The influence of smoking on sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in 1950 - 2009

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Abstract

Objective: The aim of this research is to get insight into the sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in the period 1950-2009, and to get insight into the contribution of smoking behavior to these differences. **Methods:** All-cause mortality rates were derived from the Statline database of Statistics Netherlands. Life tables were calculated for people aged 0, 65 and 80 for each year in the period 1950-2009. Non-smoking related mortality rates were derived from lung cancer mortality rates provided by the WHO mortality database using a modified version of the Peto-Lopez-method. Using these non-smoking related mortality rates, life tables were calculated for people aged 0, 65 and 80 for each year in the period 1950-2009. The obtained life expectancy numbers were compared with each other. **Results:** Since 1950, the life expectancy of Dutch women has always been higher than the life expectancy of Dutch men. For people aged 0, the gap increased during the period 1950-1985 and decreased thereafter. For people aged 65, a similar but slightly delayed pattern can be seen. For people aged 80, the life expectancy gap has increased until 1995, and stayed stable thereafter. In 1950, the life expectancy gap between men and women aged 0 was completely attributable to differences in smoking behavior between men and women. The smoking attributable proportion has since declined and was less than 30 percent as of 2009. For people aged 65 in 1950, the life expectancy gap between men and women was explained by smoking by more than 190 percent, meaning that if it was not for smoking behavior, men could expect to live longer than women instead of the other way around. Since 1950, this percentage has decreased till 30.24 percent as of 2009. For people aged 80, the smoking attributable proportion of the life expectancy gap increased until 1975, and decreased thereafter till 38.83 percent as of 2009. **Conclusion:** The life expectancy gap between men and women aged 0, 65 and 80 has increased and decreased over the period 1950-2009, while the contribution of smoking to this gap has decreased for people aged 0 and 65, and has increased and later decreased for people aged 80.

Keywords: Smoking, Life expectancy, Gender, Mortality, The Netherlands.

Table of contents

List of figures

List of tables

1. Introduction

1.1 Background

In the early 1980s, a newborn girl in a developed country could expect to live many years longer than a boy (United Nations, 1988). This was the result of the substantial widening of the sex differential in life expectancy from the 1930s through the early 1970s (Waldron, 1993), and although this trend has stopped and was even reversed in several countries in the late 1970s and early 1980s (United Nations, 1988), the difference is still six years on average for all developed countries as of 2008 (WHO, 2010a).

There have been many research studies done on the underlying causes of this life expectancy gap, and many of these research studies conclude that smoking is one of the most important determinants of the differences in life expectancy between men and women (Waldron, 1986).

However, since most of these research studies have used many different methods and assumptions, it is impossible to make a comparison between the outcomes on a scientific base. Therefore, research on the international differences of the influence of smoking on sex differences in life expectancy over time has been sparse for a long time. For that reason, Peto et al. (1992) developed an indirect method for estimating smoking-related mortality by looking at lung cancer mortality rates, which are widely available for many countries (WHO, 2010b).

Using this method Peto et al. developed, Valkonen and Poppel (1997) did a research on the influence of smoking on sex differences in life expectancy. In their study, they compared the four Nordic countries – Denmark, Finland, Norway and Sweden – and The Netherlands with each other and concluded that the contribution of smoking to sex differences in life expectancy was greatest in The Netherlands. This has led the Dutch government to aim for a decrease in smoking behavior of Dutch citizens (Government of the Netherlands, 2010), which is in line with the intention of the Ministry of Health, Welfare and Sport to improve Dutch health policies in order to maintain a healthy society (Ministry of Health, Welfare and Sport, 2010). However, the research of Valkonen and Poppel dates back to 1997 and only covers the period 1970-1989.

Janssen and Van Wissen (2007) used a modified version of the Peto-Lopez method to obtain the past trends of smoking related and non-smoking related mortality rates in several countries, among which The Netherlands. However, their research does not include the data of the year 2005 and onwards, and it does not provide life expectancy estimates for the old (age 65) and very old (age 80), while other research has shown that sex differences in life expectancy tend to vary for older ages (Deeg et al., 2002; Janssen et al., 2007).

1.2 Objective and research questions

The objective of this research is to get insight into the sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in the period 1950-2009 and into the influence of smoking on these differences.

The following research questions were derived from the research objective mentioned above:

- What are the sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in the period 1950-2009?
- To what extend does smoking contributes to the sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in the period 1950-2009?

1.3 Outline

This paper will continue with a theoretical framework in chapter 2. In section 2.1, numerous relevant theories will be discussed. Thereafter, a review of existing articles will be given in the literature review. In section 2.3, the conceptual model of this research study will be explained, after which the hypotheses derived from the literature review will be given.

Chapter 3 provides an elaboration of the data and methods used in this research. Section 3.1 provides the study design, while section 3.2 covers the operationalization of the concepts mentioned in section 2.3 and section 3.1. In section 3.3, the databases of the WHO, Statistics Netherlands and the American Cancer Society are discussed, as well as the quality of the data in these databases.

The results of this research are provided in chapter 4. In section 4.1 the sex differences in life expectancy are described, while section 4.2 gives an insight into the contribution of smoking on these sex differences.

In chapter 5, a conclusion of the results will be given along with a critical review of the research itself.

2. Theoretical framework

2.1 Theories

There are multiple models and theories available to put smoking behavior and its influence on life expectancy differences into a broader perspective. The five most important theories on this subject are explained below. The theories are complementary, which means they complete each other as opposed to contradicting each other. Furthermore, the theories are ordered in terms of decreasing level of abstraction. Coleman's model, explained in section 2.1.1, is the most abstract model, by which the other models can be put into context. The theory of planned behavior, discussed in section 2.1.5, is the least abstract model. It describes individual behavior at the micro level that has resulted in sex differences in life expectancy (section 2.1.4). These sex differences can be observed within the cigarette epidemic transition (section 2.1.3), which in turn has taken place within phases of the epidemiologic transition (section 2.1.2).

2.1.1 Coleman's model

Coleman (1990) states that the relationship between variables at the macro level can be explained by the relationship between variables at the micro level. Or, to put it differently: each global phenomenon is the result of individual social behavior.

When this concept is applied to the subject of this research, it can be concluded that the sex differences in life expectancy at the macro level can be explained by smoking behavior of individual men and women.

2.1.2 Epidemiologic transition

The epidemiologic transition theory (Omran, 1971) is a multidisciplinary theory at the macro level that states that a modernizing society is subject to several changes regarding sickness and health. Four phases can be distinguished:

1. There is a pre-industrial society where birth and death rates are high and balance each other.
2. The society is developing and the death rates decline drastically as a result of healthier food and better hygiene. The birth rates remain high, making the population grow significantly.
3. The birth rates decline as a result of contraceptive use, urbanization and higher wealth. As a result of this, the population growth is declining.
4. This phase can be characterized by low birth and death rates. In some cases a population decline can be seen as the result of the birth rates not exceeding the replacement level, which means that the women in the society do not have enough babies to compensate for the number of deaths.

The Netherlands has completed phase one, two and three and finds itself at phase four. In this phase, as for life expectancy, infectious diseases play a trivial role compared to someone's behavior, in particular someone's smoking behavior.

2.1.3 Cigarette epidemic

Lopez et al. (1994) introduced a model at the macro level by which the amount of smokers in a (developed) society, as well as the death rates of that same society, can be described over a long period of time in which the smoking prevalence is high. This period of time is called the cigarette epidemic, and can be divided into four following phases:

1. The cigarette epidemic is starting. Less than 15 % of the male population is smoking, compared to 5 to 10 % of the female population. The average person is smoking less than 500 cigarettes per year. During this phase, smoking related diseases are extremely rare and therefore do not have a significant influence on the death rates.
2. The amount of smokers is increasing, in particular among the male population. 50 to 80 % of the male population is smoking. The average cigarette consumption varies between around 1000 and 3000 per year. The average consumption among males is even higher, at around 2000 to 4000. Tobacco control policies are not well developed and there is little education and information about the hazards of smoking, though ten % of the male deaths are caused by tobacco use.
3. As the result of better education and more scientific evidence concerning the hazards of smoking, many smokers tend to quit smoking, among them many middle-aged and older men. Male prevalence declines from 60 % to 40 %, female prevalence declines to 35 %. The average cigarette consumption among males is slightly increasing, though the average cigarette consumption among females is decreasing. The smoking-related deaths are increasing significantly: 25 % of the male deaths and 5 % of the female deaths are caused by tobacco use. Public places and transport areas are smoke-free, yet smoke-free workplaces are not common. By the end of this phase smoking is regarded as socially abnormal behavior.
4. The amount of smokers is slightly decreasing. 35 % of the male population and 30 % of the female population is smoking. The smoking-related deaths are increasing at first due to a delayed effect of the smoking behavior in phases two and three. Workplaces are smoke-free and smokers who tend to quit smoking are supported by the government and foundations.

The Netherlands find itself at phase four. In the last decades, the smoking prevalence, as well as the average cigarette consumption is declining, and public places, transport areas and workplaces are smoke-free by law.

2.1.4 Sex differences in life expectancy

There are several explanations for the life expectancy gap between men and women, all of which can be grouped into the following categories (Kinsella and Gist, 1998):

1. Biological factors.
   These factors are still subject to debate. It has been argued that female hormones lower the risk of getting a heart disease, while male hormones increase them. Furthermore, it has been proposed that male hormones cause risk-taking behavior, especially when it is strengthened by social-structural factors. (Shrestha, 2006)

2. Social structural factors.
   Men are more likely to do risky jobs and heavy physical work, and they suffer on greater levels of social stress related to their social status/work (Case and Deaton, 2003).
3. Behavioral factors.
   Men are more likely to drink alcohol, which directly and indirectly decreases their life expectancy. Men are also more likely to have an unhealthy diet, and are less likely to use health services for prevention of diseases and exercise. However, the most cited behavioral contributor to the life expectancy gap between men and women is their smoking behavior. Men tend to smoke much more than women. (Statistics Canada, 1997)

2.1.5 Theory of planned behavior

The theory of planned behavior (Ajzen, 1991) is a theory at the micro level about the link between attitudes and behavior. It states that individual social behavior can be explained by three variables:

1. Behavioral attitude.
2. Subjective norms.
3. Perceived behavioral control.

The first variable shows whether a person expects a negative or positive outcome as the result of his behavior. The second variable indicates whether a person's social environment is expecting him to do something, or not to do something. The last variable displays whether the person is convinced that he is in control of his own behavior or not. These three variables determine whether a person has the intention to do something, and whether that intention leads to actual behavior.

When the theory of planned behavior is applied to the subject of this research, it can be concluded that at least one of the three variables mentioned above has different values for men and women.

2.2 Literature review

For more than 150 years, Dutch women could expect to live longer than Dutch men. In 1840, the average Dutch man had a life expectancy of 36.1, while the average Dutch woman could expect to live 38.5 years, and this life expectancy gap has since increased for both people aged 0, people aged 65 and people aged 80 (Nusselder and Mackenbach, 2000).

Valkonen and Poppel (1997) calculated that the life expectancy gap between men and women aged 0 was attributable to smoking for 72 percent in 1970-1974, while it was attributable to smoking for 53 percent in 1985-1989. This led to the conclusion that the influence of smoking behavior on sex differences in life expectancy was declining.

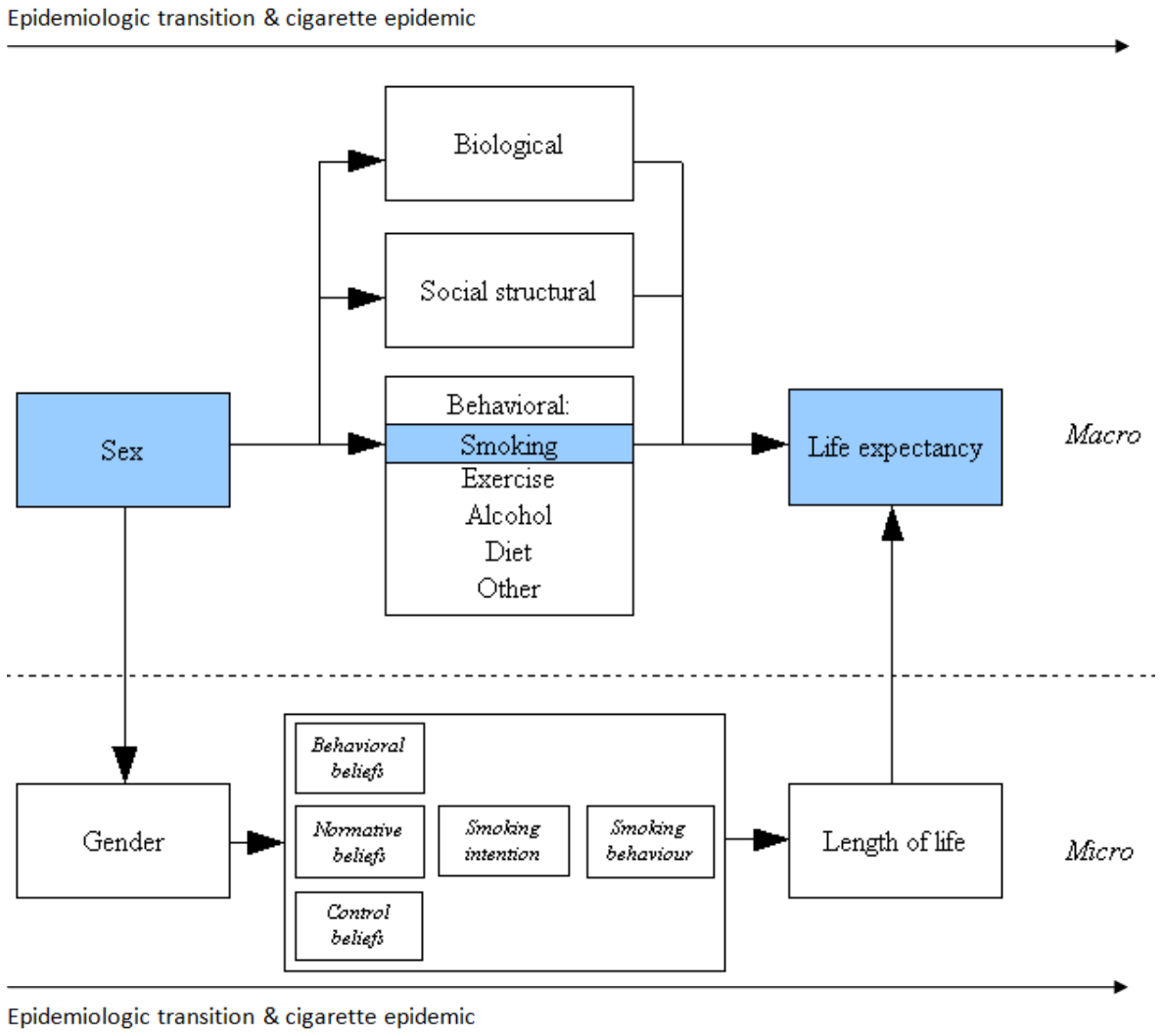
Janssen and Van Wissen (2007) underlined this conclusion, showing that the percentage of male deaths caused by smoking has decreased since 1980, while the percentage of

female deaths caused by smoking has significantly increased since 1970, thus making the life expectancy gap between men and women less attributable by smoking over time.

2.3 Conceptual model

Based on the theoretical framework a conceptual model is created (figure 2.1). The model shows the relationship between sex and life expectancy, both on the macro level and on the micro level. Coleman's model, explained in section 2.1.1, is used to make a distinction between the macro level and the micro level, which are separated by the dotted line. The concepts beneath this dotted line, i.e. the concepts at micro level, are taken from the theory of planned behavior, discussed in section 2.1.5. These concepts are related to the concepts above the dotted line, i.e. the concepts at the macro level. These concepts at the macro level are derived from the theories on sex differences in life expectancy discussed in section 4.1.4. To put it differently: sex differences in life expectancy can be described by biological, social structural and behavioral variables at the macro level, which are influenced by individual behavior at the micro level.

Figure 2.1 Conceptual model



Source: Ajzen (1991), Coleman (1990), Kinsella and Gist (1998), Lopez et al. (1994), Omran (1971)

The arrows at the top and bottom symbolize a change over time, which is described by the epidemiologic transition and the cigarette epidemic discussed in section 4.1.2 respectively section 4.1.3.

The three concepts highlighted in bleu are the major concepts around which this research study revolves, and are defined as follows:

Life expectancy: The average number of years a person can expect to live (WHO, 2010e).

Sex: Either of the two major forms of individuals that occur in many species and that are distinguished respectively as female or male especially on the basis of their reproductive organs and structures (Merriam-Webster, 1998).

Smoking: To smoke tobacco habitually (Merriam-Webster, 1998).

2.4 Hypotheses

As mentioned in section 2.2, Valkonen and Poppel (1997) and Janssen en Van Wissen (2007) have showed that the influence of smoking on the life expectancy gap between men and women has decreased over time. While their studies did not cover the most recent data, and did not focus on the old (age 65) and very old (age 80), it can be assumed that a similar trend can be seen in the most recent years and for the older ages. Therefore, the null hypothesis is as follows:

H_0: The influence of smoking on sex differences in life expectancy at age 0, 65 and 80 in The Netherlands has decreased in the period 1950-2009
H_1: The influence of smoking on sex differences in life expectancy at age 0, 65 and 80 in The Netherlands has not decreased in the period 1950-2009

3. Data and methods

3.1 Study design

To calculate the sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in the period 1950-2009, use will be made of quantitative data analysis methods. First, population numbers by age and sex for the period 1950-2009 will be derived from the Statline database of Statistics Netherlands (Statistics Netherlands, 2010). Secondly, mortality numbers by age and sex for the period 1950-2009 will be obtained from the same database. Thirdly, the obtained numbers will be subdivided into the following age groups: 0-1, 1-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, 70-75, 75-80, 80-85, 85-90, 90-95, 95+. Lastly, a life table will be calculated for each year in the period 1950-2009, using standard life table techniques (Preston et al., 2001), and with the following assumptions:

- The cohort death rates are the same as the period death rates
- Values for ${}_{n}a_{x}$, the average person-years lived in the interval by those dying in the interval, for use below age 5 will be obtained from Coale and Demeny (1983)
- Values for ${}_{n}a_{x}$ for age 5 and onwards are assumed to be 0.5 per year

This will result in the life expectancy numbers for men and women aged 0, 65 and 80 in the Netherlands in the period 1950-2009. These numbers will be compared with each other to get insight into the sex differences in life expectancy over time. Furthermore, the obtained life expectancy numbers will be compared with the life expectancy numbers provided by the Statline database of Statistics Netherlands (Statistics Netherlands, 2010).

To determine the influence of smoking on sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in the period 1950-2009, all-cause mortality rates and non-smoking related mortality rates are needed. To obtain these mortality rates, use will be made of a modified version of the Peto-Lopez method (Peto et al., 1992; Ezzati and Lopez, 2004). This is a quantitative, descriptive, retrospective data analysis method, and will be used as a longitudinal trend study (Babbie, 2007). It uses observed age specific lung cancer mortality rates as an indirect measure of the proportion of the population that was exposed to the fatal health hazards of smoking. The method has been critized in the past (Sterling et al. 1993; Lee, 1996), but after a revision was made (Ezzati and Lopez, 2004) the method seems very reliable (Rostron, 2010). The method is similar to the one used by Janssen and Van Wissen (2007).

The Peto-Lopez method can be divided into five steps (italicized concepts are further explained in section 3.2):

1. Collecting observed age and sex specific lung cancer mortality rates
   The observed age and sex specific *lung cancer mortality rates* will be compared to the *lung cancer mortality rates of smokers and never-smokers* from the second Cancer Prevention Study (CPS II) that was conducted by the American Cancer Society (ACS). Since the Peto-Lopez method ignores all smoking-related deaths

before age 35, it is only necessary to collect the age and sex specific lung cancer mortality rates from age 35 onwards. If not already done, the rates must be transformed to 5-year *age groups* from 35-39 to 75-80 and 80+ to match the data structure of the ACS CPS II study.

2. Calculating the age and sex specific proportions of the population exposed to smoking

The age and sex specific *proportions of the population exposed to smoking* can be calculated by dividing the observed lung cancer mortality rates minus the lung cancer mortality rates of never-smokers in the ACS CPS II study by the lung cancer mortality rates of smokers in the ACS CPS II study minus the smoothed lung cancer mortality rates of never-smokers in the ACS CPS II study. For various reasons, the calculated proportions can be more than 1 or less than 0 (Ezzati and Lopez, 2003). If this is the case, these values will be set to 1 respectively 0.

3. Calculating the age and sex specific relative risks of dying of smoking

The *relative risks of dying of smoking* can be derived from the ACS CPS II study by dividing the all-cause deaths of smokers by the all cause deaths of never-smokers. These relative risks will be smoothed by using regression analysis with age and age squared (Bonneux et al., 2003). However, since smoking behavior is related to various other determinants of mortality (Thun et al., 2000), the excess risks, i.e. the relative risk minus 1, will be reduced by 30 percent (Ezzati and Lopez, 2004). The relative risks are presented in Appendix A.

4. Calculating the age and sex specific etiological fractions, i.e. the proportion of the total mortality caused by smoking

The *etiological fractions* can be calculated by using the formula $EF = p(RR-1)/(p(RR-1)+1)$, where p is the proportion of the population exposed to smoking and RR is the modified relative risk.

5. Calculating the age and sex specific mortality rates caused by smoking

The *smoking-related mortality rates* can be calculated by multiplying the etiological fractions obtained at step four by observed age and sex specific *all-cause mortality rates*.

To determine the influence of smoking on the sex differences in life expectancy over a period of time, three additional steps have to be taken:

6. Calculating the age and sex specific non-smoking related mortality rates

The *non-smoking related mortality rates* can be obtained by subtracting the smoking related mortality rates from the *all-cause mortality rates*.

7. Calculating the life expectancy for all-cause mortality and non-smoking related mortality by sex and age

The *life expectancy* for all-cause mortality and non-smoking related mortality by sex and age can be derived from life tables. These life tables will be calculated using the age and sex specific all-cause mortality rates and non-smoking related mortality rates obtained at step five and six. The life tables will be calculated by using standard life table techniques (Preston et al., 2001), and with the assumptions mentioned earlier.

8. Repeating step one till eight for every year that will be researched

This will result in all-cause and non-smoking related life expectancy numbers for men and women aged 0, 65 and 80 in The Netherlands in the period 1950-2009. These results will be described and interpreted with use of graphs.

3.2 Operationalization

To be able to calculate the sex differences in life expectancy and the influence of smoking on these differences, all the aforementioned concepts are defined beneath in such a way that it is clear how the concepts will be measured.

Age groups: The classification of people of different ages into consecutive groups of equal size. In this research use will be made of the following age groups: 0-1, 1-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, 70-75, 75-80, 80-85, 85-90, 90-95, 95+. The last age group includes all lung cancer mortality above age 94.

All-cause mortality rates by age and sex: The number of male or female deaths in a given age group in a given year divided by the total number of men or women in the same age-group in the same year (Preston et al. 2001).

Etiological fractions by age and sex: The proportion of the total deaths that is attributable to smoking (WHO, 2010f).

Life expectancy: The average number of years a person can expect to live, if in the future they experience the current age-specific mortality rates in the population (WHO, 2010e). This research covers the life expectancy of Dutch men and women aged 0, 65 and 80 during 1950-2009.

Lung cancer mortality rates by age and sex *(observed)*: The number of male or female lung cancer deaths in a given age group in a given year per 100.000 men or women in the same age-group in the same year (Peto et al., 1992). Since the Peto-Lopez method excludes smoking-related deaths before age 35, use will be made of the following age-groups: 35-40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, 70-75, 75-80, 80+. The last age group includes all lung cancer mortality above age 79. The observed lung cancer mortality rates will be derived from the WHO Mortality Database and the Statline database of Statistics Netherlands (Statistics Netherlands, 2010; WHO, 2010b).

Lung cancer mortality rates of smokers by age and sex: The number of male or female deaths among smokers in a given age group in a given year per 100.000 male or female smokers in the same age-group in the same year (Peto et al., 1992). These rates will be derived from the ACS CPS II study.

Lung cancer mortality rates of never-smokers by age and sex: The number of male or female deaths among never-smokers in a given age group in a given year per 100.000 male or female never-smokers in the same age-group in the same year (Peto et al., 1992). These rates will also be derived from the ACS CPS II study.

Non-smoking related mortality rates by age and sex: The all-cause mortality rates multiplied by one minus the etiological fractions by age and sex (Janssen and Van Wissen, 2007).

Proportions of the population exposed to smoking by age and sex: The number of men or women in a given age group in a given year that has been exposed to the health hazards of smoking divided by the total number of men or women in the same age group in the same year (Janssen and Van Wissen, 2007).

Relative risks of dying of smoking by age and sex: The risk of dying as a result of exposure to smoking (WHO, 2010f).

Smoking: Lifelong consumption of about 20 cigarettes per day, with an average tar level of 15 milligram per cigarette (Peto et al., 1992).

Smoking-related mortality rates by age and sex: The mortality rates multiplied by the etiological fractions by age and sex (Janssen and Van Wissen, 2007).

3.4 Data

3.4.1 WHO Mortality Database

The age and sex specific lung cancer mortality rates are derived from the WHO Mortality Database and the Statline database of Statistics Netherlands (Statistics Netherlands, 2010; WHO, 2010b). The WHO Mortality Database contains deaths by country, year, sex and age group and underlying causes of death registered by national statistical offices, following the International Classification of Diseases (WHO, 2010c). This classification method is the international standard diagnostic classification for health research and management purposes (WHO, 2010d). The oldest data in the mortality database dates back to 1950, while the most recent year covered is the year 2008. The data of 2009 will be derived from the Statline database of Statistics Netherlands.

To obtain the age and sex specific lung cancer mortality rates, the original detailed data files will be imported into Microsoft Outlook 2007, and the rates will be selected by using a query (Appendix B).

3.4.2 American Cancer Society Cancer Prevention Study II (ACS CPS II)

The age and sex specific lung cancer mortality rates of smokers and never-smokers and the age and sex specific relative risks of dying of smoking are obtained from the second Cancer Prevention Study that was conducted and funded by the American Cancer Society. This data is presented in the Appendix of the article covering the Peto-Lopez-method (Peto et al., 1992).

3.4.3 Statistics Netherlands

The age and sex specific lung cancer mortality rates of 2009 are derived from the Statline database of Statistics Netherlands (Statistics Netherlands, 2010). Furthermore, life

expectancy estimates will be derived from the database to compare with the calculated life expectancy in this research.

3.4.4 Data quality

The quality of the data in the WHO Mortality Database seems to be relatively high (Mathers et al., 2005). The completeness as well as the coverage of the data is 100 percent, the highest percentage possible. Completeness refers to "the proportion of all deaths that are registered in the population covered by the vital registration system for a country". Coverage refers to "the total number of deaths reported from the vital registration system for a country-year [divided] by the total number of deaths estimated by the WHO for that year for the national population". These estimated deaths are derived from the UN Population Division 2000 revision.

Despite the 100 percent completeness and coverage of the data regarding The Netherlands, 15 percent of the deaths are ill-defined, making the data not entirely reliable. The main reasons for this are "incorrect or systematic biases in diagnosis, incorrect or incomplete death certificates, misinterpretation of ICD rules for selection of the underlying cause, and variations in the use of coding categories for unknown and ill-defined causes." However, this tends to affect comparison between countries – as opposed to comparisons within countries – the most (Mather et al., 2005).

4. Results

4.1 Sex differences in life expectancy

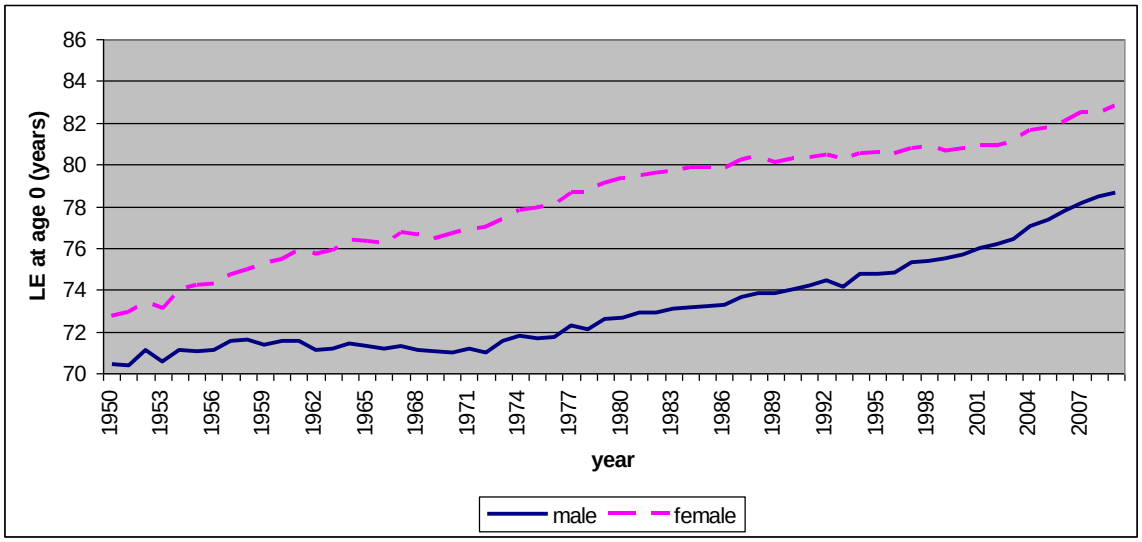
The calculated life expectancy differences are almost similar to the ones provided by Statline (appendix C, D, E). The minor differences between the Statline data and the data presented in section 4.1.1, 4.1.2 and 4.1.3 are due to different assumptions regarding open-ended age intervals, values of ${}_na_x$ (the average person-years live in the interval by those dying in the interval), cohort and period data, and other life expectancy factors.

Since the differences between the Statline data and the calculated data are not significant, the Statline data is left out of the results.

4.1.1 Sex differences in life expectancy at age 0

As figure 4.1 shows, life expectancy of men and women at age 0 has increased over the last 59 years. In 1950, men were expected to live 70.45 years, while women had a life expectancy of 72.73 at birth. In 2009, men could expect to live 78.67 years, while the life expectancy of an average woman was 82.80. However, the life expectancy of women has increased gradually over the years, while the life expectancy of men was more or less stable in the period 1950-1970, and rose quickly thereafter.

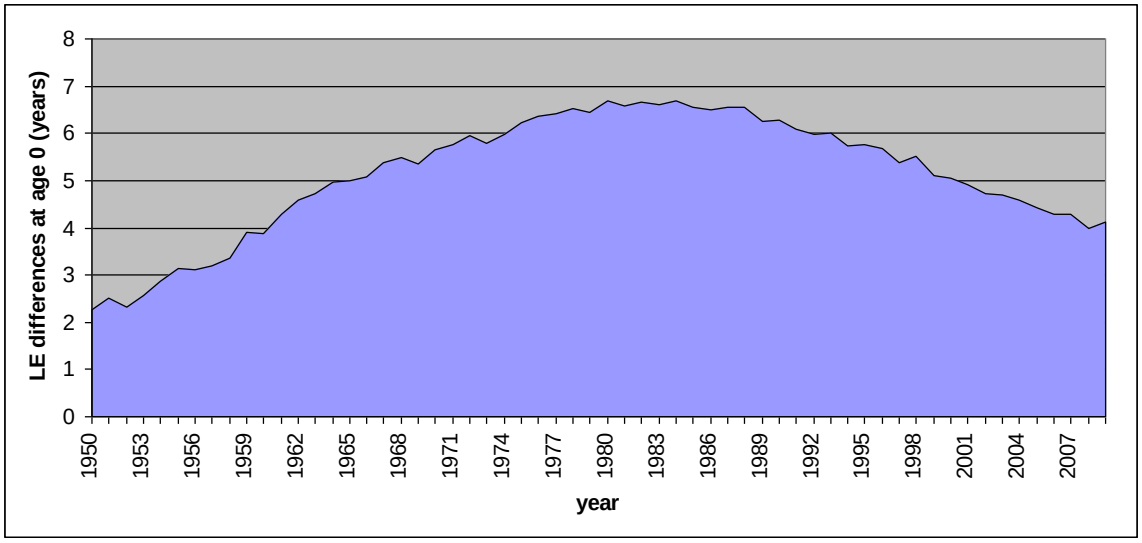
Figure 4.1 Life expectancy at age 0 of males and females in The Netherlands during 1950-2009



Source: Statistics Netherlands (2010), own calculation

Figure 4.2 clearly shows that the life expectancy gap between men and women has increased until 1980s, while decreasing thereafter. The gap was smallest in 1950, when the life expectancy of women was 2.28 years higher than the life expectancy of men. The gap was greatest in 1984, when the average woman lived 6.69 years longer than the average man. As of 2009, the gap is reduced to 4.13 years.

Figure 4.2 Sex differences in life expectancy at age 0 in The Netherlands during 1950-2009

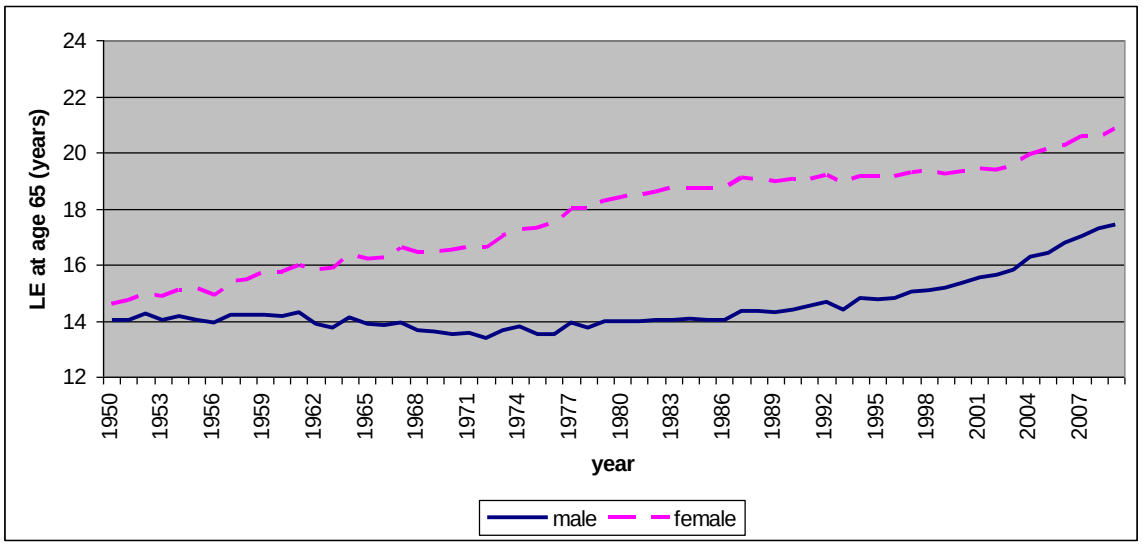


Source: Statistics Netherlands (2010), own calculation

4.1.2 Sex differences in life expectancy at age 65

In 1950, the average Dutch man of age 65 had a life expectancy of 14.02 years, while the average Dutch woman of age 65 could expect to live 14.56 years. The life expectancy of women has since gradually increased to 20.82 as of 2009, while the life expectancy of men has first decreased to 13.38 in 1972, and after that has increased to 17.42 as of 2009 (figure 4.3).

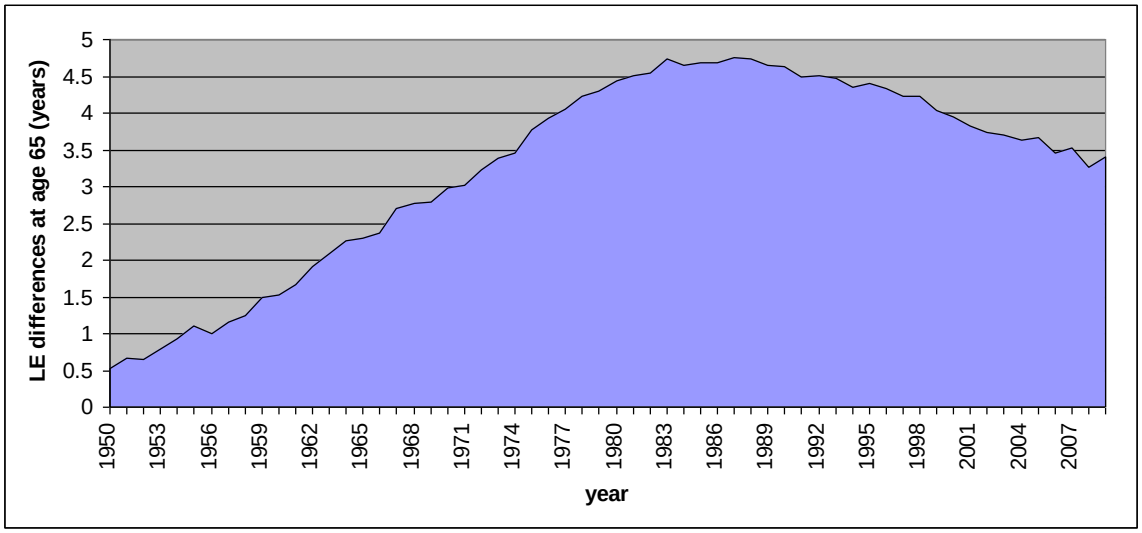
Figure 4.3 Life expectancy at age 65 of males and females in The Netherlands during 1950-2009



Source: Statistics Netherlands (2010), own calculation

The life expectancy gap between men and women at age 65 follows a similar pattern of the life expectancy gap between men and women at age 0: the gap was smallest in 1950, covering only 0.53 years (figure 4.4), and greatest in 1987, covering as much as 4.76 years. Since then, the gap has decreased to 3.40 as of 2009.

Figure 4.4 Sex differences in life expectancy at age 65 in The Netherlands during 1950-2009

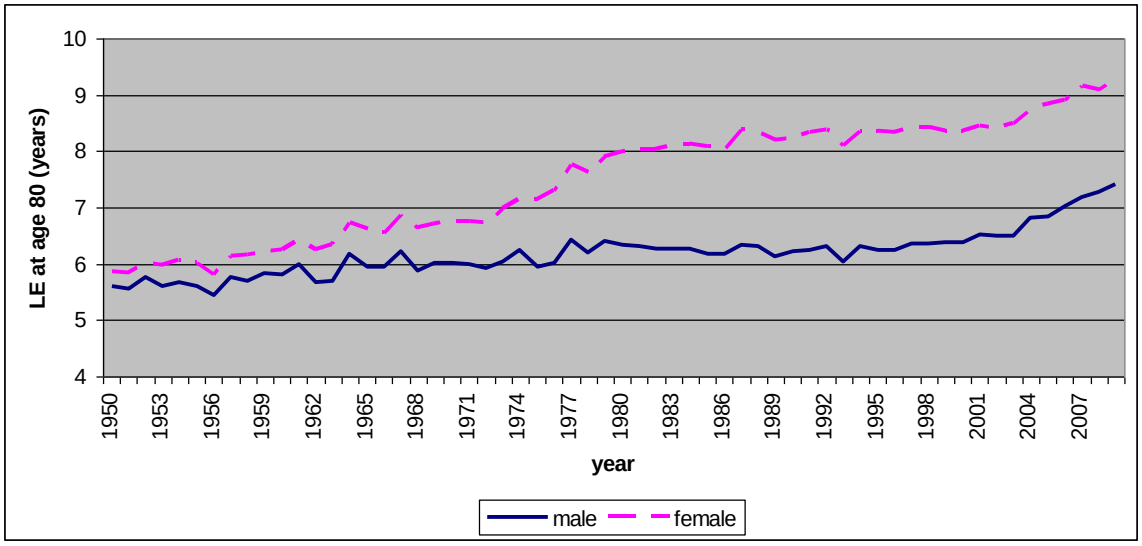


Source: Statistics Netherlands (2010), own calculation

4.1.3 Sex differences in life expectancy at age 80

The life expectancy of men and women aged 80 has increased from 5.61 respectively 5.85 in 1950 to 7.40 respectively 9.29 in 2009. The life expectancy of women aged 80 has increased the most during the period 1970-1980, while the life expectancy of men aged 80 has increased the most during the period 2000-2009. During the period 1980-2000, the life expectancy of both men and women stayed almost stable (figure 4.6).

Figure 4.5 Life expectancy at age 80 of males and females in The Netherlands during 1950-2009

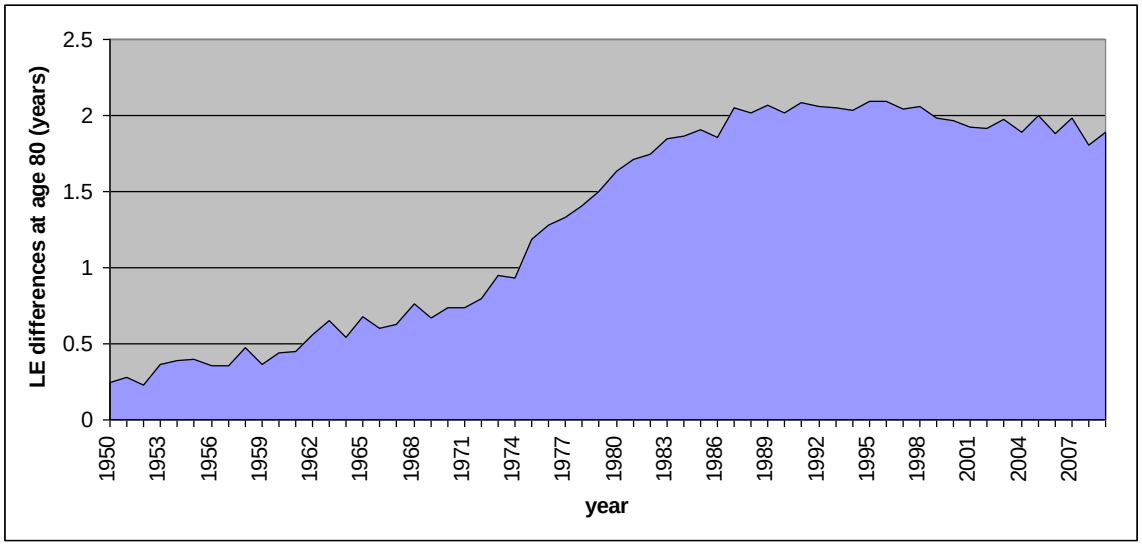


Source: Statistics Netherlands (2010), own calculation

The life expectancy gap between men and women aged 80 has increased significantly over time. In 1950, the gap was less than 0.25 years, while in 1995 the gap has risen to

2.07 years. However, the past decade the trend seems to have reversed, and as of 2009 the life expectancy gap between men and women aged 80 is 1.89 years (figure 4.6).

Figure 4.6 Sex differences in life expectancy at age 80 in The Netherlands during 1950-2009



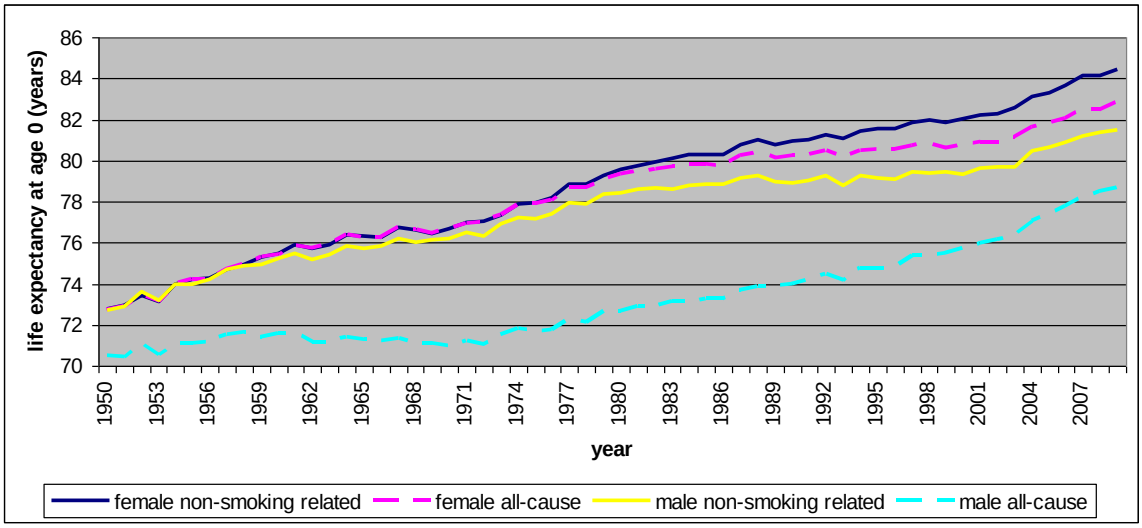
Source: Statistics Netherlands (2010), own calculation

4.2 Influence of smoking to sex differences in life expectancy

4.2.1 Influence of smoking to sex differences in life expectancy at age 0

Figure 4.7 shows the life expectancy of men and women over time based on all-cause mortality, as well as the calculated life expectancy of men and women based on non-smoking related mortality.

Figure 4.7 Life expectancy at age 0 of males and females in The Netherlands during 1950-2009 for all-cause mortality and smoking-related mortality

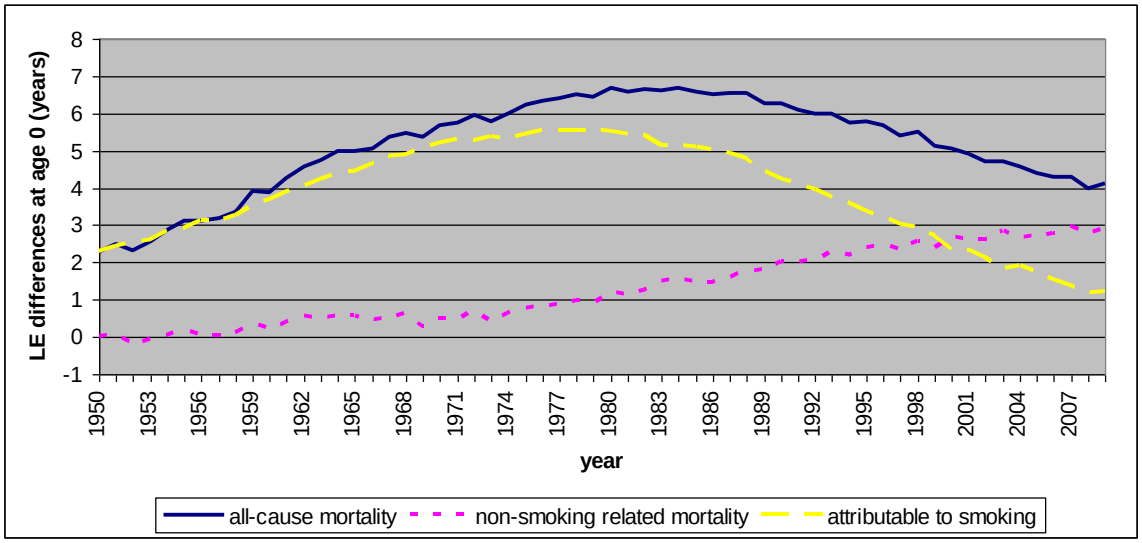


Source: Statistics Netherlands (2010), WHO (2010b), own calculation

Based on non-smoking related mortality, the life expectancy of a male was 72.73 in 1950, and has since increased to 81.50 in 2009. The average woman could expect to live 72.74 in 1950, while her life expectancy in 2009 was 84.43 years. Furthermore, as figures 4.7 illustrates, the difference between the life expectancy based on all-cause mortality, and the life expectancy based on smoking-related mortality has always been far greater for men than for women.

As stated in section 4.1.1, the life expectancy gap between men and women has increased till the 1980s, and decreased thereafter. In contrast to this, the life expectancy gap between men and women based on non-smoking related mortality has increased gradually since 1950 till 2009 (figure 4.8).

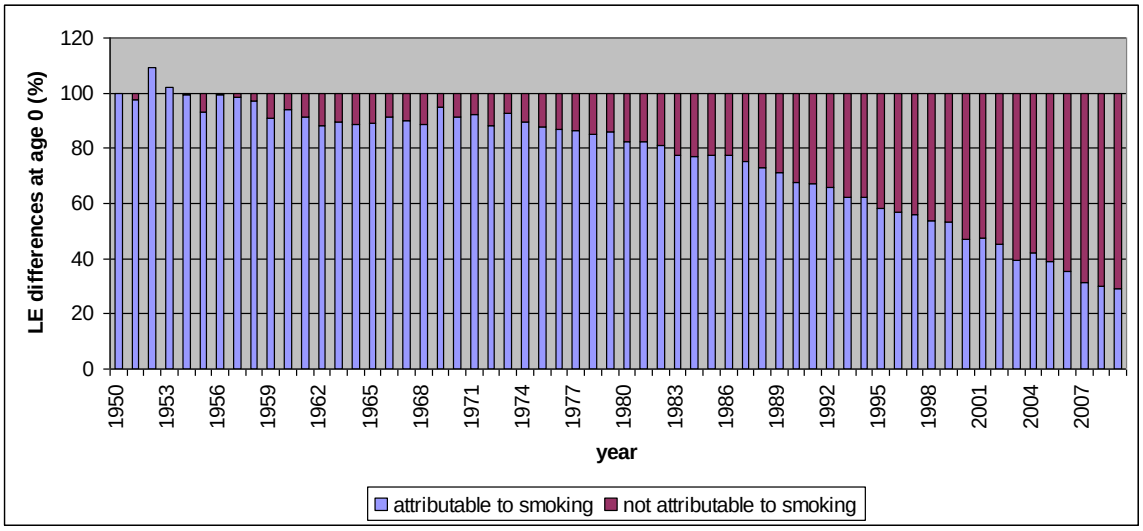
Figure 4.8 Sex differences in life expectancy at age 0 in The Netherlands during 1950-2009 for all-cause mortality and non-smoking related mortality



Source: Statistics Netherlands (2010), WHO (2010b), own calculation

Since the life expectancy gap between men and women based on non-smoking related mortality has increased over time, the contribution of smoking to life expectancy differences between men and women has decreased (figure 4.9). In 1950, 99.67 percent of this life expectancy gap was explained by smoking behavior, while as of 2009 only 29.06 percent of the gap could be explained by smoking behavior. In 1952, even 109.43 percent of the gap was due to smoking, meaning that if it was not for smoking behavior, the average man could expect to live longer than the average woman.

Figure 4.9 Contribution of smoking to sex differences in life expectancy at age 0 in The Netherlands during 1950-2009

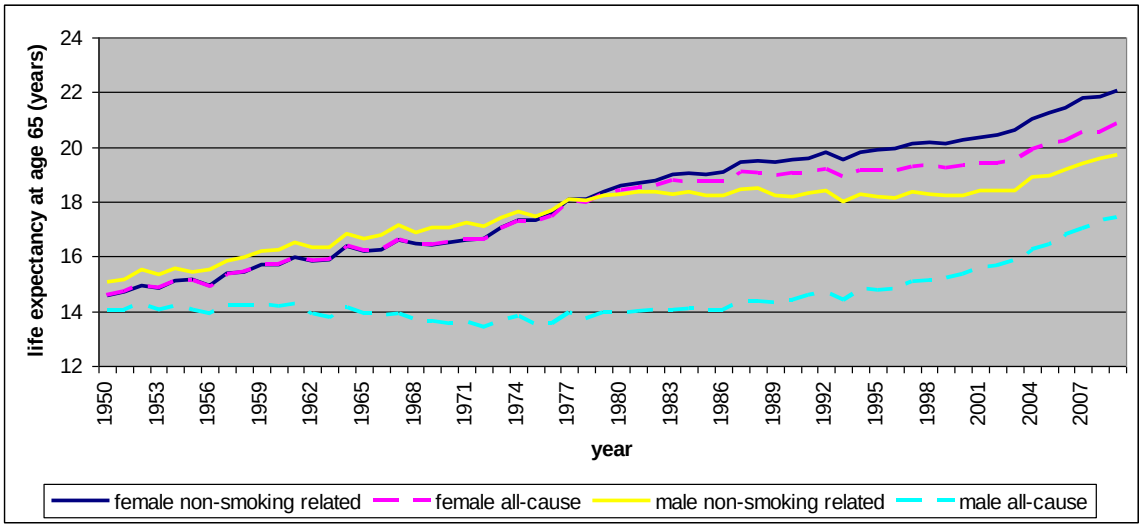


Source: Statistics Netherlands (2010), WHO (2010b), own calculation

4.2.2 Influence of smoking to sex differences in life expectancy at age 65

The life expectancy of men and women aged 65 based on non-smoking related mortality has significantly increased over the last 59 years (figure 4.10). Until 1978, the life expectancy of men was higher than the life expectancy of women. After that, the life expectancy of women rose to 22.08 years in 2009, while the life expectancy of men rose to 19.71 years.

Figure 4.10 Life expectancy at age 65 of males and females in The Netherlands during 1950-2009 for all-cause mortality and smoking-related mortality

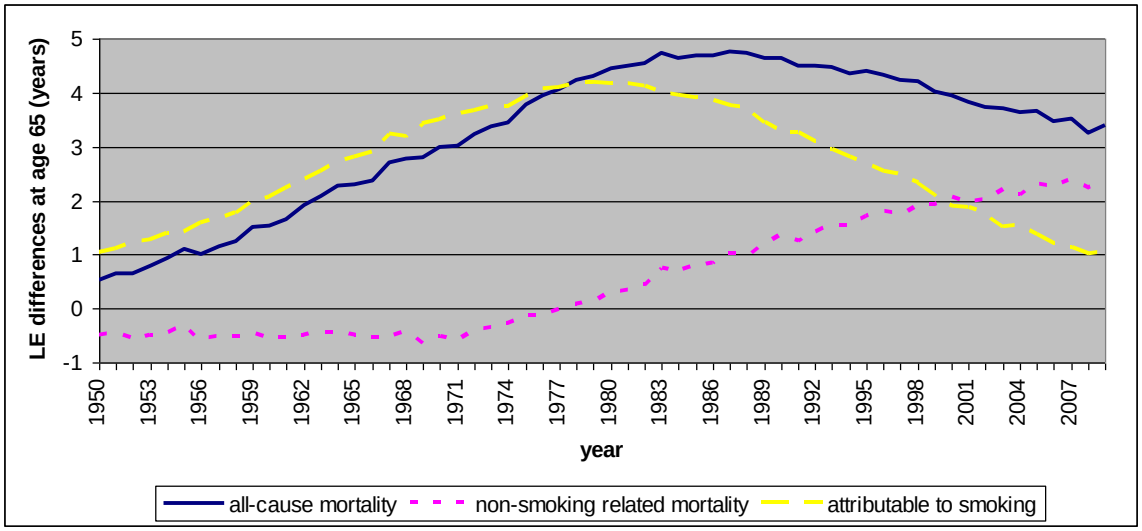


Source: Statistics Netherlands (2010), WHO (2010b), own calculation

As figure 4.10 illustrates, the average man aged 65 lost many life years due to smoking behavior in the period 1950-2009, while the average women lost almost no life years in the period 1950-1980, and less than half of men in the period 1980-2009.

While the life expectancy gap between men and women aged 65 increased and decreased over the years, the life expectancy gap between men and women aged 65 based on non-smoking related mortality was stable until 1972, after which it increased up till 2009 (figure 4.11).

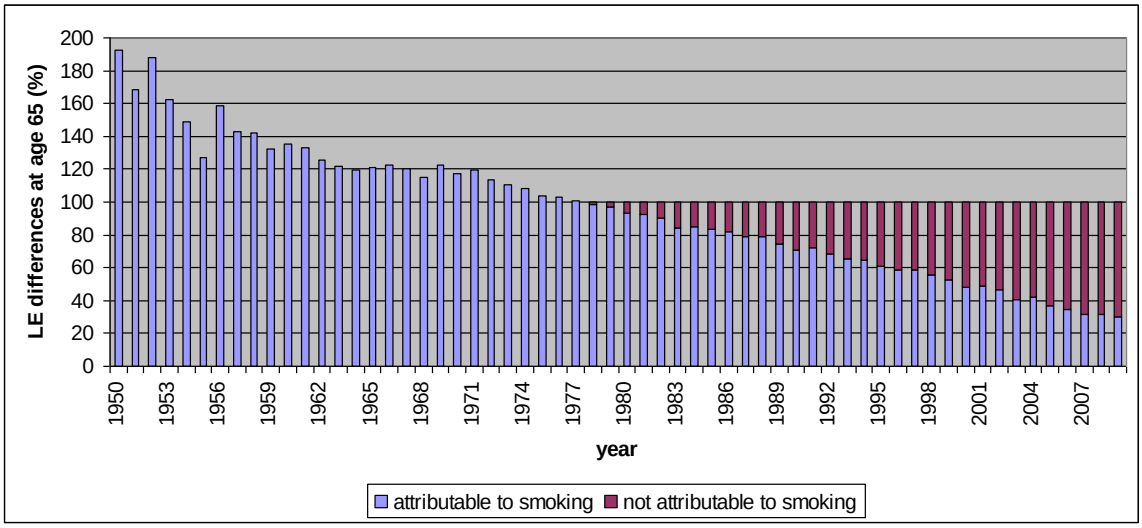
Figure 4.11 Sex differences in life expectancy at age 65 in The Netherlands during 1950-2009 for all-cause mortality and non-smoking related mortality



Source: Statistics Netherlands (2010), WHO (2010b), own calculation

As a result of the increasing life expectancy gap between men and women aged 65 based on non-smoking related mortality, the life expectancy gap between men and women cannot be fully explained by smoking behavior anymore as of 2009 (figure 4.12).

Figure 4.12 Contribution of smoking to sex differences in life expectancy at age 65 in The Netherlands during 1950-2009



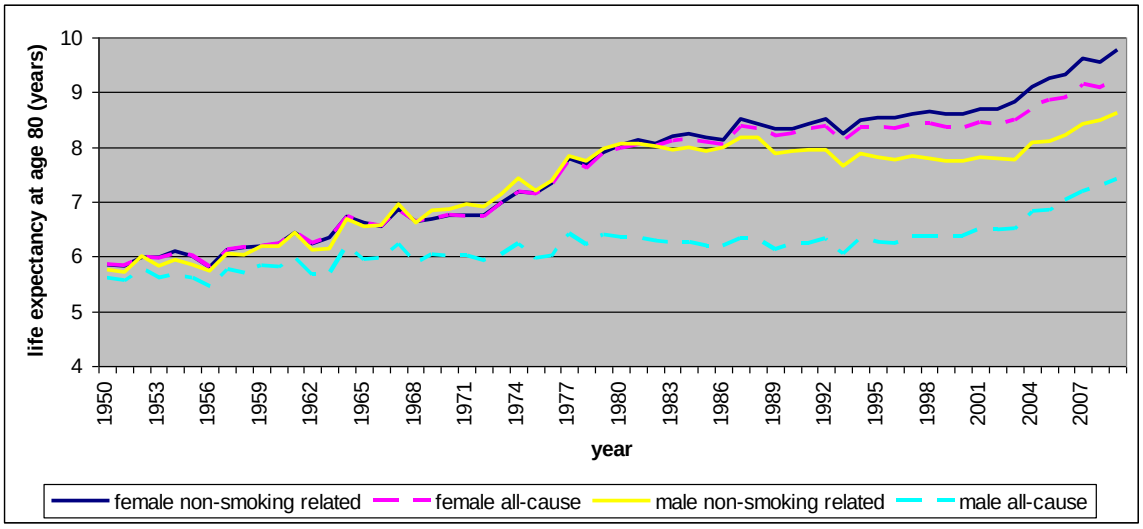
Source: Statistics Netherlands (2010), WHO (2010b), own calculation

While the gap was explained by smoking behavior for 192.21 percent in 1950 – meaning that the gap would have been reversed if it was not for smoking behavior – by 2009, smoking behavior explained 30.24 percent of the gap.

4.2.3 Influence of smoking to sex differences in life expectancy at age 80

The life expectancy of females aged 80 based on non-smoking related mortality has increased since 1950, starting at 5.85 years and ending in 9.76 years in 2009. The life expectancy of males aged 80 based on non-smoking related mortality has increased as well, from 5.76 years in 1950 till 8.18 in 1987, but after that it has declined to 7.76 in 2003, after which it increased again (figure 4.13).

Figure 4.13 Life expectancy at age 80 of males and females in The Netherlands during 1950-2009 for all-cause mortality and smoking-related mortality

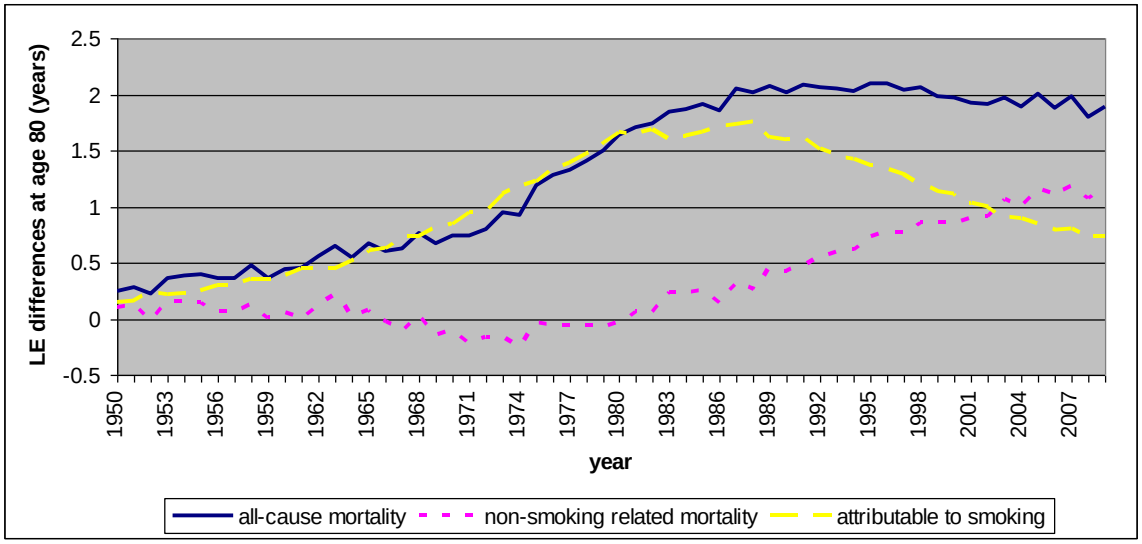


Source: Statistics Netherlands (2010), WHO (2010b), own calculation

Just as men aged 0 and men aged 65, men aged 80 lost many life years due to smoking, while women aged 80 almost lost none till 1980, and lost less than half of men till 2009 (figure 4.13). While men tend to lose less years since 1990, women tend to lose more since 1950 up until 2009.

While the life expectancy gap between men and women aged 80 has increased till 1990 and then stabilized, the life expectancy gap between men and women based on non-smoking related mortality has declined till 1974 – when, based on non-smoking related mortality, the life expectancy of men was higher than the life expectancy of women – and increased significantly thereafter (figure 4.14).

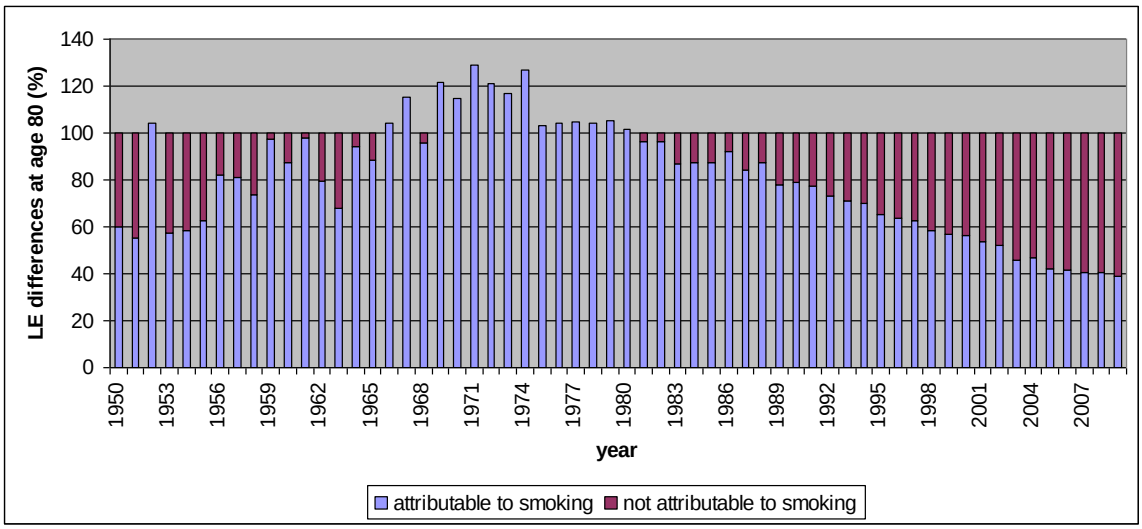
Figure 4.14 Sex differences in life expectancy at age 80 in The Netherlands during 1950-2009 for all-cause mortality and non-smoking related mortality



Source: Statistics Netherlands (2010), WHO (2010b), own calculation

The decrease and increase of the life expectancy gap between men and women based on non-smoking related mortality has resulted in an increasing and decreasing smoking attributable proportion of the life expectancy gap between men and women aged 80 (figure 4.15). In 1950, 60.02 percent of the life expectancy gap between men and women aged 80 could be explained by smoking behavior. In 1971, that percentage has rose to 128.71 – meaning that, based on non-smoking related mortality, men could expect to live longer than women – but as of 2009, the percentage had declined to 38.83.

Figure 4.15 Contribution of smoking to sex differences in life expectancy at age 80 in The Netherlands during 1950-2009



Source: Statistics Netherlands (2010), WHO (2010b), own calculation

5. Conclusion and discussion

5.1 Conclusion

The main goal of this research was to get insight into the sex differences in life expectancy at age 0, 65 and 80 in The Netherlands in the period 1950, and to get insight into the contribution of smoking to these differences.

Since 1950, the life expectancy of Dutch women has always been higher than the life expectancy of Dutch men. For people aged 0, the gap increased during the period 1950-1985 and decreased thereafter, covering 4.13 years as of 2009. For people aged 65, a similar but slightly delayed pattern can be seen, where the gap decreased from 4.76 years in 1987 to 3.40 years in 2009. For people aged 80, the life expectancy gap has increased until 1995, and has yet to decrease, covering around 2 years since 1995.

In 1950, the life expectancy gap between men and women aged 0 was completely attributable to differences in smoking behavior between men and women. The smoking attributable proportion has since declined and was less than 30 percent as of 2009. This is in line with the hypotheses mentioned in section 2.4.

For people aged 65 in 1950, the life expectancy gap between men and women was explained by smoking by more than 190 percent, meaning that if it was not for smoking behavior, men could expect to live longer than women instead of the other way around. Since 1950, this percentage has decreased till 30.24 percent as of 2009. This too was in line with the expectations.

For people aged 80, the smoking attributable proportion of the life expectancy gap increased until 1975, and decreased thereafter. As of 2009, 38.83 percent of the life expectancy gap between men and women was attributable to smoking behavior. The increasing attributable proportion until 1975 was not foreseen in the theoretical framework.

5.2 Discussion

This research has presented an overview of the life expectancy gap between Dutch men and women over time at various ages, and an overview of the contribution of smoking behavior to this life expectancy gap. To get more insight into this topic, further research needs to be done about the underlying causes of the increasing and decreasing life expectancy gaps at the micro level. Furthermore, similar research needs to be done about other (western) countries, so that the results can be compared with each other.

This research has made use of a modified version of the indirect Peto-Lopez-method, which is based on various assumptions. Although the method seemed reliable and accurate when it was compared to other methods and observations, it is recommended that the method will be further tested in the future to make sure that the assumptions based on the past can be applied to future research studies as well.

Based on the results, policymakers are recommended to shift their focus from smoking-related mortality to non-smoking related mortality when they try to narrow the life expectancy gap between men and women. Especially for people aged 0 and 65, the life expectancy gap is increasingly attributable to factors other than smoking behavior.

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Appendix A: Relative risks

Table A.1 Relative risks of dying of smoking

RR ACP CPS-II		RR after regression analysis		RR reduced by 30 %	
Male	Female	Male	Female	Male	Female
2,370787	1	2,602175	1	2,121522	1
3,38	1	2,848269	1	2,293788	1
2,654321	1,711268	3,005618	1,607199	2,403933	1,425039
3,088496	1,952128	3,074224	2,019341	2,451957	1,713539
3,239437	2,306897	3,054085	2,278215	2,43786	1,894751
2,746606	2,322275	2,945202	2,383822	2,361642	1,968675
2,714154	2,366864	2,747576	2,33616	2,223303	1,935312
2,504197	2,118457	2,461205	2,135231	2,022843	1,794662
2,170091	1,834369	2,086089	1,781034	1,760263	1,546724
1,578585	1,244104	1,62223	1,273569	1,435561	1,191498

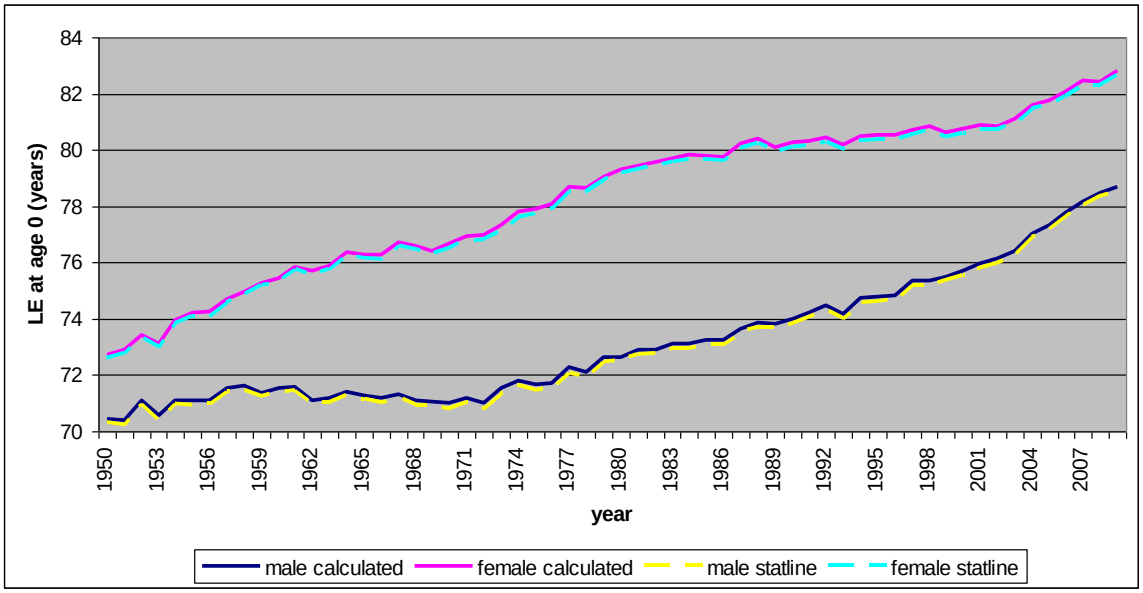
Source: Peto et al. (1992), own calculation

Appendix B: Query to select lung cancer mortality

```
SELECT Mortality.* FROM Mortality WHERE
(
        (country=4210)
        AND
        (
                ((List="07A") AND (Cause="A050"))
                OR
                ((List="08A") AND (Cause="A051"))
                OR
                ((List="09B") AND (Cause="B101"))
                OR
                ((List="10M") AND (Cause="C33" OR Cause="C340" OR Cause="C341"
                OR Cause="C342" OR Cause="C343" OR Cause="C348" OR
                Cause="C349"))
                OR
                ((List="104") AND (Cause="C33" OR Cause="C340" OR Cause="C341"
                OR Cause="C342" OR Cause="C343" OR Cause="C348" OR
                Cause="C349"))
        )
);
```

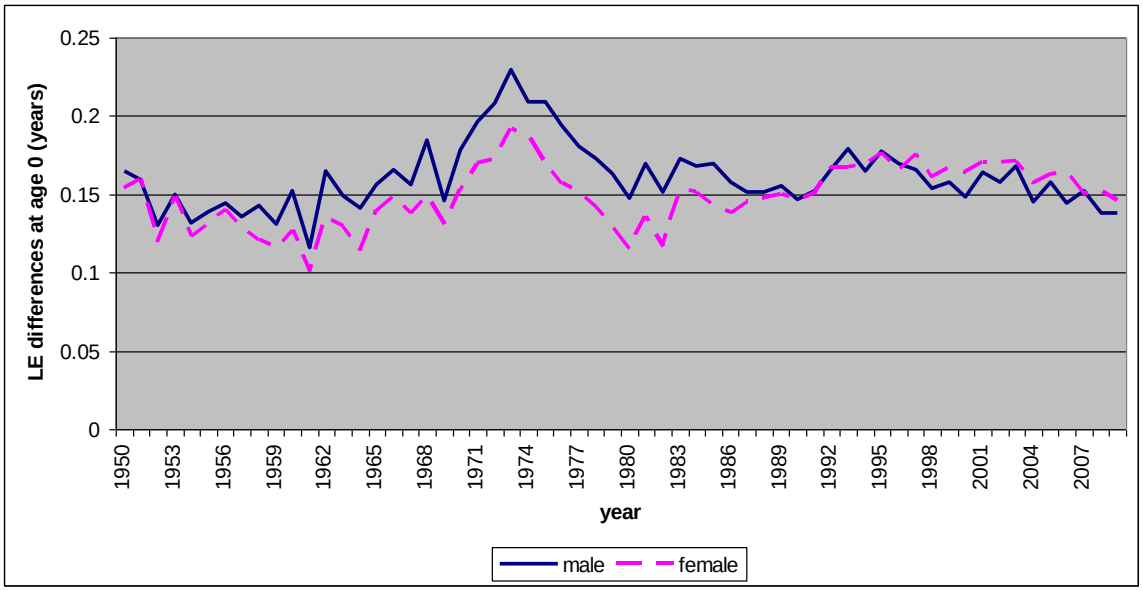
Appendix C: Data differences, life expectancy at age 0

Figure C.1 Life expectancy at age 0 of males and females in The Netherlands during 1950-2009, Statline data and own calculation



Source: Statistics Netherlands (2010), own calculation

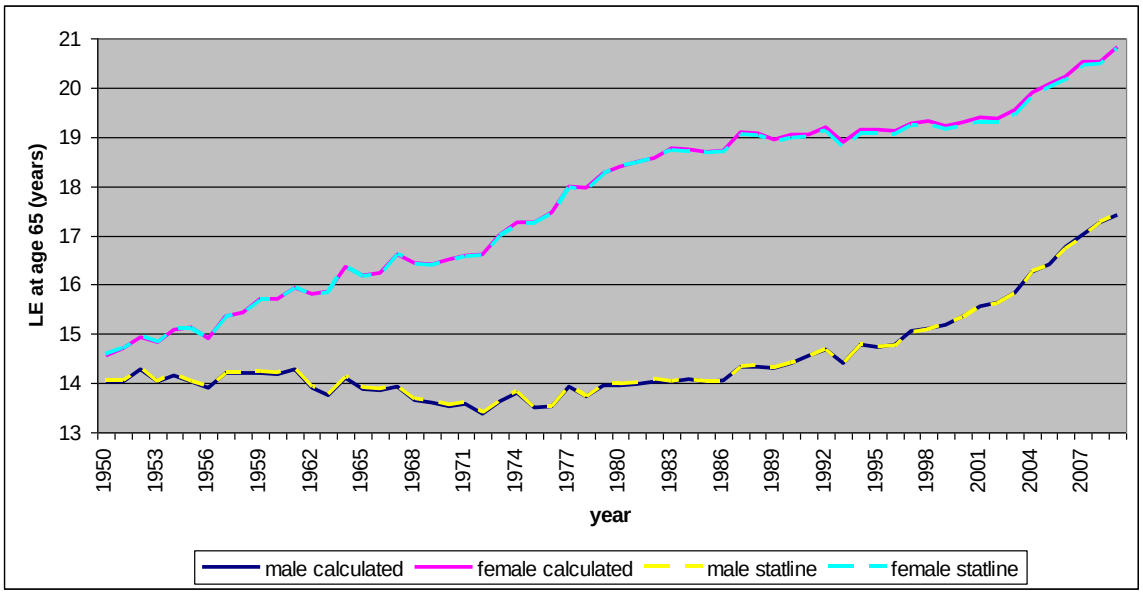
Figure C.2 Life expectancy at age 0 of males and females in The Netherlands during 1950-2009, differences between Statline data and own calculation



Source: Statistics Netherlands (2010), own calculation

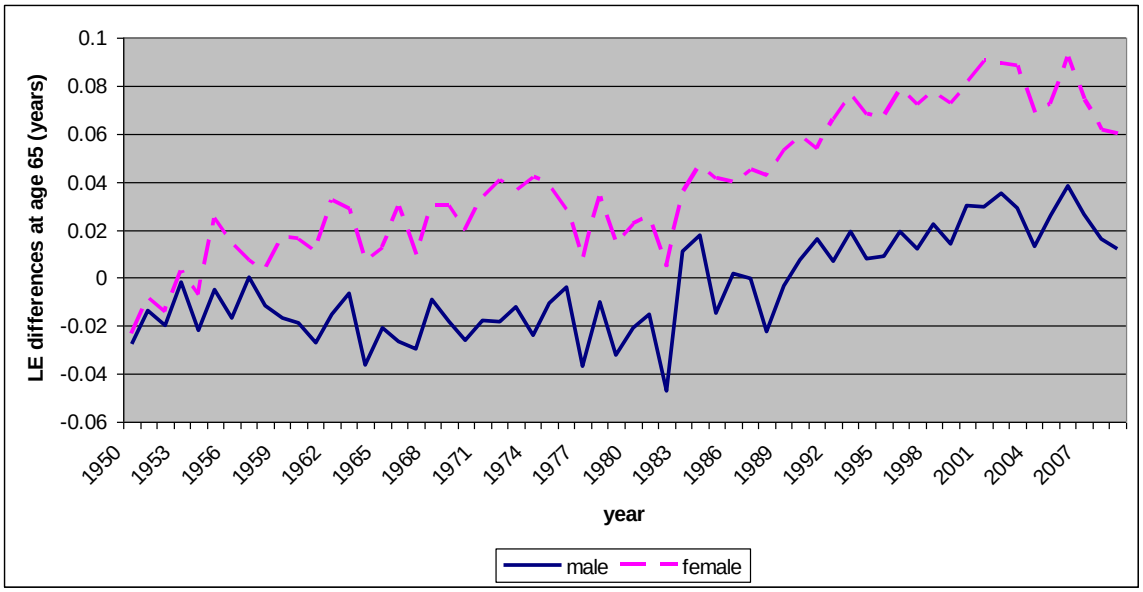
Appendix D: Data differences, life expectancy at age 65

Figure D.1 Life expectancy at age 65 of males and females in The Netherlands during 1950-2009, Statline data and own calculation



Source: Statistics Netherlands (2010), own calculation

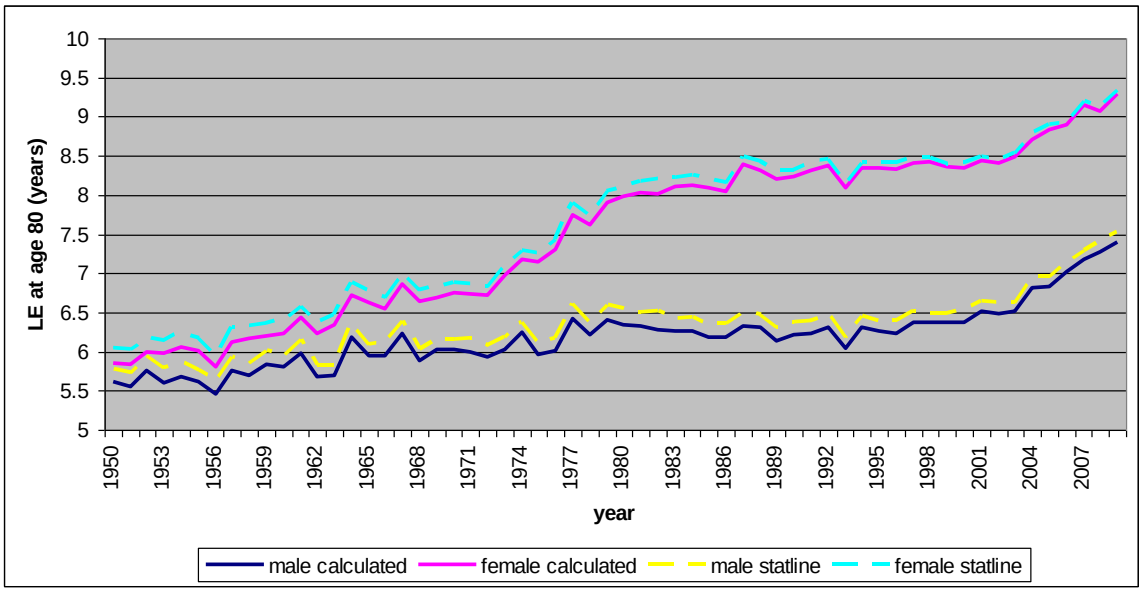
Figure D.2 Life expectancy at age 65 of males and females in The Netherlands during 1950-2009, differences between Statline data and own calculation



Source: Statistics Netherlands (2010), own calculation

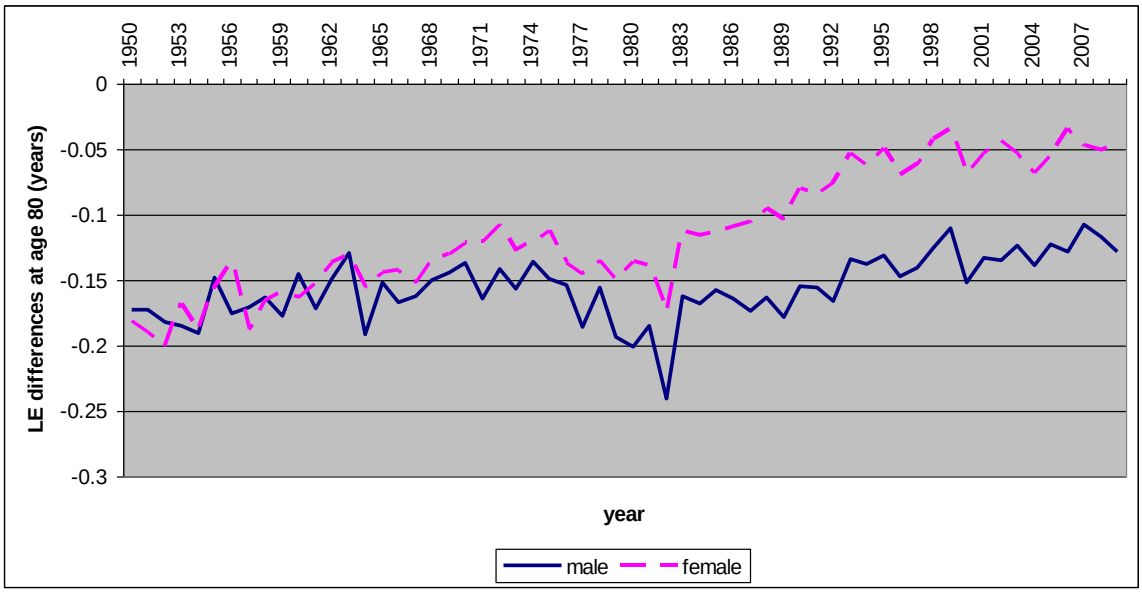
Appendix E: Data differences, life expectancy at age 80

Figure E.1 Life expectancy at age 80 of males and females in The Netherlands during 1950-2009, Statline data and own calculation



Source: Statistics Netherlands (2010), own calculation

Figure E.2 Life expectancy at age 80 of males and females in The Netherlands during 1950-2009, differences between Statline data and own calculation



Source: Statistics Netherlands (2010), own calculation