Regional differences in life expectancy in the Northern Netherlands: spatial analysis of life expectancy, socioeconomic status and underlying causes of death

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Abstract

Within the Northern Netherlands life expectancy is on average lower than the standard of the Netherlands. Comprehension of the determinants of regional differences in life expectancy can contribute to a more targeted policy advice on geographical variations in health outcomes. However, until now little research on geographical differences in health has been carried out at the municipality level.

The objective of this research is to understand the factors that contribute to the regional differences in life expectancy in the Northern Netherlands. The factors under study are socio economic status (SES) and underlying causes of death (mortality due to malignant neoplasms, lung cancer, circulatory diseases, respiratory diseases and external causes of death).

Data on life expectancy, SES and Comparative Mortality Figure´s (CMF´s) and Standardized Mortality Ratio´s (SMR´s) of the underlying causes of death (males and females separately) for the period 2011-2014 were retrieved through the RIVM for the 59 municipalities. Mapping and spatial cluster analysis in ArcGIS was applied to determine geographical patterns and variations.

Results reveal that life expectancy was significantly clustered in the Northern Netherlands from 2011-2014. Clusters of low life expectancy are observed in the northeast of the region, both for males and females. For both sexes, SES and mortality due to circulatory diseases, respiratory diseases and lung cancer revealed similar patterns compared to the spatial clustering that was observed for life expectancy and therefore contributed to the regional differences in life expectancy. Among males, mortality due to malignant neoplasms also reflected similar patterns to life expectancy. It is remarkable that for females more low-low clusters were observed for circulatory diseases and lung cancer (also higher mortality was observed compared to males), indicating that high mortality due to these causes is somewhat more pronounced for females in this region. No significant results were found for male and female mortality due to external causes of death as well as for female mortality due to malignant neoplasms and therefore these variables do not contribute to the explanation of lower life expectancies within the Northern Netherlands.

In conclusion, low life expectancy in the northeast of the region is attributable to a lower SES and its influence on unhealthy lifestyles (high share of heavy smokers and heavy drinkers and obese people) in the region. However, because not all the municipalities with low SES had poorer health outcomes, it is likely that other factors, such as population decline, are related to lower life expectancies. Furthermore it is recommended that policymakers target at the reduction of risk factors as heavy smoking and heavy drinking and obesity and focus on the broader determinants of health such as (un)employment and poverty in their local health policies.

Key words: regional differences life expectancy, spatial analysis, municipalities, SES, main groups of causes of death, lung cancer mortality

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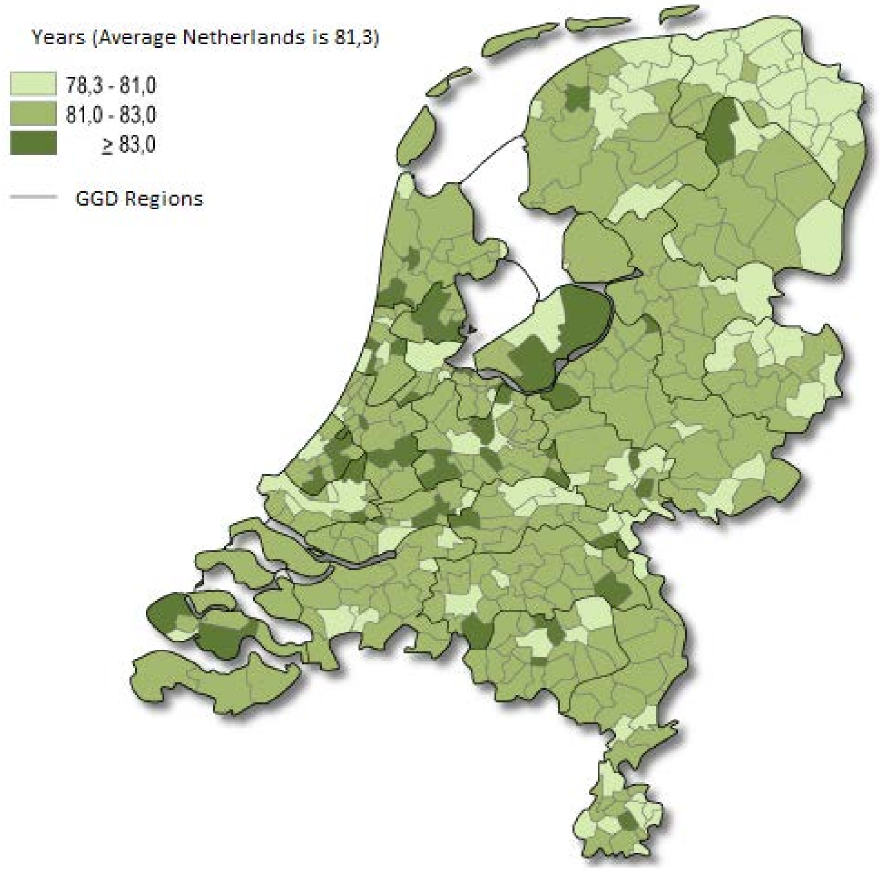
1.Introduction

1.1 Background

In Europe, life expectancy at birth has risen by 10 years in the last 50 years, mainly due to economic progress; improvements in lifestyles; and advancements in healthcare and medicine, and is expected to further increase in the upcoming years (EUROSTAT, 2016). However, there are large differences in morbidity and mortality between and within countries in the European Union (Mladovsky et al., 2009) to a large extent related to the social conditions in which people live (CSDH, 2008). Health inequalities not only exist in developing countries, but also in developed countries with qualitative good healthcare facilities (Mackenbach, 2012).

Within the Netherlands the average life expectancy at birth rise from 71,4 in 1950 to 81,3 years in 2013. Also within the Netherlands, one of the countries with the highest life expectancies in the world, there are large regional differences in life expectancy at birth. A publication by the RIVM (The National Institute for Public Health and the Environment) (see figure 1) shows considerable differences in life expectancy at birth at the regional level in 2011-2014 (Volksgezondheidszorg.info, 2016b). Particularly in the Northern Netherlands life expectancy is on average lower compared to 81.3 years in the Netherlands.

Figure 1: Life expectancy at birth in The Netherlands, 2011-2014



Source: Volksgezondheidszorg.info (2016b)

In the Netherlands, like in other countries in Europe, the leading causes of death are due to cardiovascular diseases, cancer and chronic respiratory diseases (Mladovsky, 2009). cancer is the main cause of death within the country since 2007 onwards (Volksgezondheidzorg.info, 2016a) and is higher compared to the average in the European Union (Eurostat, 2015). Chronic diseases, such as cancer and cardiovascular diseases, accounted for 89% of all deaths in 2012 in the Netherlands (WHO, 2014). Although about 50% of the Dutch population suffer from at least one disorder, chronic diseases are more prevalent at older ages and also more found among women than men (CBS, 2014). Due to the ageing of the population it is estimated that both the number and share of the population with a chronic disease will increase (Daalhuizen et al., 2013). However, even when adjusted for age and sex, the percentage of people with a chronic disease and multimorbidity has increased with respectively 12% and 17% in the period 2004-2011 (Gijsen et al., 2013).

This study is part of an collaboration between the RIVM and the Academic Collaborative Centre for Public Health Northern Netherlands (AWPGNN) to improve the understanding of regional differences in life expectancy in the Northern-Netherlands. The RIVM is the advisory and independent research body of the government and its main task is to monitor and promote public health and a clean and safe living environment in The Netherlands (RIVM, 2016. In the northern region, the Academic Collaborative Centre for Public Health Northern Netherlands (AWPGNN) aims at improving the quality of life of people in the Northern Netherlands by building a sustainable cooperative framework between community and public health services, education sector and policy makers (AWPGNN, 2016). The work of the AWPGNN corresponds to the main goal of the Academic Collaborative Centers for Public Health in The Netherlands to raise the quality of the public health policy making at the municipal level (ZonMw, 2016b).

1.2 Societal relevance

The research of the regional differences in life expectancy at birth fits within the European and national health policies to diminish health inequalities within countries and regions (EC, 2016; Government of the Netherlands, 2015; WHO Regional Office for Europe, 2016). Therefore, the Dutch government stimulates an integrated local public health policy through prevention and intervention at municipality and neighbourhood level (Schippers & Van Rijn, 2015). The focus of this research is to identify and explain the health differences between municipalities in life expectancy at birth and should ideally contribute to a more targeted policy advice on regional differences in life expectancy at the local level.

1.3 Academic relevance

There are few studies on regional differences in life expectancy within the Netherlands. Until now research on socio-economic differences in life expectancy were mainly targeted at neighbourhoods in the major cities (Verweij & Van der Lucht, 2014). Loke & de Jong (2013) estimated regional differences in life expectancy at age 65 at the municipality level using predicted risks of death. Spatial analysis techniques can reveal geographical patterns and variations and identify high risk areas within the Northern region and therefore contribute to the understanding of differences in health outcomes.

1.4 Objective

The aim of this research is to identify and explain the factors that contribute to the regional differences in life expectancy in the Northern-Netherlands.

1.5 Research questions

The main question of the research is: How can the recent regional differences in life expectancy in the Northern – Netherlands be explained, taking into account both sexes?

In order to answer this main question some sub- questions have been formulated:

1. What are the regional patterns of life expectancy?
2. To what extent can the regional differences be explained by the socio economic status?
3. What are the regional differences if we take into account the underlying causes of death?

1.6 Structure

In the second chapter the theoretical framework will be discussed. Based on the theory and literature review a conceptual model and some hypotheses will be formulated. Chapter three describes the data that are used and the sources from which the data were collected and it also explains the methods that are applied in this study. In the fourth chapter the results will be presented by mapping and cluster analysis. The last chapter summarizes and discusses the findings of the study and draws some conclusions and recommendations.

2. Theory

2.1 Theoretical framework

2.1.1 Demographic transition theory

The demographic transition theory is a description of the process of population change over time due to transitions of fertility and mortality as societies shift from pre-industrial societies to industrialized or modern societies. The underlying assumption is that population change is driven by development (Gould, 2009). Four different stages can be distinguished.

The first stage is the pre-industrial or pre-modern stage. In this stage both death rates and fertility rates are high, although there could be large fluctuations in mortality due to food shortages, disease outbreaks and epidemics. Although fertility rates were around 4 or 5 children per woman, the average life expectancy was around 30 to 40 years. Therefore population growth is slow in this stage. This stage characterizes western and northern European societies until the 18^{th} century (Gould, 2009).

The second stage characterizes the western and northern European societies from the late 18^{th} century onwards. In this early industrializing stage natural population growth is increasing due to declining mortality rates, while the fertility rates remain constant at the same level as in the pre-industrial stage. Life expectancy rises from 40 years until 50 years and over (Gould, 2009).

In the late industrializing stage the gap between mortality and fertility is diminishing as of falling birth rates. This decrease in fertility was rather voluntary than organized by family planning policies and is presumably facilitated by increased education and participation of women in the labor force, further economic development and urbanization which in turn influence a desire for smaller family size less traditional values towards family and marriage and a desire for smaller families (Gould, 2009).

Since the end of the second world war mortality rates moderately declined and fertility dropped around or below replacement level. Life expectancies reach from the high 70s and 80s for both men and women. This is characterized as the post-industrial or low equilibrium stage (Gould, 2009). When applying the demographic transition theory to the situation in Netherlands, it can be stated that the Netherlands now is in the fourth stage of the transition. Looking at the population pyramid of the Netherlands in the year 1950 (see Figure 2) a rather wide base can be distinguished which indicates a high proportion of children. It reflects the period of the births of the baby boom generation in the Netherlands. This also indicates that in society larger families are desirable and that traditional gender roles are common. However, the population pyramid of 2015 (see Figure 3) shows that death rates are low and only occur at very old ages. Like in many other countries, there is ongoing ageing of the population. Besides, life expectancy is high, with many people reaching old ages. This indicates that people receive good medical care and that there is a high standard of living. Also, there is a narrow base which indicates that the total fertility rate, the average children a woman gets, is low and, consequently, population growth is moderate. This follows the pattern of other developed countries. Therefore, it is observable that the Netherlands is now in stage four of the demographic transition theory, with low fertility levels and people reaching high life expectancies.

Figure 2: Population pyramid Netherlands (in thousands), 1950

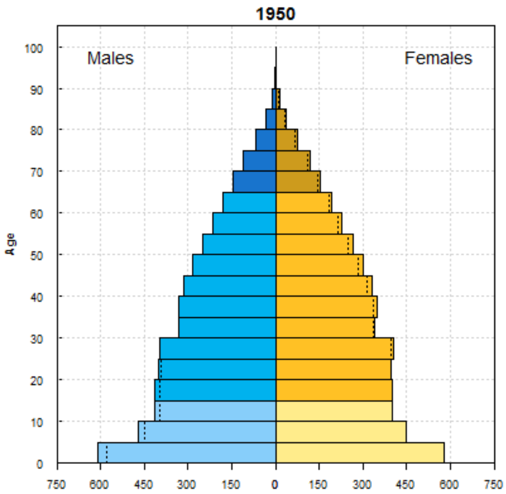
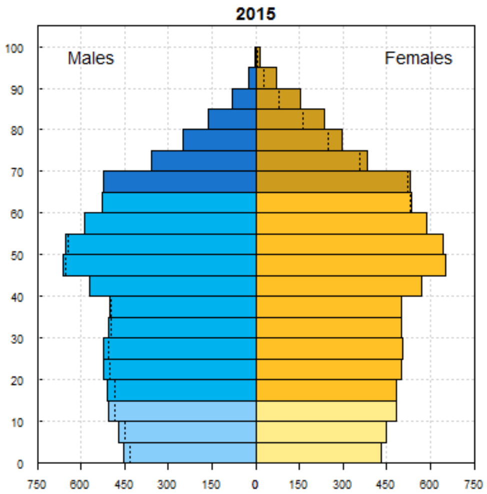


Figure 3: Population pyramid Netherlands (in thousands), 2015



Source: UN (2015)

2.1.2 Epidemiological transition theory

The Epidemiological transition theory was introduced by Omran (1971) as he believed that the demographic transition theory had some limitations in explaining the changing mortality patterns. The main focus of the epidemiological transition theory is: " the complex change in patterns of health and disease and on the interaction between these patterns and their demographic, economic and sociologic determinants and consequences" (Omran 2005: 732). Therefore, there is a clear link with the demographic transition theory and the demographic and developmental changes in societies.

The epidemiological theory describes the changing patterns of health and disease of the demographic transition. As societies develop, the main causes of death shift from infectious to non-infectious diseases. These changes occurred at the end of the 18th century in Western Europe (Gould, 2009).

Omran acknowledged the different stages of mortality decline, as described in the demographic transition theory. The first stage, *the age of pestilence and famine,* is characterized by high and fluctuating levels of mortality. Also birth rates are high, however due to high death rates population growth is low. Overall life expectancy is around 20-40 years and child mortality is high: more than 200 deaths per 1000 live births. It is estimated that some 75% of deaths were attributed to infectious diseases, mainly due to a poor standard of living and limited sanitation. Also traditional family roles were highly valuated and women's status was low. This stage was common for societies in Western Europe until the end of the 18th century (Omran, 1998).

From the late 18th century the second stage, *the age of receding pandemics*, began. In this stage mortality declined in Western European countries and life expectancy increased to 40-50 years. Also, child mortality decreased below 200 deaths per 1000 live births due to improved living conditions, nutrition and basic health care services. Therefore, a sustained population growth can be distinguished. Although communicable diseases continue to be the leading cause of death, an increase in heart diseases, stroke and cancer is noticeable in society (Omran, 1998).

From mid-19th century in Western European countries the third stage, *the age of degenerative and man-made diseases,* developed. In this stage there is an increasing prevalence of degenerative, man-made and stress related diseases. Om the other side, there is a continuing mortality decline and life expectancy at birth increases from 50 to 75 years. Especially, child mortality decreases under 25 deaths per 1000 live births. Besides, modern health care services become widely available as well as sanitation and improved living conditions. In this stage fertility becomes a crucial factor in population growth (Omran, 1998).

In the fourth stage, the age of cardiovascular mortality, ageing, lifestyles adaption, emerging and resurgent diseases, there is a further rise in life expectancy from 80 to 85 years. This was especially attributed to the reduction in mortality due to cardiovascular diseases since the 1970s through effective drug use, lifestyle adaptations and reducing risk factors. On the other side, mortality due to cancer gradually increased and there is also a rise in morbidity and ageing of the population. Besides, there is a rise of emerging and a resurgence of diseases such as HIV, Hepatitus B and C and Ebola. Fertility reaches very low levels or even below replacement level, resulting in a population decline. Overall, the standard of living is very high. This stage occurred in Western Europe after the second World War (Omran, 1998).

In the future stage, the age of aspired quality of life with paradoxical longevity and persistent inequities, life expectancy at birth rises to 90 years and over. Due to disease control and healthy lifestyle adaptations there will be paradoxical longevity. However, there will also be chronic morbidity and health inequalities within and between counties. Chronic, man-made and stress related diseases are the leading cause of morbidity and death as well as depression, loss of independence and isolation. In this stage there will be a continuing effort to improve the quality of life through medical breakthroughs, adapting healthy lifestyles and increasing the lifespan for disadvantaged population groups (Omran, 1998).

The epidemiological transition describes the change from mortality at young ages due to infectious diseases, towards mortality at old ages due to chronic or lifestyle diseases. Within the Netherlands the main causes of death are due to chronic diseases in 2014 (WHO, 2014). Cancers are the main cause of death (33% of total deaths), followed by cardiovascular diseases (29% of total deaths) and diseases of the respiratory system (6% of total deaths). In the Netherlands, six in every ten people dies as a consequence of cardiovascular diseases and cancer (CBS, 2013). Simultaneously, life expectancy is very high, many people reaching 80 years and over.

2.1.3 Explaning geographical differeces in health: composition versus context

In explaining the spatial variations in health we can distinguish between composition and contextual effects (Shaw et al., 2002). The core question is whether the regional differences in health are caused exclusively by the composition of the population in a region or if there is an added effect of the context in which people live (Boyle et al., 2004). The compositional effects account for the differences in health at the individual level and population health is seen as the aggregate of these individual level characteristics (Shaw et al., 2002). The characteristics of the population that are considered as compositional are age, sex, gender, smoking, diet and socio economic status (Shaw et al., 2002). There might be differences in the percentage of smokers or older people or the share of people with a higher income within a certain region (Kibele et al., 2015). An example of compositional effects on all-cause mortality in 86 neighborhoods in the city of Eindhoven (Netherlands) is shown by Bosma et al. (2001). The study revealed that among a random sample of males and females in the age of 15-74s the neighborhoods with a high share of people living in poverty and/ or that were un employed had higher mortality rates compared to neighborhoods with a lower share of people that were unemployed and /or lived in poverty in the period 1991-1996.

The contextual effect is about the environment in which people live their lives and include among others the social environment and the physical environment. The social environment consists of the socio-economic situation, provision and utilization of services, for example healthcare and sport facilities, and regional health policies. Examples of the influence of the physical environment of health are climate, pollution and air and water quality (Anthamatten and Hazen, 2011). Research shows that living near air polluting places such as industries or high traffic roads raises the risk of cancers and asthma and respiratory diseases (Houston et al. 2004).

If the regional differences are accounted for by compositional effects, then we assume that the context doesn't impact health outcomes and vice versa (Shaw et al., 2002). However, there is an ongoing debate about whether spatial variations in health can be attributed to compositional or contextual differences (Boyle et al., 2004). Mitchell et al. (2000) found that in the united Kingdom in the 1980s and 1990s the majority of the mortality differences could be attributed by compositional effects, although for some regions mortality variations could not be explained and these differences might be due to the influence of contextual factors. Therefore, in researching the variations in health differences, the common viewpoint is to take into account the compositional factors first before turning to contextual factors (Boyle et al., 2004).

2.2 Literature on regional differences in life expectancy

Several studies on geographical variations in health indicate an association between morbidity and mortality and socio-economic factors. Within England **r**esearch on regional differences in life expectancy indicates that there is north-south divide in life expectancy at birth. For males, living in the wealthiest regions added five years to the life expectancy at birth, while this was 3,6 years for females in the year 1998. Mortality in the poorest regions was almost twice as high for males and 1,6 times higher for females, compared to the wealthiest region (Woods et al, 2005). Bebbington (1993) found that geographical variations in health outcomes in great Britain in the 1980s were associated with social class: people with the lowest social class lived on average nine years shorter than people in the upper classes. Fitzpatrick et al., (2000) stated that declining life expectancies in England were related with increasing deprivation, more strongly related for males than for females. Within New Zealand Pearce and Dorling (2006) reported that inequalities in life expectancy have widened rapidly between 1980 and 2001 due to inequalities in income and the most impoverished areas have lost years of life expectancy. Within Spain poorer health outcomes were observed in the south of Spain: higher mortality was associated with high unemployment and illiteracy rates (Benach and Yasui, 1999). Higher socio economic status explained to a large extent the disability free life expectancy for different regions in Spain (Gutierrez-Fisac et al., 2000). Mackenbach et al., (2008) researched mortality in 22 European countries based on education level and occupation class, including main causes of death such as cardiovascular diseases and cancers. They found that differences in mortality are associated with differences in socio- economic status and are particularly related to mortality due to cardiovascular diseases, smoking and alcohol related mortality, both for males and females.

Within the Netherlands, a similar pattern is found by a study on the socio-economic differences in mortality by Kulhánová et al. (2014). Some of their findings were that in the Netherlands exist large socio-economic differences in mortality, both for men and women, based on the education level. For lower educated life expectancy is on average six years lower compared to higher educated (Pharos, 2014). In terms of healthy life expectancy the difference between lower and higher educated is even 19 years (Eengezondernederland.nl, 2017). People with primary school live on average 53 years in good health compared to 72 years for people with higher education (CBS, 2015). Therefore, higher educated not only live longer but also spent more years in good health and without physical limitations. Like in other western-European countries these differences are mainly due to mortality because of cardiovascular diseases and cancer (Kulhánová et al., 2014). However, concerning lung cancer, socio-economic differences are much higher in the Netherlands than in other countries, especially for men (Kulhánová et al., 2014). Loke. & de Jong (2013) showed that in the Netherlands mainly in the Provinces Groningen, Drenthe, Amsterdam and Limburg there are relatively many municipalities with a high percentage of the population who receive a unemployment or occupational disability benefit or income support. Mainly cardiovascular diseases and respiratory diseases resulted in a negative influence on life expectancy. Also, their research indicates that risk of mortality due to cardiovascular diseases is somewhat higher in the Northern region of the Netherlands and the Southern area of Limburg.

These differences in health outcomes are due to the influence of socio economic status on health behaviors: people with a lower socio economic status have on average a more unhealthy lifestyle; they smoke more often, drink more alcohol and undertake less physical exercise (Gesthuizen et al., 2011). Although smoking is associated with different types of cancers, tobacco smoking is the most important factor for lung cancer and is estimated to be associated with 80% to 90% of the mortality due to lung cancer (CDC, 2016). Smoking also increases the risk of mortality due to heart diseases and strokes: it is estimated that some 31% of the heath attacks and 20% in the case of strokes are due to smoking behavior (Van Gelder et al., 2014).

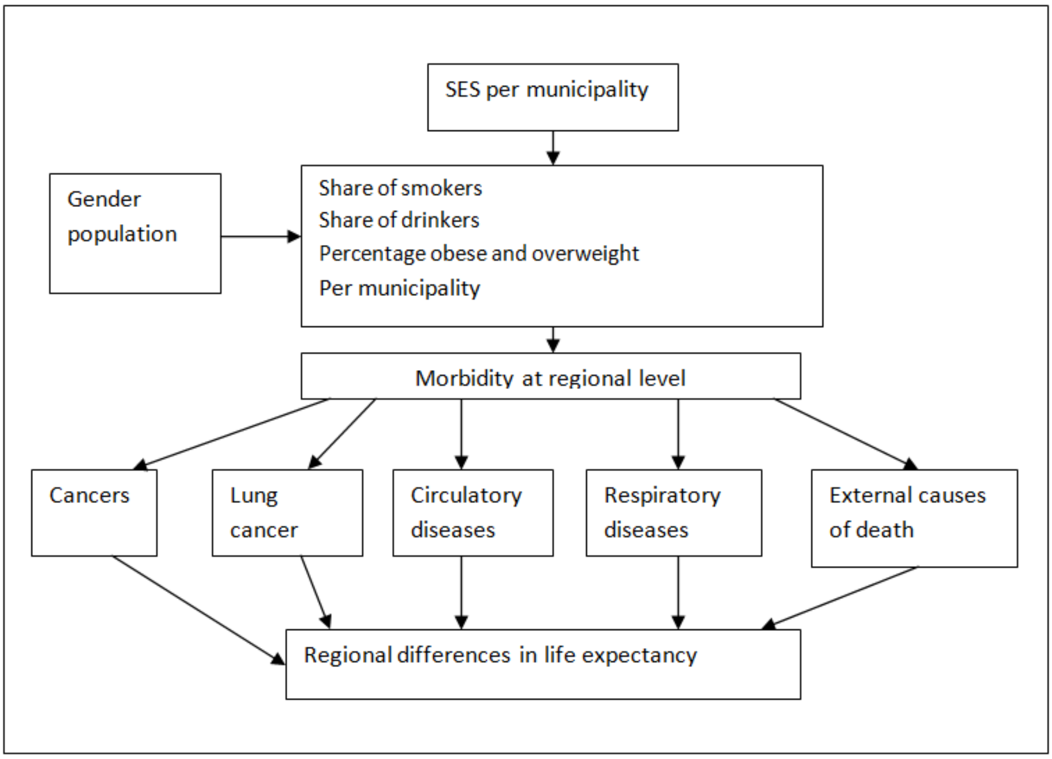
Research on geographical variations in mortality in Canada showed that tobacco smoking, obesity and unemployment was associated with a higher risk of mortality due to cardio vascular disease and ischemic heart disease (Filate et al., 2003). Mortality differences by socio-economic status due to smoking related diseases were also found by Siegler et al. (2008). Their findings indicate that although mortality due to all causes was higher for routine workers than for managers, differences were mainly found in mortality due to lung cancer, liver and chronic respiratory diseases than other diseases. Janssen and Spriensma (2012) found that smoking related mortality contributed significantly to the regional differences in all-cause mortality within the Netherlands. Their research estimates that that 26.6% of all-cause mortality was caused by smoking behaviour in the case of men and 11.0% in the case of women. Regionally, high levels of smoking related mortality were observed in areas which conventionally have a lower socioeconomic status such as in the province of Groningen, the east of Limburg and other areas in the east of the Netherlands. This corresponds with a change in smoking behaviour: some decades ago smoking was more common in groups with a higher socio-economic status, nowadays it is the opposite (Mackenbach et al.,1990; Mackenbach, J.P., 1992).

However, deaths from all causes is higher for the lower educated than for the higher educated in all countries (Mackenbach et al., 2008) reported that mortality due to cardiovascular diseases is responsible for 34% of the education associated differences in mortality for men and 51% for women. In the case of smoking associated death inequalities by education level produce 22% of the differences for men and 6% for women. Mortality due to alcohol consumption is linked with 11% of the differences in mortality by education level for men and 6% for women. From this research it appears that differences in mortality by education level are largest for the main causes of death such as cardiovascular diseases and smoking related disorders.

2.3 Conceptual model

In this paragraph the conceptual model will be presented. The model consists of the main concepts as described in the theoretical framework. From the literature it was shown that difference in socio economic factors could explain regional differences in health. Mortality is on average higher for the people with a lower socio economic status than for the higher socio economic classes. Studies showed that these differences were mainly shown for cardiovascular diseases, lung cancer and other smoking related diseases and respiratory diseases (Mackenbach et al., 2000; Siegler et al., 2008). Furthermore it is expected that within the northern region higher mortality rates will be observed in the province of Groningen and Drenthe as these regions have lower outcomes in socio economic status (Janssen and Spriensma, 2012; Loke and De Jong, 2013). As was discussed in the theoretical framework the effect of the socio economic status on life expectancy at the regional level is influenced by the health behaviours and risk factors of the population. Smoking is an important risk factor that increases the risk of morbidity and mortality due to different causes. For example a high share of (heavy) smokers will increase the risk of mortality due to lung cancer within a region. Besides, the share of heavy drinkers or overweight people influence the risk on different diseases. Particularly when multiple risk factors are present in the population then overall mortality risk in the region will increase.

Figure 4: Conceptual model



2.3.1 Hypotheses

Based on the theoretical framework some hypotheses were formulated:

1. Patterns and clusters of low life expectancy will be shown in the east of the Northern Netherlands
2. Patterns and clusters of low socio economic status will be identified in the northeast of the region
3. Regional differences in life expectancy can be mainly attributed by mortality due to lung cancer, respiratory diseases and circulatory diseases
4. For males mortality due to lung cancer and respiratory diseases will show similar clusters as for life expectancy and will largely explain the regional differences in life expectancy for males
5. For females mortality due to circulatory diseases will show similar clusters as for life expectancy and will largely explain the regional differences in life expectancy for females

3. Data and methodology

3.1 Study area and level of analysis

This research is based on analysis of data on life expectancy, SES and underlying causes of death at the municipality level in the Northern Netherlands. The northern region consists of 59 municipalities (see figure 5). The province of Groningen covers 23 municipalities and the provinces of Friesland and Drenthe are subdivided in 24 and 12 municipalities respectively. The data in this study are based on the administrative division of municipalities of the Netherlands for the year 2015. This choice for a specific year is arbitrary, however according to the RIVM it is common to calculate data based on the most recent administrative division of municipalities. In addition, it is also beneficial to work with recent data when carrying out this research and making some recommendations about local health policy making in the Northern Netherlands.

Figure 5: Map of the municipalities within the Northern-Netherlands

3.2 Outcome measure

The outcome measure of this study is life expectancy at birth, by sex and municipality in the period 2011-2014. Aggregated data on life expectancy was calculated and retrieved trough the RIVM. The definition of life expectancy at birth is the average years a new born is expected to live if mortality rates continue to prevail as during the time of birth (WHO, 2006). Calculations of life expectancy are based on regional death statistics by age, sex and municipality in the period 2011-2014. Life expectancy at birth per municipality is then calculated by the RIVM with the use of the age specific death rates based on the Sullivan method (Volksgezondheidszorg.info, 2016b). Life expectancy at birth is one of the most common used health status indicators of the population (Anthamatten and Hazen, 2011).

3.3 Independent variables

Based on the research questions, data on SES and underlying causes of death (malignant neoplasms, lung cancer, circulatory diseases, respiratory diseases and external causes of death) were retrieved trough the RIVM.

Data on SES scores were obtained by the RIVM through The Netherlands Institute for Social Research (SCP). SES scores indicate the social status of an neighbourhood based on the income, education and labour market position. The SCP calculates a four-digit postal code area score, ranging from a low (-2 and lower) to a high status (2 and higher), based on a factor analysis. SCP states that this ranking is arbitrary chosen. The standard for each year that is published is the Netherlands (average= 0). Industrial areas or areas with less than 100 households are not taken into account in these calculations (SCP, 2015). Data are available for the years 1998, 2002, 2005, 2010 and 2014 and can be requested through the SCP website (SCP, 2016). The RIVM aggregated the SES scores at the municipality level. The most recent status scores are available for the year 2014 and will be used in this research.

Standardized data on the underlying causes of death by sex and municipality were provided by the RIVM for the period 2011-2014. The RIVM calculated comparative mortality figures (CMF's) and standardize mortality ratios (SMR's) based on the cause of death statistics of the National Statistical Office. When comparing mortality between different populations it is necessary to use standardized data as of the difference in age composition of the population; mortality will be higher in an aging population than in a younger population. The CMF and the SMR are comparative measures of mortality that are most commonly used (Eysink and Poos, 2010). The standard population (=100) is used as a reference to compare mortality between different populations. For example if mortality is set as 152 in a region, then mortality is 52% higher compared to the standard population. The advantage of the use of the CMF compared to the SMR is that you can compare municipalities mutually as they are related to the same age distribution. This is not the case when using SMR's and therefore you can only analyze the outcome of mortality in comparison to the standard population. Direct standardized data (CMF's) were obtained on the main groups of causes of death by sex and municipality: malignant neoplasms, lung cancer, diseases of the circulatory system, diseases of the respiratory system and external causes of death. For mortality due to lung cancer Indirect standardized data (SMR's) were retrieved by sex and municipality. Table 1 shows the Beldo classification list of the underlying causes of death that are used in this study. The Beldo classification is produced by the National Statistical Office and includes a list of causes of death that are relevant to the Netherlands and besides corresponds to the international classification of diseases of the World Health organization that is worldwide used (Poppelaars et al., 2011; WHO, 2016).

For the underlying causes of death there were some missing cases observed (see table 2). These missing values are mainly due to a low amount of cases that were reported and therefore to these data are not made available as of privacy concerns. For the spatial analysis in ArcGIS a different data set was used based on a selection in order to perform cluster analysis. Therefore it is expected that the influence of the missing cases is limited.

Table 1: Beldo list and corresponding ICD-10 classification

Beldo	Beldo Name	ICD-10
2.1	Malignant neoplasms	C00-C97
2.1.10	Malignant neoplasms of bronchus or long	C33-C34
7	Diseases of the circulatory system	I00-I99
8	Diseases of the respiratory system	J00-J99
17	External causes of morbidity and mortality	V01-Y89

Source: CBS (2016a)

Table 2: Missing values by sex and underlying cause of death

Variable	Males	Females
Circulatory diseases	1	1
Respiratory diseases	4	4
External causes of death	9	9
Lung cancer	3	13

3.4 Ethical issues

Statistics Netherlands provides on a quarterly basis official data on the causes of death from persons that have died since 1901. In principal all citizens are covered as everyone who stays in the Netherlands for a time longer than four months is required to register in the municipal database. CBS handles the data with care and no personal name is linked to the death register. Therefore researchers should handle the data with care because of confidentiality issues (CBS, 2016b). The accuracy of the death statistics are high: in 2013 98.5% from all death records could be linked to the international classification of diseases. However, from the persons that died in another country than the Netherlands, hardly any data is received. However, without taking into account the Dutch that have passed away in another country, the accuracy would be 99.7% (CBS, 2016c).

3.5 Methods

Spatial analysis will be carried out by mapping and cluster analysis of the outcome measure and the independent variables with the use of ArcGIS. The advantage of mapping geographical data is that maps can identify and explore spatial patterns and relations between locations (Anthamatten and Hazen, 2011). Besides spatial statistical methods can be applied to analyse spatial patterns and determine their significance (Anthamatten and Hazen, 2011).

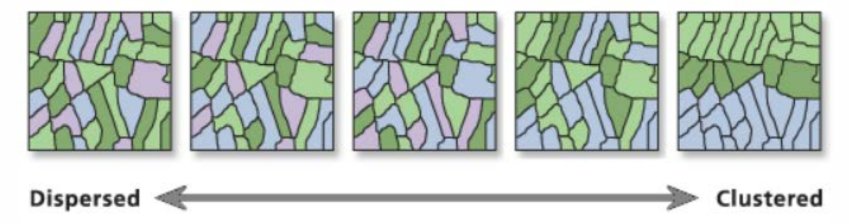
3.6 Mapping variables

The first step in the analysis to display and visually analyse geographical patterns of the outcome measure and independent variables separately in ArcGIS. Maps are compared to observe how variables are related with the outcome measure. Visual representation of the maps could then also be used to determine patterns that can be further explored. In ArcGIS tables of data on the different variables were joint with a layer of the municipalities of the northern region which was taken as a separate layer from the original maps with the 393 municipalities of the Netherlands) and then visually displayed using appropriate symbology and classification groups. Missing values were handled separately and visually displayed as “No data ”. The base map that was used as input of the analysis is the map of the municipalities of the year 2015, since the data is based on the administrative division of the municipalities of the year 2015. Maps of the administrative division of the municipalities are available for different years through the website of the statistical office. Problems that came up with joining tables (for some municipalities data were not displayed when joining different tables and could therefore not be visualized) were fixed manually in order to display all the data in maps.

3.7 Cluster analysis

The second step in the analysis was to test whether the geographical patterns that were observed are significantly clustered in the region and also to determine where clusters of high or low values are located. A cluster is a region that has unusual high values; a local concentration of high rates (Cromley & McLafferty, 2002). Cluster analysis was carried out with the spatial statistics toolbox and more specifically the analysing patterns toolset in ArcGIS. The Global Moran's I tests whether the patterns that are identified are clustered, dispersed, or randomly distributed across the region (see figure 6). The calculation of the z-score and the p-value assesses whether the outcomes are significant. The null-hypothesis of the Global Moran's I states that the patterns are randomly distributed in the region under study. If the p-value is statistically significant, then the null hypothesis can be rejected.

Figure 6: Illustration of the outcome of the spatial autocorrelation test: patterns are clustered or dispersed



Source: ESRI.COM, 2017

The output of the spatial autocorrelation tool also provides a Moran's Index. The outcome of this index can vary between -1 and 1, whereas a value of -1 indicates negative spatial autocorrelation and 1 indicates positive spatial autocorrelation and a zero value indicates that the pattern is random. The closer to 1, the more clustered patters are in the study area (Mitchell, 2005). Once the outcome of the Moran's I test shows positive spatial autocorrelation a local Moran's I can be performed to determine in which areas spatial clustering is found (Dijkstra et al., 2013). The output of the COType field in the output will indicate where clusters of high values (HH), clusters of low values (LL), outliers in which high values are surround by low values (HL), and outliers in which low values are surrounded by high values (LH) are located (ESRI.COM, 2017).

4. Results

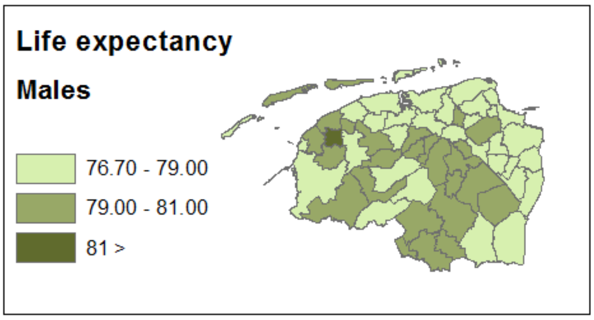
In this chapter the results will be presented using maps to highlight and understand geographical patterns and differences between males and females. The aim of this research is to understand the factors that contribute to the regional differences in life expectancy. To explore and research these factors first the regional patterns in life expectancy will be shown. Second, the geographical patterns of the socio economic status (SES) will be taken into account to know to what extent the SES contributes to the differences in life expectancy. Next, the major causes of death, mortality due to malignant neoplasms, lung cancer, circulatory diseases, respiratory diseases and external causes will be discussed to understand the underlying causes of disease and mortality.

4.1 Life expectancy

Among males, average life expectancy is 79.9 years. The range is between 76.7 and 83.8 years (with outliers of 86,4 and 89,8 years). Lower life expectancy for males is observed in the north of the Netherlands (see figure 7). Among females, the average life expectancy is 83.7 years. The range of life expectancy is between 79.9 and 88.6 years (one outlier of 105.5 years is observed). For both males and females life expectancy is on average lower in the north and east of the northern region (See figure 7 and figure 8 for male and female life expectancy respectively).

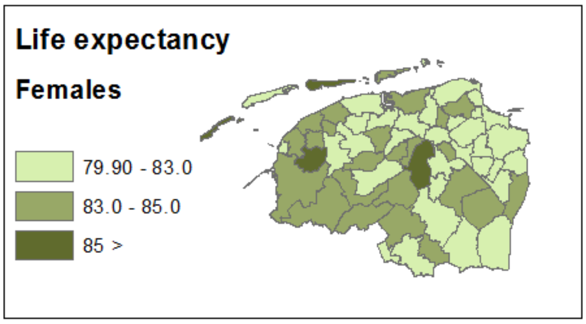
Tests for spatial clustering indicate that life expectancy for both males and females is significantly clustered at the 99% confidence interval (see table 3). Cluster maps show that clusters of low life expectancy for males are located in the north and east of the region (see figure 9). On the other hand, high life expectancy clusters are distinguished in the west and centre of the region. For females, clusters of low life expectancy are located in the northeast of the region (see figure 10). Therefore, particularly the northeast of the region has the lowest life expectancy both for males and. females. Thus, although life expectancy is on average lower in the Northern Netherlands, particular low life expectancies are found in the northeast of the region, resulting in an on average poorer health status of the population. The next step in the explanation will be to analyse patterns of SES as from the literature review it became clear that regional differences in life expectancy can be explained by the socio economic status in a certain region.

Figure 7:
Life expectancy,
Males, 2011-2014



Source data: RIVM

Figure 8:
Life expectancy,
Females, 2011-2014



Source data: RIVM

Figure 9:
Clusters and outliers
Life expectancy

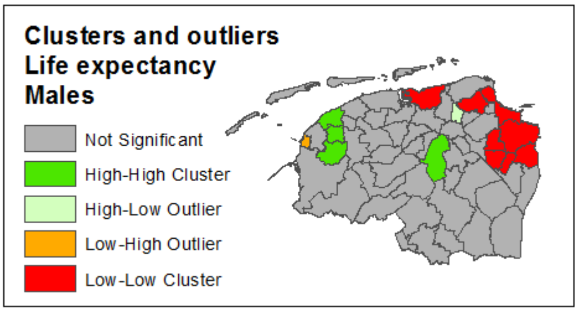
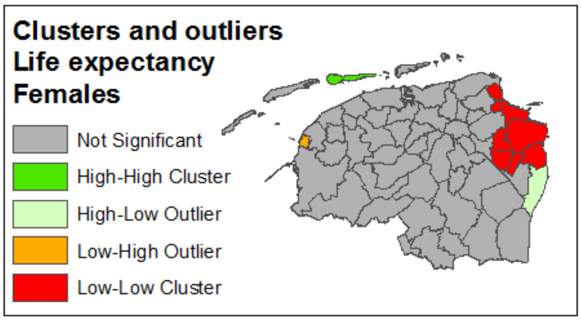


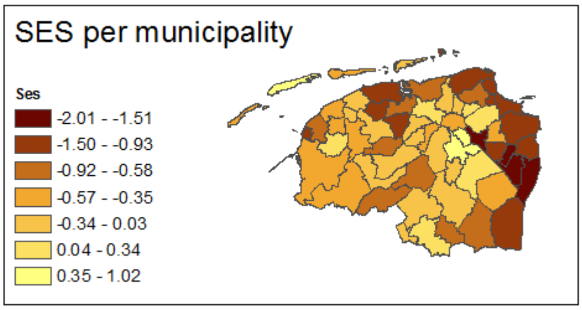
Figure 10:
Clusters and outliers
Life expectancy



4.2 Socio economic status

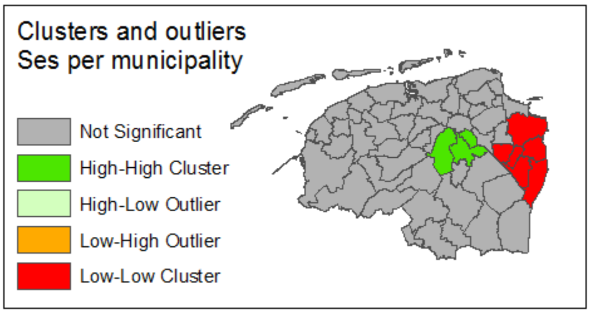
The SES ranges from -2 in the municipality with lowest SES to 2 in the municipality with highest SES. Figure 11 reveals that especially in the north and east of the region the SES is remarkably lower than in other parts of the region. High values of SES are observed mainly in the centre of the region.

Figure 11:
Socio economic status
per municipality, 2014



Source data: RIVM

Figure 12:
Clusters and outliers
Socio economic status



Source data: RIVM

Tests for spatial clustering were carried out and the outcome indicates that SES is significantly clustered in the region. The outcome of the Moran's I test for SES is 0.193455 and significant ($p < 0.05$) (see table 3). Second, local spatial autocorrelation was performed to observe the location of spatial clustering. Figure 12 shows that low SES is clustered in the east of the region. On the other side, high clusters are identified in the centre of the region as was expected when observing figure 11. From the maps it is observed that socio economic status is particularly low within the northeast of the region and. Besides, it is shown that there are similarities in the patterns of life expectancy and therefore low life expectancy and low SES seem to be related. Within the next paragraph the relation between life expectancy and SES will be further explored through a correlation analysis.

4.3 Life expectancy and SES

Results indicate that SES is modestly correlated with life expectancy in the northern region (R^2 = 0, 237). It is observed that the lower the SES, the lower the life expectancy and also the higher the SES, the higher the outcomes in life expectancy. Figure 13 shows that within the northern region lowest life expectancies are particularly found in municipalities within the province of Groningen. When taking into account the COROP regions (see figure 14), it is observed that life expectancy is lower in east Groningen, greater Delfzijl, rest of Groningen and North Friesland. Besides, it is also observed that some municipalities with similar SES score differently in life expectancy outcomes; for example not all municipalities with lower SES have corresponding low life expectancies. This indicates that lower SES is related with lower life expectancy, however it does not completely explain the regional differences in health outcomes and due to what causes health is worse in some municipalities compared to others. From the theory it was shown that the effect of SES on life expectancy in a region is particularly influenced by the lifestyle factors. Areas with lower SES have in general a higher share of smokers, people with poor diets and excessive alcohol consumption and these lifestyle factors influence the risk of mortality due to different causes. Therefore, to further explain the differences in life expectancy the underlying causes of death will be discussed in the next paragraph.

Figure 13: Correlation analysis life expectancy and SES by province in the northern region

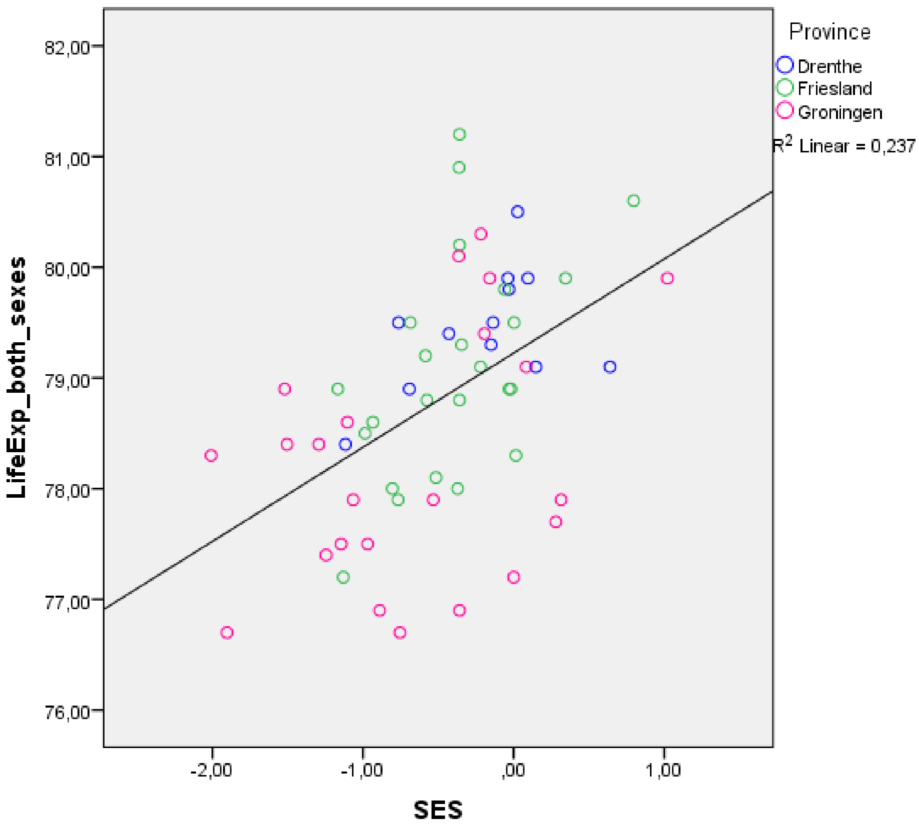
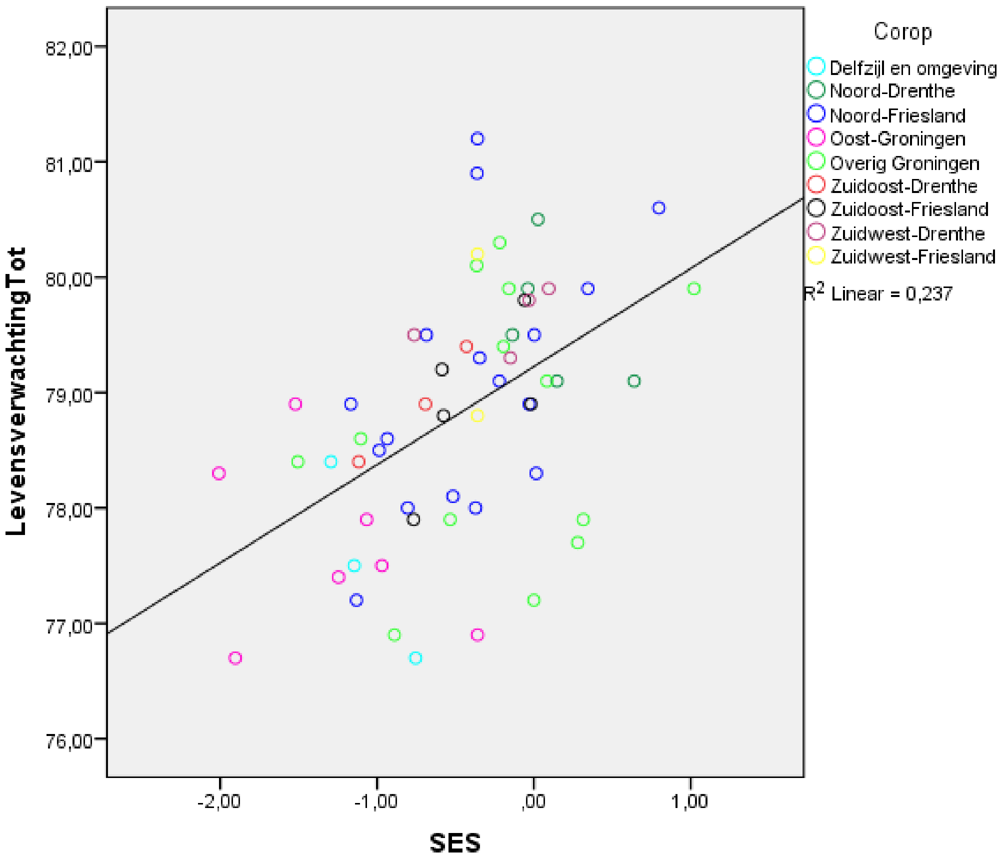


Figure 14: Correlation analysis life expectancy and SES by COROP region in the northern region



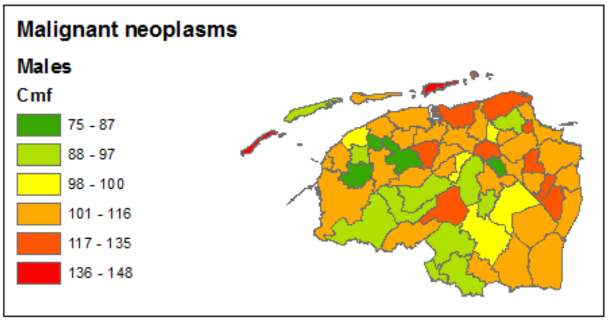
4.4 Mortality

4.4.1 Mortality due to malignant neoplasms

The comparative mortality figure for male mortality due to malignant neoplasms ranged from 75 to 148. Figure 15 displays the CMF´s for male mortality due to malignant neoplasms. Higher mortality is observed in the north and east of the region. On the other side, low mortality is spread in the west and south of the region. Tests of spatial clustering indicate that male mortality is significantly clustered in the region (see table 3). Clusters of high mortality for males are located in the north of the region, whereas, low mortality clusters are found in the west of the region (see figure 17).

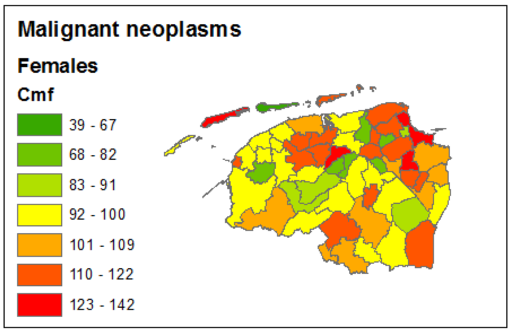
For females, the range of the comparative mortality figure is between 39 and 142. Low female mortality is spread across the region and high mortality rates are mainly found in the north and east of the region (see figure 16). However, remarkable is that for females no significant results were found and therefore female morality due to malignant neoplasms is randomly distributed in the northern region($p > 0.05$). It is observed that while for males mortality due to malignant neoplasms seems to be associated with differences in life expectancy, this is not the case for females as mortality patterns were not significantly clustered. In the next paragraph spatial patterns of mortality due to lung cancer will be discussed.

Figure 15:
Mortality due to malignant neoplasms,
Males, 2011 - 2014



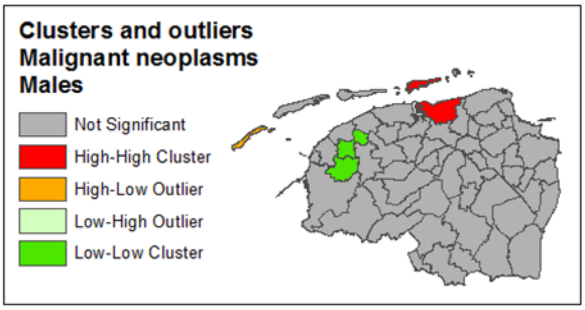
Source data: RIVM

Figure 16:
Mortality due to malignant neoplasms,
Females, 2011 – 2014



Source data: RIVM

Figure 17:
Clusters and outliers
Male mortality due to malignant neoplasms

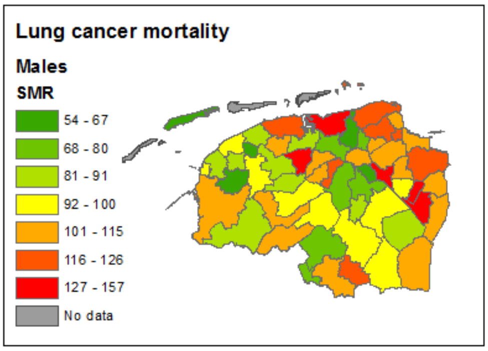


4.4.2 Mortality due to lung cancer

For males the comparative mortality figure for mortality due to lung cancer ranges from 54 to 157. Visual analysis of the maps of mortality indicates that high mortality is identified in the north and east of the region, while lower mortality is distributed across the region (see figure 18). Besides, it is also observed that in the north there are some municipalities with low mortality which are located next to municipalities with high mortality. This might be related to different risk factors such as a higher share of smokers within the region, which shall be discussed in the next chapter.
For females the comparative mortality figure is between 56 and 162. High mortality is clearly observed in the northeast of the region, while low mortality is observed across the region (see figure 19). For females, the test for spatial clustering was significant at the 95% level, while for males it was significant at the 90% level (although a 95% significance level is common as a standard). For females high clusters are observed in the north and east of the region and for males clusters of high mortality are located in the east of the region (see figure 20 and 21).

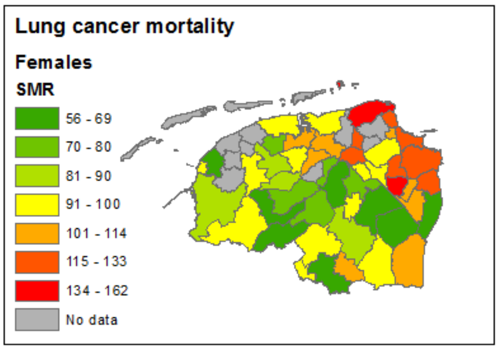
Remarkable is that for females the comparative mortality figure is higher compared to males and also more high-high clusters are displayed for female mortality due o lung cancer. Visual analysis of the maps indicates that life expectancy, SES as well as mortality due to malignant neoplasms and lung cancer showed significant spatial clustering in the northeast of the region, indicating that high risk populations are located in this region. In the next paragraph mortality due to circulatory diseases will be presented to observe if similar patterns could be found.

Figure 18:
Mortality due to lung cancer
Males, 2011 - 2014



Source data: RIVM

Figure 19:
Mortality due to lung cancer
Females, 2011 – 2014



Source data: RIVM

Figure 20:
Clusters and outliers
Mortality due to lung cancer
Males, 2011 - 2014

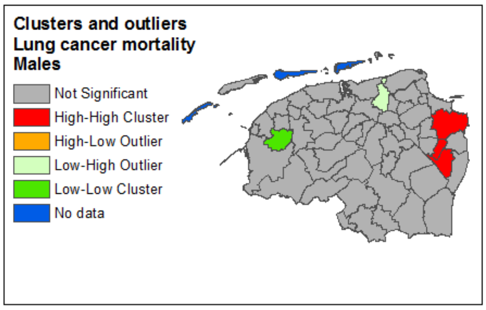
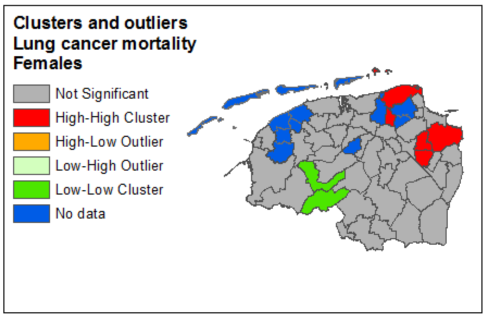


Figure 21:
Clusters and outliers
Mortality due to lung cancer
Females, 2011 – 2014

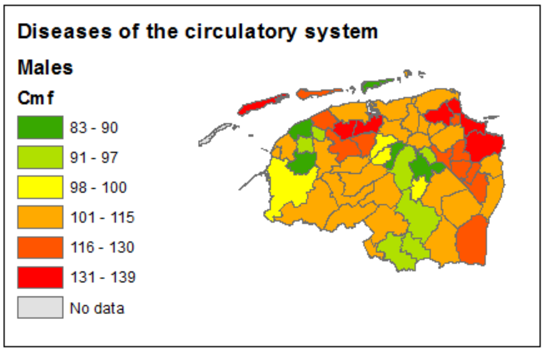


4.4.3 Mortality due to diseases of the circulatory system

Within the north of the Netherlands, the comparative mortality figures for males ranged from 83 to 139 in the 58 municipalities. Mortality for males is on average high in the region, however it is observed that mortality is remarkably high in the north and east (see figure 22). On the other side, low mortality is located in the northwest and the centre of the region. For females the range of the comparative mortality figure is between 82 and 148. As for males, mortality is on average high in the north and east (see figure 23), whereas mortality is low across the region.

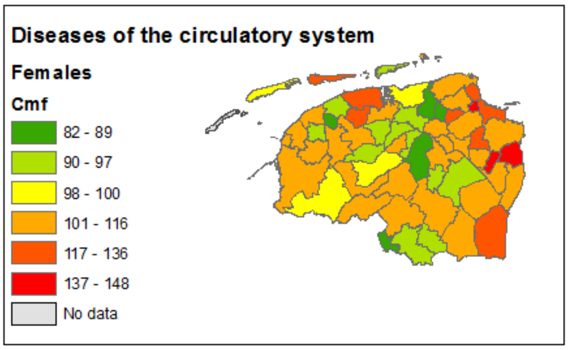
Mortality due to diseases of the circulatory system was significantly clustered within the region and local cluster maps identified high-high clusters in the northeast of Groningen, both for males and females (see figure 24 and 25). Therefore, patterns that were found correspond to the previous patterns that were seen for life expectancy, SES and other underlying causes of death.

Figure 22:
Mortality due to circulatory diseases,
Males, 2011 - 2014



Source data: RIVM

Figure 23:
Mortality due to circulatory diseases,
Females, 2011 – 2014



Source data: RIVM

Figure 24:
Clusters and outliers
Mortality due to circulatory diseases
Males

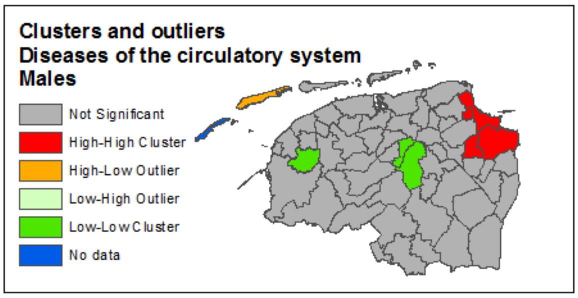
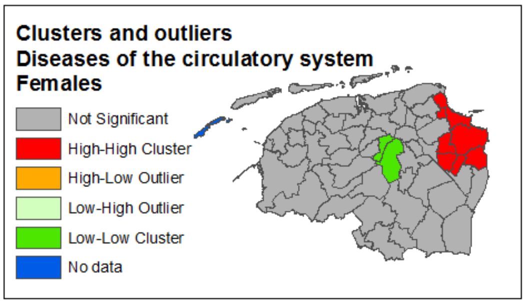


Figure 25:
Clusters and outliers
mortality due to circulatory diseases
Females

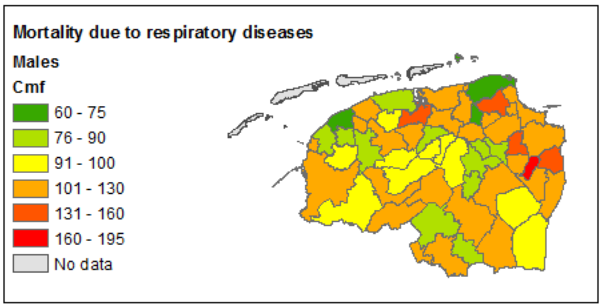


4.4.4 Diseases of the respiratory system

Within the north of the Netherlands, the comparative mortality figures for males ranged from 50 to 195 in the 55 municipalities. This is among the highest mortality rates for males. Mortality is almost twice as high compared to the Netherlands. Also there are considerable regional differences since there is a large difference between the lowest and highest comparative mortality figure. Figure 26 shows that mortality is mainly high in the east of the region, while low mortality is observed across the region. For females the comparative mortality figure ranged from 55 to 143 in the 55 municipalities. High mortality is mainly observed in the east of the northern region (see figure 27).

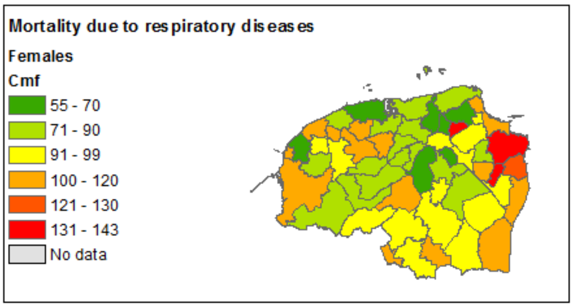
Mortality due to respiratory diseases was significantly clustered, both for males and females. Local cluster maps revealed that for both sexes clusters of high mortality are observed in the east of the region(see figure 28 and 29). Therefore, spatial patterns that are found are similar to the observed patterns of life expectancy, SES and underlying cause of death.

Figure 26:
Mortality due to diseases of the respiratory, system, Males, 2011 - 2014



Source data: RIVM

Figure 27:
Mortality due to diseases of the respiratory system Females, 2011 – 2014



Source data: RIVM

Figure 28:
Clusters and outliers
Male mortality due to respiratory diseases

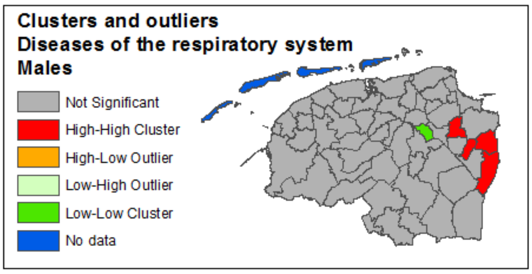
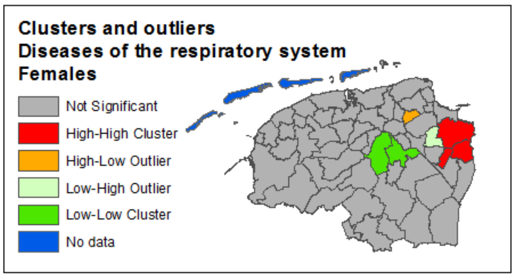


Figure 29:
Clusters and outliers
Female mortality due to respiratory diseases

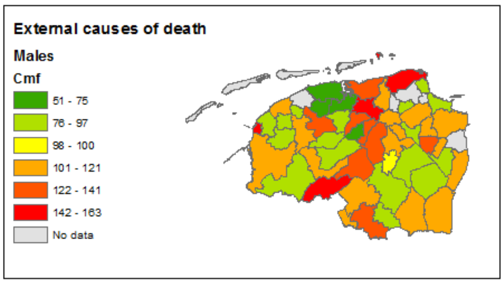


4.4.5 External causes of death

In the north of the Netherlands the range of the comparative mortality figure for males is between 51 and 163. High mortality due to external causes of death is spread across the region as well as low mortality (see figure 30). For females, the comparative mortality figure ranged from 53 to 144 in the 51 municipalities. It is observed that, as for males, high mortality is also spread across the region as well as low mortality (see figure 31).

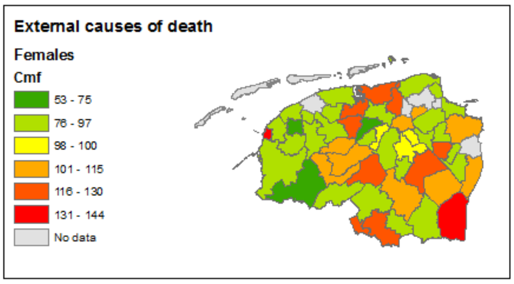
Mortality due to external causes of death was not significantly clustered, as both for males and females the p-value is than 0.05 (see table 3). Patterns of external causes of death are randomly distributed across the region. As mortality due to external causes does not show similarities in the spatial patterns with life expectancy it does not seem to contribute to the explanation of the geographical variations in life expectancy.

Figure 30:
Mortality due external causes of death,
Males, 2011 - 2014



Source data: RIVM

Figure 31:
Mortality due to external causes of death
Females, 2011 – 2014



Source data: RIVM

Table 3: Results of tests for spatial clustering for males and females

Variable	**Males**		**Females**	
	Moran's I	*P-value*	*Moran's I*	*P-value*
Life expectancy	0.241328	**0.000003**	0.209693	**0.000002**
SES per municipality	0.193455	**0.000011**	0.193455	**0.000011**
Mortality due to malignant neoplasms	0.115330	**0.005329**	0.008929	0.557540
Mortality due to lung cancer	0.078326	0.077758	0.288307	**0.003029**
Mortality due to circulatory diseases	0.201119	**0.000056**	0.291731	**0.000000**
Mortality due to respiratory diseases	0.231100	**0.002176**	0.163474	**0.030336**
Mortality due to external causes of death	0.040980	0.515280	-0.000487	0.832767

5. Conclusion

The aim of this study was to understand the factors that contribute to the regional differences in life expectancy in the Northern Netherlands. From this objective, the following research question and sub-questions were formulated: How can the regional differences in life expectancy in the Northern – Netherlands be explained?
In order to answer this main question some sub- questions have been formulated:

1. What are the regional patterns of life expectancy?
2. To what extent can the regional differences be explained by the socio economic status?
3. What are the regional differences if we take into account the underlying causes of death?

This study is based on municipality-level data of the possible determinants of life expectancy. As patterns of life expectancy differ geographically spatial analysis was used to analyse the regional variations in health. In the next paragraph a short summary of the results will be given.

5.1 Summary of the results

Results reveal that life expectancy was significantly clustered in the Northern Netherlands from 2011-2014. For males as for females, clusters of low life expectancy were found in the northeast of the region, indicating that these are the high risk areas with poorest health outcomes. Both SES and underlying causes of death were significantly clustered within the northeast of the region. However, no significant results were found for male and female mortality due to external causes of death as well as female mortality due to malignant neoplasms. Therefore these mortality patterns were randomly distributed across the northern region and don't contribute to the explanation of regional differences in life expectancy.

5.2 Reflection on data and methods

This study used data that were collected from the CBS and SCP, institutes that are known for their accurate and reliable statistics. Therefore, the data was that was used as an input for this study is considered to be of high quality. Furthermore, spatial clustering methods used can help understand public health questions at the local level to describe regional patterns and identify high incidence events (Cromley & McLafferty, 2002) and therefore support the public health policy decision making.

However, one of the issues that should be mentioned concerning the data is that there were missing values in the dataset from mortality due to diseases of the respiratory and circulatory system, and mortality due to external causes of death and lung cancer mortality. In mortality related to these causes of death no data was available on all the 393 municipalities in the Netherlands. This was mainly due to privacy reasons in the release of the data for small regional areas. In the handling of the data a selection of the data set was used to perform the statistical analyses. However, since the spatial clustering methods takes into account the mean for all the features and compares the neighbouring features and destine feature, the outcome of the test result can somewhat be influenced by the selection of the data set.

Another issue that should be mentioned here is the transition from a manual coding to an automatic coding of underlying causes of death. Since 2013, the CBS incorporated this method to enhance international comparability and provide greater stability in the registration of death statistics over time (CBS, 2014). This transition could potentially influence the registration and thus the quality of the data as for this study data on causes of death in the years 2011to 2014 was used. However, data on the underlying causes of death shows that the effect of the transition to automatic coding cannot be distinguished from changing patterns in diseases, with the exception of diseases of the respiratory system (Harteloh, Van Hilten & Kardaun, 2014). In this case, the decline of 15,3% in the deaths due to diseases of the respiratory system in the year 2013, compared to the previous year, is attributable to the change in method (Harteloh, Van Hilten & Kardaun, 2014). Therefore, the interpretation should be handled with care as mortality due to respiratory diseases could be underestimated in this case.

Another point that should be taken into account here is the geographical scale. The scale at which mortality patterns are studied can mask patterns at other scales. Therefore the municipality's average might result from communities with unusual high rates and others with unusual low rates (Cromley & McLafferty, 2002). In this case, the difference in rates might be lost due to the aggregate level at which the data is researched.

5.3 Discussion of findings

The first objective of this study was to identify the regional patterns in life expectancy. Significant spatial clustering of low life expectancy was found in the northeast of the region, both for males and females. This indicates that, although overall life expectancy is lower in the Northern Netherlands, the population in the northeast of the region has worse health outcomes compared to other areas. For males, clusters of low life expectancy are found in the municipalities of De Marne, Loppersum, Delfzijl, Oldambt, Menterwolde, Veendam, Pekela and Bellingwedde in the province of Groningen (see figure 32A). Among females, clusters of low life expectancy are observed in the municipalities of Delfzijl, Appingedam, Oldambt, Menterwolde, Veendam, Pekela and Bellingwedde (see figure 33A). These municipalities have considerable lower life expectancies than the surrounding municipalities in the region and are therefore considered as high risk areas.

The second aim in explaining the geographical variations in life expectancy was to identify patterns of SES per municipality within the region and to determine whether there are similarities in the spatial patterns between SES and life expectancy. As was hypothesized SES per municipality was significantly clustered within the northeast of the region. Cluster maps revealed six low-low clusters in the northeast of the region. Comparison of the cluster maps of SES and life expectancy showed similarities for the municipalities of Oldambt, Veendam, Pekela and Bellingwedde within the province of Groningen, for both males and females (see figure 32 A and B and 33 A and B). This finding is supported by the theory that regional differences in life expectancy are associated with socio-economic factors as lower SES groups in general have more unhealthy lifestyles compared to higher SES groups (Loke and De Jong, 2013).

The third objective in explaining the regional differences in life expectancy was to identify the patterns of underlying causes of death. Comparison of these findings with cluster maps of life expectancy could explain what are the main causes of death for both males and females and what are the risk factors of disease and mortality.

Mortality due to malignant neoplasms is significantly clustered in the north of the region for males. Among females no significant spatial clustering was found. Therefore patterns of mortality due to malignant neoplasms are randomly distributed throughout the northern region and therefore don't contribute to the regional differences in life expectancy. For males, two clusters of high mortality are found in the north of the region. This indicates that, although overall mortality due to malignant neoplasms is on average high for males in this region, significant higher mortality is observed in these municipalities. When comparing cluster maps of malignant neoplasms and life expectancy one similar cluster is found in the municipality of De Marne, within the province of Groningen and therefore contributes to the geographical variations in life expectancy for males (see figure 32A and C). From all cancers, some 90%-95% are estimated to be associated with lifestyle factors (Anand et al, 2008). Risk factors for cancer are among others tobacco smoking, unhealthy diets, insufficient physical exercise, overweight and obesity, and alcohol consumption (WHO, 2017). As cancers are related with lifestyle factors the socio economic status of the region influences the health outcomes of the population. Overall SES is lower within the northern region and therefore higher mortality due to cancers is related to unhealthy lifestyles. Cancers in these areas constitute about 35% of the total morality compared to about 31% in the province of Groningen and the average in the Netherlands (RIVM, 2015b). Particularly for males within the northwest of Groningen the results that were found could be explained by the higher share of (heavy) smokers and drinkers within these areas (RIVM, 2015b).

Figure 32 A-E*:* Maps of spatial clustering males

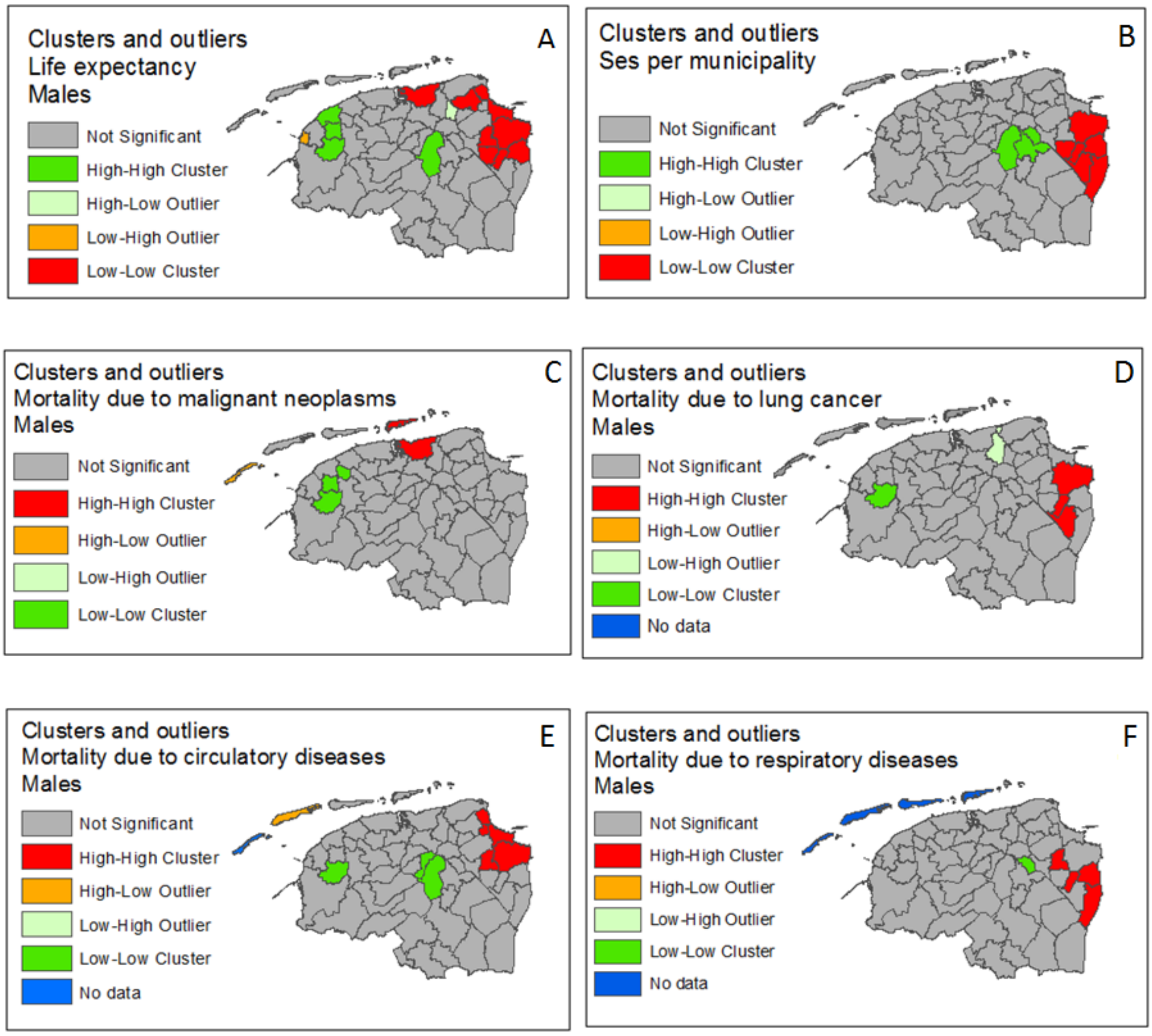
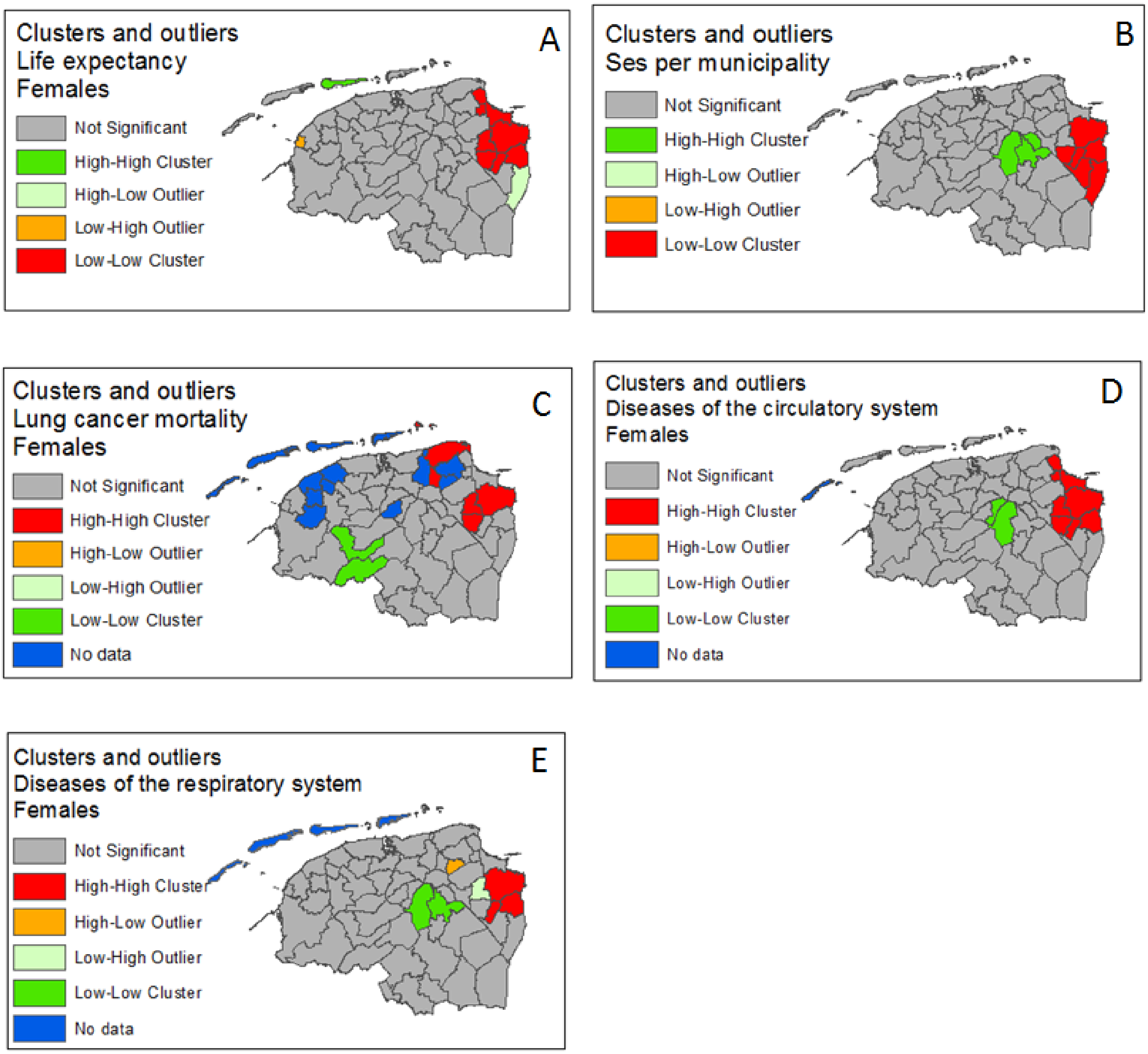


Figure 33 A-E*:* Maps of spatial clustering females



For both males and females lung cancer mortality was significantly clustered and patterns of higher mortality were observed in the northeast of the region. For males three clusters of high mortality due to lung cancer were identified, from which two clusters of the municipalities of Oldambt and Pekela correspond to the patterns of male life expectancy and therefore contribute to the regional differences in health (see figure 32A and D). Among females five clusters of high mortality due to lung cancer were identified in the northeast of the region. Three clusters of the municipalities of Oldambt, Menterwolde and Veendam are related to the patterns of female life expectancy and contribute to the explanation of geographical variations in health outcomes (see figure 33A and C). It is remarkable that for females more clusters of high mortality were observed for lung cancer. Besides, higher mortality rates for lung cancer were observed for females compared to males, indicating that high mortality due to lung cancer is somewhat more pronounced for females in the northeast of the region. This result is rather unexpected since from the theory it was hypothesized that mortality due to lung cancer would be more important in the explanation of regional differences of life expectancy for males (Kulhánová et al., 2014). Although smoking is associated with different types of cancers, tobacco smoking is the most important factor for lung cancer and is estimated to be associated with 80% to 90% of lung cancers (CDC, 2016). Smoking is among the main risk factors of morbidity and mortality within the Netherlands (RIVM, 2014). The northern region and particularly the province of Groningen is among the regions with the highest proportion of smokers (Broer & Kuiper, 2012). A high share of heavy smokers, both males and females, are found in the east of Groningen and the north of the province of Friesland (Volksgezondheidszorg.info, 2015b). Therefore, higher mortality due to lung cancer in this region seems to be attributable to a higher share of smokers in these area that influences regional difference in health outcomes.

Significant spatial clustering for mortality due to diseases of the circulatory system was observed both for males and females in the region. For males four high- high clusters were identified in the northeast of the region. Therefore, mortality rates due to circulatory diseases are significantly higher compared to other municipalities in the region. Three clusters of the municipalities of Oldambt, Delfzijl and Menterwolde are similar to the spatial patterns that were shown for male life expectancy and are therefore associated with the geographical variations in health outcomes (see figure 32A and E). This confirms the findings that regional differences in cardiovascular mortality are related to lower socio economic status (Filate et al., 2003). For females, seven significant clusters of high mortality due to circulatory diseases were identified in the northeast of the region: in the municipalities of Delfzijl, Appingedam, Menterwolde, Oldambt, Veendam. Pekela and Bellingwedde within the province of Groningen. All these clusters are identical to the patterns of females life expectancy that were observed and therefore mortality due to circulatory diseases largely explains the regional differences in life expectancy for females (see figure 33A and D). Although among males and females similar spatial patterns of high mortality due to circulatory diseases are found in the northeast of the region, for females a larger cluster coverage is observed. This conforms the view that for females education related differences in mortality are largest for cardiovascular diseases (Mackenbach et al., 2008). The main risk factors for diseases of the circulatory system include: high blood pressure, smoking, obesity, physical inactivity, unhealthy diets and diabetes (Mackay & Mensah, 2004). Within the northeast of Groningen smoking and obesity are the main risk factors for males and females (RIVM, 2015a) and seems to be related to the higher mortality due to circulatory diseases.

Mortality due to diseases of the respiratory system is significantly clustered both for males and females in the northeast of the region. For males, three clusters of high mortality due to respiratory diseases for the municipalities of Menterwolde, Pekela and Bellingwedde correspond to the patterns that were observed for life expectancy and therefore contribute to the regional variations in life expectancy (see figure 32A and F). These findings of the contribution of respiratory diseases on regional differences on life expectancy are also confirmed by Loke & De Jong (2013). For females, three clusters of high mortality due to respiratory diseases of the municipalities of Oldambt, Bellingwedde and Pekela are similar to the patterns of female life expectancy (see figure 33A and E) and therefore partly explain the geographical variations in health. Respiratory diseases involve diseases of the lungs and airways: Chronic Obstructive Pulmonary Disease (COPD) is the most common respiratory disease and tobacco smoking is the primary risk factor of COPD (WHO, 2017b). Some of the risk groups for chronic respiratory diseases are people with lower education, people who are unemployed or disabled to work and smokers and ex-smokers (CDC, 2015). Higher mortality due to respiratory diseases within the northeast of Groningen therefore seems to be related with lower SES and the on average higher share of heavy smokers within the region, both for males and females (Volksgezondheidszorg.info, 2015b).

Mortality due to external causes of death showed no significant spatial clustering both for males and females and therefore geographical patterns are randomly distributed across the region. From this it can be concluded that regional differences in life expectancy in the Northern Netherlands are not explained by the external causes of death.

5.4 Recommendations

In conclusion, regional differences in life expectancy in the northeast of the region are attributable to a lower SES of the population and its influence on unhealthy lifestyles. Both for males and females, the municipalities of Oldambt and Pekela within the province of Groningen are most frequently observed in the cluster analysis. Therefore, these municipalities are regarded as high risk areas with high mortality due to malignant neoplasms (males), lung cancer, circulatory diseases and respiratory diseases; this reflects the diversity of the health problems in the northeast of the region. Major risk factors within the region include a high share of heavy smokers and drinkers and overweight and obese people.

However, not all the municipalities with low SES showed poorer health outcomes. It is likely that other factors, such as population decline, are related to lower life expectancies in these areas. As the numbers of households decrease, more service like healthcare and education services and the housing and labour market are affected and consequently, this has implications for the liveability, the economy and the quality of life (Provincie Groningen, 2016). Also the presence of nursing homes could influence mortality rates within a certain region. Future research should therefore focus on the integration of contextual factors as well. In this analysis comparison of local cluster maps contributed to the comprehension of geographical variations in life expectancy and besides identified ``problem`` areas and important risk factors that should be addressed by policymakers. In this case, spatial analysis techniques are beneficial in identifying and tackling health issues within the northeast of the region.

Health policies at the local level should be targeted at the reduction of heavy smoking and drinking by males as these factors are related to higher mortality due to malignant neoplasms for males within the northwest of the province of Groningen. Higher mortality due to lung cancer, circulatory diseases and respiratory diseases, for both males and females, is associated with a higher share of heavy smokers and heavy drinkers and a higher percentage of obese people within the northeast of the region. Local health policies should therefore integrate health promotion programs to adopt healthy lifestyles by addressing the needs of vulnerable groups such as lower educated, people with lower income, unemployed, people with chronic or psychological disorders and elderly people. Furthermore it is recommended that policy makers focus on the broader determinants of health such as (un)employment and poverty. For example, research showed that reintegration into work (eventually together with a health promoting program) of unemployed in the city of Rotterdam positively influenced health status compared to an health promotion program solely (Eengezondernederland.nl, 2017). Also it is recommended to focus on the attraction of higher educated and young families within the region as this promotes attractive and sustainable communities.

References

AWPGNN (2016) *Missie en visie.* Retrieved on October 30, 2016 from: http://www.publiekegezondheid.nl/ Leeuwarden: Academische Werkplaats Publieke Gezondheid Noord-Nederland

Benach, J., and Yasui, Y. (1999) Geographical patterns of excess mortality in Spain explained by two indices of deprivation. *Journal of Epidemiology and Community Health,* 53 (7) 423-431

Bosma, H., Van de Mheen, H.D., Borsboom, G.J., and Mackenbach, J.P., (2001) Neighboorhood socioeconomic status and all-cause mortality. American Journal of Epidemiology 153 (4), 363-371

Boyle, P., Curtis, S., Graham, E., Moore, E. (2004) The Geography of Health Inequalities in the Developed World. Views from Britain and North America. Hants (England) & Burlington (USA): Ashgate Publishing Limited
CBS (2013) *Bijna 60 procent overlijdt aan kanker of hart- en vaatziekten.*

Retrieved on July 16, 2016 from: https://www.cbs.nl/nl-nl/nieuws/2013/38/bijna-60-procent-overlijdt-aan-kanker-of-hart-en-vaatziekten. The Hague/Heerlen: CBS

CBS (2014) *Chronic diseases, smoking and sedentary lifestyle make people feel unhealthy*. Retrieved on July 16, 2016 from: https://www.cbs.nl/en-gb/news/2014/27/chronic-diseases-smoking-and-sedentary-lifestyle-make-people-feel-unhealthy. The Hague/Heerlen: CBS

CBS (2015) *Aantal zelfdodingen in 2014 niet verder gestegen.* Retrieved on March 16, 2017 from: https://www.cbs.nl/nl-nl/nieuws/2015/37/aantal-zelfdodingen-in-2014-niet-verder-gestegen. The Hague/Heerlen: CBS

CBS (2016a) Sleutellijst van belangrijke doodsoorzaken (BELDO) gebaseerd op ICD-10. Heerlen/ The Hague: CBS

CBS (2016b) *Beschrijving Doodsoorzakenstatistiek*. Retrieved on October 31, 2016 from: https://www.cbs.nl/nl-nl/onze-diensten/methoden/onderzoeksomschrijvingen/aanvullende%20onderzoeksbeschrijvingen/beschrijving-doodsoorzakenstatistiek. Heerlen/The Hague: CBS

CBS (2016c) *Doodsoorzakenstatistiek.* Retrieved on October 31, 2016 from: https://www.cbs.nl/nl-nl/onze-diensten/methoden/onderzoeksomschrijvingen/korte-onderzoeksbeschrijvingen/doodsoorzakenstatistiek. Heerlen/The Hague: CBS

CDC (2015) *Chronic Respiratory Disease*. Retrieved on March 24, 2017 from: https://www.cdc.gov/healthcommunication/toolstemplates/entertainmented/tips/chronicrespiratorydisease.html. Atlanta: CDC

CDC (2016) *What Are the Risk Factors for Lung Cancer?* Retrieved on March 3, 2017 from: https://www.cdc.gov/cancer/lung/basic_info/risk_factors.htm. Atlanta: CDC

CSDH (2008) *Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health.* Geneva: World Health Organization.

Cromley, E.K. & McLafferty. S.L. (2002) GIS and Public Health. New York: The Guilford Press

Eengezondernederland.nl (2017) Heden en verleden: levensverwachting en sterfte. Retrieved on March 17, 2017 from: http://www.eengezondernederland.nl/Heden_en_verleden/Levensverwachting. Bilthoven: RIVM

ESRI.com (2017) *How cluster and outlier analysis: Anselin Local Moran´s I works.* Retrieved on March 16, 2017 from: http://resources.esri.com/help/9.3/arcgisengine/java/gp_toolref/spatial_statistics_tools/how_cluster_and_outlier_analysis_colon_anselin_local_moran_s_i_spatial_statistics_works.htm. Redlands CA: ESRI

Eurostat (2015) *Death due to cancer, standardized death rate per 100.000 habitants. Retrieved on July 7, 2016 from http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tps00116&plugin=1.* Luxembourg: Eurostat.

EUROSTAT (2016*) Statistics explained: Mortality and life expectancy statistics*. Retrieved on July 7, 2016 from: Luxembourg: EUROSTAT

Daalhuizen, F., Dam, van, F., Groot, de, C., Middelkoop, van, M., Peeters, P. (2013) *Vergrijzing en ruimte. Gevolgen voor de woningmarkt, vrijetijdsbesteding, mobiliteit en regionale economie.* The Hague: Planbureau voor de Leefomgeving http://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2013_Vergrijzing%20en%20ruimte_450.pdf

Eengezondernederland.nl (2017) *Gezond aan de slag*. Retrieved on March 24, 2017 from: http://www.eengezondernederland.nl/Kansen_en_keuzes/Samenspel_gezondheid_en_participatie/Voorbeeld_Gezond_aan_de_slag

EC (2016) *Health strategy. Policy.* Retrieved on July 11, 2016 from: http://ec.europa.eu/health/strategy/policy/index_en.htm. Luxembourg: EC

EU(2014) *Tackling health inequalities. EU support to improve health across all sectors of society.* Brussels: European Union.

Eurostat (2016) *Causes of death statistics*. Retrieved on July 12, 2016 from: http://ec.europa.eu/eurostat/statistics-explained/index.php/Causes_of_death_statistics. Luxembourg: Eurostat

Eysink, P. E. D. (2010) Sociaaleconomische status. Retrieved on October 11, 2016 from: http://www.toolkitvtv.nl/inhoud/indicatoren-en-bronnen/bevolking/sociaaleconomische-status/. In: *Volksgezondheid Toekomst Verkenning, Toolkit regionale VTV.* Bilthoven: RIVM

Eysink, P.E.D. and Poos, M.J.J.C. (2010) Methodologie. Sterfte en levensverwachting: verschillende sterftematen. *In: Volksgezondheid Toekomst Verkenning, Toolkit regionale VTV*. Retrieved on October 11, 2016 from: http://www.toolkitvtv.nl/inhoud/methodologie/verschillende-sterftematen/. Bilthoven: RIVM

Fitzpatrick, J., Griffiths, C. and Kelleher, M. (2000). Geographic inequalities in mortality in the United Kingdom during the 1990s. Health Statistics Quarterly 7: 19-31

Gutierrez-Fisac, J.L., and Gispert, R., Sola, J. (2000) Factors explaining the geographical differences in Disability Free Life Expectancy in Spain. *Journal of Epidemiology and Community Health,* 54 (6), 451-455

Gesthuizen, M., Huijts, T. en Kraaykamp, G. (2011) De gezondheidskloof tussen lager en hoger opgeleiden. Verschillen tussen landen verklaard door overheidsuitgaven in de gezondheidszorg en arbeidsmarktomstandigheden. *Mens en Maatschappij,* 2, 157-180

Van Gelder, B.M., Poos, M.J.J.C., Harbers, M.M. (2014) *Wat zijn de gezondheidsgevolgen van roken?* Retrieved on August 26, 2014 from http://www.nationaalkompas.nl> Nationaal Kompas Volksgezondheid\Determinanten\Leefstijl\Roken,

Gijsen, R., Oostrom, SH, van & Schellevis, F.C., (2013) Neemt het aantal mensen met chronische ziekten en multimorbiditeit toe of af? In: *Volksgezondheid Toekomst Verkenning*, *Nationaal Kompas Volksgezondheid.* Bilthoven: RIVM

Government of the Netherlands (2016) *Population decline: causes and effects of population decline.* Retrieved on July, 16, 2016 from: https://www.government.nl/topics/population-decline/contents/causes-and-effects-of-population-decline. The Hague: Ministry of the Interior and Kingdom Relations.

Government of the Netherlands (2015) *Kabinet zet succesvol gezondheidsbeleid door.* Retrieved on July 11, 2016 from: https://www.rijksoverheid.nl/actueel/nieuws/2015/12/04/kabinet-zet-succesvol-gezondheidsbeleid-door. The Hague: Government of the Netherlands.

Gould, W. S. (2009) *Population and development* . London: Taylor & Francis Group

Häkkinen, H. (2009) *Health care challenges in regions with declining and ageing population*. Brussels: Council of European Municipalities and Regions (CEMR)

Harbers, M.M. & Eysink, P.E.D. (2011) Wat zijn determinanten van (on)gezondheid? *In: Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid*. Bilthoven: RIVM

Houston, D., Wu, J., Ong. P. and Winer, A. (2004) Structural disparities of urban traffic in southern caifornia: implications for vehicle-related air pollution exposure in minority and Hh-poverty neighbourhoods. Journal of Urban Affairs, 26 (5), 565-592

Janssen, F. en Spriensma, A.S. (2012) The contribution of smoking to regional mortality differences in the Netherlands. *Demographic Research,* Vol. 27 (9), 233-260.

Kibele, E.U.B., Klüsener, S. & Scholz, R. D., (2015) Regional Mortality Disparities in Germany. Long-Term Dynamics and Possible Determinants, *Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie*, 67, 241–270.

OECD (2014) Using well-being indicators for policy making: Region of the North of the Netherlands, Netherlands. Paris: OECD

Provincie Groningen (2016) *Dossiers: Krimp,* retrieved on March 21, 2016 from http://www.provinciegroningen.nl/actueel/dossiers/krimp/. Groningen: Provincie Groningen

Kulhánová, I., Hofmann, R., Eikemo, T.A., Menvielle, G., Mackenbach, J.P. (2014) Sociaal-economische verschillen in sterfte naar Doodsoorzaak. Eerste Nederlandse gegevens. In: *Nederlands Tijdschrift Geneeskunde*, 158: A8188

Loke, R. & de Jong, A. (2013) *Regionale verschillen in sterfte verklaard.* The Hague: PBL & The Hague/Heerlen: CBS

Loketgezondleven.nl (2017) *Gezondheidsvaardigheden*. Retrieved on February, 18, 2017 from: https://www.loketgezondleven.nl/vraagstuk/gezondheidsvaardigheden

Mackenbach JP, Kunst AE, Looman CW. Regionale verschillen in sterfte aan ischemische hartziekte. *Ned Tijdschr Geneeskunde.* 134, (12), 596–601.

Mackenbach, J.P. (1992) Socio-economic health differences in The Netherlands: a review of recent empirical findings. In: *Social Science and Medicine*, 34, (3), 213-226.

Mackenbach, J.P., Stirbu, I., Roskam, A.J.R., Schaap,M. M., Menvielle, G., Leinsalu, M., Kunst, A.E. (2008) Socioeconomic Inequalities in Health in 22 European Countries. In: *The New England Journal of Medicine,* 358, 2468-2481.

Mackenbach, J.P. (2012) The persistence of health inequalities in modern welfare states: The explanation of a paradox. In: *social science & medicine*, 75, (4), 761-769

Marmot, M. (2013) *Review of social determinants and the health divide in the WHO European Region: final report.* Geneva: WHO

Meijer, S. (2015) *Groningen kent het hoogst aantal zelfdodingen*. Retrieved on March 15, 2017 from: http://www.groningerkrant.nl/2015/09/groningen-kent-hoogste-aantal-zelfdodingen-van-nederland/. Groningen: Groningerkrant

Mitchell, A. (2005) The ESRI Guide to GIS analysis, Volume 2. Redlands: ESRI Press

Mitchell, R., Dorling, D. and Shaw, M. (2000) *Inequalities in life and death: what if Britain were more equal?* Bristol: The Policy Press

Mladovsky, P., Allin,S.,Masseria,C., Hernández-Quevedo,C., McDaid,D., and Mossialos, E. (2009) *Health in the European Union, trends and analysis.* Copenhagen: WHO Regional Office Europe

Mulder M (RIVM), Hertog FRJ den (RIVM). Kanker totaal per gemeente . *In: Volksgezondheid Toekomst Verkenning, Nationale Atlas Volksgezondheid*. Bilthoven: RIVM, <http://www.zorgatlas.nl> Zorgatlas\Gezondheid en ziekte\Sterfte\Sterfte naar doodsoorzaken, 28 mei 2014.

Omran, A.R (1971) The Epidemiologic Transition: A Theory of the Epidemiology of Population Change. In: *The Milbank Memorial Fund Quarterly,* 49, 509-538

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. In: *The Milbank Quarterly*, 83 (4), 731-757

Pearce, J., and Dorling, D., (2006) Increasing geographical inequalities in health in New Zealand, 1980-2001. International Journal of Epidemiology, 35 (3), 597-603

Pharos (2014) *Factsheet sociaaleconomische gezondheidsverschillen*. Retrieved on March17, 2017 from:
http://www.pharos.nl/documents/doc/factsheet_sociaal_economische_gezondheidsverschillen.pdf

Poppelaars, J. and Rijs, K. (2011) Mortality data and cause of death. Retrieved on October 31, 2016 from: http://www.lasa-vu.nl/themes/generic/mortality.htm. Amsterdam: EMGO Institute for Health and Care Research

RIVM, (2013). Aantal chronisch zieken neemt toe. Retrieved on July 16, 2016 from: http://www.rivm.nl/Documenten_en_publicaties/Algemeen_Actueel/Nieuwsberichten/2013/Aantal_chronisch_zieken_neemt_toe. Bilthoven: RIVM

RIVM (2015a) *Gemeentelijk gezondheidsprofiel* Delfzijl
Retrieved on March 24, 2017
from: http://www.rivm.nl/media/profielen/profile_10_Delfzijl_gezonddet.html

RIVM (2015b) *Gemeentelijk gezondheidsprofiel D e Marne* . Retrieved on March 24, 2017 from: http://www.rivm.nl/media/profielen/profile_1663_De_Marne_gezonddet.html. Bilthoven: RIVM

RIVM (2016) *Mission and strategy.* Retrieved on October 30, 2016 from:
http://www.rivm.nl/en/About_RIVM/Mission_and_strategy. Bilthoven: RIVM

Schippers, E. I., & Van Rijn, M. J. (2015) *Landelijke nota gezondheidsbeleid 2016-2019*. The Hague: Ministery of Health, Welfare and Sports

SCP (2009) *Statusscores*. Retrieved on October 11, 2016 from: https://www.scp.nl/Onderzoek/Lopend_onderzoek/A_Z_alle_lopende_onderzoeken/Statusscores. The Hague: SCP

SCP (2015) *Veelgestelde vragen over de statusscores. versie 5 maart 2015.* The Hague: SCP

Shaw, M., Dorling, D. & R. Mitchell (2002). Chapter 5: Health Inequalities: Composition or Context? In: *Health, Place and Society*. London: Pearson

Siegler, V., Langford, A., Johnson, B. (2008). Regional differences in male mortality inequalities using the National Statistics Socio-economic Classification, England and Wales, 2001-3. *Health Statistics Quarterly,* 40*,* 6-*17*

Sloggett, A. (2015). The demographic transition. In *Population Analysis for Policy and Programmes*. Retrieved at July 13, 2016 from http://papp.iussp.org/sessions/papp101_s01/PAPP101_s01_090_010.html. Paris: International Union for the Scientific Study of Population.

Smith, M. M., Lutgendorf, S.K. & Sood, A.K. (2010) Impact of stress on cancer metastasis. In: Future Oncology, 6(12), 1863–1881.

SPG (2016) *Leefbaarheid in Noord-Nederland*, Retrieved on February 17, 2017 from http://sociaalplanbureaugroningen.nl/dynamic/media/1/documents/thema_krimp/ervaren%20leefbaarheid/FSP_feitenblad_krimp_Noord-DEF-lr.pdf. Groningen: SPG

United Nations (2015). World Population Prospects: The 2015 Revision. Washington D.C.: UN

Verweij, A & Van der Lucht, F. (2014) *Gezondheid in krimpregio's. Verdiepingsstudie. RIVM Briefrapport 270742001/2014.* Bilthoven: RIVM

Volksgezondheidszorg.info (2016a) *Chronische ziekten en multimorbiditeit> Regionaal & Internationaal>Regionaal.* Retrieved on July 7, 2016 from https://www.volksgezondheidenzorg.info/onderwerp/chronische-ziekten-en-multimorbiditeit/regionaal-internationaal/regionaal#node-e%C3%A9n-meer-chronische-ziekten-gemeente. Bilthoven: RIVM

Volksgezondheidszorg.info (2016b) *Levensverwachting bij geboorte per gemeente*. Retrieved on July 7, 2016 from: https://www.volksgezondheidenzorg.info/onderwerp/levensverwachting/regionaal-internationaal/bij-geboorte#!node-levensverwachting-bij-geboorte-gemeente

Volksgezondheidszorg.info (2016c) Sterfte naar doodsoorzaak. Retrieved on July 7, 2016 from: https://www.volksgezondheidenzorg.info/onderwerp/sterfte-naar-doodsoorzaak. Bilthoven: RIVM

Volksgezondheidszorg.info (2017a) Contact met huisartsen per GGD regio. Retrieved on March 24, 2017 from± https://www.volksgezondheidenzorg.info/onderwerp/eerstelijnszorg/regionaal-internationaal/huisartsenzorg#node-contact-met-huisartsen-ggd-regio. Bilthoven: RIVM

Volksgezondheidszorg.info (2017b) *Zware rokers mannen per GGD-regio.* Retrieved on March 17, 2017 from: https://www.volksgezondheidenzorg.info/onderwerp/roken/regionaal-internationaal/regionaal#node-zware-rokers-mannen-ggd-regio. Bilthoven: RIVM

Wendel, G.C.W. (2014) Wat zijn de mogelijke gezondheidsgevolgen van lichamelijke (in)activiteit? In: Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid. Bilthoven: RIVM

Wolleswinkel-van den Bosch, J.H., Looman, C.W.N., Poppel, van F.W.A. & Mackenbach, J.P.(1997), 'Cause-Specific Mortality Trends in The Netherlands, 1875-1992: A Formal Analysis of the Epidemiologic Transition', *International journal of epidemiology : official journal of the International Epidemiological Association,* 26 (4), pp. 772-781.

Woods, L.M., Rachet, B., Riga, M., Stone, N., Shah, A., Coleman, M.P. (2005) Geographical variation in life expectancy at birth in England and Wales is largely explained by deprivation. *Journal of epidemiology and community health* 59 (2), 115-120

WHO (2004) *Risk factor: tobacco.* Retrieved on July 16, 2016 from: http://www.who.int/cardiovascular_diseases/en/cvd_atlas_07_tobacco.pdf?ua=1. Geneva: WHO

WHO (2014) *Noncommunicable Diseases (NCD) Country Profiles*, Netherlands. Geneva: WHO

WHO (2016) Classifications: International Standard. Retrieved on October, 31 from: http://www.who.int/classifications/icd/en/ . Geneva: WHO.

WHO Regional Office for Europe (2016) *Reducing inequalities*. Retrieved on July 11, 2016 from: http://www.euro.who.int/en/health-topics/health-policy/health-2020-the-european-policy-for-health-and-well-being/about-health-2020/strategic-objectives/reducing-inequalities. Copenhagen: WHO Regional Office for Europe

WHO (2017a) *Cancer*. Retrieved on March 14, from: http://www.who.int/mediacentre/factsheets/fs297/en/. Geneva: WHO

WHO (2017b) *Chronic respiratory diseases*. Retrieved on March 14, 2017 from: http://www.who.int/respiratory/en/. Geneva: WHO

ZonMw (2016a) *Nieuws: Samenwerking gemeente, universiteit en GGD levert winst op voor maatschappelijke vraagstukken.* Retrieved on November 3, from: http://www.zonmw.nl/nl/programmas/programma-detail/academische-werkplaatsen-publieke-gezondheidvervolgprogramma/actueel/?tx_zonmwdata_pi1%5Bmode%5D=1&tx_zonmwdata_pi1%5Btt_news%5D=6238&cHash=9ef5d312f50135567625133f74d6aa52. The Hague: ZonMw

ZonMw (2016b) *Programme: Academic Collaborative Centres Public Health*. Retrieved on October 31, 2016 from: http://www.zonmw.nl/en/programmes/academic-collaborative-centres-public-health/programme/. The Hague: ZonMw