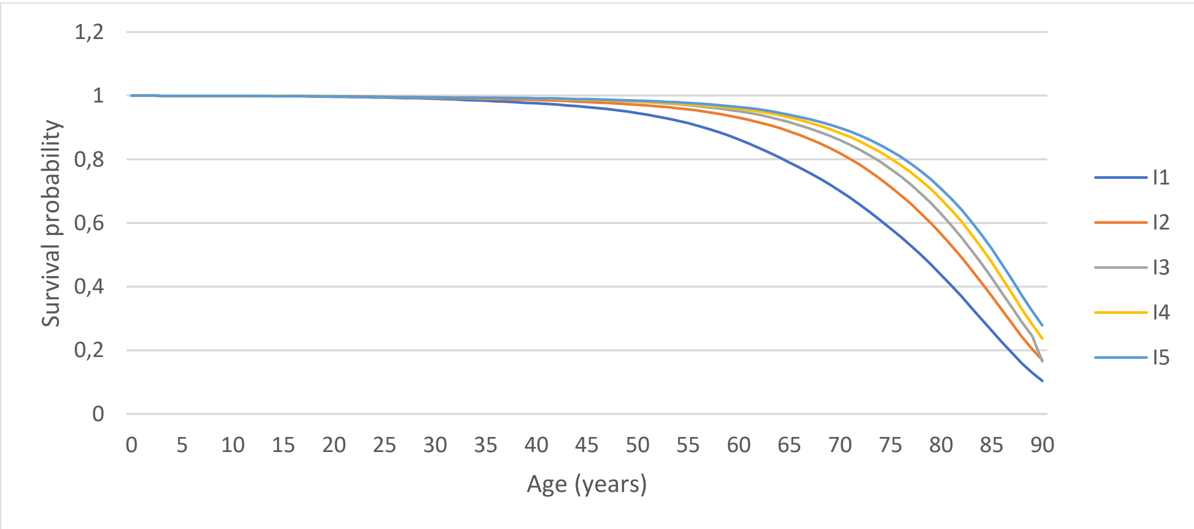
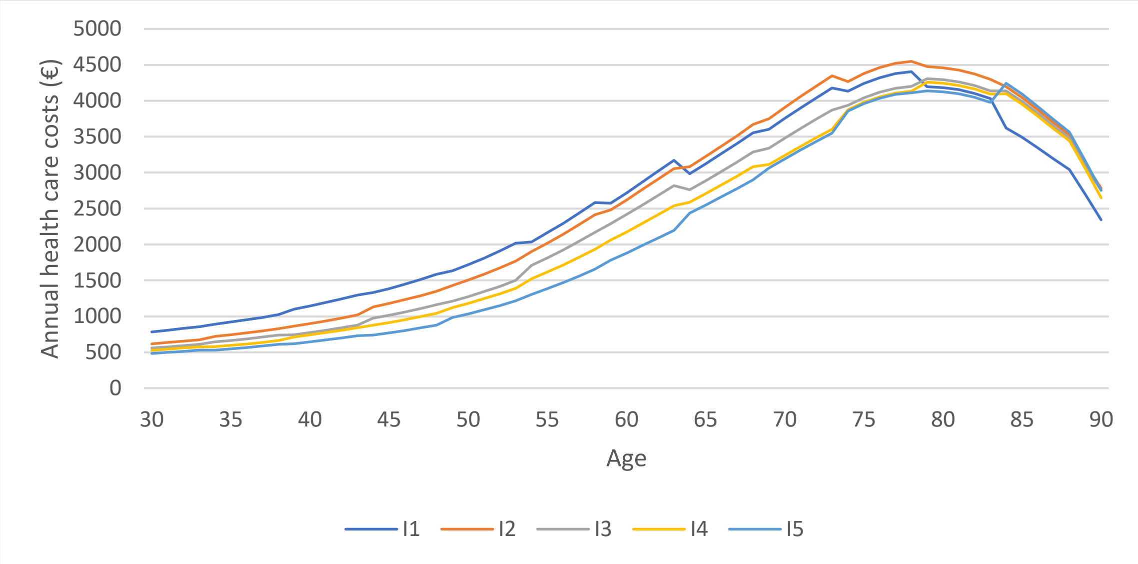


Figure 8. *Standard annual average health care costs*



The survival probabilities were then used to calculate the standard LE, shown in figure 9. The distribution of figure 9 confirms that LE increases with income. The difference between the lowest income group (I1) and the highest income group (I5) is approximately 7.5 years. The difference in LE between I1 and I2 is notably high compared to the difference between the other income groups. This trend is confirmed by the differences between I1 and I2 in the survival curve (figure 7).

The expected annual health care costs were then calculated by multiplying the annual average health care costs with the survival probabilities. The sum of all expected annual health care costs resulted in the standard LHC. These are shown in figure 10. First, a strong negative relation between income and LHC could be observed for I2 to I5. For these income groups, LHC decreases with an increase in income. However, I1 does not follow the same trend. The standard LHC of I1 are substantially lower than I2, I3 and even I4. The dark blue line, representing I1, in the survival curve (figure 7) shows that I1 has very low survival probabilities during relatively expensive ages (65+). This is an effect of relatively low longevity, consequently the LHC are lower. However, this decrease in LHC due to low longevity is not fully compensated by higher average annual health care costs. This could be observed by the dark blue line (I1) in figure 8. It shows that the average annual health care costs of I1 are lower than I2 from the age of 62 and even the lowest of all income groups from the age of 82.

Figure 9*. Standard LE*

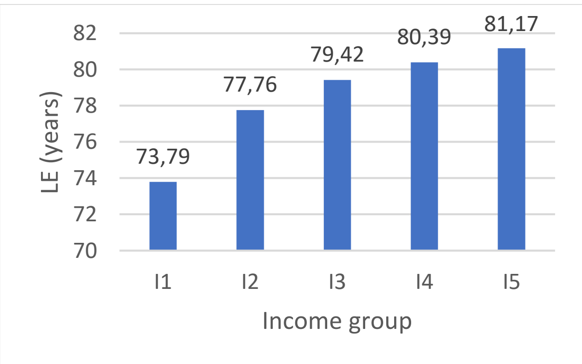
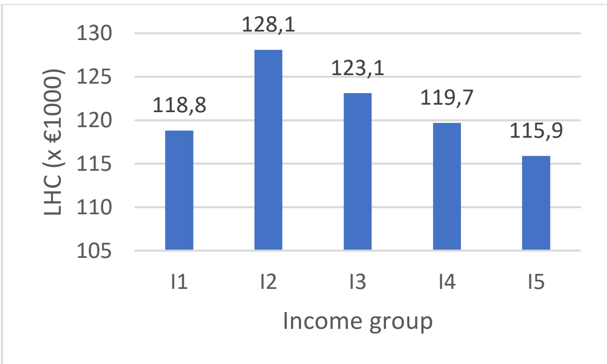


Figure 10*. Standard LHC*

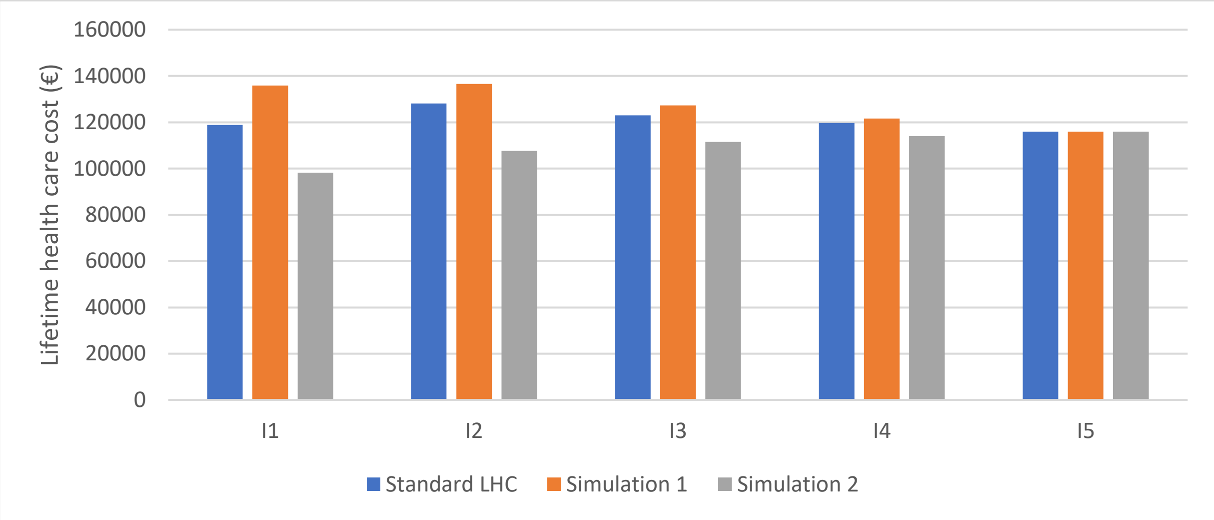


4.2 Simulation scenarios

The standard LHC for all income groups were then used to simulate the effect of an increase in longevity (simulation 1) and a decrease in average health care costs (simulation 2) for I1 to I4. Both simulations are presented in figure 11. Simulation 1 was calculated using income-specific average annual health care costs (h_a^d and h_a^s), but mortality probabilities (q_a) from I5 were used. Simulation 2 was calculated using income-specific mortality probabilities (q_a), but average annual health care costs (h_a^d and h_a^s) from the I5 were used.

Based on simulation 1 can be concluded that an increase in longevity, without any change in average annual health care costs, causes an increase in LHC. Simulation 2 shows that a decrease in average annual health care costs, without any change in longevity, causes a decrease in LHC. Disease prevention includes the effect of both, a decrease in average annual health care costs and an increase in longevity. These simulations confirm that the effect of disease prevention on LHC is dependent on the interaction between both effects.

Figure 11. *Standard LHC and simulations*



4.3 Cause deleted scenarios

Table 2 contains all results in LE for the base scenario (standard LE) and the five scenarios when a single disease is prevented (cause-deleted LE), for all five income groups. Additionally, the table contains the scenario in which all five diseases would be prevented. The table includes all values of, as well as absolute and relative changes in, LE at birth. Subsequently, the LE of I5 is given as a proportion of the LE of I1. This proportion is a measurement to indicate the level of inequality within each scenario.

Taking the standard life tables as a base case, elimination of all diseases increases LE at birth for all income groups. The disease with the highest increase in longevity for all income groups is lung cancer (between +0,58 and +0,94 years from high income to low income respectively). The disease with the lowest (almost none) increase in longevity is mood disorders (between +0,00 and +0,02 years from high income to low income respectively). In the scenario that all five diseases would be prevented, LE increases between 1,09 and 1,82 years (high income to low income respectively).

The changes in LHC after disease elimination are presented in table 3. Elimination of all disease categories would result in lower LHC for all income groups. The disease categories that, after elimination, would decrease LHC the most are ischaemic heart diseases (between €4.700 and €6.800) and diabetes (between €500 and €800). The disease category that, after elimination, would decrease LHC the least is mood disorder (between €0 and €100). These findings will be explained in the discussion.

Based on theory, it would be expected that the high level of increase in longevity (observed in table 2), for fatal-diseases like lung cancer and ischaemic heart disease, would increase the LHC. However, the results in table 3 do not confirm that theory. A closer look at the decomposition (Appendix I) of the costs of longevity gains and the savings of disease costs after disease elimination, shows that the costs of longevity are outweighed by the savings of prevented disease costs. This causes a decrease in LHC after elimination of all disease categories individually.

4.4 Socioeconomic differences

For all diseases (except mood disorders), individually as well as combined, elimination increases in longevity favours the low-income groups. This is reflected by the decrease in inequality proportion for all scenarios, accept mood disorders. Elimination of lung cancer decreases inequality in LE the most and the effect of elimination of mood disorders is negligible. This confirms that elimination of all five diseases decreases inequality in health, except for mood disorders.

The inequality in LHC between the income groups is shown in table 1. Table 1 shows the LHC of I1 to I4, for each scenario, compared to I5. The sum of all inequality for each scenario is shown by 'total inequality'. The column 'total inequality' shows that inequality is decreased for each cause-deleted scenario. However, this decrease can only be observed for I2, I3 and I4. I1 does not show this reduction of inequality in health care costs (except for chronic lower respiratory diseases). It even increases after elimination of ischaemic heart diseases and diabetes. The decomposition tables (Appendix I) show that the increase in costs due to longevity outweigh the disease-related cost savings for ischaemic heart diseases (I1) and diabetes (I1).

***Table 1**. Estimated inequality in LHC (x €1000)*

	I1	*I2*	*I3*	*I4*	*I5**	*Total inequality*
None	2.9	12.2	7.2	3.8	0	26.1
Lung cancer	2.9	12	7	3.7	0	25.6
Diabetes	3	11.9	6.9	3.5	0	25.3
Mood disorders	2.9	12.1	7.1	3.7	0	25.8
ischaemic heart diseases	3.7	10.9	6	2.7	0	23.3
Chronic lower respiratory diseases	2.8	11.7	6.9	3.5	0	24.9

*Comparator group – costs of this groups are (from top – to down (x €1000)): 115.9; 115.9; 115.4; 115.9; 110.4; 115.5.

4.5 Additional scenario

LHC were also calculated for each scenario, using a discount rate of 1.5%. The results of these calculations can be found in table 3. The effects of disease elimination remain largely the same when LHC are calculated using a discount rate. When LHC are discounted for, the negative relationship between income and LHC becomes stronger. The difference between I1 and I2 becomes smaller in all calculated scenarios. This confirms that the difference between I1 and I2 could be explained by I2 having higher costs in the later ages. Because discounting moderates high costs at later ages. Lung cancer, diabetes and chronic lower respiratory diseases still have a decreasing effect on health care costs inequality. However, elimination of ischaemic heart diseases doesn't seem to increase inequality anymore. There doesn't seem to be any effect of elimination of ischaemic heart diseases on LHC inequality anymore.

Table 2. *Life expectancy at birth after disease elimination*

Disease eliminated	*LE at birth / absolute difference /relative difference (I1)*	*LE at birth / absolute difference /relative difference (I2)*	*LE at birth / absolute difference /relative difference (I3)*	*LE at birth / absolute difference /relative difference (I4)*	*LE at birth / absolute difference /relative difference (I5)*	*I5 as a proportion of I1*
None (base)	73,79	77,76	79,42	80,39	81,17	1,100
Lung cancer	74,73 / +0,94 / +1,28%	78,61 / +0,85 / +1,09%	80,09 / +0,67 / +0,85%	80,99 / +0,60 / +0,75%	81,64 / +0,47 / +0,58%	1,092
Diabetes	74,06 / +0,27 / +0,37%	77,90 / +0,14 / +0,18%	79,53 / +0,11 / +0,14%	80,49 / +0,11 / +0,13%	81,25 / +0,07 / +0,09%	1,097
Mood disorders	73,81 / +0,02 / +0,03%	77,77 / +0,01 / +0,01%	79,43 / +0,01 / +0,01%	80,39 / +0,00 / +0,01%	81,18 +0,00 / +0,01%	1,100
Ischaemic heart diseases	74,47 / +0,68 / +0,92%	78,34 / +0,58 / +0,75%	79,93 / +0,51 / +0,65%	80,83 / +0,44 / +0,55%	81,55 / +0,37 / +0,46%	1,095
Chronic lower respiratory diseases	74,31 / +0,51 / +0,69%	78,13 / +0,37 / +0,47%	79,69 / +0,27 / +0,34%	80,57 / +0,18 / +0,23%	81,32 / +0,15 / +0,18%	1,094
All disease prevented	75,61 / +1,82 / +2,46%	79,17 / +1,41 / +1,81%	81,07 / +1,65 / +2,08%	81,77 / +1,38 / +1,72%	82,27 / +1,09 / +1,35%	1,088

Table 3. *Lifetime healthcare costs base and eliminated disease*

Disease eliminated	*Lifetime health care costs (x €1000) / absolute difference / relative difference (I1)*	*Lifetime health care costs (x €1000) / relative difference (I2)*	*Lifetime health care costs (x €1000) / relative difference (I3)*	*Lifetime health care costs (x €1000) / relative difference (I4)*	*Lifetime health care costs (x €1000) / relative difference (I5)*
None (base)	118,8	128,1	123,1	119,7	115,9
Lung cancer	118,8 / -0,0 / -0,03%	127,9 / -0,2 / -0,14%	122,9 / -0,2 / -0,14%	119,6 / -0,1 / -0,06%	115,9/ +0,0 / +0,00%
Diabetes	118,4/ -0,5 / -0,38%	127,3 / -0,8 / -0,59%	122,3 / -0,8 / -0,61%	118,9 / -0,7 / -0,62%	115,4 / -0,5 / -0,46%
Mood disorders	118,8 / -0,0 / -0,03%	128,0 / -0,01 / -0,05%	123,0 / -0,01 / -0,05%	119,6 / -0,0 / -0,04%	115,9 / -0,0 / -0,04%
Ischaemic heart diseases	114,1 / -4,7 / -3,95%	121,3/ -6,8 / -5,30%	116,4 / -6,7 / -5,41%	113,1 / -6,6 / -5,49%	110,4 / -5,8 / -5,42%
Chronic lower respiratory diseases	118,3/ -0,5 / -0,41%	127,2 / -0,9 / -0,72%	122,4/ -0,6 / -0,52%	119,0 / -0,7 / -0,55%	115,5 / -0,04 / -0,34%

Table 4. *Discounted LHC*

Disease eliminated	*Lifetime health care costs (x €1000) / absolute difference / relative difference (I1)*	*Lifetime health care costs (x €1000) / absolute difference / relative difference (I2)*	*Lifetime health care costs (x €1000) / absolute difference / relative difference (I3)*	*Lifetime health care costs (x €1000) / absolute difference / relative difference (I4)*	*Lifetime health care costs (x €1000) / absolute difference / relative difference (I5)*
None (base)	57,1	58,6	55,8	53,6	51,4
Lung cancer	56,8 / -0,3 / -0,50%	58,4 / -0,3 / -0,43%	55,6 / -0,2 / -0,37%	53,4 / -0,1 / -0,28%	51,3 / -0,1 / -0,18%
Diabetes	56,8 / -0,3 / -0,46%	58,3 / -0,3 / -0,60%	55,4 / -0,3 / -0,59%	53,2 / -0,3 / -0,59%	51,7 / -0,2 / -0,43%
Mood disorders	57,1 / -0,0 / -0,04%	58,6 / -0,0 / -0,05%	55,7 / -0,0 / -0,05%	53,6 / -0,0 / -0,04%	51,4 / -0,0 / -0,03%
Ischaemic heart diseases	55,1 / -2,0 / -3,47%	55,9 / -2,7 / -4,61%	53,2 / -2,6 / -4,65%	51,1 / -2,5 / -4,75%	49,2/ -2,2 / -4,32%
Chronic lower respiratory diseases	56,8 / -0,3 / -0,60%	58,2 / -0,4 / -0,72%	55,5 / -0,3 / -0,53%	53,3 / -0,3 / -0,52%	51,2 / -0,2 / -0,34%

5.0 Discussion

This study estimated the effect of disease prevention on LE and LHC for different socioeconomic groups, by elimination of five preventable disease categories. The results of this study show that disease prevention, by elimination of disease-specific mortality and health care costs, increases health and decreases health care costs for all income groups. The distinction between the effect of disease prevention on LHC of fatal and non-fatal diseases, found by Goortjans-van Kampen and colleagues, was not found in this study (Goortjans- van Kampen et al., 2014). Differentiating for different socioeconomic groups made it possible to conclude on the effect of prevention on inequality in health and health care costs for each scenario. Prevention of four out of five (not mood disorders) disease categories would lead to a higher increase in LE for individuals with a low-income than for individuals with a high-income. This concludes that disease prevention decreases socioeconomic inequalities in health. Prevention of all five included disease categories decreases inequalities in health care costs, this could be observed over all income-quintiles except the first income-quintile. However, the effect on inequalities in health care costs for prevention of lung cancer and mood disorders is marginal.

5.1 Limitations

One of the limitations of this study is the use of income as a outcome measurement for SES. Socioeconomic status is determined by a variety of variables, including fortune, income, education, occupation, race, ethnicity, and so on (Cutler et al., 2008). Other studies on socioeconomic inequality often operationalize SES by combining variables like income and education or income and fortune. However, due to a lack in data on education- or fortune-specific mortality rates and health care spending this method was not feasible for this study. The downside of the use of income as a outcome-variable for SES is that it is not very accurate, especially in the determination of the lowest socioeconomic group. For example, it may be the case that retired well educated people have a very low income, these people are wrongful determined to the lowest socioeconomic group. Most likely, these people live under the same circumstances as people within the highest socioeconomic group, and are more likely to live in greater health, and do most likely have lower health care spending. This is reflected in this study by the difference in LHC between I1 and I2 (within both the base and the cause-deleted scenarios). Following this abnormality, it is expected to also be reflected in potential gain in LE as well. However, this is not the case, with the first income-quintile being the group that benefits the most from disease prevention. The costs of these gains in LE are reflected by the higher costs of longevity (Appendix I) and the costs per life year gained (Appendix II) are equal within each cause-deleted scenario, except for mood disorders (because of its marginal effect on LE and LHC). This means that this limitation is more reflected in the annual health care costs than in the mortality probabilities.

A second limitation is that this study only included hospital care costs. Hospital care spending are only a fraction of the total health care costs in the Netherlands. Hospital care expenses were estimated to be a little more than €26 billion of the total of approximately €97 billion spend on health care in the Netherlands in 2017 (CBS, 2017). The exclusion of other care facilities could explain the difference in effect of disease prevention on LHC, compared to other studies on disease prevention (Bonneux et al., 1998; Goortjans- van Kampen et al., 2014). Fatal diseases cause higher hospital care costs, when eliminated these costs will be exterminated. The increase in longevity cause an increase in health care costs in other settings like nursing and residential care facilities, because these costs are at a older age. This is also reflected by the study of Goortjans- van Kampen and colleagues (2014). Where elimination of neoplasms and coronary heart diseases cause a decrease in hospital care spending, but cause a major increase in expenses for nursing and residential care facilities.

Third, this study used conventional life table techniques to determine LE and LHC. With the use of this method the assumption was made that hospital care costs observed in 2017 will remain constant into the future, and that mortality rates in of 2014-2017 can be used to predict survival rates in future years. The attribution of socioeconomic factors are assumed to influence costs in the last year of life the same as costs in other years of life. These assumptions may not hold in practice, but they give a reasonable indication of the relative mechanisms and effects of disease prevention.

Finally, it is important to discuss the level of uncertainty. Several data sources were combined to obtain the needed data for this study, because actual data on e.g. income-specific mortality rates and health care costs was not obtainable. This increases the level of uncertainty of this study. However, the writer of this study feels, that the findings of this study still provide a reasonable indication of the relative mechanisms and effects of disease prevention.

5.2 Recommendations

Disease prevention potentially has a positive effect on the population's health. This effect also reduces socioeconomic inequality in health, by favouring the poor. Disease prevention also reduces lifetime (hospital) health care costs for all incomes and all five included diseases, with a small decrease of inequality in health care spending. However, only hospital care spending are included in this study. The method of this study could be used to study the effects of disease prevention on spending in other health care settings. Studies like this one could change the scope of disease prevention to a potential measure to reduce socioeconomic inequalities in health and health care costs.

The Dutch government shows great interest in disease prevention with the realisation of covenants like the national prevention agreement (VWS, 2018). However, it is important for policymakers to have knowledge on the effects of different types of prevention on health and health care costs. The outcomes of this study enable researchers to make decisions on what preventable disease would have the greatest impact on health, without causing a high increase in health care costs. Secondly, this research shows that policymakers should also take into account the effect of different types of prevention on inequality in health and health care costs. The effects of disease prevention differ per socioeconomic groups and disease prevented. Disease prevention could be seen as an intervention to decrease inequality. This is an important factor, since an increase in inequality could endanger the solidarity of the Dutch health care system (Rele & Van der Horst, 2013; Wouterse et al., 2016). But the effects of prevention on inequality also differ per disease. To conclude, this study estimated the effects of disease prevention by the hypothetical scenario where all mortality and disease-related health care costs would be prevented. A challenge for policymakers is to transfer these conceptual findings into suitable policy measures in practice.

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Appendix I – Decomposition tables

The decomposition of the changes in LHC after disease elimination are shown in table 4 until table 8. Within these tables are for each income-quintile the following variables presented for each income-quintile: the costs of disease *z* and the costs of living longer.

Table 5. *Decomposition table lung cancer in euro's*

Quintile	Costs disease *z*	Costs of living longer
1	2.435	2.394
2	2.462	2.278
3	1.870	1.699
4	1.549	1.476
5	1.164	1.167

Table 6. *Decomposition table diabetes in euro's*

Quintile	Costs disease *z*	Costs of living longer
1	1.109	655
2	1.112	352
3	1.027	273
4	993	256
5	711	180

Table 7. *Decomposition table mood disorders in euro's*

Quintile	Costs disease *z*	Costs of living longer
1	83	46
2	88	19
3	84	18
4	57	10
5	45	2

Table 8. *Decomposition table ischaemic heart diseases in euro's*

Quintile	Costs disease *z*	Costs of living longer
1	6.216	1.520
2	8.131	1.339
3	7.792	1.132
4	7.521	957
5	6.659	825

Table 9. *Decomposition table chronic lower respiratory diseases in euro's*

Quintile	Costs disease *z*	Costs of living longer
1	1.760	1.273
2	1.912	984
3	1.338	695
4	1.120	458
5	766	372

Appendix II – Costs per life year gained

Table 10 to table 14 presents the costs per life year gained. These are calculated by dividing the costs of living longer by the life years gained.

Table 10. *Costs per life year lung cancer*

Quintile	Costs of living longer (€)	Life years gained	Costs per life year (€)
1	2394	0,94	2547
2	2278	0,85	2680
3	1699	0,67	2536
4	1476	0,60	2460
5	1167	0,47	2483

Table 11. *Costs per life year diabetes*

Quintile	Costs of living longer (€)	Life years gained	Costs per life year (€)
1	655	0,27	2425
2	352	0,14	2511
3	273	0,11	2480
4	256	0,11	2326
5	180	0,07	2567

Table 12. *Costs per life year mood disorders*

Quintile	Costs of living longer (€)	Life years gained	Costs per life year(€)
1	46	0,02	2279
2	19	0,01	1902
3	18	0,01	1758
4	10	0	0
5	2	0	0

Table 13. *Costs per life year ischaemic heart diseases*

Quintile	Costs of living longer (€)	Life years gained	Costs per life year (€)
1	1520	0,68	2236
2	1339	0,58	2308
3	1132	0,51	2220
4	957	0,44	2175
5	825	0,37	2230

Table 14. *Costs per life year chronic lower respiratory diseases*

Quintile	Costs of living longer (€)	Life years gained	Costs per life year (€)
1	1273	0,51	2497
2	984	0,37	2659
3	695	0,27	2573
4	458	0,18	2542
5	372	0,15	2483