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A spatial analysis of the recent stagnation of life expectancy in the Netherlands

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Master Thesis Population Studies
28 March 2021

Abstract

Recently, the increasing trend in life expectancy at birth is stagnating in various Western countries, also in the Netherlands from 2012 onwards. The reasons behind this stagnation have not been studied much, only at the national level. The objective of this research is therefore to analyse the recent stagnating trend in life expectancy at birth for the different municipalities in the Netherlands and to examine to what extent lifestyle factors and socioeconomic status contribute to regional differences in this stagnation. Data for 390 municipalities on life expectancy at birth for males and females for the years 2002 until 2016 is retrieved from the RIVM; prevalence data on smoking, drinking, overweight, and obesity from the Health Monitors of 2012 and 2016, and data on household income from the RIVM for the years 2012 and 2016. This data is used to perform spatial analyses (mapping and spatial autocorrelation) and to calculate and assess correlations. Five main findings resulted from this research. First, life expectancy is stagnating in more municipalities for females than for males. Second, male life expectancy is increasingly converging towards female life expectancy. Third, municipalities without stagnation in life expectancy started in 2012 with a lower life expectancy than stagnated municipalities. The absolute change between 2012-2016, however, did increase in non-stagnated municipalities but decreased in stagnated-municipalities. Fourth, there is no clustering of the stagnation in life expectancy at the municipality-level for both males and females. And fifth, there is not a significant (linear) correlation between the absolute change in life expectancy and the prevalence in 2012 or the absolute change in lifestyle factors and socioeconomic status at the municipality level in the Netherlands. To conclude, the recently stagnated increase in life expectancy differs per municipalities and per gender. Policymakers should take these differences into account when formulating future policies related to healthy ageing.

Keywords: life expectancy at birth, smoking, heavy drinking, overweight, obesity, low income

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List of abbreviations

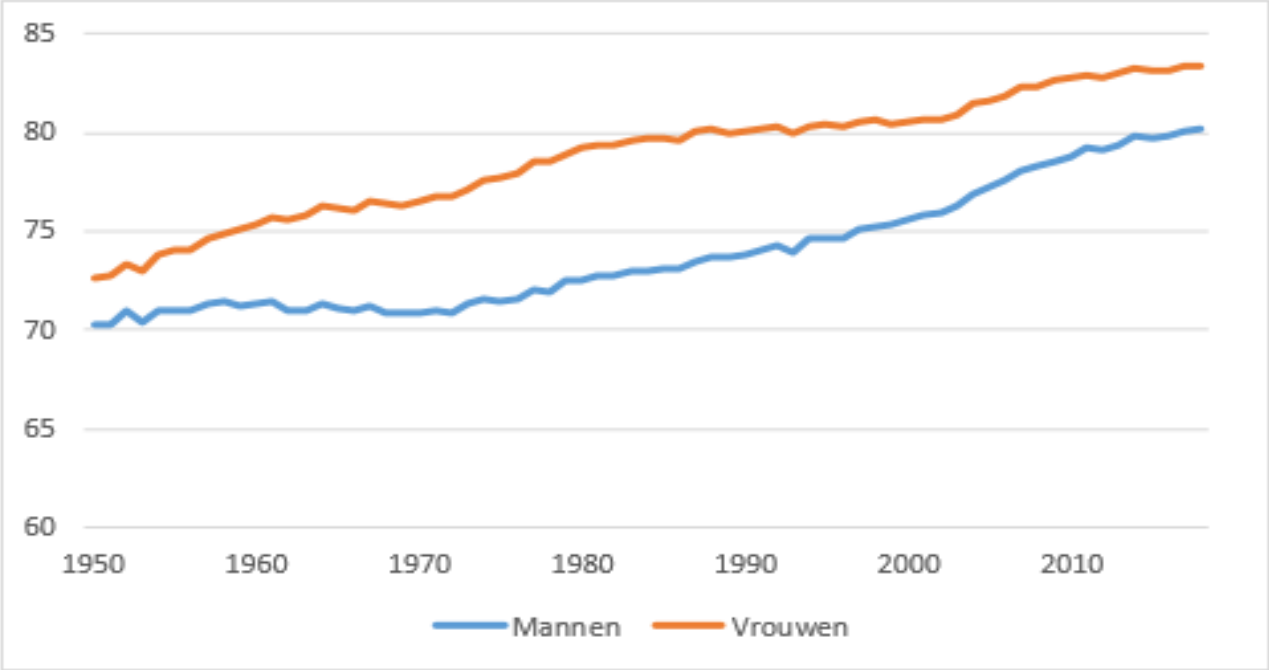
AC	Absolute change
AIDS	Acquired ImmunoDeficiency Syndrome
BMI	Body Mass Index
CBS	Statistics Netherlands
CVD	Cardiovascular disease
e0	Life expectancy at birth
GGD	Dutch Regional Public Health Services
N	Number of observations
OECD	Organisation for Economic Co-operation and Development
RIVM	Dutch National Institute for Public Health and the Environment
sd	Standard deviation
UK	United Kingdom
US	United States
WHO	World Health Organization

Chapter 1. Introduction

1.1 Societal relevance

Globally, life expectancy at birth has risen from 30 years in 1800 till 72 years in 2016 and this trend is expected to continue in the future (WHO, n.d.). Fluctuations over time in life expectancy at birth are common with years of high increase due to rising living standards, improvements in the quality of life and healthcare, or medical developments, but also years of low increase as a result of a war, pandemic, or economic depression (Stoeldraijer, 2020; Riley, 2001; OECD, n.d.). Recently, however, various European countries have experienced a different trend in its life expectancy at birth than that of the previous period, namely not having the expected high increase after a period of a stagnated increase (CBS, 2018; Stoeldraijer, 2020). Nevertheless, just this time there is not a clear reason for this stagnation. Stoeldraijer (2020) studied this phenomenon for the Netherlands and found a flattened increase in life expectancy too from 2012 onwards after a period of high increase in the early 2000s (figure 1), however, at a less extreme pace than some other countries did experience (Office for National Statistics, 2018).

Figure 1. Dutch Life expectancy at birth for males and females



Source: Stoeldraijer (2020)

Life expectancy at birth describes the average number of years that a new-born could expect to live if current death rates do not change (OECD, n.d.). It is a common measure of the health status of a population over time and the performance of a countries' healthcare system and is therefore often used to compare health differences between countries as well as within a country (WHO, n.d.). Stagnating trends can indicate a decline in the health profile of a population driven by adverse socio-economic trends, a deterioration in healthcare services, or worsening behavioural factors (Ho & Hendi, 2018).

In this research this stagnated trend at the municipality level in the Netherlands and which factors contributed to variations within the country is assessed. The outcome of this research could be significant for policymakers to understand regional differences in trends on life expectancy and help them to decrease future regional inequalities in health outcomes in the Netherlands.

1.2 Academic relevance

Although, commonly, trends in life expectancy at birth fluctuate over time, recently it has been noticed that the expected recovery stayed away in some countries. Currently, there are only a few studies about this stagnation and until now, research on this stagnating trend for the Netherlands has only been carried out by Stoeldraijer (2020) who found that in recent years (2012-2016) the life expectancy increased by 0.7 years compared to 2.6 years in the period before (2002-2012). However, up till now, studies explaining any regional variation within the Netherlands in the stagnation of life expectancy and the factors that influence these regional differences are lacking. This research tries to fill this research gap with the use of spatial analysis.

1.3 Objective

The purpose of this research is to analyse the recent stagnating trend in life expectancy at birth for the municipalities in the Netherlands and to examine to what extent lifestyle factors and socioeconomic status contribute to regional differences in this stagnation.

1.4 Research questions

The main question of this research is: “How can the recently stagnated increase in life expectancy at birth be explained at the municipality-level in the Netherlands?”.
With the sub-questions:

- What differences between municipalities exist in the stagnation in life expectancy?
- To what extent do lifestyle factors contribute to these regional differences in the stagnation in life expectancy?
- To what extent does socioeconomic status contribute to these regional differences in the stagnation in life expectancy?

Chapter 2. Theory

2.1 Theoretical framework

2.1.1 Epidemiological transition theory

Omran's (1971) theory of epidemiological transition outlines different stages that present the shift from mortality at young ages by infectious diseases in pre-modern times, towards mortality at older ages as a consequence of chronic diseases and lifestyle factors in modern times. By 1971, Omran identified three different stages and thirty years later in an updated version, two additional stages were added. Important to keep in mind is that the stages overlap and that one stage never completely displaces the next stage in this theory (Omran, 1998).

The first stage is 'the age of pestilence and famine' with high and fluctuating mortality (Omran, 2005; Santosa et al., 2014). Characteristics of this stage are high fertility- and death rates, an average life expectancy between 20 and 35 years, and slow population growth (Santosa et al., 2014). This stage portrays societies in Western Europe approximately until the 19th century and by the mid-20th century the Third World (Omran, 1998).

Secondly, 'The age of receding pandemics', started between the late 18th century and the beginning of the 19th century (Omran, 1998). This stage illustrates decreasing mortality rates and high levels of fertility, followed by an exponential curve in population growth (Omran 1998; Omran 2005). The average life expectancy varies between 40 and 50 years due to control of epidemics, improvements in sanitation, and medical breakthroughs, like contraception (Santosa et al., 2014; Omran, 2005). Nonetheless, infectious diseases are still significant causes of death, and non-communicable diseases are beginning to increase (Santosa et al., 2014).

'The age of degenerative and man-made diseases' is the third stage and started around the second half of the 19th century in the West. During this third stage, the average life expectancy was around 50 till 70 years, introducing the relative ageing of a population (Omran, 2005; Omran, 1998). The health care, living condition and sanitation improved significantly, and women became more emancipated and better educated (Omran, 1998).

The fourth stage, 'the age of declining cardiovascular mortality, ageing, lifestyle modification, emerging and resurgent diseases', has not arrived in all countries yet, but it did in the West after WWII (Omran, 1998). The life expectancy increases even further (especially for women) mostly due to reasons that are inherent to the first part of the stages' title (Omran, 1998). Fertility levels stay low and, in some countries, population even declines during this stage (Omran, 1998).

Lastly, 'the age of aspired quality of life with paradoxical longevity and persistent inequalities', also called the futuristic stage, is expected to take place mid-21st century (Omran, 1998). Medical breakthroughs, adaptation of healthy lifestyles and expanding the lifespans of disadvantaged people will help to improve the quality of life further during this stage. Despite this, there will be inequalities between and within countries because of peoples' socio-economic status. Furthermore, Omran (1998) expects that during this stage, depression will become a global pandemic due to stressful lifestyles and competitiveness. In addition, people seek less support from religious and cultural groups.

2.1.2 Convergence and divergence in mortality

There are some disadvantages of Omran's epidemiological transition theory according to Vallin & Meslé (2004). Omran (1971) presented a general convergence of life expectancy, however, not all societies were able to benefit from the improvements in health. This has led to patterns of not only convergence but also divergence in the global process of health transition. Instead of adding a fourth 'age' to cover the cardiovascular revolution and even a fifth 'age' to cover AIDS in Omran's theory, Vallin and Meslé (2004) create their own three major stages adjusted by new developments in health and the diversity in the world. These three stages are related to the vanquishing of infectious diseases, the cardiovascular revolution, and the fight against ageing.

Their first stage is similar to the first three stages of Omran's epidemiological transition. A couple of Western European countries together with New Zealand were among the pioneers of improvements in life expectancy by the 18th century, which led to a process of divergence (Vallin & Meslé, 2004). Other countries joined this trend at different times between the late 18th and early 20th century depending on their economic, social and political situation and this led to convergence between countries. Around the 1950s, divergence was happening again as females were predicted to age above 65 years in advanced countries (Vallin & Meslé, 2004). After 1950, many developing countries got access to European methods of infectious diseases control and with this a rapid catch-up was made resulting in a period of convergence. Despite this, most countries in sub-Saharan Africa were exceptions to this completion of the three stages of Omran and the first stage of Vallin and Meslé, in particular as these countries have been ravaged by wars, political unrest and AIDS epidemics over the decades followed by economic and social issues (Vallin & Meslé, 2004).

The second stage presents the time when man-made diseases were under control and declined in the 1960s, and new medical improvements were made in the field of cardiovascular diseases resulting in increased life expectancy (Vallin & Meslé, 2004). After a period of convergence with the generalized decrease in infectious mortality, this new stage started in the mid-1960s with a striking divergence in life expectancy as a consequence of the division of East and West given their social and political systems. Where the western countries experienced quick progress, the eastern European countries on the other hand experienced stagnation and sometimes even deterioration (Vallin & Meslé, 2004). However, from the 1990s onwards most eastern European countries started to converge towards the Western countries.

Vallin & Meslé's (2004) third stage looked at ageing and with this a new process of divergence-convergence because some countries already started a significant attempt in fighting against ageing while other countries were lagging behind. This stage started around the 1980s when a new period of divergence of life expectancy was noted, which was especially seen for females and less for males (Vallin & Meslé, 2004). Then, convergence was noticed because of the improvements in the fight against cardiovascular diseases contributing to the general process against ageing. Nevertheless, stagnation in life expectancy as a result of man-made diseases like cancer, respiratory diseases and digestive diseases since these were often due to smoking and drinking habits, led to a divergence between countries (Vallin & Meslé, 2004).

Noteworthy is that these stages are still incomplete due to not only limited historical data for various countries but also incomplete because countries differ from each other in how and

when events happen. Furthermore, one stage does not need to be completed before entering a new stage and the order of stages can be different too.

2.1.3 Health inequalities: context or composition

Health outcomes are different over time, between regions, between gender, and between the rich and the poor, this can also be referred to as health inequalities. Understanding health inequalities is especially important for governments making policies regarding health and for those planning health services. Shaw et al. (2002) tried to analyse these inequalities by identifying two determinants that clarify the variations between health outcomes, namely context and composition.

Contextual factors are about the setting in which people live, so the physical, economic and social environment. Factors such as health and services in an area, factories, and the absence of leisure and sport facilities are of a contextual nature. Contextual factors can furthermore be the less tangible determinants in the social context, like sense of community and group cohesion, crime rates and fear of crimes (Shaw et al., 2002). Compositional factors refer to factors that determine the differences between people on the individual level. Here, population health examines as an aggregate of the health of its individuals. Compositional factors to consider are age, sex, smoking and diet, but furthermore, social class, poverty or wealth (Shaw et al., 2002).

Both, contextual and compositional factors could answer questions like ‘Why do people of another city have higher mortality rates than we do here?’, ‘Is it because they are poorer?’ (composition) and ‘Is it because our city is a nicer place?’ (context). Nevertheless, not all factors can be classified as easy as above and could even fit both contextual and compositional factors. To give an illustration of this, a diet can be the way it is as a result of the food that is available but also because of what a person prefers to eat. It is therefore that researchers in this field of study state that context and composition are not mutually exclusive but rather about a balance between the two interpretations (Shaw et al., 2002).

Although both context and composition are important in understanding health inequalities, the data in this research only includes some compositional factors (sex, income and unhealthy behaviour) and no contextual factors. This makes that the reader should be critical when drawing conclusions.

2.2 Literature review

2.2.1 Recent trends in life expectancy at birth in the Netherlands

The Netherlands has experienced a long-term trend of mortality improvements and raising life expectancy. But as is common, there have been some fluctuations in this as well with years of increase, stagnation and even decrease. In the period 2002-2012, an accelerated increase of 2.6 years in life expectancy took place which was quite high in comparison with the 1.1 years increased in the previous decade (Stoeldraijer, 2020). After this high increase, a flattened increase in life expectancy was observed from 2012 onwards on the national scale (Stoeldraijer, 2020).

Previous studies have investigated the different trends in life expectancy for the Netherlands and possible causes of the increases and decreases in these trends. One of these studies is done by Mackenbach et al. (2011) and these researchers compared trends of

mortality of the period before and after 2001 and looked especially at some of the determinants. These researchers noticed that although there was a high increase in life expectancy there were many unfavourable trends after 2001 like increasing prevalence of smoking, obesity and hypertension. One of the few favourable factors was the improvement in health care delivery. By 2001, the relaxation of budgetary constraints caused the expansion of health care together with a rapid increase in the health care expenditure per head of population. This was especially the result of the growing number of older people visiting secondary care, using prescribed drugs, being admitted to a hospital, and underwent surgery more often during 2001-2007 than during the period before (Mackenbach et al., 2011).

Furthermore, Stoeldraijer (2020) looked at possible explanations for the stagnated increase after 2012 on the national scale. First, a biological limit of life expectancy might be reached and the closer people get to this, the slower and less the gain will be. Second, a decrease in the availability and quality of healthcare services and this could contribute to stagnation in life expectancy. Third, medical developments are considered as a possible explanation since the prevention and curing of cardiovascular diseases tend to be at their maximum level, however, this is not the case for many other causes of death (Stoeldraijer, 2020). Fourth, differences in socioeconomic status, like income, employability and education, between groups of people became bigger indirectly influencing life expectancy on the national scale (Stoeldraijer, 2020). And lastly, Stoeldraijer (2020) states that changes in lifestyle factors such as smoking, drinking, unhealthy diets, physical inactivity can manipulate life expectancy. Some of these factors are specific for a certain region, gender differences, or even differences within a group of people (Stoeldraijer, 2020).

2.2.2 International comparison

Trends in life expectancy are not only flattening down in the Netherlands recently. England is another country where this has been visible, especially since 2010 when improvements in life expectancy started to slow down or even stagnated sooner and faster than predicted (Office for National Statistics, 2018; Murphy et al., 2019). Murphy et al. (2019) noticed some variations within the country and between genders. To elaborate of this, life expectancy grew slower in the most deprived areas when they were compared to the least deprived areas in the period 2011-2016. Besides this, improvement rates of females were lower than that of males, sometimes even towards zero since recent years (Murphy et al., 2019). Even between females there are variations, for example the most affluent females gained about 3-4 years in life expectancy compared to 1.6 years for the least affluent females in the period 2001-2016 (Bennett et al., 2018). This latter group even turned out to be the worst off of all other groups. In England's neighbouring country Scotland, comparable outcomes were found with improvements in all deprived groups were slowing down, indicating increasing inequality gaps (Fenton et al., 2019). According to Murphy et al. (2019), potential causes of the stagnating trend in life expectancy in the United Kingdom could be influenza, austerity, and stalling improvements in cardiovascular diseases mortality. The impact of influenza, however, did not tend to be extraordinary these years. Austerity is seen as one of the most significant reasons because of the substantial changes in a range of welfare, social care and health services since 2010. Lastly, Murphy et al. (2019) argue that changes in population-level risks led to slowing down of improvements in CVD improvements and therefore a decline in related mortality. The researchers particularly mention

determinants of CVD like poor diets and pack of exercises that have contributed to increasing levels of overweight and obesity.

Next to the UK, trends in life expectancy have been stagnating in the United States too since 2010 and are even declining for males from 2014 onwards (Barbieri, 2019). The US already started lagging behind other OECD countries around the 1980s and has not caught up with the OECD average ever since (excluding Eastern Europe). Cardiovascular diseases and cancer are the main contributors to these mortality trends in the US, however, the number of deaths by these contributors have fallen over the last decade. Nevertheless, combating deaths due to cardiovascular diseases have slowed down since the beginning of the 21st century, which is in particular the consequence of the increasing prevalence of obesity and diabetes (Sidney et al., 2016). Moreover, deaths due to respiratory diseases, especially among males above 60, deaths from external causes for both sexes, and the residual category of death by other causes, are adding to the slowdown of life expectancy trends (Barbieri, 2019). Examples of external causes are suicide and overdoses from drugs, what accounts for half of the years of life lost between 2014 and 2017, but even if the implemented measures to combat such external causes turn out to lower the number of deaths, it will be too little to improve life expectancy trends since factors like poor eating habits are still major components of the stagnating and decreasing trends in life expectancy in the US (Barbieri, 2019).

2.2.3 Additional determinants

Various other literature mentions additional factors that influence health in the long term and therefore could be significant determinants to changing trends in life expectancy. For instance, Murphy et al. (2019) touch on psychosocial factors like tobacco, poor nutrition, alcohol and drug use, and low physical activity, that are risk factors of poor health especially since they stimulate the prevalence of overweight and obesity (Murphy et al., 2019). To elaborate further on smoking, it affects trends in life expectancy and sex differences in mortality, and especially in high-income countries it is one of the main risk factors for premature mortality (Janssen et al., 2015; WHO, 2002). In the Netherlands, for instance, smoking has been accountable for most of the previous period of stagnation in life expectancy in the last 70 years, especially among males (Stoeldraijer et al., 2013). Besides this, differences in the past between male and female life expectancies can be substantially ascribed to smoking (Stoeldraijer et al., 2013). In the Netherlands, for instance, smoking is accountable for most of the stagnation in life expectancy (especially among males) and fluctuations in sex differences over time (Stoeldraijer et al., 2013). Smoking, in addition with alcohol and obesity, as the three main elements for population health issues in Europe are also examined by Janssen & Poppel (2015) and they did affect premature mortality and lifestyle trends over the years.

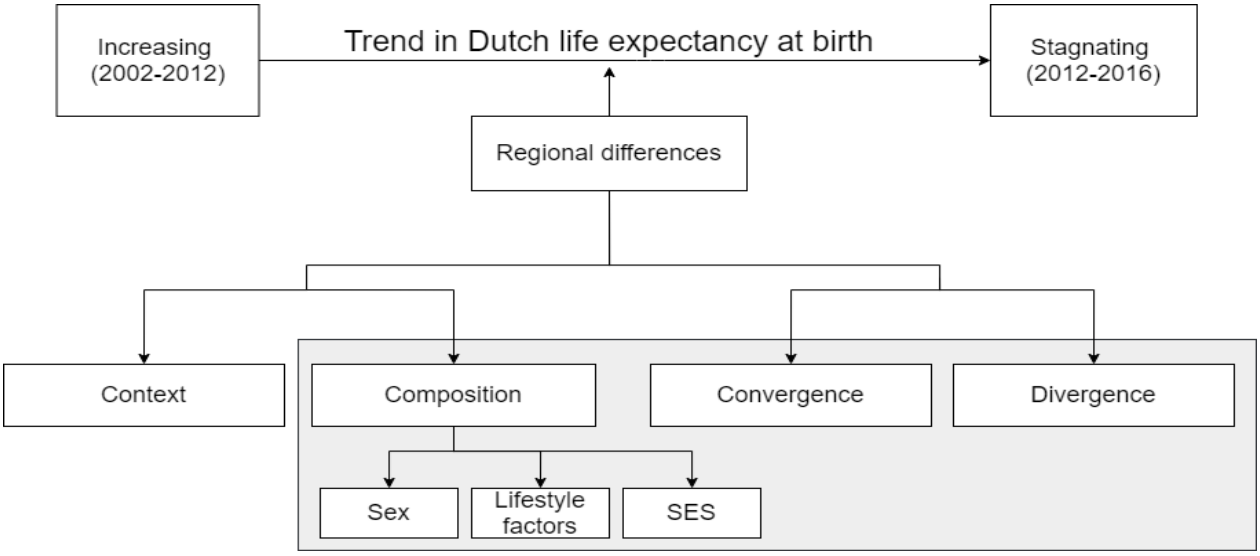
2.3. Conceptual model and hypotheses

Figure 2 represents the conceptual model derived from the theory. This research studies the trend in Dutch life expectancy at birth at the municipality level and in particular the trend after 2012 when on the national level it turned out to be stagnating compared to the period before (Stoeldraijer, 2020). This research focuses especially on two theories from Vallin & Meslé (2004) and Shaw et al. (2002). The first one from Vallin & Meslé (2004) highlights the processes of convergence and divergence in life expectancy over time. Not all societies benefit from

improvements in health in the same way and a new convergence-divergence phase occurred when some countries already started to fight ageing while others lagged behind (Vallin & Meslé, 2004). Variations between males and females are of particular importance, since female life expectancies diverged and the life expectancies of males less (Vallin & Meslé, 2004). According to Shaw et al. (2002) health inequalities are determined by context and composition. Contextual determinants are about their physical, economic and social environment in which people live. Compositional determinants are at the individual level and refer to their characteristics, like lifestyle factors or socioeconomic status. These factors lead to differences between for instance individuals, regions or countries over time.

Based on this conceptual model and the literature discussed, several hypotheses are formed. First, municipalities near each other will have similar life expectancies. Since the first law in geography states that near things are more related than distant things and therefore clusters of municipalities with similar life expectancies will be present. Second, regional differences in stagnation in life expectancy at birth are the result of the process of convergence-divergence between genders. Where male life expectancy at birth is catching up to female life expectancy (convergence) and female life expectancy is no longer increasing that much and lags behind the years progress that male life expectancy makes (divergence). Third, regional differences in the stagnation in life expectancy are determined by differences in contextual and compositional factors. The retrieved data for this research is about lifestyle factors and socioeconomic status, and therefore only the compositional part of this theory by Shaw et al. (2002) is studied in this research. The grey area in figure 2 represents the parts of the two theories that are looked into further during this research.

Figure 2. Conceptual model



H1: Municipalities near each other will have similar life expectancies.
H2: Regional differences in the stagnation in life expectancy are the result of the process of convergence-divergence between genders.
H3: Regional differences in the stagnation in life expectancy are determined by differences in contextual and compositional factors.

Chapter 3. Data and methodology

3.1 Study area and level of analysis

This research focuses on analyses of data on life expectancy at birth, lifestyle factors and socioeconomic status at the municipality level in the Netherlands. This data is based upon the administrative division of municipalities of the Netherlands for the years 2016 and by then the country consisted of 390 municipalities (figure 3). Two periods are studied in this research, namely 2002-2012 and 2012-2016 and the reason for this is because of previous literature from Stoeldraijer (2020) in which a stagnated increase in life expectancy from 2012 onwards was found after a period of rapid increase. Since this research is especially interested in the period of stagnation, it will dig deeper into the period from 2012 onwards and in particular to what extent lifestyle factors and socioeconomic status contribute to this stagnation in life expectancy at regional level in the Netherlands.

Figure 3. Dutch municipalities in 2016

Source: Esri

3.2 Dependent variable

The dependent variable of this research is the absolute change in life expectancy at birth per gender and per municipality in the Netherlands for the period 2012-2016. Data on life expectancy at birth was collected by the RIVM and this institute conceptualizes life expectancy at birth as the number of the years a new-born could expect to live if current mortality rates continue to apply (RIVM, 2020e). Life expectancy at birth at municipality level is based on the death rates per gender and region. These death rates themselves are based on the CBS-causes of death database from the years 2001 until 2016 and the municipalities used are based upon the administrative divisions of 2016 (390 municipalities). Life expectancy was then calculated in four-year periods, using age-specific mortality rates by the means of the Sullivan method (RIVM, 2020e).

This data consists of life expectancy at birth per municipality, for males, females and the total (adult) population, for the years 2001-2016, however, it needed to be converted in order to answer the research questions. To be exact, life expectancy at birth in this dataset was measured as an average of four years. 2001-2004 and 2003-2006 are two examples of the time periods in the dataset and this continues to the period 2013-2016. The midpoint of these time periods are therefore officially 2002,5 and 2004,5 respectively to the examples. For the sake of convenience, this research will refer to these midpoints as 2002 and 2004. This life expectancy data is first converted into annual absolute changes for the periods 2002-2012 and 2012-2016 to be able to compare the two periods with each other since the literature describes that there was a period of high increase between 2002 and 2012 followed by stagnation (Stoeldraijer, 2020). Transforming the life expectancy at birth data this way makes it possible to visualize the municipalities that experienced stagnation after 2012 compared to the period before, and the municipalities that did not. Additionally, the life expectancy data is converted into absolute

changes over the period 2012-2016 to analyse the relationship between life expectancy at birth and the explanatory variables. This is done for the first period by subtracting the year 2012 from that of 2002 and for the second period by subtracting the year 2016 from that of 2012.

3.3 Explanatory variables

There are five explanatory variables studied in this research, which are divided into lifestyle factors (smoking, alcohol consumption, overweightness, and obesity) and socioeconomic status (low income).

3.3.1 Lifestyle factors

Data on lifestyle factors is retrieved from the Health Monitors 2012 and 2016, which is a joint research project conducted by the GGD-Nederland, the RIVM and CBS, and is held once every four years at GGD-region and municipality level. The retrieved data provides insights into the health and lifestyle of adults living in the Netherlands. The data on the lifestyle variables is retrieved for the Health Monitor by using the following conceptualisations:

- Smoking is conceptualised as the percentage of adults that answered yes on the survey question “do you ever smoke?”.
- Heavy drinking is defined as the percentage of adults that drink six or more (for males) or four or more (for females) glasses of alcohol on one day at least once a week
- Overweightness is based on the BMI, calculated as BMI = weight / height^2. It is described as the percentage of adults with a BMI between 25,0 kg/m^2 and 30,0 kg/m^2.
- Obesity is also based on the (BMI, calculated as BMI = weight / height^2. It is calculated as the percentage of adults with a BMI above 30 kg/m^2.

This data on lifestyle factors was only available for the total population. Nevertheless, information on these factors per gender is very relevant for this research and although there might be some downsides to the following method like less precise and reliable outcomes, it is very interesting to analyse lifestyle data per sex. The data on the prevalence of the lifestyle factors on the national level for males and females of one of the years (2012 or 2016) and by recalculating this with the use of the total prevalence of a region, a percentage per gender per region (and per year) can be calculated and therefore the absolute change between 2012 and 2016 by subtracting the percentage of 2016 by the percentages of 2012.

3.3.2 Socioeconomic status

The variable low-income is used in this research as a factor for socioeconomic status. This data on low income per municipality is retrieved from the same dataset as the dependent variable, so originally from the RIVM and is the percentage of people in a municipality that have a low income for at least one year in both 2012 and 2016 at the household level. Even though this data is coming from the same data set, the low-income data was already available for one-year time periods only. The absolute change in the period 2012-2016 is also determined by subtracting the percentage of people with a low income in 2016 by the percentages of people that had a low income in 2012.

3.3.3 Dutch municipality borders

The layer “Gemeentegrenzen 2016” from Esri is used as a base layer. The data of the dependent and independent variable(s) is joined to this polygon base layer. This base layer corresponded the most with already retrieved data in this research that were based upon the administrative division of municipalities of the Netherlands for the years 2016. Nevertheless, three municipalities have no data which is most likely due to the municipal reorganizations during that year. Moreover, after joining the explanatory variables to the layer, a couple of municipalities had missing values, errors or outliers, which is probably also due to multiple municipal reorganizations between 2012 and 2016. These 24 municipalities are left out from the correlation analyses.

3.4 Ethical considerations

An important ethical aspect of quantitative research is how the data is collected, managed and stored. Since this research uses secondary data, ethical considerations of data collection are managed by the third party responsible for this. The parties that collected the data have substantial knowledge and experience in the field of conducting surveys and meet the European General Data Protection Regulation. Therefore, it is assumed that caution and confidentiality during the data collection was provided and that the privacy of the respondents was prioritized. Nevertheless, all users of this data are responsible for ethical issues too and should try to limit issues regarding this as much as possible.

3.5 Method of analysis

To retrieve an answer on the main question of this research “How can the recently stagnated increase in life expectancy at birth be explained at the municipality-level in the Netherlands?”, three sub-questions are conducted.

To answer the first question “What differences between municipalities exist in the stagnation in life expectancy?”, two maps by the use of ArcGIS Pro are made for males and females separately that showed what kind of annual absolute change a municipality had over the period 2012-2016 compared to the period 2002-2012. Four categories are made that represent whether these municipalities had an increase or a decrease in the first and second periods. This way, it becomes clearer to see which municipalities had stagnation from 2012 to 2016 compared to the period before (2002-2012), and therefore what the regional variations are and especially the difference between males and females. Furthermore, four additional maps are made of which two illustrate the life expectancy of the year 2012 per municipality per sex and the other two the absolute change in life expectancy over the years 2012 until 2016 per municipality per sex. These maps give a better understanding of whether a municipality had a relatively low or high life expectancy at the beginning in 2012 and whether it had a relatively low or high absolute change until 2016.

Next to this, the degree to which near and distant annual absolute changes per municipality are related (first law of geography) is checked for. The Global Moran’s I tool checks this spatial autocorrelation. The outcomes of this statistic will determine whether the observed patterns are clustered, dispersed, or random. This statistic calculates Moran's I, a z-score and a p-value. Moran’s I is an index that can range between -1 and 1, where -1 equals negative spatial autocorrelation (dispersed), 1 positive spatial autocorrelation (clustered) and 0 a random

pattern (ArcGIS Pro., n.d.). The z-score and p-value indicate whether the outcome is significant or not. A statistically significant p-value results in rejecting the null hypothesis, which states that “the attribute being analysed is randomly distributed among the features in the study area” (ArcGIS Pro., n.d.). An inverse distance band of 0 and Euclidean distance are used when performing this test to get the most optimal result with this data.

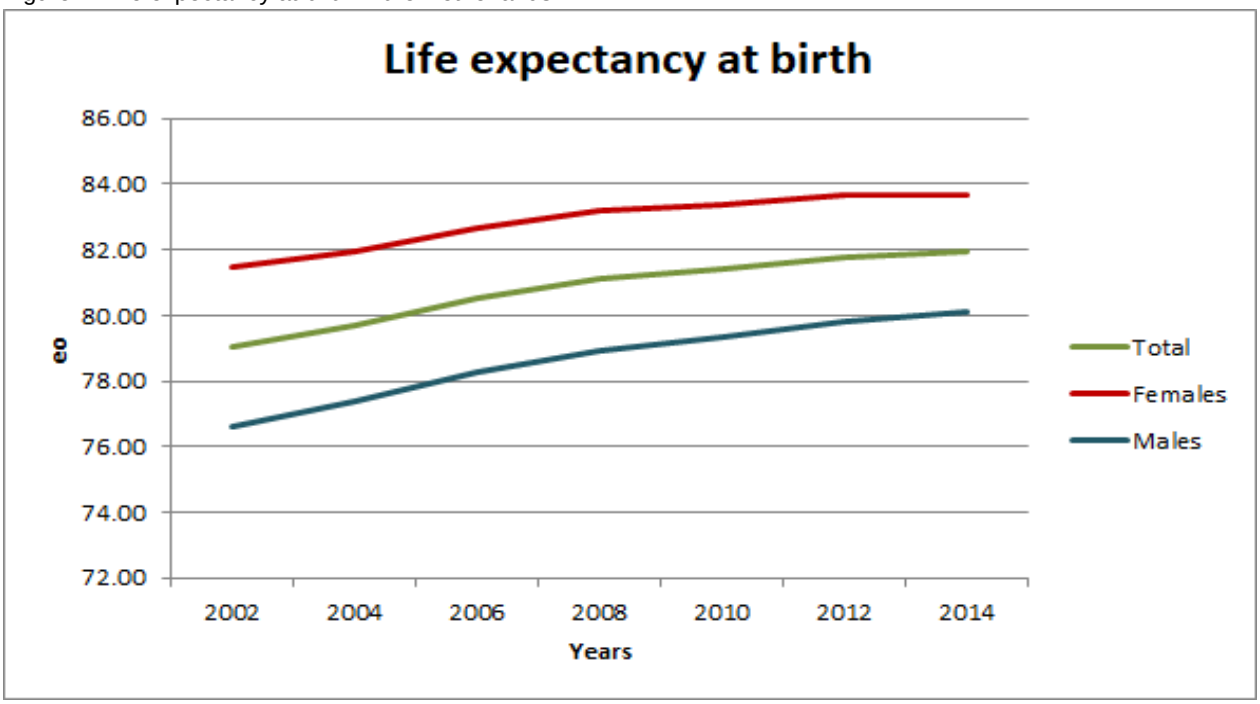
To answer the research questions about to what extent the explanatory variables, such as smoking, heavy drinking, overweightness, obesity (lifestyle factors) and low income (socioeconomic status), contribute to the stagnation in life expectancy at birth at the municipality level, multiple maps are made. For all these variables one map per gender is made about the percentage of the variable in 2012 and about the absolute change in the period 2012 until 2016. Besides, these maps and correlations are created and calculated to evaluate the (statistical) relationship between the explanatory variables and life expectancy at birth.

Chapter 4. Results

4.1 Descriptives

Graph 4 shows the average life expectancies at birth for males, females and the total population in the Netherlands during 2002 until 2016. In general, the average life expectancies increased rapidly until 2012, with an annual absolute increase of 0.65 years for males, 0.43 years for females and 0.54 years for the total population. However, it did not continuously increase as rapidly in the period after 2012, especially for females the line is stagnating from 2012 onwards with an annual absolute increase that dropped to 0.03 years. For males and the total population this is slightly less extreme with an annual absolute increase of 0.30 years for males and 0.15 years for the total population. The graph further illustrates convergence between male and female life expectancy over time. The average differences in life expectancy between males and females decreased from 4.87 years in 2002 to 3.54 years in 2016.

Figure 4. Life expectancy at birth in the Netherlands



Source: Own figure based on data from RIVM.

Table 1 summarizes the average mean and standard deviation of life expectancy at birth and the lifestyle variables for males and females and socioeconomic status for households in the Netherlands. The table presents both the starting values in 2012 as well as the absolute changes over the period 2012-2016 for these variables. A division has been made here between municipalities that showed stagnation in life expectancy during 2012-2016 compared to the period before on the one hand and municipalities that showed this stagnation compared to the period before on the other hand. Due to this, it is possible to compare the different values of the stagnated municipalities with values of the non-stagnated municipalities.

Concerning the average life expectancy at birth, table 1 demonstrates that in 2012 life expectancy lower is in municipalities that did not experience stagnation compared to municipalities that did have stagnation. This is the case for both males and females with a life expectancy of 79.66 years versus 80.19 years for males and 83.48 versus 83.80 for females respectively. The absolute change on average is increasing with 0.67 years for males and 0.54 years for females in municipalities that did not have stagnation between 2012 and 2016, however, the absolute change is decreasing with 0.47 for males and 0.48 for females in the stagnated municipalities.

Next to life expectancy, the lifestyle factors and socioeconomic status appear to be different for municipalities with stagnation and the municipalities without stagnation compared to the period before. First, the percentage of smoking males in 2012 was lower for municipalities with stagnation (26.60%) in the life expectancy than in municipalities without stagnation (27.47%). For females this is the other way around, since 20.09% smoked in the stagnated municipalities and 19.90% in the non-stagnated municipalities. The absolute change in smoking decreased in all the municipalities, however, it decreased slightly more in the municipalities with stagnation for both males and females than in the non-stagnated municipalities. Second, the percentages of heavy drinking males (10.22%) and females (7.43%) in 2012 turn out to be higher in the stagnated municipalities compared to the non-stagnated municipalities (9.66% and 7.23%). For both males and females, the absolute decrease is higher in the stagnated municipalities than in the non-stagnated municipalities. Third, regarding overweight in the country, the percentage of males (46.47%) and females (41.74%) with overweight in 2012 is lower in the stagnated municipalities than in the non-stagnated municipalities (46.74% and 41.81%). Although the absolute change decreased for smoking and heavy drinking over the years, this is not the case for overweight and obesity. The absolute change increased the highest in the non-stagnated municipalities for males and for females in the stagnated municipalities. Fourth, obesity has the lowest percentages of prevalence in 2012 in stagnated municipalities for males and females (10.47% and 12.06%) compared to the non-stagnated municipalities (10.78% and 12.66%). Nevertheless, there is a difference in the absolute change since males have a higher absolute change in the non-stagnated municipalities (1.58 versus 1.44) and females a higher absolute change in the stagnated municipalities (4.60 versus 4.36). Lastly, when looking at low income at the household level, it appears that the percentage of households with a low income is slightly lower in the stagnated municipalities (5.81%) than in the non-stagnated municipalities (5.85%). The absolute change is the same in all the municipalities with 0.02.

Table 1: Descriptives

Males			eo	Smoking	Heavy drinking	Overweight	Obesity	Low income (household)
Non-stagnated municipalities	Prevalence in 2012	Mean	79.66	27.49	9.66	46.74	10.78	5.85
		SD	1.25	3.77	2.31	4.37	2.06	2.18
	Absolute change (2012-2016)	Mean	0.67	-3.60	-1.30	7.36	1.58	0.02
		SD	0.61	3.30	2.34	3.48	2.00	0.43
Stagnated municipalities	Prevalence in 2012	Mean	80.19	26.60	10.22	46.65	10.47	5.81
		SD	1.56	4.18	2.56	3.98	2.53	-1.98
	Absolute change (2012-2016)	Mean	-0.47	-3.64	-1.53	7.00	1.44	0.02
		SD	0.94	3.24	2.42	3.21	2.10	-0.42
Females								
Non-stagnated municipalities	Prevalence in 2012	Mean	83.48	19.90	7.23	41.81	12.66	
		SD	1.33	2.71	1.80	3.95	2.73	
	Absolute change (2012-2016)	Mean	0.54	-4.08	-1.31	6.49	4.36	
		SD	0.45	2.24	1.65	2.88	2.34	
Stagnated municipalities	Prevalence in 2012	Mean	83.80	20.09	7.47	41.74	12.06	
		SD	2.04	3.05	1.80	3.64	2.36	
	Absolute change (2012-2016)	Mean	-0.48	-4.23	-1.58	6.80	4.60	
		SD	0.75	2.47	1.77	3.20	2.69	

Source: own calculation based on data from the RIVM and the Health Monitors of 2012 and 2016.

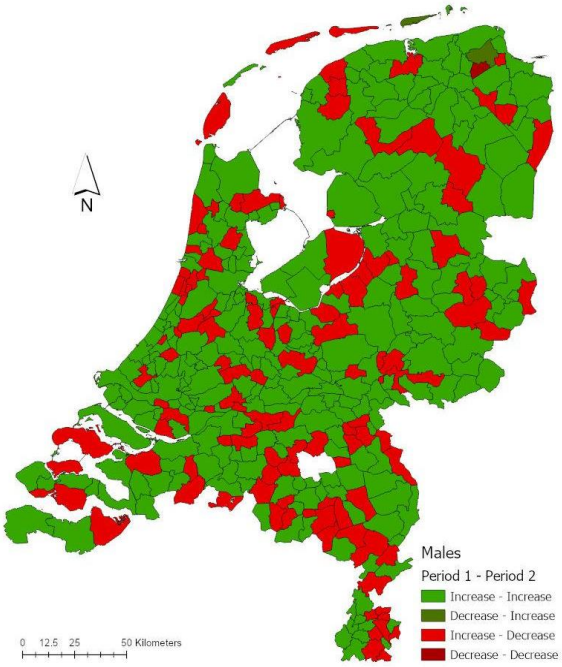
4.2 Regional differences

4.2.1 Life expectancy at birth

As seen in the last paragraph, there appear to be differences on the national scale between municipalities that encountered stagnation and the municipalities that did not. This next paragraph will look at these differences on the regional level. The maps in figures 5 and .6 illustrate how municipalities, divided into four categories representing whether or not a municipality had stagnation in life expectancy at birth in period 2012-2016 (period 2) compared to the period before this from 2002-2012 (period 1), are spread throughout the country. The first category is increase-increase (bright green), which includes municipalities that had an increase in the absolute change in life expectancy over both periods. To this category belong 261 municipalities for males and 185 for females. Decrease-increase (dark green) is the second category, and this involves two municipalities for males and nine municipalities for females that had a decrease in the absolute change in life expectancy in the first period followed by an increase in the second period. The third category is increase-decrease (bright red) and municipalities in this category experienced an increase in the absolute change in life expectancy in the first period and a decrease in the second period. This is the case for males in 124 municipalities and for females in 188 municipalities. The fourth and final category is decrease-decrease (dark red) and it includes municipalities with a decrease in the absolute change in life expectancy in both periods. And to this category belong one municipality for males and six municipalities for females.

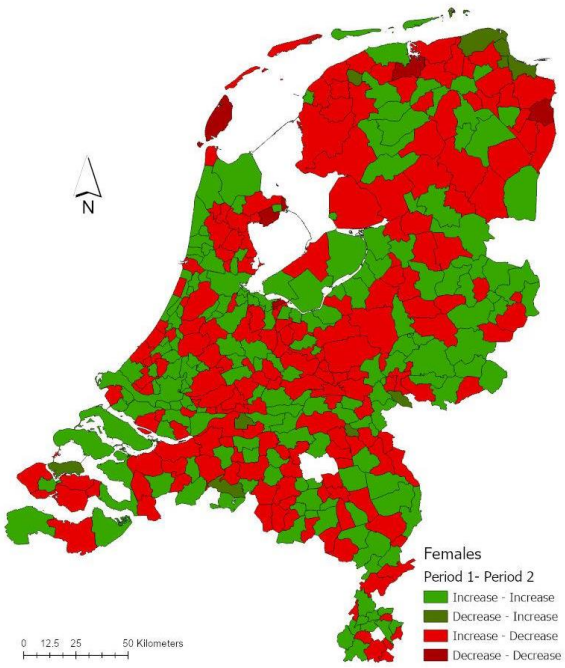
To sum, one third of the municipalities for males (125) and half of the municipalities for females (261) had stagnation over the second period (2012-2016) compared to the period before (2002-2012).

Figure 5. Life expectancy males 2002-2012 (period 1) - 2012-2016 (period 2)



Source: own figure based on data from RIVM

Figure 6. Life expectancy females 2002-2012 (period 1) -2012-2016 (period 2)

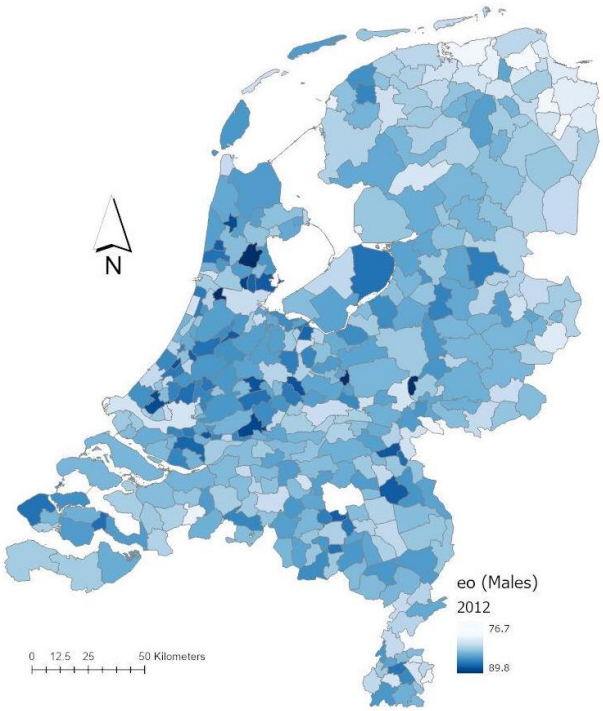


Source: own figure based on data from RIVM

To get a better understanding of what the life expectancy was of these municipalities in 2012 and how this changed over the period until 2016, maps are made that indicate the life expectancy in 2012 as well as maps about the absolute change over the years after this.

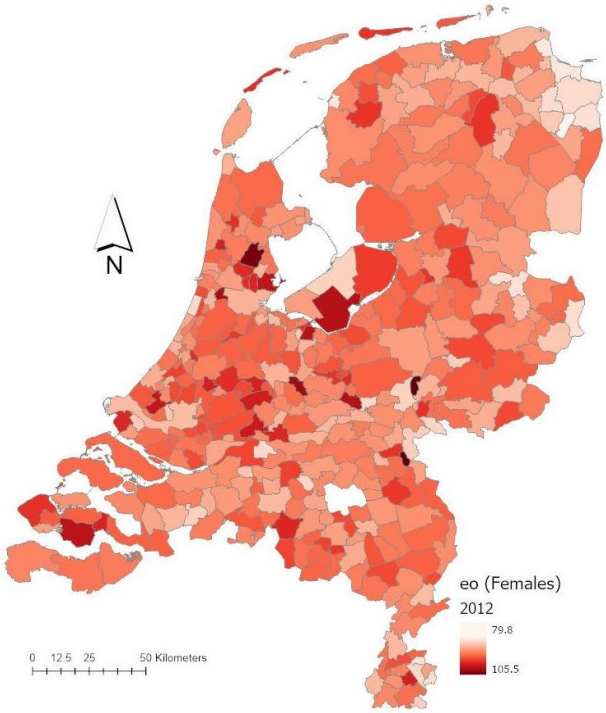
For males, the lowest life expectancies are found in the north-east of the country (figure 7). It seems like the more north-east municipality is situated, the lower the life expectancy is. Life expectancy is furthermore relatively low in the mid-eastern municipalities that are close to Germany. Life expectancy is quite high in the mid-western region, which is the area that is equal "the Randstad"). Although the absolute changes in life expectancy for males are increasing in almost every municipality (Appendix A), it seems that many of the municipalities with a low life expectancy in 2012 are increasing at a higher rate than municipalities that already had a relatively high life expectancy in 2012. This might indicate that this first group of municipalities is catching up with the second group. Figure 8 shows that the average life expectancy per municipality for females in 2012 is higher than that of males. Similar to males, female life expectancy is lowest in the north-eastern part of the country and highest in the region of the Randstad. The absolute change for females is on average lower than that of males and many municipalities did not even have an increase over the period until 2016 (Appendix B). For females, it looks like that a couple of the municipalities with relatively low life expectancies in 2012 catch up with the municipalities with the higher life expectancies. However, it seems more the case that municipalities with relatively high life expectancies in 2012 lagged behind with their improvements in life expectancies over the period until 2016 and therefore had a decrease.

Figure 7. Life expectancy of males in 2012



Source: own figure based on data from RIVM

Figure 8. Life expectancy of females in 2012



Source: own figure based on data from RIVM

4.2.2 Clustering of life expectancy at birth

To identify the distribution of the annual absolute change in life expectancy during 2012-2016 at the municipality level, Global Moran's I tool is used. This tool analyses the overall observed patterns of the absolute change and makes sure that a check for spatial autocorrelation is executed, which means that the degree whether near and distant annual absolute changes in life expectancy are related to each other could be analysed. In other words, the index measures whether or not the observations are independent which is important to prevent violation of one of the basic assumptions in statistics (independence of the data).

Table 2. Global Moran's I's of the annual absolute change in life expectancy (2012-2016)

	Global Moran's I	z-score	p-value
Males	-0.002040	0.140403	0.888342
Females	-0.008715	-1.550609	0.120995

Source: own calculations

Table 2 presents the outcomes of this tool and determines whether the observed overall patterns are clustered, dispersed, or random. The Global Moran's I index of the annual absolute change in life expectancy of -0.00204 for males and -0.008715 for females are very close to 0 meaning that there is no autocorrelation and almost perfectly dispersed. Nevertheless, this tool is an inferential statistic and therefore it needs to be defined within the context of its null hypothesis: "the annual absolute changes of life expectancy at birth are randomly distributed among the municipalities of the Netherlands". Assessment of the p-values and z-scores are of importance to interpret the results. The p-values for both males and females are not statistically significant and this makes it very likely that the spatial distribution of the absolute change per municipality is the outcome of random spatial processes. The null hypothesis for males as well as females cannot be rejected and for that reason is this observed spatial pattern of the annual absolute changes in life expectancy per municipality for males and females one of the many random possible spatial patterns. Additionally, given these z-scores, the patterns do not appear to be significantly different than random.

4.2.3 Explanatory variables

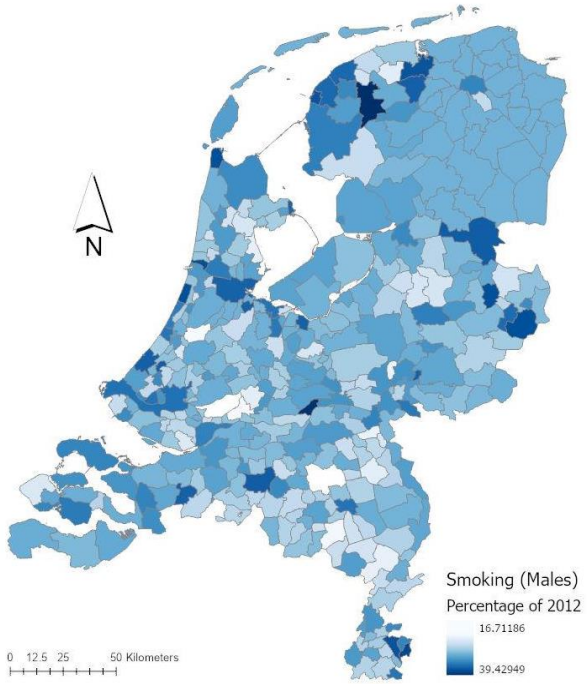
To determine to what extent the explanatory variables influence the regional differences in the stagnated life expectancy, maps with the prevalence of the explanatory variables in 2012 and the absolute change of the explanatory variables over the period 2012-2016 are made.

4.2.3.1 Smoking

Smoking is more prevalent for males than females in 2012 and a higher absolute change compared to females. Assessment of the regional differences, the first notable element in the maps in figure 9 and 10 is the similarity of male and female percentage of smokers in 2012 especially in the north-east of the Netherlands. Nevertheless, the absolute change in smoking is varying in most of these municipalities (Appendices C and D). Especially, the municipalities in the eastern part of this area have the highest absolute change in smoking compared to the

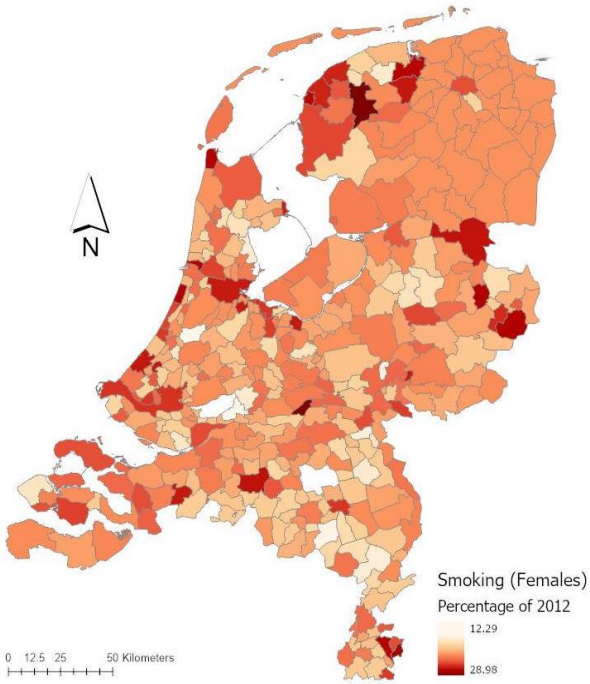
municipalities in the rest of this region. In the remaining parts of the country, municipalities have diverse percentages of smokers. Overall, many of the municipalities that have a high percentages of smokers in 2012 experience a lower absolute change and vice versa for municipalities with a low percentage of smokers in 2012.

Figure 9. Prevalence smoking of males in 2012



Source: own figure based on data from RIVM and CBS

Figure 10. Prevalence smoking of females in 2012

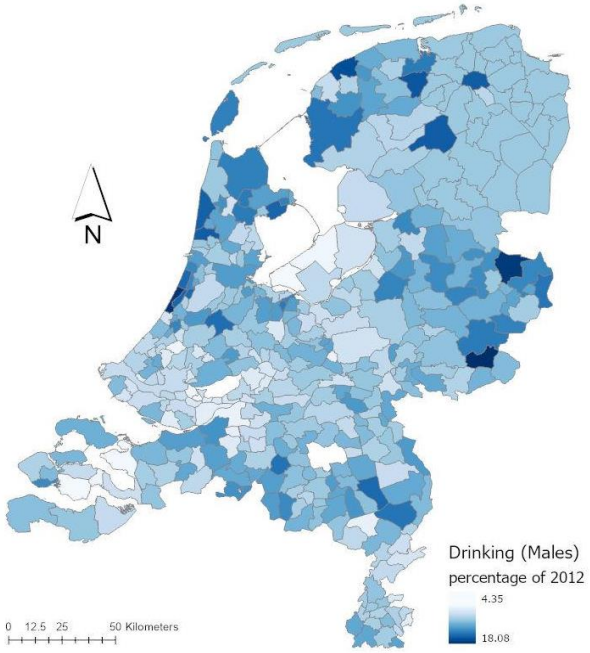


Source: own figure based on data from RIVM and CBS

4.2.3.2 Heavy Drinking

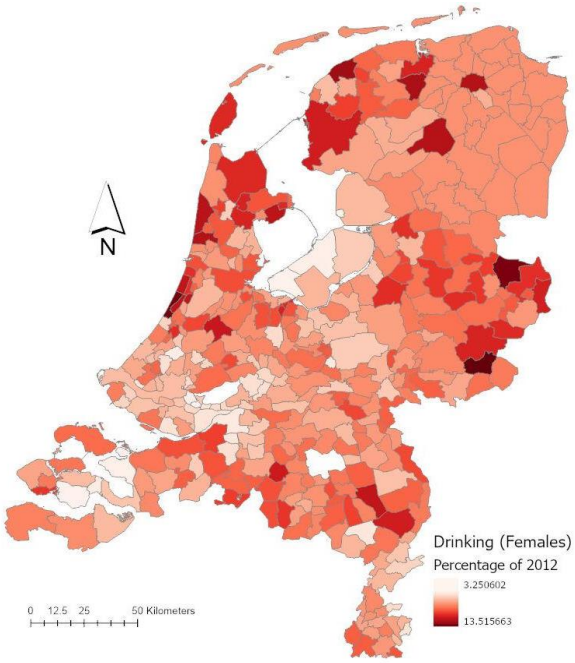
Secondly, for the variable heavy drinking, the percentages of heavy drinking in 2012 for both male (figure 11) and female (figure 12) are lower than the percentages of smoking. Females started the period with a lower percentage of heavy smokers than males and also the absolute change is lower for females (Appendices E and F). It looks like that most municipalities with a high percentage of heavy drinkers in 2012 experienced a lower absolute change than other municipalities and municipalities that had a low percentage in 2012, often did have the higher absolute changes, however, these changes are still low. Like smoking, the north-east part of the country has similar values at the start of the period, but the absolute change is varying for the different municipalities in that region. Moreover, municipalities that started with a relatively high percentage of heavy drinkers are located in the north-west, the mid-east and the mid-south. Municipalities with low percentages of heavy drinkers in 2012 are mainly situated in the south-east, south-west, the islands and in the middle of the country.

Figure 11. Prevalence heavy drinking of males in 2012



Source: own figure based on data from RIVM and CBS

Figure 12. Prevalence heavy drinking of females in 2012

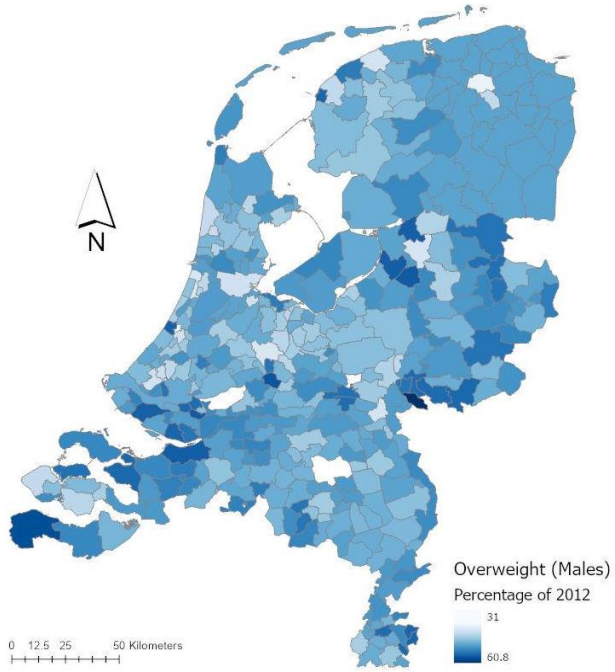


Source: own figure based on data from RIVM and CBS

4.2.3.3 Overweight

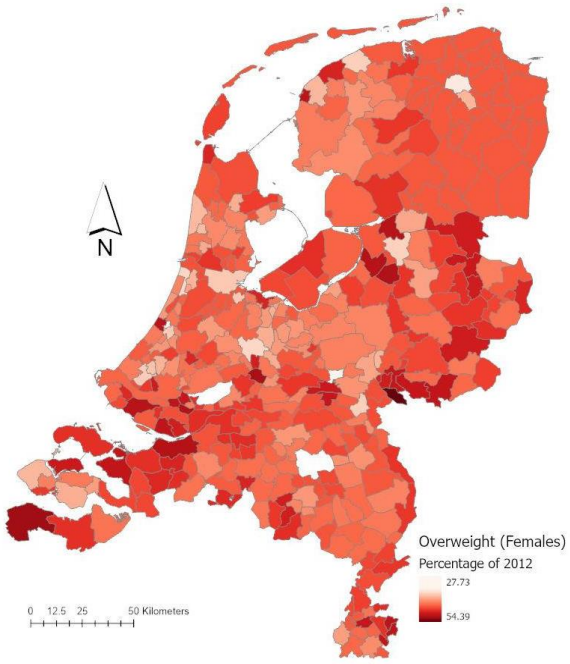
At third, many municipalities started in 2012 with a high percentage of males and females with overweight (figures 13 and 14). And in almost every municipality, these percentages increased over the period, both for males and females (Appendices G and H). In line with the two other variables, the municipalities in the north-east have similar percentages of overweight males and females, with absolute changes turning out to be increasing the more east a municipality is located. Relatively lower percentages of overweight are situated in municipalities in the north-west, the south-east, in the middle of the country, and some municipalities in the western coastal region. Relatively higher percentages in 2012 can be found in the north-east, mid-east and south-west. The highest absolute changes are in the north-east and the two municipalities in the north-west, that had relatively low percentages of overweight males and females at the start of the period. Different from the variables smoking and heavy drinking, it looks like there are not major differences between municipalities near each other.

Figure 13. Prevalence overweight of males in 2012



Source: own figure based on data from RIVM and CBS

Figure 14. Prevalence overweight of females in 2012

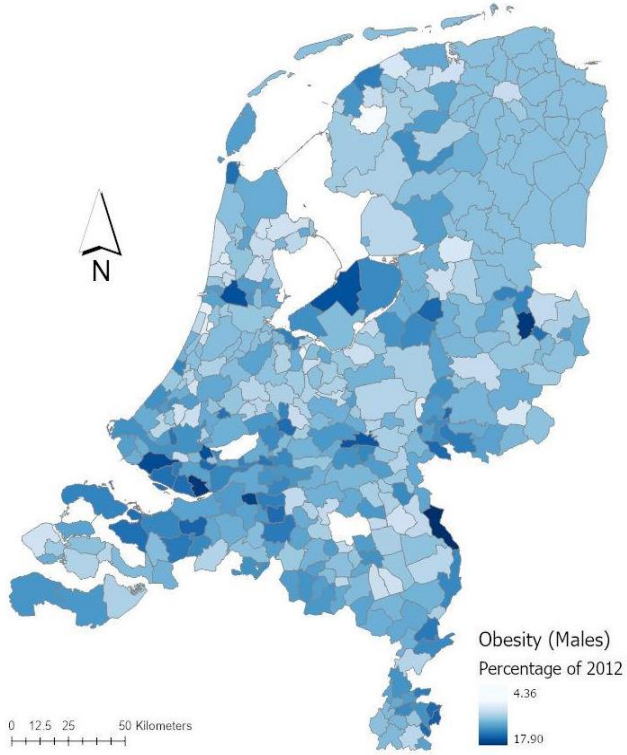


Source: own figure based on data from RIVM and CBS

4.2.3.4 Obesity

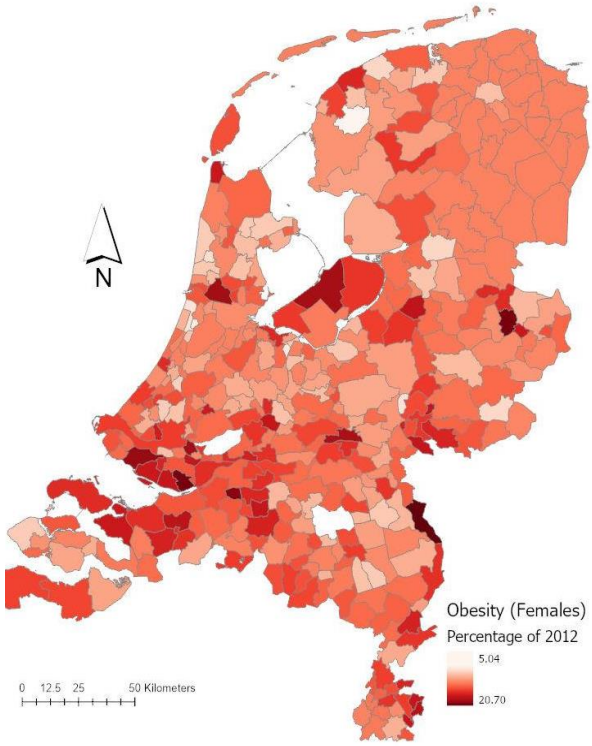
The fourth variable is obesity. In contrast with the previous three variables, the prevalence of obesity in 2012 as well as the absolute change until 2016 is higher for females than for males. Next to this, the municipalities in the north-east (provinces of Groningen and Drenthe) have similar percentages of obesity like these municipalities have for the other variables as well, only now there are even more municipalities with these similar percentages at the bottom making this region even bigger (figure15 and 6). The absolute changes become higher the more north-east a municipality is situated in this region (Appendices I and J). Municipalities with relatively low starting percentages in 2012 are located in the north-west and in the middle of the country. Municipalities in the south-west, middle and the border municipalities next to Germany in the south have relatively high percentages of obesity in 2012. The municipalities that started with a high percentage are often the municipalities with a low absolute change in the period between 2012 and 2016. Low absolute changes can further be observed at the border in the south(-east) of the Netherlands. Most of these had relatively high percentages at the start.

Figure 15. Prevalence obesity of males in 2012



Source: own figure based on data from RIVM and CBS

Figure 16. Prevalence obesity of females in 2012

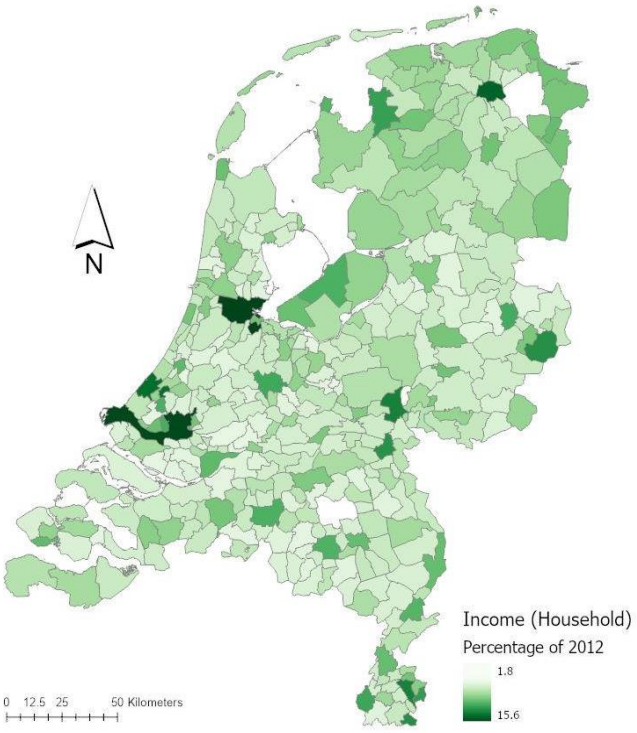


Source: own figure based on data from RIVM and CBS

4.2.3.5 Low income

The fifth and last variable is low income at the household level. The map in figure 17 illustrates that in particular municipalities in the upper third of the country have the high percentages of households with a low income in 2012, with the highest percentages at the edges of the region and lowest percentages in the middle of the region with the exception of one municipality. The absolute change in this northern region is relatively high in the municipalities that already had a high percentage of low-income households in 2012 (Appendix K). This means that the number of households with a low income increased in these municipalities over the years. Within this region, it looks like that the more east a municipality is situated, the higher the absolute change. With a couple of exceptions, the percentage of households with a low income is relatively low in the

Figure 17. Low income prevalence in 2012



Source: own figure based on data from RIVM

remaining municipalities in the country. Regarding the absolute change, it seems that municipalities with a relatively high percentage in 2012 show an absolute decrease over the period until 2016. The rest of the municipalities do not show exceptional situations since most of these only have a small increase or decrease.

4.3 Relationship between life expectancy and explanatory variables

Next to analysing the different maps of the variables, correlations are examined to evaluate the (statistical) relationships between the absolute change in life expectancy and the explanatory variables at the municipality level. Table 3 presents a summary of the r, the r-squared, the t and the p-values of males and the household-level for both non-stagnated municipalities and stagnated municipalities. Table 4 shows a summary of the r, the r-squared, the t and the p-values of females. The r-squares (R2) of the prevalence in 2012 and the absolute change of all the explanatory variables are close to zero and this means that there is almost nothing that explains the variation in the absolute change in life expectancy at the municipality level. This is the case for both males and females in municipalities without stagnation as well as in municipalities with stagnation in life expectancy. This is also the case for the variable low income at the household level. Next to this, the p-values of all the explanatory variables for both the prevalence in 2012 and the absolute change are not significant for both non-stagnated municipalities and stagnated municipalities, indicating that there is not a significant (linear) correlation between the absolute changes in life expectancy at birth and the prevalence in 2012 or the absolute change of the lifestyle factors or income for both males and females at the municipality level in the Netherlands. The same results apply for the variable low income on the household level.

Table 3. Correlations for males

Males	Variable		r	R2	t	p-value
Non-stagnated municipalities	Smoking	Prevalence in 2012	-0.10	0.01	1.57	0.12
		Absolute change (2012-2016)	0.06	0.00	1.03	0.31
	Heavy drinking	Prevalence in 2012	-0.02	0.00	0.25	0.80
		Absolute change (2012-2016)	0.06	0.00	1.05	0.30
	Overweight	Prevalence in 2012	0.07	0.00	1.10	0.27
		Absolute change (2012-2016)	0.02	0.00	0.29	0.77
	Obesity	Prevalence in 2012	-0.02	0.00	0.27	0.79
		Absolute change (2012-2016)	0.12	0.01	1.91	0.06
Stagnated municipalities	Smoking	Prevalence in 2012	0.15	0.02	1.68	0.10
		Absolute change (2012-2016)	-0.08	0.01	0.84	0.40
	Heavy drinking	Prevalence in 2012	-0.07	0.00	0.77	0.45
		Absolute change (2012-2016)	-0.08	0.01	0.88	0.38
	Overweight	Prevalence in 2012	0.13	0.02	1.43	0.16
		Absolute change (2012-2016)	-0.01	0.00	0.12	0.90
	Obesity	Prevalence in 2012	0.14	0.02	1.55	0.12
		Absolute change (2012-2016)	-0.03	0.00	0.33	0.74
Non-stagnated municipalities	Low income (household)	Prevalence in 2012	-0.07	0.01	1.10	0.27
		Absolute change (2012-2016)	0.04	0.00	0.56	0.58
Stagnated municipalities		Prevalence in 2012	0.14	0.02	1.63	0.11
		Absolute change (2012-2016)	0.01	0.00	0.15	0.88

Source: own calculation based on data from the RIVM and the Health Monitors of 2012 and 2016.

Table 4. Correlations for females

Females	Variable		r	R2	t	p-value
Non-stagnated municipalities	smoking	Prevalence in 2012	-0.16	0.03	2.22	0.06
		Absolute change (2012-2016)	0.12	0.01	1.69	0.09
	heavy drinking	Prevalence in 2012	-0.04	0.00	0.59	0.56
		Absolute change (2012-2016)	0.07	0.00	0.94	0.35
	overweight	Prevalence in 2012	0.09	0.01	1.31	0.19
		Absolute change (2012-2016)	0.11	0.01	1.49	0.14
	obesity	Prevalence in 2012	-0.05	0.00	0.65	0.52
		Absolute change (2012-2016)	0.11	0.01	1.47	0.14
Stagnated municipalities	smoking	Prevalence in 2012	0.21	0.05	3.02	0.06
		Absolute change (2012-2016)	-0.13	0.02	1.83	0.07
	heavy drinking	Prevalence in 2012	-0.03	0.00	0.43	0.67
		Absolute change (2012-2016)	-0.07	0.00	0.93	0.35
	overweight	Prevalence in 2012	0.09	0.01	1.26	0.21
		Absolute change (2012-2016)	0.00	0.00	0.00	1.00
	obesity	Prevalence in 2012	-0.11	0.01	1.47	0.14
		Absolute change (2012-2016)	0.02	0.00	0.23	0.82

Source: own calculation based on data from the RIVM and the Health Monitors of 2012 and 2016.

Chapter 5. Conclusion

This research analysed the recent stagnating trend in life expectancy at birth at the municipality-level in the Netherlands. Spatial analyses (mapping, spatial autocorrelation) and correlations have been performed, calculated and assessed to determine the distribution of stagnation in the absolute change in life expectancy while taking into account gender and to examine to what extent lifestyle factors and socioeconomic factors are associated with the regional differences in the stagnation in life expectancy.

5.1 Summary of the results

Five main findings are resulting from this research, which are the following. First, life expectancy is stagnating more for females than for males since half of the municipalities for females (261) and only one third of the municipalities for males (125) had stagnation in life expectancy over the period 2012-2016 compared to the period before (2002-2012). Second, resulting from this, male life expectancy is increasingly converging towards female life expectancy. Third, municipalities without stagnation in life expectancy started the research period in 2012 with a lower life expectancy than municipalities with stagnation for both males and females. The absolute change between 2012 and 2016 did increase in non-stagnated municipalities but decreased in stagnated municipalities. This might indicate that non-stagnated municipalities are catching up with the life expectancy of the stagnated municipalities since they had a higher life expectancy in 2012 and stagnated municipalities are lagging behind these improving trends in life expectancy of the non-stagnated municipalities. Fourth, there is no clustering of the stagnation of life expectancy at the municipality level, for neither males nor females. The spatial distribution of the annual absolute changes of life expectancy at birth of males and females are randomly distributed among the municipalities of the Netherlands. Fifth and last, the extent to which lifestyle factors and socioeconomic status contribute to regional differences in the stagnation in life expectancy is very limited, both for males and females. Outcomes show that there is not a significant (linear) correlation between the absolute change in life expectancy and the prevalence in 2012 or the absolute change in lifestyle factors and socioeconomic status at the municipality level in the Netherlands.

5.2 Discussion of the results

In line with a previous study by Stoeldraijer (2020), a stagnated increase in the trend of life expectancy at birth in the Netherlands is found for the period 2012-2016 compared to the period 2002-2012. This research, however, looked deeper into this stagnation on the municipality-level, in particular between males and females.

The findings of this research support the hypothesis that regional differences in the stagnation in life expectancy are the result of the process of convergence-divergence between genders. Vallin & Meslé (2004) mention processes of convergence-divergence that are visible in the fight against ageing. These researchers relate these processes to differences and similarities between countries and gender and the outcomes of this research correspond to their theory. The findings show that female life expectancy is stagnating more than male life expectancy, since female life expectancy is stagnating in half of the municipalities (261) after 2012 compared with the years before and for males this is only in one third of the municipalities (125). Life expectancies of males and females turn out to converge since the average

differences in life expectancy between males and females decreased from 4.87 years in 2002 to 3.54 years in 2016. It seems that many of the municipalities with a low life expectancy in 2012 have a higher increase than municipalities that already had a relatively high life expectancy in 2012, especially for male. Not only is male life expectancy catching up to female life expectancy, but most municipalities stagnate in female life expectancy resulting in female life expectancy lagging behind the improvements in the life expectancy that males show during 2012-2016. Furthermore, there is a difference between municipalities with stagnating life expectancies between 2012-2016 compared to 2002-2012 and municipalities without stagnation. The non-stagnated municipalities started the research period in 2012 with a lower life expectancy than the stagnated municipalities for both males and females. The absolute change between 2012 and 2016, however, did increase in municipalities without stagnation but decreased in municipalities with stagnation. Next to this, it was expected that municipalities near each other would have similar life expectancies since the first law of geography states that near things are more related than distant things. However, this research did not find evidence for this. The outcomes of the Global Moran's I tool demonstrate that the spatial distribution of the absolute change in life expectancy among the municipalities in the Netherlands over the period 2012-2016 is a result of random spatial processes. This means that there is no clustering.

The regional differences between the stagnation in life expectancy at the municipality-level were expected to be determined by contextual and compositional factors (Shaw et al., 2002). Contextual factors are about their physical, economic and social environment in which people live, and compositional factors are at the individual level and refer to their characteristics, like lifestyle factors or socioeconomic status. Since the retrieved data in this research is about lifestyle factors and socioeconomic status, only the compositional part of this theory by Shaw et al. (2002) can be studied. This research found that the lifestyle factors and socioeconomic status appear not only to be of different importance for municipalities with and without stagnation, but also of different importance per gender. Assessing the regional differences of lifestyle factors and socioeconomic status, a similar process seems to appear to that of life expectancy by which many of the municipalities that had a high prevalence of smoking, heavy drinking, overweight, obesity or low income in 2012, showed a lower absolute change over the period until 2016 and vice versa for municipalities with a low prevalence of these factors in 2012. By calculating and analysing the correlations, the extent to which life expectancy and the explanatory variables at the municipality level are related is examined. Contrary to the expectations, this relationship turned out to be very limited, both for males and females. There is not a significant (linear) correlation between the absolute change in life expectancy and the prevalence in 2012 or the absolute change in the lifestyle factors and socioeconomic status at the municipality level in the Netherlands. A possible explanation for this result for smoking and heavy drinking can be that the prevalence of people smoking and drinking during the period 2012-2016 is used, however, these prevalence are not directly corresponding with the deaths during that same period that are influencing the life expectancies during that period. People often die from diseases that are related to smoking and heavy drinking years later. This is in line with a study from Janssen (2021) that describes this phenomenon by the use of the smoking epidemic theory indicating that changes in smoking behaviour results in similar patterns of smoking-attributable mortality 30-40 years later. Furthermore, there can be many other explanatory variables for regional differences in life expectancy that are not studied in this

research, since Vallin & Meslé (2004) stated that not only compositional factors but also contextual factors that could potentially explain variations. Additionally, Murphy et al. (2019) mentioned drug use and low physical activity as risk factors and Stoeldraijer (2020) looked at other possible explanations for the stagnated increase on the national scale, like the availability and quality of healthcare services that might differ per region.

5.3 Reflection of the data and methods

One of the limitations is the geographic level on which the data is based. Although it was very insightful to work with data on the municipality-level, it also had a couple of disadvantages. Data on lifestyle factors per municipality were missing for males and females and was only available for the total population. Nevertheless, by adjusting the data as described in chapter 3, it was possible to work it, but conclusions on this adjusted data should be interpreted with caution. Furthermore, data on life expectancy was missing for three municipalities due to reorganization of municipalities within the years of the research. In addition, even more municipalities needed to be dropped because of missing values, outliers or error in the explanatory variables. Next to the geographical scale that caused some limitations, the data on smoking and heavy drinking turned out to have some downsides. It would have been preferable to have used data on mortality attributable to smoking and heavy drinking instead of the prevalence of smoking and heavy drinking at the moment of the research, since this prevalence often have an impact on mortality 30-40 years later.

5.4 Policy recommendations and further research

It is recommended for policy makers to look into the differences in health and lifestyles between gender since life expectancy is mostly increasing for males but decreasing for females, and therefore policies based on males or females separately could make a difference in future health inequalities. Additionally, since the biological limit of life expectancy has not been reached yet, improvements in healthy lifestyles and in a good healthcare system are necessary to achieve this. Furthermore, policies on the municipality-level are needed since various municipalities are lagging behind other municipalities with the improvements in life expectancy as the findings suggest.

Based on the difficulties with the data, future researchers could consider conducting research on the stagnation of life expectancy on another geographic level, such as the provinces of the GGD's since there might be more data available, such as smoking-attributable mortality. In addition, these geographical levels could provide data on both compositional and contextual factors that potentially explains the stagnation in life expectancy within the Netherlands and with less data adjustments the results will be of a higher reliability. Next to this, future research could consider digging deeper into the differences in stagnation in life expectancy between genders, in particular how various variables have a different influence on these life expectancies. The prevalence of obesity, for example, is increasing faster for females than for males. Looking more in-depth into these gender differences might give interesting outcomes that could help policymakers to implement policies and health interventions specifically focused on males or females. Furthermore, it would be interesting if a future researcher on this topic could dig deeper into the differences between the two periods (2002-2012 and 2012-2016) as according to the final version of Stoeldaijer's (2020) research, it is

probably that the period of 2002-2012 has had an outstanding increase in the life expectancy and that the stagnation that has been noticed in the period after 2012 looks more like the change in life expectancy as has been seen before 2002. The differences in various factors could give interesting insights in for instance the changes in health policies or changes in lifestyle over the years, or maybe even about the composition of the population that have changed. Lastly, future research could also look into the COVID-19 as an explanatory variable because there are regional differences in the prevalence within the Netherlands, which potentially influence the stagnation in life expectancy at birth (Hoekman et al., 2020).

In conclusion, this research has found that the differences between municipalities in the stagnation in life expectancy exist in that more municipalities have a stagnation in life expectancy for females than for males in the Netherlands. Besides this, stagnated municipalities started with a higher life expectancy in 2012 than non-stagnated municipalities. Additionally, the absolute change between 2012-2016 decreased in stagnated municipalities and increased in non-stagnated municipalities. Next to this, the extent to which lifestyle factors and socioeconomic status contribute to the regional differences in the stagnation in life expectancy is very limited since there is not a significant (linear) correlation between the absolute change in life expectancy and the prevalence in 2012 or the absolute change in lifestyle factors and socioeconomic status at the municipality level in the Netherlands. Everything considered, the recently stagnated increase in life expectancy differs per municipality and per gender. These differences should be taken into account when policymakers formulate future policies on healthy ageing and for further research on this topic.

References

ArcGIS Pro. (n.d.). *How Spatial Autocorrelation (Global Moran's I) works.* Retrieved on July 19, 2020 from https://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/h-how-spatial-autocorrelation-moran-s-i-spatial-st.htm

Barbieri, M. (2019). The decrease in life expectancy in the United States since 2014. *Population Societies*, (9), 1-4.

Bennett, J. E., Pearson-Stuttard, J., Kontis, V., Capewell, S., Wolfe, I., and Ezzati, M. (2018). Contributions of diseases and injuries to widening life expectancy inequalities in England from 2001 to 2016: a population-based analysis of vital registration data. *The Lancet Public Health,* 3(12), e586-e597.

CBS. (n.d.). *Privacy*. Retrieved on July 19, 2020 from https://www.cbs.nl/nl-nl/over-ons/organisatie/privacy

CBS (2013). Regionale verschillen in sterfte verklaard. Retrieved on May 24, 2020 from https://www.cbs.nl/nl/achtergrond/2013/07/regionale-verschillen-in-sterfte-verklaard.

CBS (2018). *Lower gains in life expectancy here and in the EU.* Retrieved on May 21, 2020 from https://cbs.nl/en-gb/news/2018/36/lower-gains-in-life-expectancy-here-and-in-the-eu.

CBS. (2019a)). *3 in 10 deaths are caused by cancer*. Retrieved on June 18, 2020 from https://www.cbs.nl/en-gb/news/2019/27/3-in-10-deaths-caused-by-cancer.

CBS. (2019b). *Life expectancy*. Retrieved on June 18, 2020 from https://longreads.cbs.nl/european-scale-2019/life-expectancy/.

Esri. (n.d.). *Cluster and Outlier Analysis (Anselin Local Moran's I) (Spatial Statistics)*. Retrieved on December 18, 2020 from https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/cluster-and-outlier-analysis-anselin-local-moran-s.htm.

Fenton, L., Minton, J., Ramsay, J., Kaye-Bardgett, M., Fischbacher, C., Wyper, G. M., & McCartney, G. (2019). Recent adverse mortality trends in Scotland: comparison with other high-income countries. *BMJ open*, *9*(10).

Hoekman, L. M., Smits, M. M. V., & Koolman, X. (2020). The Dutch COVID-19 approach: Regional differences in a small country. *Health Policy and Technology*, *9*(4), 613-622.

Ho, J. Y., & Hendi, A. S. (2018). Recent trends in life expectancy across high income countries: retrospective observational study. *bmj*, *362*, k2562.

Janssen, F. (2021). The Role of Smoking in Country Differences in Life Expectancy Across Europe, 1985–2014. *Nicotine and Tobacco Research*, *23*(1), 152-160.

Janssen, F., & van Poppel, F. (2015). The adoption of smoking and its effect on the mortality gender gap in Netherlands: a historical perspective. *BioMed research international*, *2015*.

Janssen, F., Rousson, V., & Paccaud, F. (2015). The role of smoking in changes in the survival curve: an empirical study in 10 European countries. *Annals of epidemiology*, *25*(4), 243-249.

Mackenbach, J. P. (2011). Can we reduce health inequalities? An analysis of the English strategy (1997–2010). *Journal of Epidemiology & Community Health*, *65*(7), 568-575.

Murphy, M. Luy, M.. and Torrisi, O. (2019). Mortality change in the United Kingdom and Europe, Social Policy Working Paper 11-19, London: LSE Department of Social Policy.

OECD. (n.d.). *Life expectancy at birth*. Retrieved on February 3, 2021 from https://data.oecd.org/healthstat/life-expectancy-at-birth.htm

Office for National Statistics. (2018). *Changing trends in mortality in England and Wales: 1990 to 2017 (Experimental Statistics)*. Retrieved on June 19, 2020 from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articl e s/changingtrendsinmortalityinenglandandwales1990to2017/experimentalstatistics.

Omran, A. R. (1971). The Epidemiologic Transition: A Theory of the Epidemiology of Population Change*. The Milbank Memorial Fund Quarterly,* 49(4), 509-38.

Omran, A.R. (1998), The epidemiologic transition theory revisited thirty years later, World *Health statistics Quarterly*, 51, 99-119.

Omran, A. R. (2005). The Epidemiologic Transition: A Theory of the Epidemiology of Population Change. *Milbank Quarterly*, 83(4), 731–757.

Raleigh, V. (2019), “Trends in life expectancy in EU and other OECD countries : Why are improvements slowing?”, *OECD Health Working Papers*, No. 108, OECD Publishing, Paris.

Riley, J. C. (2001). *Rising life expectancy: a global history.* Cambridge University Press.

Santosa, A., Wall, S., Fottrell, E., Högberg, U., & Byass, P. (2014). The development and experience of epidemiological transition theory over four decades: a systematic review. *Global health action*, *7*(1), 23574.

Shaw, M., Dorling D. and Mitchell, R. (2002) Health, Place and Society. Pearson: London

Sidney, S., Quesenberry, C. P., Jaffe, M. G., Sorel, M., Nguyen-Huynh, M. N., Kushi, L. H., & Rana, J. S. (2016). Recent trends in cardiovascular mortality in the United States and public health goals. *JAMA cardiology*, *1*(5), 594-599.

Stoeldraijer, L., van Duin, C. & Janssen, F. (2013). Bevolkingsprognose 2012-2060: model en veronderstellingen betreffende de sterfte. *Den Haag/ Heerlen: Centraal Bureau voor de Statistiek.*

Stoeldraijer, L. (2020). *Sterfte en levensverwachting in de 21ste eeuw: minder vooruitgang of*

vooruitgang minder toegepast?.

United Nations. (1975). *World population prospects, 1970-2000.* New York, United Nations, 50 p.

Vallin, J., & Meslé, F. (2004). Convergences and divergences in mortality: a new approach of health transition. *Demographic research*, *2*, 11-44.

WHO. (n.d.). *Life expectancy at birth*. Retrieved on June 21, 2020 from https://www.who.int/gho/mortality_burden_disease/life_tables/situation_trends_life_expectancy/en

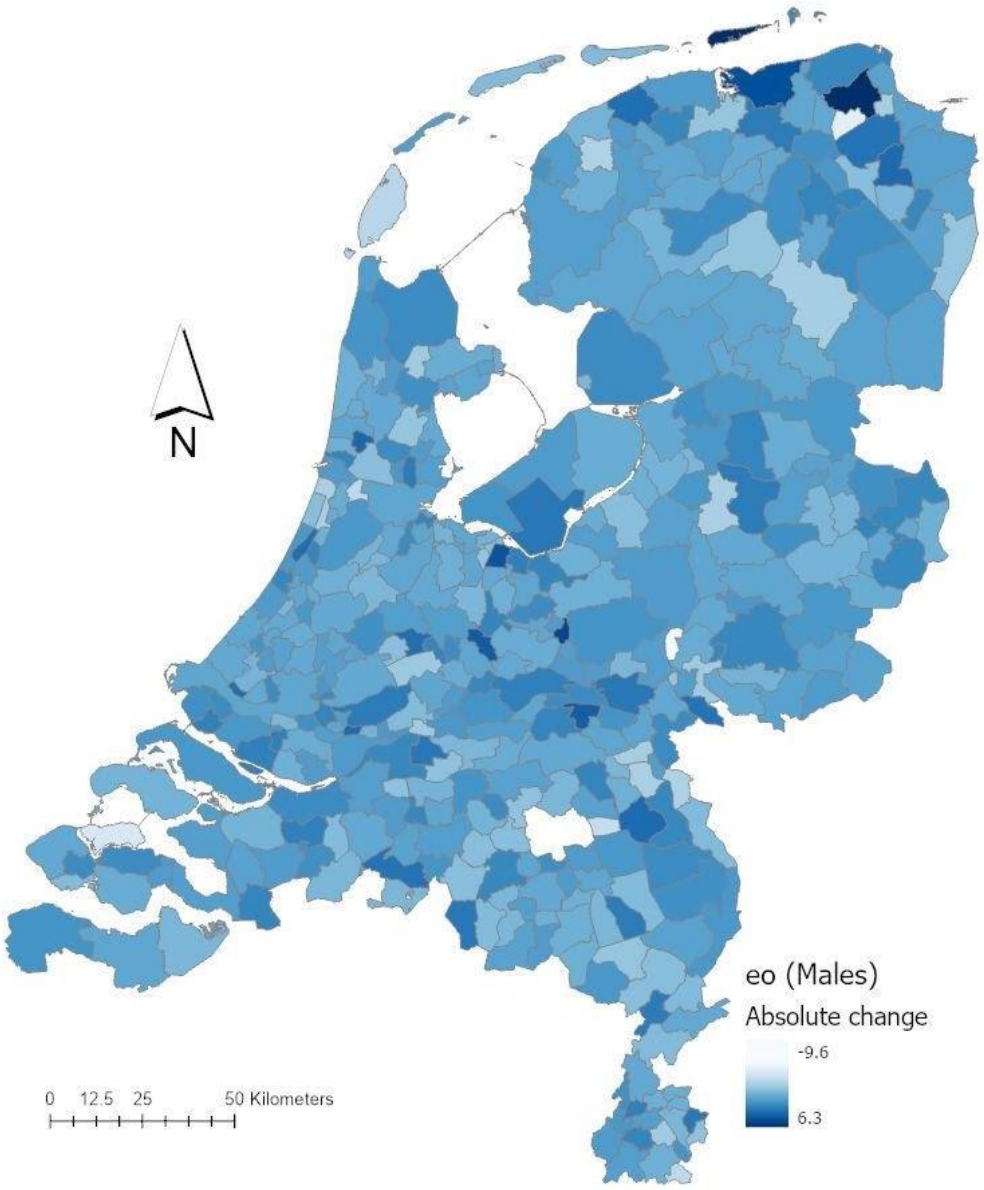
World Health Organization (2002). *The World Health Report 2002: Reducing risks, promoting healthy life.* Geneva: WHO.

Geodata

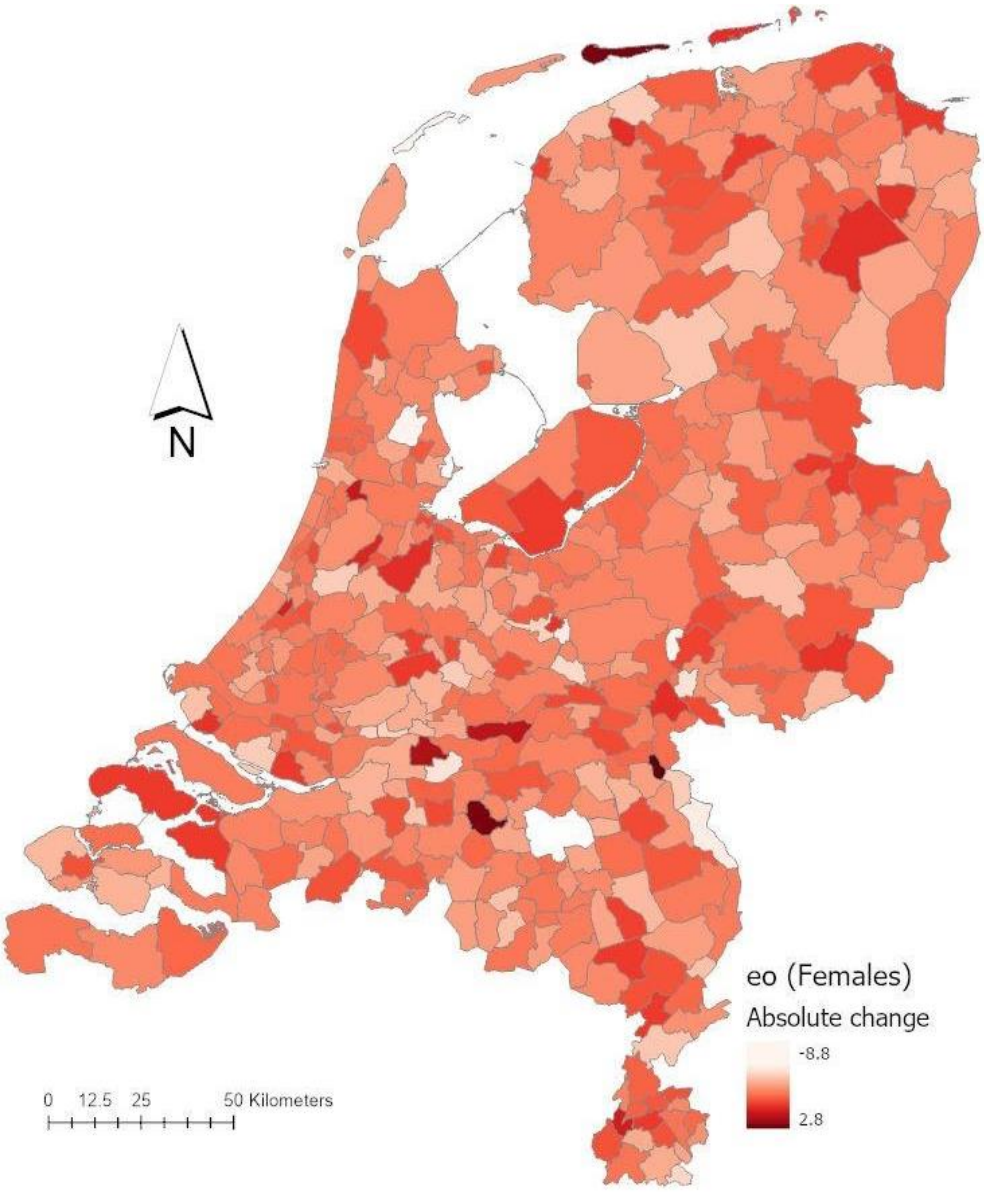
Gemeentegrenzen 2016 [polygon layer]. The Netherlands: Esri Nederland, 2016. Available: ArcGIS <https://services.arcgis.com/nSZVuSZjHpEZZbRo/arcgis/rest/services/Gemeentegrenzen_2016/FeatureServer> (Assessed November 12, 2020).

Appendices

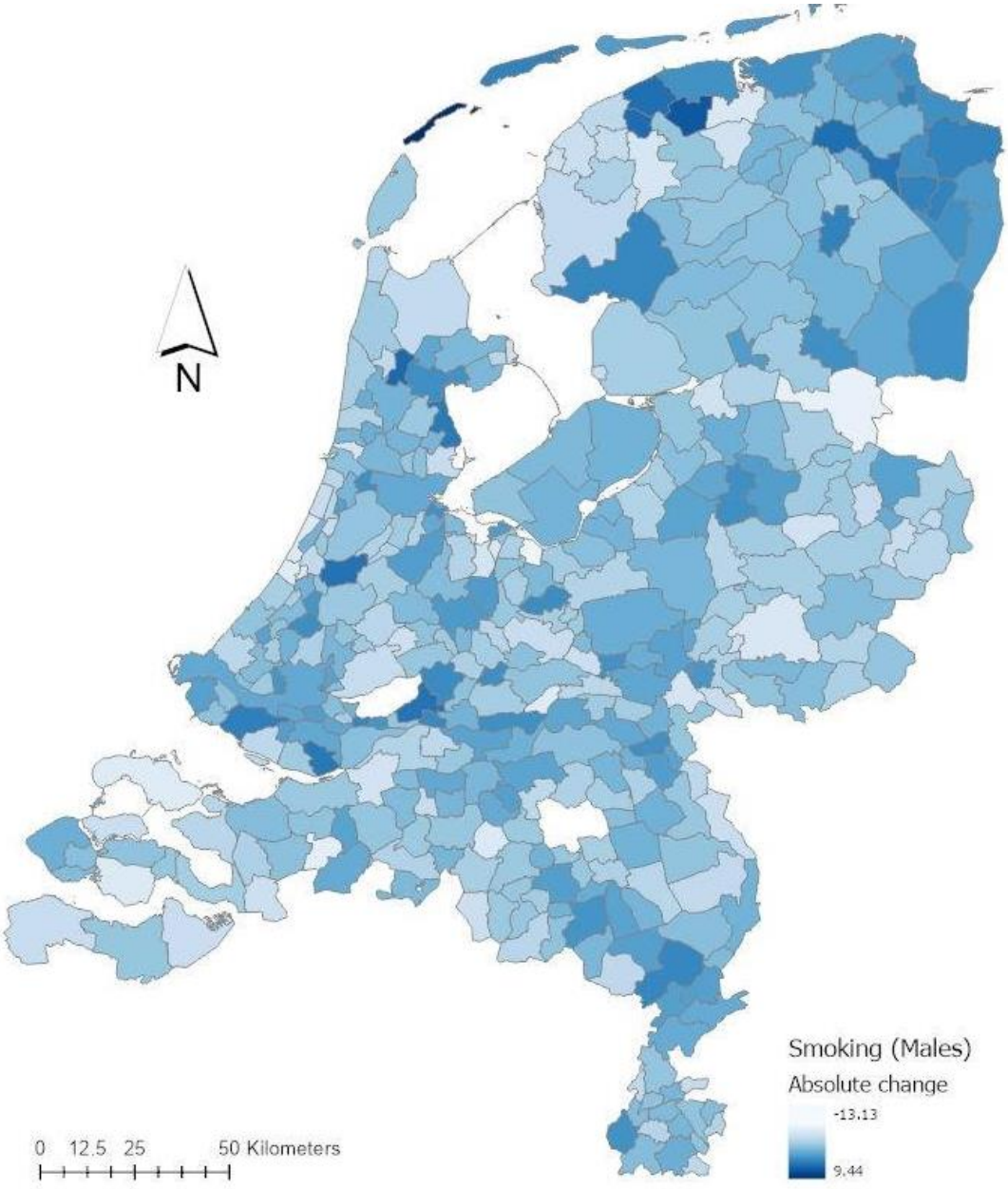
Appendix A. Absolute change in life expectancy males (2012-2016)



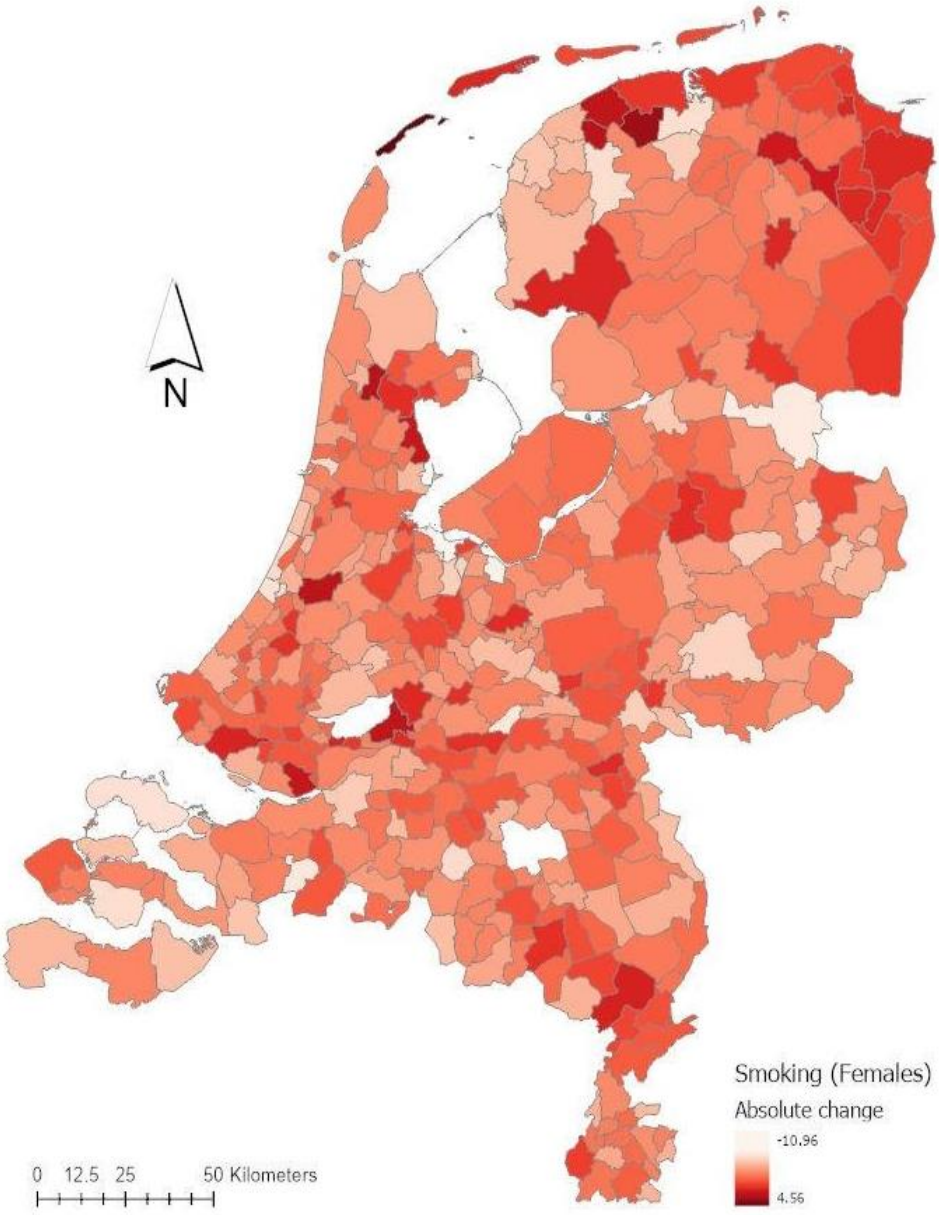
Appendix B. Absolute change in life expectancy females (2012-2016)



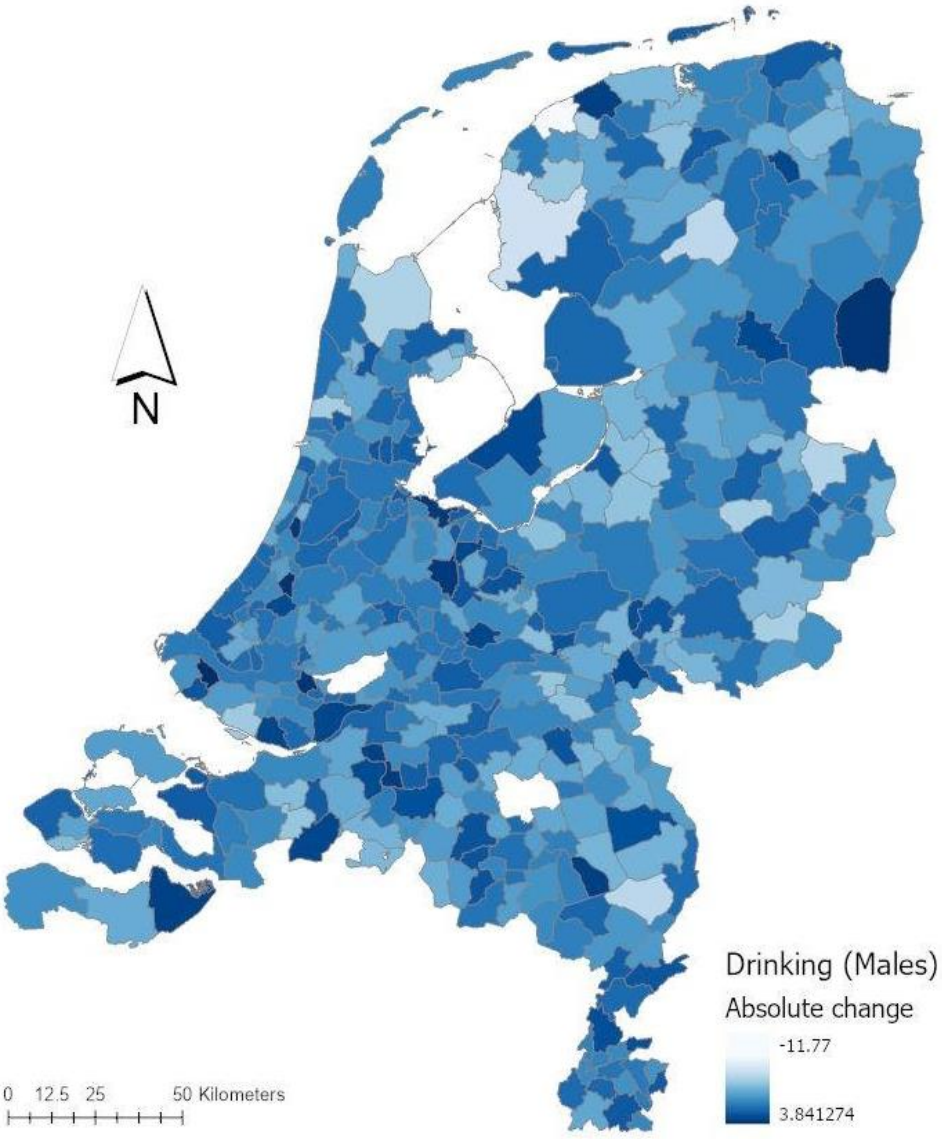
Appendix C. Absolute change in smoking males (2012-2016)



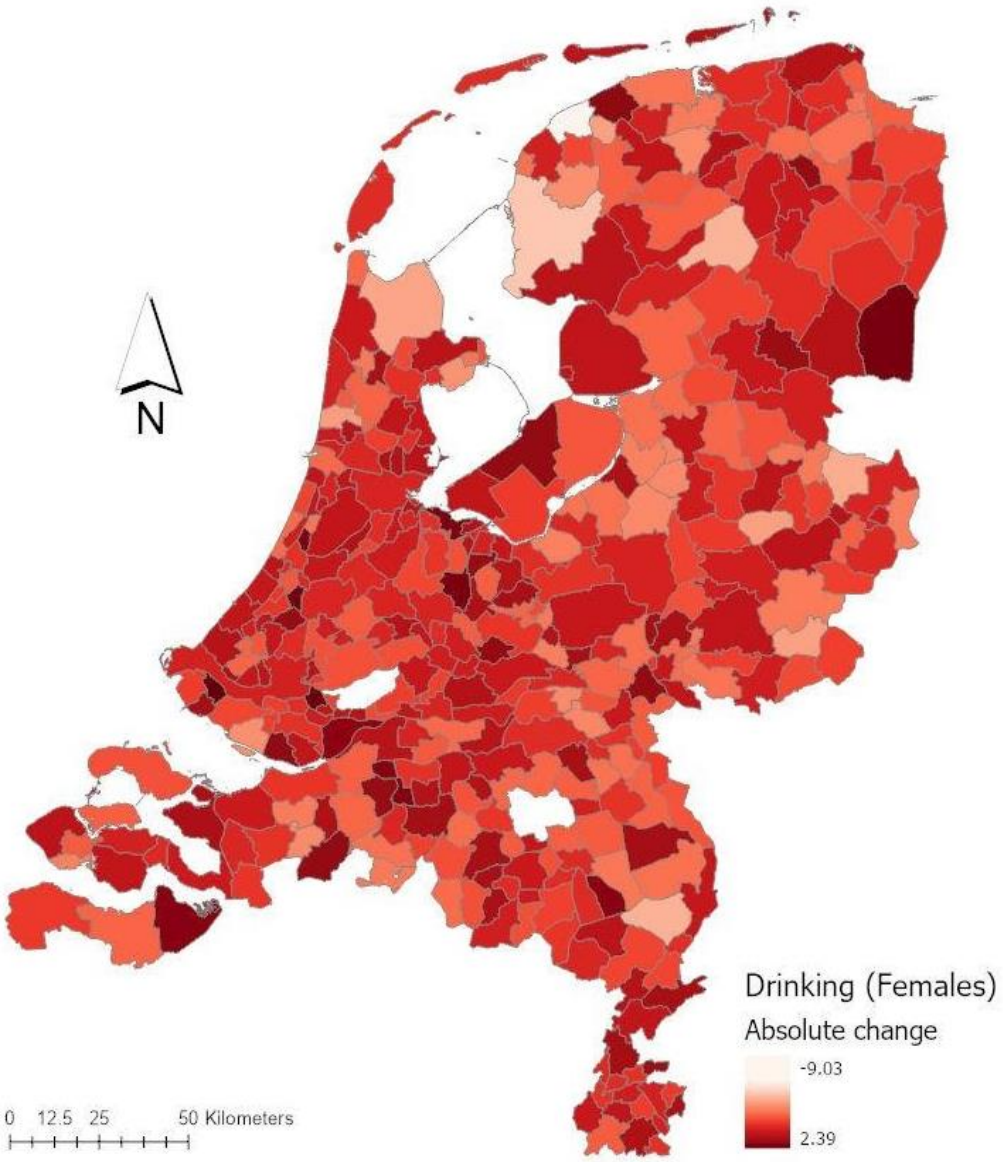
Appendix D. Absolute change in smoking females (2012-2016)



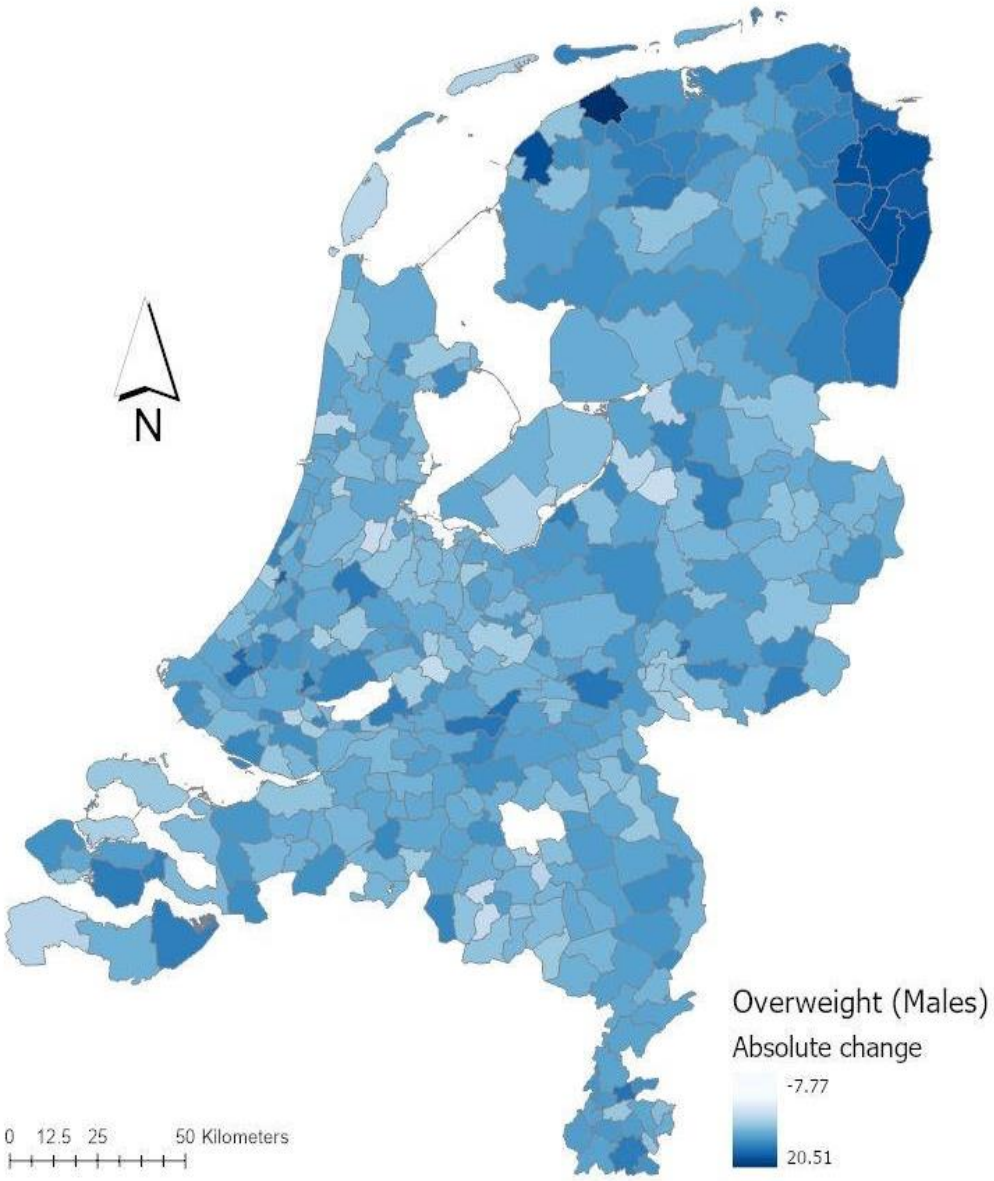
Appendix E. Absolute change in heavy drinking males (2012-2016)



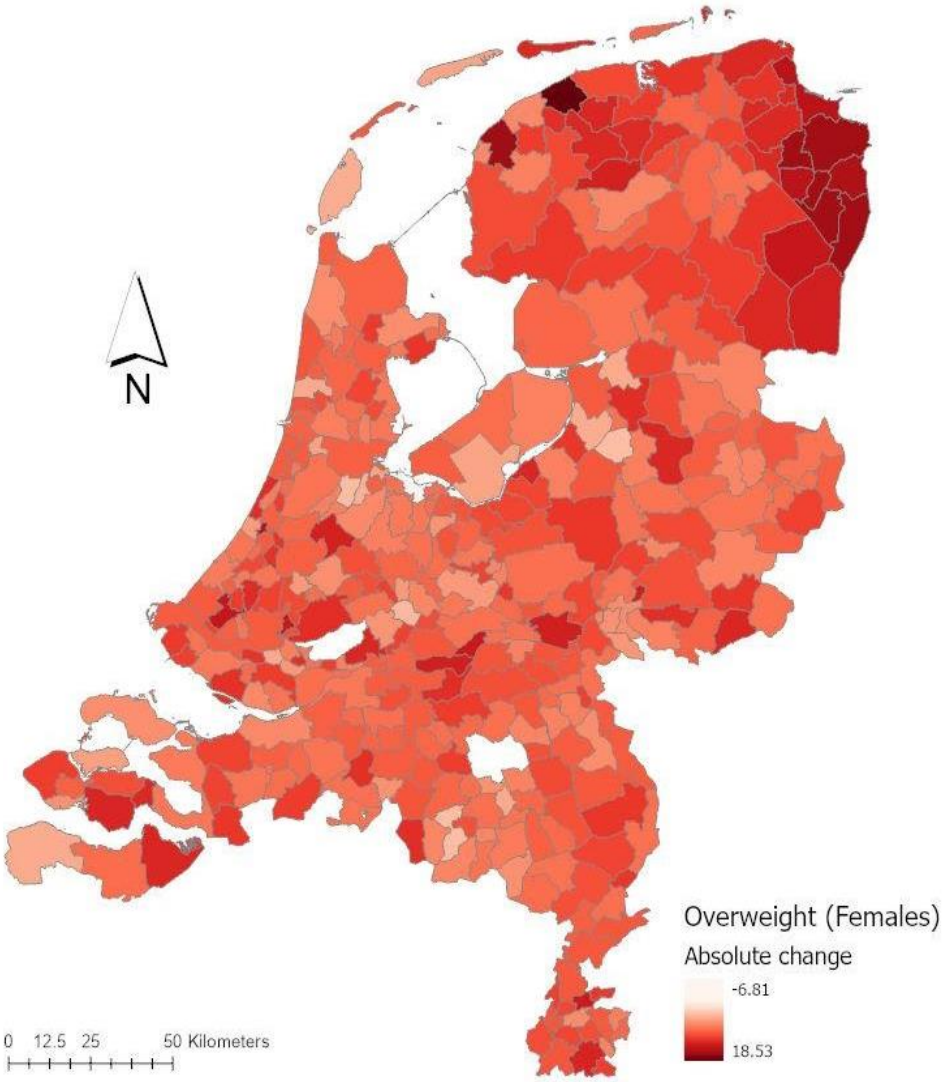
Appendix F. Absolute change in heavy drinking females (2012-2016)



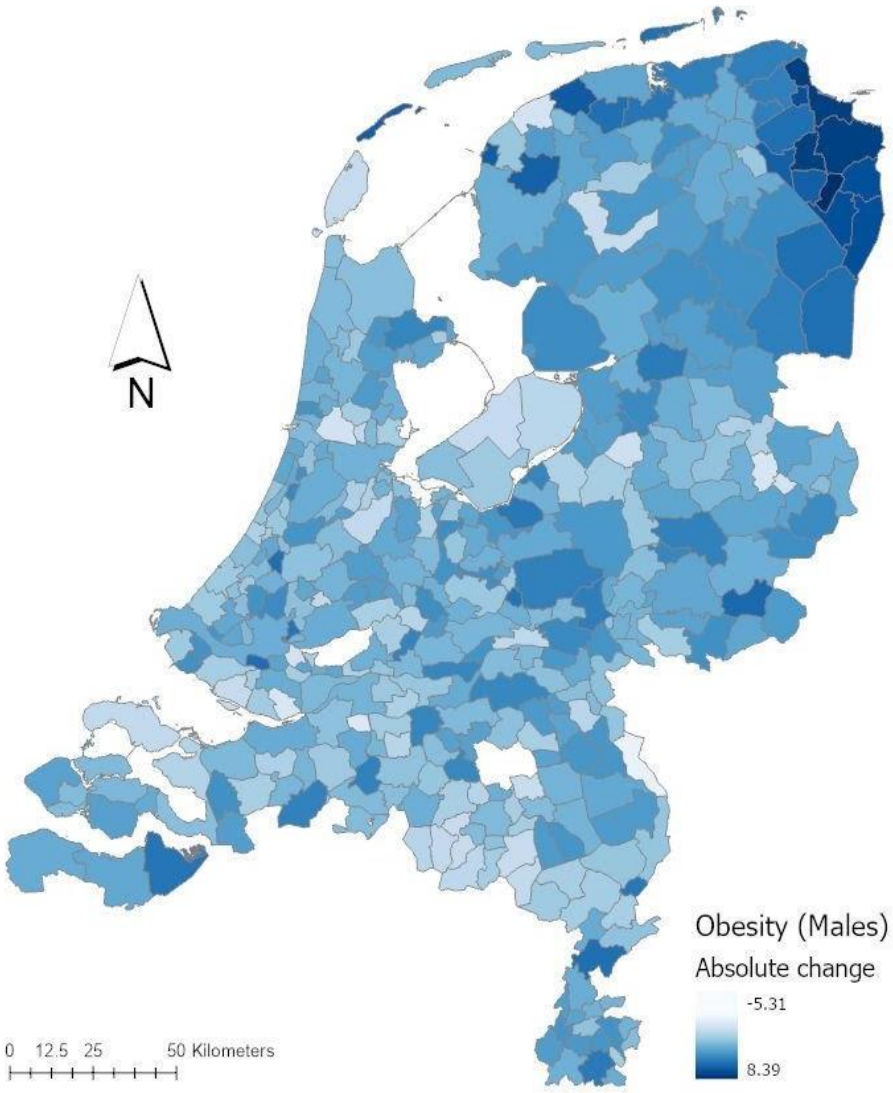
Appendix G. Absolute change in overweight males (2012-2016)



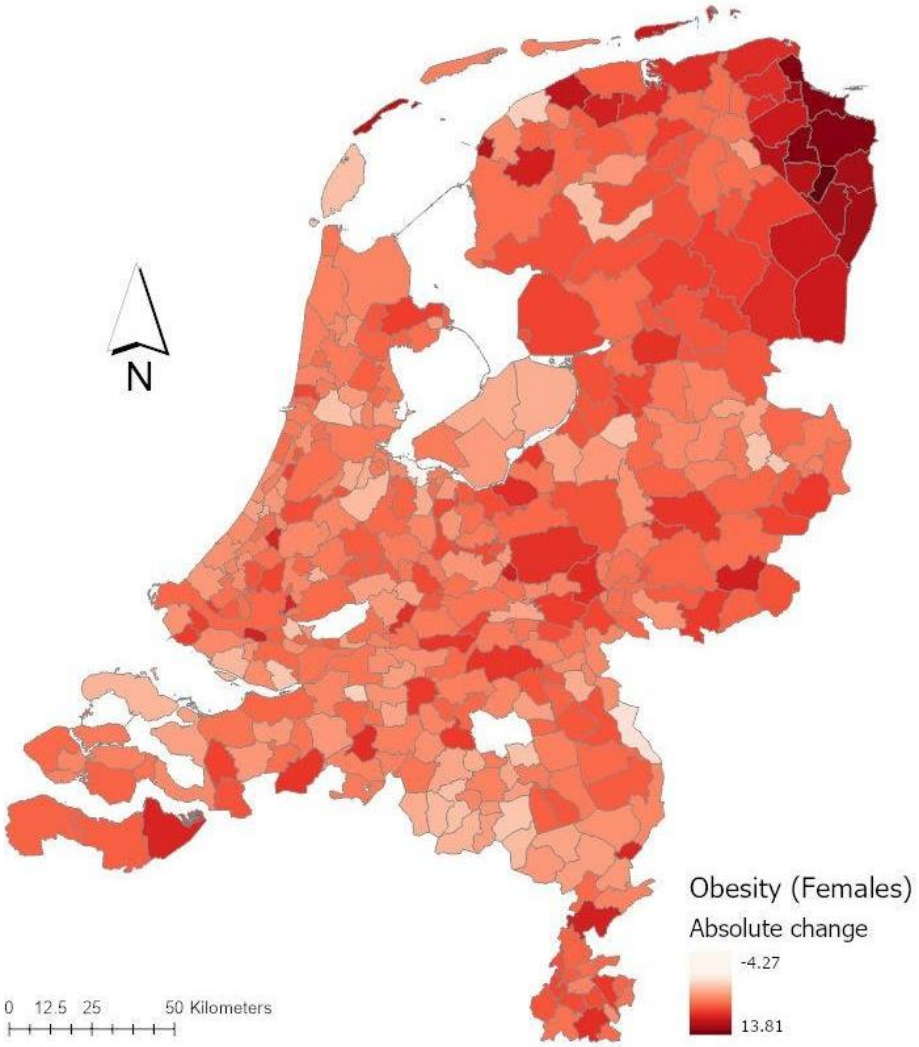
Appendix H. Absolute change in overweight females (2012-2016)



Appendix I. Absolute change in obesity males (2012-2016)



Appendix J. Absolute change in obesity females (2012-2016)



Appendix K. Absolute change in low income households (2012-2016)