# A GEOSPATIAL ANALYSIS OF SOCIO-ECONOMIC CONDITIONS AND THEIR ASSOCIATION WITH HEALTH STATUS AND HEALTH EXPENDITURE: THE CASE OF THE TWENTE REGION

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March, 2017

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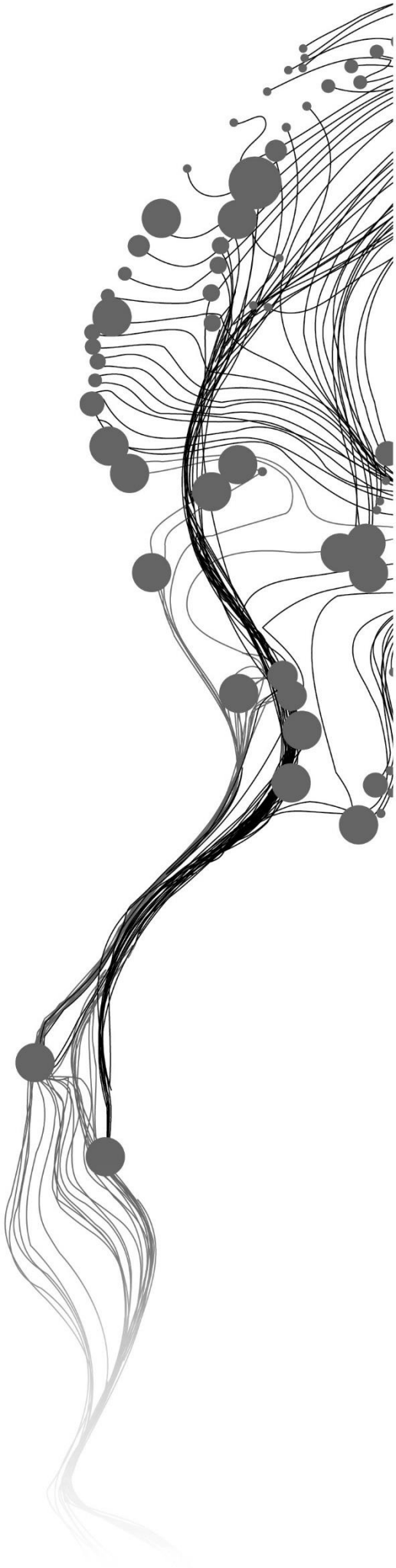

# A GEOSPATIAL ANALYSIS OF SOCIO-ECONOMIC CONDITIONS AND THEIR ASSOCIATION WITH HEALTH STATUS AND HEALTH EXPENDITURE: THE CASE OF THE TWENTE REGION

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# ABSTRACT

Socio-economic status (SES) has an important role in explaining health, both as unified and multidimensional concept. A spatially disaggregate level analysis of SES in relation to health status and health behaviour, on the one hand, and healthcare use and health expenditures, on the other hand, may enrich understanding population health and guide health and healthcare interventions and policies. This research developed a methodological approach including various data processing techniques for the purpose of capturing the relationship between socio-economic characteristics, health status, and health expenditure in the Twente region in the Netherlands. Data used are secondary, regularly collected and annually updated open source data about health from various sources (i.e. CBS, VAAM, VEKTIS). These data are prepared and combined into a unified database in order to do a comparative intra-urban analysis of the fourteen municipalities of the Twente region. Research was conducted using statistical and spatial analysis. Statistical analysis involved multiple linear regression applied in a two-phase approach. First part analysed how SES relates to health status (i.e. overweight, hypertension, diabetes, respiratory conditions, chronic conditions) and health behaviour (i.e. smoking, alcohol consumption, physical exercise). On the other hand, second part analysed to what extent are variations in SES and health status connected with healthcare consumption and health costs (i.e. general practitioners, medical specialists, and mental health). A GIS-based spatial analysis was done to visualise spatial variation of health behaviour, health status, health utilization and health expenditure. Observed as one-dimensional variable, low SES is associated with worse health outcomes (i.e. overweight, chronic conditions, and diabetes) and smoking and prescription medication. Moreover, high education, as a variable of SES, is associated with better health outcomes (i.e. overweight, hypertension, and chronic diseases). The main finding of the research is the existence of strong association between SES, both as composite and multidimensional concept, with health behaviour and health status, healthcare use, and, likewise, health expenditures.

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# 1. INTRODUCTION

*This section provides background information on health status at the current state of research of its association with socio-economic circumstances. Moreover, it introduces the possibility of including health costs in the analysis, and presents the study area of the research. Next, the research problem is identified, followed by the research objectives, general and specific.*

## 1.1. Background on health status and its association with socio economic conditons and justification for the study

With increased rates of urbanization, cities becoming overpopulated and inequalities being more visible, health is considered to be a crucial aspect of quality of life. Promoting good health is one of the targets of Europe 2020, the European Union's strategy for smart, sustainable, and inclusive growth. But to do so, we should first understand what health means, what are its dimensions and what are the factors that influence health status.

Health is an elusive concept and hard to measure due to lack in theoretical basis (Forrest, 2014). An early definition by the World Health Organization describes it as 'a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity' (World Health Organization, 1946). Literature suggests that human health includes five separate, but related dimensions which are the physical, emotional, mental, social, and spiritual. Moreover, these dimensions have also been the basis of developing different measures to quantify health, such as the Health-related Quality of Life concept (HRQoL). This concept focuses on the overall outcomes of health and its importance in quality of life (Foundation Health Measures, 2010). These dimensions are influenced by different factors which can vary from excellent health to ill health status. They determine individuals and communities' health status based on their environment and other circumstances like genetics, income and education level or relationships with one another. They can be categorised as: the social and economic determinants, the physical environment, and the person's individual characteristics and behaviours (World Health Organization, n.d.).

Studies show that there have been advantages in those populations that have enhanced conditions in which people are born, grow, live, and work (Marmot, Allen, Bell, Bloomer, & Goldblatt, 2012). In the last two decades, a crucial importance has been given to the social and economic determinants in shaping health. These studies acknowledge the importance of medical care, access and use of health services, but they indicate that they have less of an impact than commonly assumed (Braveman & Gottlieb, 2014).

Communities are categorised by different circumstances and environments, consequently differing socio-economic status. This categorization leads to inequalities in early childhood, education, nature of employment and working environment, and the physical and natural environment in which they reside making them more or less vulnerable to poor health (CSDH, 2008). This association of socio-economic determinants with health has been an important part of studies on how to improve health status. An integration of Geographic Information Systems (GIS) in explaining and mapping these relations can lead to better prevention and intervention strategies.

Studies in public health have been examining the relationships between health and both social and physical environmental characteristics. In his study about the use of GIS and spatial analytical tools in public

health, Rushton (2003) claims that the use of the GIS technologies rest on the perceived needs of the public health community for these tools to provide decision support. Moreover, Luginaah et al. (2002) in their study argue that the use of GIS technologies together with spatial statistics has been neglected or not fully articulated in literature, but they can be advantageous for addressing the limitations of identifying the characteristics of neighbourhoods based on socio-economic determinants for health study purposes and related risk factors.

In the Dutch health care system, public health services are main providers of preventive care, and the municipalities manage disease prevention, health promotion and health protection. Out of 403 municipalities there are 29 municipal health services (Gemeentelijke Gezondheidsdiensten- GGDs) performing these services (Peinado, Villalba, Mansoa, & Sánchez, 2015). Twente region is one of the regions with low performance in The Netherlands when looking at life expectancy and mortality rates as indicators for health status (Peinado et al., 2015). With its population projections and ageing process, this region is at a high risk of health status decline and increase in mortality rate from health conditions (GGD Twente, 2011).

With an aim to improve health in this region, GGD Twente generates data and reports annually on health status but it lacks an explicit geographic perspective when analysing these data. Publicly available data which exist seem to be rich in content but there appears to be difficulties in relating existing data sources because of differences in spatial and temporal resolution.
This brings to a need for spatial analysis of socio-economic circumstances and their association with health status. There is need to explicitly understand the impacts these socio-economic circumstances have on the health status of the inhabitants of the region. Moreover, an evaluation of the effect of socio-economic determinants and health status on health expenditure can enrich the analysis of this research.

### 1.2. Research problem

Different areas within a city have different socio-economic characteristics, and this can potentially influence differences in health care use and cost for their inhabitants. Apart from medical care, other factors affect these differences. Based on the demographic profile of the inhabitants, health care demands and health outcomes are different. While for non-elderly adults, education and household income can be indicators of health status (Galobardes, Shaw, Lawlor, Lynch, & Davey Smith, 2006), individuals with multiple comorbidities (i.e. multiple illnesses) are high utilizers of healthcare. This brings out the importance of observing and identifying how socio-economic and demographic determinants influence health and how this association can be spatially analysed. Whether those factors and health status overlap with one another or which factors come more into focus, can help understand and improve the delivery of health services and healthcare locally. Furthermore, it can, at the same time help keep health expenditures manageable. Geo-spatial analysis is deficient in health status analysis in Twente region. Health data has not been used to its capacity to explore different influences on improving health status and the benefits they have in developing future intervention strategies.

A geo-spatial analysis of socio-economic circumstances of the population of Twente may help in identifying trends in high-cost communities and explain whether they are also high-need. Health and socio-economic data can be combined to better understand their association. Additionally, this association can be analysed with health expenditure spatially to understand what determines the consumption of healthcare and health spending. A challenging step is developing an approach to usefully combine existing secondary data with different spatial resolution, by bringing them to a common unit of analysis.

## 1.3. Research objectives

### 1.3.1. General objective

To examine the relation between socio-economic circumstances, health status, heath behaviour, and health expenditure in the Twente region on the basis of publicly available and spatially disaggregate secondary data sources.

### 1.3.2. Specific objectives

1. To identify socio-economic indicators that influence health
2. To examine the association between socio-economic circumstances with health status and health behaviour
3. To explore the influence of socio-economic circumstances, health status, and health behaviour on health expenditure

## 1.4. Research questions

1. To identify socio-economic indicators that influence health
    a) What are the existing measures of socio-economic circumstances used in the Twente region?
    b) Which are the indicators of socio-economic circumstances that can predict health status?

2. To examine the association between socio-economic circumstances with health status and health behaviour
    a) Do socio-economic circumstances influence health status and health behaviour?
    b) Which are the common indicators of socio-economic circumstances that explain health conditions?
    c) What is the spatial relationship between socio-economic status with health status and health behaviour?

3. To explore the influence of socio-economic circumstances, health status, and health behaviour on health expenditure
    a) What is the relationship between health expenditure and socio-economic circumstances?
    b) What is the relationship between health status and health behaviour with health expenditure?

# 2. HEALTH STATUS AT NEIGHBOURHOOD LEVEL AND THE FACTORS THAT INFLUENCE IT

*This chapter gives an overview of the key literature on the main concepts of the research. It also provides examples of studies focusing on similar topics and how these define and operationalize the concepts. Moreover, it gives an understanding of the relations between them, and how they influence each other. In addition, it introduces the conceptual framework of the research. At the end, it goes through methods used on similar researches.*

## 2.1. Socio-economic circumstances and their measure

Social and economic characteristics measured at neighbourhood level have the potential to affect, and thus help understand the variations in health status of people living there. Differences in socio-demographic, cultural, and economic factors have been used as indicators of socio-economic status (SES) (Cassedy et al., 2013). Studies using SES in relation to health have been growing (Oakes & Rossi, 2003). Although the term "socio-economic" has had a vast use since it was first used in 1883 by sociologist Lester Ward, there is a lack of a nominal definition or measurement tool and essential indicators for SES. This lack of a unified definition makes it difficult for researchers from different fields to analyse it in a comparable way, so that they can merge the researches and create a common ground for mutual benefit.

Different studies define SES depending on the context of the application. A common definition is one from Dutton and Levine (1989) which defines SES as "a composite measure that typically incorporates economic status, measured by income; social status, measured by education; and work status, measured by occupation"(p. 30). Similarly, other studies incorporate income, education, and occupation as the most common indicators to compose SES (Berkman & Macintyre, 1997; Cutler, Lleras-Muney, & Vogl, 2008; Shavers, 2007). Additionally, some of them consider other indicators such as: wealth or race and ethnicity (Cutler et al., 2008; Kapur et al., 2004; Van Oyen, Deboosere, Lorant, & Charafeddine, 2011).

Socio-economic inequalities like income have negative implications on health (Blouin, Chopra, & van der Hoeven, 2009), but also people who live in poor neighbourhoods are assumed to have poor health. Disadvantaged neighbourhoods in regards to socio-economic determinants and concentration of convenience stores are assumed to have health consequences of chronic diseases that appear only decades later. These neighbourhoods have been linked to tobacco use, lower availability of fresh products and higher availability of fast-food outlet, fewer recreational areas all leading to poorer nutrition and less physical activity (Braveman & Gottlieb, 2014). This research focuses only on the one-way influence that SES indicators have on health outcomes. Looking at the opposite direction of influence can help understand the behaviour of people and what are the factors to be improved for a better health status.

## 2.2. SES in health research

SES has been used in health research as a variable to consider its association with health outcomes and health spending, and although it has had an increase in use, it is still not exactly determined how SES and health status interact (Kaplan & Lynch, 1997). Researchers have been examining these relations, and have considered SES to be an important factor for population's health, and argued that an association exists between low SES and poor health (Krause & Lampert, 2015).

To evaluate the impact SES has on health outcomes, first an observation of the relation between SES and health status as used in health research should be considered. Then the ideal measures of SES in health should be identified. Grundy (2001) in his study claims that three types of factors are important when studying the relations between SES and health status: materialist factors, behavioural or "lifestyle" factors, and psychosocial factors.
The first, emphasises on the fact that people with higher income can afford better environment and access to health care. The second, considers factors like smoking, diet and alcohol and skill of information and use of healthcare. Finally, psychosocial factors refer to empowerment, social status, and integration and how they influence important areas in life.

To bring these factors into context, and measure SES, the most used indicators have been: income, education, and occupation (Berkman & Macintyre, 1997). But studies focusing on different neighbourhood composition, based on either their group age or other factors like gender or ethnicity use different indicators more specific to their characteristics.
Therefore, defining SES indicators to analyse their impact in health depends on the health outcomes and the types of analysis needed to use in the research. Thus, knowing how each SES indicator influences specific health outcomes and employing the right SES indicators measures helps understand the variations of health due to SES (Cassedy et al., 2013). Table 1 gives an overview of indicators of SES that have been used in research in relation to health status and health outcomes.

Table 1. Indicators of Socio-economic Status that influence Health Status used in different studies

| **Authors** | **Indicators of SES** |
|---|---|
| *Dutton and Levine (1989)* | Income<br>Education<br>Occupation |
| *Berkman and Macintyre (1997)* | Income<br>Education<br>Occupation |
| *Kapur et al. (2004)* | Income<br>Education<br>Wealth |
| *Shavers (2007)* | Income<br>Education<br>Occupation |
| *Galobardes et al (2006)* | Income<br>Education<br>Occupation based measures<br>Housing tenure, housing conditions, and housing amenities |
| *Cutler et al. (2008)* | Income<br>Education<br>Occupation<br>Race & Ethnicity |

On the other hand, an important discussion is the argument for greater emphasis on the multidimensional nature of SES, instead of using it as a composite index. The influence SES has on health, is documented by many studies. However, treating SES as a unified concept has been questioned. Different indicators of health cannot be considered to have the same underlying characteristics and be fully interchangeable (Geyer, Hemström, Peter, & Vågerö, 2006; Steward, 2009; Torssander & Erikson, 2008). Depending on the characteristics of the area to be analysed, different indicators can be more influential and provide better prediction of health outcomes. This study will make use of a composite index of SES as well as individual indicators of socio-economic characteristics like *gender, age groups and ethnicity*. Furthermore, a second part of the analysis will consider each indicator of the index separately, and present the case where health outcomes are explained the most.

### 2.3. SES in the Twente region

Twente is classified as a region with increasing levels of socio-economic status of neighbourhoods (Knol, 2012). The Netherlands Institute for Social Research (SCP) has calculated a status score for postal code 4 level, starting from 1995. Status score is a composite index reflecting the social and economic status of districts in The Netherlands. These districts are postcode 4 areas, and they include zones where more than 100 households are present. The index is derived from some characteristics of the people living in those areas; jobs, income, and their education level. The composite index is calculated with factor analysis, using four indicators:

- *people not working,*
- *average income per income recipient,*
- *percentage of people with low income, and*
- *percentage of people with low education.*

The index results with scores ranging from negative to positive, where the higher the score, the higher the status of the postcode. The data for the composition of the index comes from EDM BV, an organization that provides overviews of the Dutch postcodes and households profiles.

SCP has a tradition in describing social status of neighbourhoods. In 1998, they published "From high to low; from low to high. The socio-spatial development of districts between 1971-1995", a publication that gave an overview of socio-economic position of postcode areas in the Netherlands. It initiated an interest in making the status continuously available to include further analysis for different fields. In response to that, SCP calculated and published the score for: 1998, 2002, 2006, 2010 and 2014.
A follow-up publication was that of 2012 for the development of the districts between 1998 and 2010. It stated that there have been increased values of social status of Dutch neighbourhoods between those years. The reasons for that might have been, first, that new postcodes which have higher status are integrated, and second, the education level of the postcodes has increased (Knol, 2012).

These changes of socio-economic status in postcodes and municipalities are assumed to reflect in changes in other domains of quality of life for inhabitants too. Differences in SES in the Netherlands are linked with differences in health status. Variations in education level result to variations in life expectancy up to seven years in average and there is also a relationship between people with low socio-economic status and higher number of diseases and health conditions (RIVM, 2015).

GGD Twente, a municipal health service organization for the region, aims to promote and provide better health status for the inhabitants. They collect data and collaborate with other institutions and organizations to have a wholesome dataset available for the public on the health status of the region at the

municipal level. On their website, they include the SES index calculated by SCP, with available options to spatially visualise the index and interpret the differences.
This research will use the social scores index as a SES indicator, to look how it can explain the changes in health status and health expenditure.

## 2.4. Health status

Health status of neighbourhoods is a concept that presents the health condition of that area, and its outcomes can be determined by the presence or absence of any disease. It is documented that these outcomes result from both biological and individual risks, and also social indicators like education, gender, wealth and so on (Khanna, 2016). These social indicators shape the differences within the neighbourhoods, resulting in different health outcomes and have a major influence in health inequalities. Hence, analysing and acting upon them can result in improving the health status (UNDP, 2011).

Health status has been the topic of many researchers, particularly measuring it and analysing the influencing indicators to improve it. Determining the status of health indicates referring the state of health outcomes of the inhabitants and health care use. This includes different health conditions and the affected inhabitants.

### 2.4.1. Determinants of health

Measuring health and health outcomes is a complex task where wide range of determinants have to be taken into account. Moreover, these determinants interact with each other in a specific way on various scales, producing particular conditions for health status to be improved or deteriorated. Health status, life expectancy and health conditions are subjected to differences due to changes in these determinants. For example, reduced number or people who smoke have a positive effect on number of death caused by cardio vascular diseases (Hoeymans, Melse, & Schoemaker, 2010). Moreover, the effect is even greater combined with increased use of high blood pressure reducing and cholesterol lowering medicines. This is only one of various examples of the complex relation and therefore influences on health different determinants can have. Determinants are classified into personal, behavioural and environmental, based on the main characteristics (Hoeymans et al., 2010). Personal determinants are associated with personal characteristics of inhabitants and health outcomes such as overweight, diabetes, high blood pressure and so on. Behavioural determinants include inhabitant's habits such as physical activity, smoking and drinking habits. They are mostly associated with healthy or unhealthy life style and individual choices people make in their daily routine. Environmental determinants are connected to the living environment, the characteristics of the neighbourhoods and the way individual characteristics can be observed when looking at the inhabitants as a group of people cohabitating in a certain area.

***Personal determinants - health status outcomes***

Personal characteristics of inhabitants contribute to the general health status. These characteristics include obesity, blood pressure, diabetes, psychosocial characteristics, and genetic factors. These determinants are also observed as risk factors.

***Behavioural factors***

Differences in people's behaviour are often considered as one of the important determinants in defining health status. Arcaya, Arcaya, & Subramanian (2015) wrote about how differences in smoking or eating habits might explain differences in health status across individuals or social groups. However, they also raised a question about factors leading to these habits. This study tries ty identify the influence socio-

economic circumstances have on behavioural determinants, and, on the other hand, how they affect health care utilization. According to studies (Jepson, Harris, Platt, & Tannahill, 2010), of all the behavioural determinants, smoking is proven to be responsible for deteriorated health status. This is followed by physical activity and alcohol usage. Similarly, in this study the focus is on these three determinants.

***Environmental***

Studies examining health and health status often consider environmental characteristics as an important health determinant. These determinants are addressed as traditional environmental exposures or physical characteristics of the environment, such as air pollution, availability of clean drinking water, transportation, street design, public spaces, and so on (Diez Roux et al., 2010). However, recent studies regarding health status go beyond the pure physical characteristics, giving more attention to physical environment in the sense of the characteristics of the neighbourhoods and living conditions as relevant determinants influencing the health status of the inhabitants (Diez Roux et al., 2010). When considering environmental determinants in this study, the focus is on the fact that people have certain socio-economic characteristics based on the geographic location and the way the group of people is clustered or organised. For example, people that like to exercise are more likely to choose a place of residence with characteristics suitable for carrying out desired activities, close to the parks and recreational areas. In their research Flacke and Kockler (2015) argue that aggregated socio-economic characteristics of neighbourhoods and built environmental factors both have independent effect on health outcomes.

### 2.4.2. Measures

Health status can be measured in different ways, by objective or subjective measures.

***Objective measures***

Objective measures take into consideration objective conditions of health status. Commonly used objective indicators for health status are mortality and life expectancy, where traditionally the focus was on mortality. In health studies, mortality is addressed not just through the number of dead people, but the focus was also on the age of death. In this study, the focus is on number of consultations and number of prescriptions per inhabitant as a measure of healthcare use.

***Subjective measures***

Subjective measures focus on how inhabitants perceive their health status. While personal opinions of people can confirm the findings from the objective analysis or reports focusing on objective conditions, there are cases where people's subjective perceptions differ from the objective health status. This emphasises the fact that health has different meaning for different people and communities and therefore it lacks the universal definition and methodological approach to measure it. For example, after receiving news about the change in the health conditions, individuals react in different ways and therefore define their self-evaluated health status according to their personal characteristics, expectations, and the level of perceived change

## 2.5. Health expenditure

Health care expenditure in simple terms is the amount of money spent in relation to health. Over the last few decades, healthcare expenditures have steadily increased all across the globe. This is of growing concern as higher health care costs could diminish the accessibility of health services to the general population, especially the economically vulnerable population. Health care expenditure can come from

people themselves, from the government, insurance companies or from external aids. External aids have been steadily increasing, especially in developing nations. The share of health expenditure increased from 12% in 2000 to 17% in 2006 in developing countries (WHO, 2009). In most countries health expenditure is paid partly by the people and partly by one of the other parties. The proportion of expenditure depends on many factors such as health systems, insurance plan of the person, and type of expenditure to be made but it is clear that increase in health expenditure is observed in both households and governments. This increase is not increasing in the same rate across all the nations. One study shows that the pace of growth is dependent on the level of economic development of countries (Ke, Saksena, & Holly, 2011). Health expenditure by governments which is usually given as percentage of GDP has shown to have positive relations with higher life expectancy (Rizzo, 2012). According to Grossman (1972) healthcare expenditures are crucial investments in health and potential productivity. A healthy population is more likely to have higher productivity. The effects of healthcare expenditure on health is not yet clear and there is no proof of a causal relationship (Heuvel & Olaroiu, 2017). In absence of a clear knowledge about these relationships which is evidently very complex, it is crucial to deepen the understanding of, first the factors that influence health expenditure to achieve positive outcomes.

Health expenditures are affected by many factors such as income, age, technological advancements, health status, lifestyle and institutional factors. Many studies have highlighted income as one of the significant factor that influences health expenditure (Gerdtham & Jönsson, 2000; Ke et al., 2011). This is logical as income of household increases, the ability to spend on health care also increases. It is also likely that the willingness to spend on health also increases with higher income. However, other factors such as age, technological advancements and institutional factors, although significant, have been debated in literature as to their effect (positive or negative) on health expenditure (Elk, Mot, & Franses, 2010). Health behaviour and life style such as tobacco consumption can increase health expenditure (Chrisntiansen, Bech, Lauridsen, & Pascal, 2006; Ke et al., 2011). However, these studies did not indicate significant influences of alcohol consumption. Recent studies have hinted at alternate approaches such as analysing relative price of healthcare to explain health expenditure. Van Elk et al. (2010) argue that growth of health care expenditure in short term is significantly influenced by relative price and in the short term, the growth of it is mainly affected by changes in the relative price and changes in share of public financing.

Many of the indicators such as age and technological advancements have been well established as significant determinants but the variability in their relationship found is of concern. Additional factors must be included to explain the underlying reasons for this variability and better understand the relationship between health expenditure and its determinants. In this regard, socio economic status (SES) attributes have been used in previous research (Kapur et al., 2004) using indicators such as education, income, wealth, health behaviour, marital status, and race to calculate the effect of SES on Medicare expenditure.

### 2.5.1. Healthcare Expenditure in Netherlands

The Netherlands has one of the highest expenditure in health in proportion to its GDP, second to only USA in 2012 (OECD, 2014). The same report informs that most of this expenditure comes from the government or social insurance which was around 86% and is slowly increasing over the years. Table 2 gives a brief overview of the health expenditure in the Netherlands under various dimensions.

Table 2. Health expenditure in the Netherlands, source: (OECD, 2014)

| S.N. | Health Expenditure in Netherlands | 2012 | 2000 |
|---|---|---|---|
| 1 | Health expenditure as a % GDP | 11.8 | 8.0 |
| 2 | Health expenditure per capita (US$ PPP) | 5099 | 2343 |
| 3 | Pharmaceutical expenditure per capita (US$ PPP) | 450 | 274 |
| 4 | Pharmaceutical expenditure (% health expenditure) | 8.8 | 12.3 |
| 5 | Public expenditure on health (% health expenditure) | 85.8 | 66.4 |
| 6 | Out-of-pocket payments for health care (% health expenditure) | 6.0 | 8.0 (2003) |

### 2.6. Methods from similar researches

Different studies analysing health outcomes and what influences them are presented in the table below. Furthermore, some of them look at the health outcomes and the health expenditure. Table 3 looks at the methods they use in order to examine the relationship between the concepts related to socio-economic conditions, health status, and health expenditure.

Table 3. List of different studies and the methods they use to analyse the data

| | Study | Methods used |
|---|---|---|
| 1 | Abel-Smith (1967) | Descriptive statistics across time series data, |
| 2 | Grossman (1972) | Economic Model |
| 3 | Grundy (2001) | Logistic regression |
| 4 | Luginaah et al. (2002) | Principle component analysis, correlation, multivariate spatial statistical analysis |
| 5 | Kapur et al. (2004**)** | Multiple linear regression |
| 6 | Chrisntiansen et al. (2006) | Multiple linear regression |
| 7 | Elk et al. (2010) | Macro model, conditional error–correction model with time series data |
| 8 | Ke et al. (2011) | Static & dynamic panel data models |
| 9 | Rizzo (2012) | 2 stage linear Regression |
| 10 | Strode and Parmar (2015) | Weighted multi-attribute index & GIS |
| 11 | Ferguson, Kemp and Kost (2016) | Network analysis |
| 12 | Heuvel and Olaroiu (2017) | Bivariate correlation, linear regression |

## 2.7. Conceptual framework

This study explores socio-economic circumstances and its association with health status and health expenditure. In order to address this multidimensional relationship and serve as a guideline for the research, conceptual framework is designed (Figure 1).

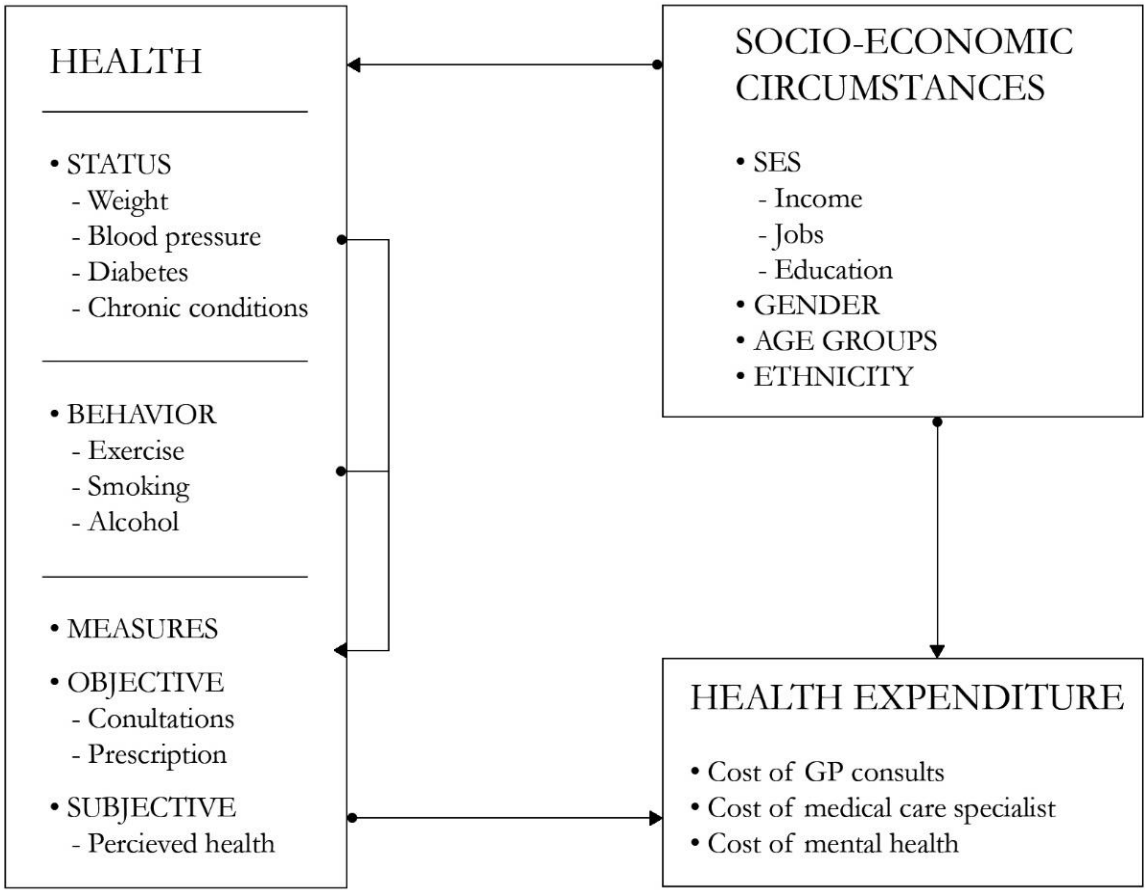


Figure 1. Conceptual framework of the research

# 3. RESEARCH DESIGN

*This chapter gives a description of the research design, methods, and tools needed to answer the specific research questions. It provides with a brief overview of the area for the case study, an introduction the characteristics of it and the health care system, and a justification for selecting this area.*

## 3.1. Twente region

The Twente region is located on the eastern border of The Netherlands, in the Province of Overijssel.
It is an agglomeration of fourteen municipalities, with an area of 143,000 hectares (Figure 2). These municipalities form a joint project to accomplish activities in the fields of: public health, economic activities, recreation and truism (Regio Twente, n.d.).
Twente is home to 626,500 inhabitants, half of whom live in the three biggest cities (Enschede, Almelo and Hengelo) (Peinado et al., 2015). Twente is identified by its own dialect, and also symbols like the flag (with the Twente horse), the anthem and regional products (Sijgers, Hammer, ter Horst, Nieuwenhuis, & van der Sijde, 2005). Apart from that, Twente has a well-known industrial heritage.
After 1955, the region experienced de-industrialization, resulting with a decrease in the textile industry job market. After 1980, the region focused on the emerging knowledge economy.

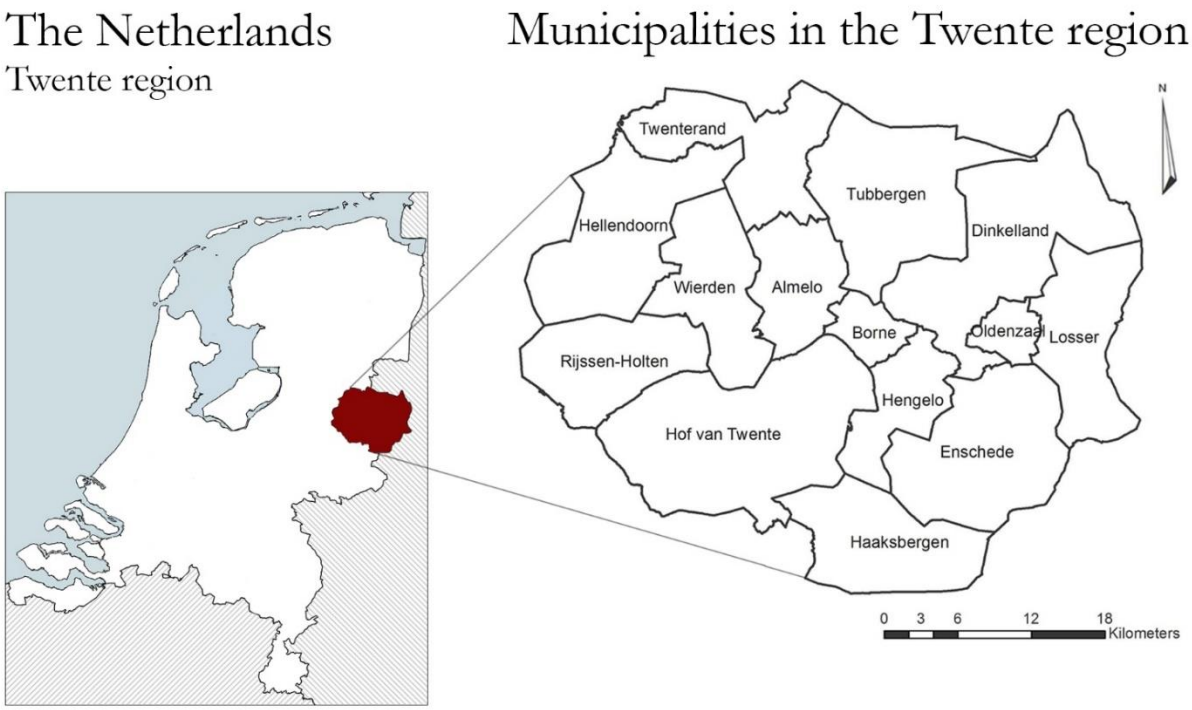


Figure 2. Map of Twente region in the context of Netherlands, and showing the municipalities of Twente.

Today, Twente is still considered to be more industrial (manufacturing) compared to the other regions of the Netherlands. It has been listed in the top five Research and Development hot spots in the country, but still is home to a multiple deprived and excluded urban areas (Garlick, Benneworth, Puukka, & Vaessen, 2006).

To improve the status of life of its inhabitants, the region works constantly to increase sustainable economic development and improve the quality of inhabitants by developing agendas and development strategies (Management Committee Regio Twente, 2008).

In the Dutch health care system, public health services are main providers of preventive care, and the municipalities manage disease prevention, health promotion and health protection. Out of 403 municipalities there are 29 municipal health services (Gemeentelijke Gezondheidsdiensten-GGDs) as shown in Figure 3,performing these services on behalf of each municipality (Peinado et al., 2015). GGDs monitor health risks and try to improve health status. They focus on preventing ill health. GGDs collect the information on health status from general practitioners (Huisarts in Dutch), and report to the Dutch National Institute for Public Health and the Environment RIVM. GGD Twente is located in Enschede, and their mission consist of monitoring and promoting health for Twente region inhabitants.

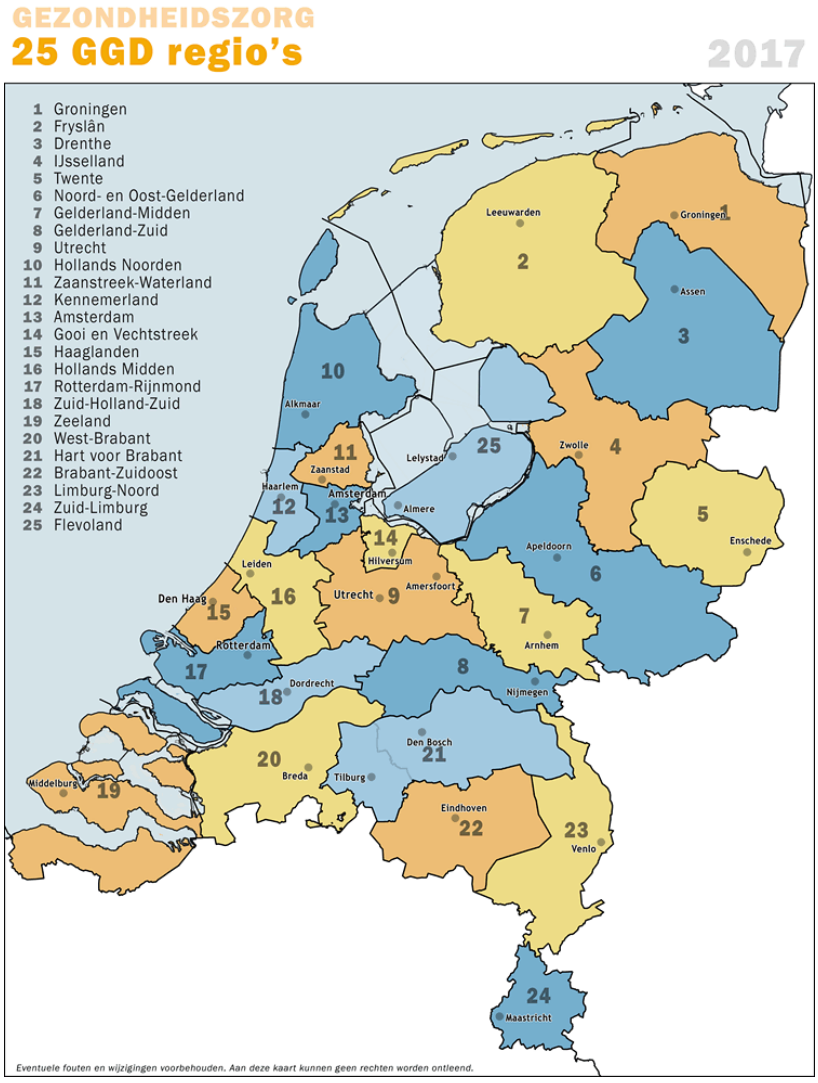

Figure 3. Public Health Regions (GGDs) in the Netherlands

## 3.2. Justification for case study selection

Twente region was chosen as the area for the case study for several reasons.Based on GGD annual report (GGD Twente, 2011), Twente region shows the lowest health status in the Netherlands; however, the region does not list on the areas with lowest socio-economic circumstances. This is contrary to the common belief that low socio-economic circumstances are related to low health status.

On the other hand, the demographic structure of the region is different from the average age in the Netherlands, with 16% of population above 65 in 2010 (GGD Twente, 2011). This group has been linked with worst health outcomes in literature, thus can influence the health outcomes of the region.
This research will try to identify which indicators of socio-economic circumstances are affecting health status and behaviour, and health expenditure.

Next, there is high quality data available for this area, which can be spatially analysed using GIS technology but has not been fully utilised for research. GGD Twente collects data annually, without further analysing the influences of other aspects in health status. At the same time, there is a considerable amount of data available for socio-economic circumstances, health expenditures, and other aspects that might influence health. This data is open source. This research with try to bring together these datasets from different sources and try to define the relationship they have amongst each other.

However, there is a challenge in combining these different datasets because of their different spatial resolutions. Data is either collected in different units or for ethical reasons or aggregated to a higher unit, limiting their integration. This study will focus on bringing them to a common unit of analysis, and explore the possibility of incorporating this data for attaining the research objective.

## 3.3. Research design

The research was designed to find the most appropriate methods to come to the required results essential to answer the research questions. The main goal is to explore the possibility of combining data of different sources, and analysing them together. It aims to explain the influence one factor has on another factor. Specifically, it explores the relationship between socio-economic circumstances and the influence they have on health status and health expenditure.

This research is based on quantitative method to answer the aforementioned research questions. The analysis consists of statistical analysis using SPSS, to explain the influence socio-economic circumstances have on health status, health behaviour and health expenditure. This was done by first bringing the data of different sources to a same unit of analysis. A necessary step was preparing and combining the data into a unified database and modifying them to fit the method used. Multiple linear regression modelling was used to explain the influence of each relation, and answer the research questions.

This analysis was done in two phases. First by analysing the association of socio-economic circumstances and health status and behaviour, and second, the association between socio-economic circumstances and health status on health expenditures. This analysis brought initial results, and made it possible to answer the questions, but additionally a second step of the analysis was initiated.

The second step, was done using ArcGIS, to visualize and interpret the relationships between the concepts. Variables of each concept are mapped and analysed for any indication of spatial correlation.

GIS-based spatial analysis was done to capture the accumulation of problems and visualise spatial variation of health behaviour, health status, health utilization and health expenditure.

The two parts of the analysis integrated together brought a better summary of the results and completed the general objective of the research.

Table 4 provides research design matrix summarizing data, tools, and methods necessary for examining the relation between socio-economic circumstances, health status and health expenditure in Twente region

Table 4. Research design matrix

| Specific objectives | Research questions | Data analysis | Data and tools required | Anticipated results |
|---|---|---|---|---|
| To identify socio-economic indicators that influence health | What are the existing measures of socio-economic circumstances used in the Twente region? | Literature review | Literature<br>CBS Data | List of indicators of SES that can explain health outcomes |
| | Which are the indicators of socio-economic circumstances that can predict health status? | | | Index of SES used in explaining health outcomes |
| To examine the association between socio-economic circumstances with health status and health behaviour | Do socio-economic circumstances influence health status and health behaviour? | Literature review<br>Descriptive statistics<br>Statistical analysis (Regression modelling)<br>GIS spatial analysis | Literature<br>CBS data<br>Nivel-Vaam Data<br>SPSS<br>ArcGIS | Socio-economic indicators that influence health used in the research |
| | Which are the common indicators of socio-economic circumstances that explain health conditions? | | | Regression modelling results explaining the health status by indicators of SES |
| | What is the relationship between health status and health behaviour with health expenditure? | | | Maps of SES indicators and health status and behaviour and the relation between them |
| To explore the influence of socio-economic circumstances, health status, and health behaviour on health expenditure | What is the relationship between health expenditure and socio-economic circumstances? | Literature review<br>Descriptive statistics<br>Statistical analysis (Regression modelling)<br>GIS spatial analysis | Literature<br>CBS Data<br>Vektis Data<br>SPSS<br>ArcGIS | Regression modelling results explaining the health expenditure by indicators of SES |
| | What is the relationship between health status and health behaviour with health expenditure? | | | Maps of SES indicators and health expenditure and the relation between them<br>Maps of health status, health behaviour and health expenditure and the relation between them |

## 3.4. Ethical considerations

Studies regarding health and using health data present ethical issues to be considered both when conduction data and analysing them.

While research involving health data aims to improve health and health conditions of people, it also has to take into consideration possible ethical issues and privacy concerns. One of the main considerations is to make sure that researched subjects are not harmed in any way. Therefore, ethical issues that can be raised when dealing with data about health are covered. Using secondary data for the research means that these data already exist and are collected for another purpose by another research or other institution or individual. The data used in this research has been aggregated to a higher level, and is anonymous and cannot be traced to the source of the information. It is also open source data published by institutes that have considered all the privacy issues, thus does not present any ethical threat.

## 3.5. Data description

This research includes three types of data coming from different sources, all of them open source data. Table 5 below presents a summary of the data, and a more detailed explanation is given in the following sections.

Table 5. Overview of the data

| Data source | Used for | Area of Unit | Year |
|---|---|---|---|
| **CBS Statistics Netherlands** | Socio-economic circumstances | Buurt/Neighbourhood<br>Wijk<br>Gemente/Municipality | 2014 |
| **Nivel-Vaam** | Health status | Postcode 4 | 2014 |
| **Vektis** | Health expenditure | Postcode 3 | 2014 |

### 3.5.1. Socio-economic circumstances data

The first dataset is from CBS Statistics Netherlands, where a set of attributes describe the circumstances of the neighbourhoods(buurt) in the Netherlands. The data is available at buurt, wijk and municipal level, with postcode 4 information in tabular form and with geographic boundaries (shapefiles). Apart from the information CBS gives for the neighbourhoods, they integrate in the dataset the composite index of SES, status score, calculated by The Netherlands Institute for Social Research (SCP). The index is postal code 4 level and reflects the characteristics of the population living there based on their education, income level and employment.

This index is available for 5 different years: 1998, 2002, 2006, 2010 and 2014 and is one of the determinants used in the research to look into the socio-economic circumstances of the neighbourhoods and their influence in health status. In this research, data from 2014 is used for analysis.

Apart from the composite SES index, the research analysed the four indicators that composed SES separately. It looked at the way the index behaves as a composite, and the individual indicators when explaining health status, health behaviour and health expenditure. Furthermore, indicators like *gender, age groups* and *ethnicity* were added to the analysis to explore their influence, and achieve the best understanding of the relation between SES and health.

### 3.5.2. Health Status data

The second dataset is from The Netherlands Institute for Health Services Research (NIVEL). Vraag Aanbod Analyse Monitor Eerste Lijn (VAAM) generates estimated demand for primary care of the Netherlands for NIVEL. The data is available at different levels, including postcode 4 areas. The estimated demand is calculated based on the composition of the population of the area. Using linear regression modelling, data of national level and population characteristics are used to estimate the local demand. Estimates are made at individual level, and then aggregated to postcode 4 for publication.
Data source for estimation is NIVEL care registration, and data from general practitioners(GP) is collected from more than 372 GP practices. Population data is derived from CBS.
The data used in the research is from 2014, and it includes attributes like visits to GP, and other health facilities, which in this research will be used to measure the health use of these areas.

### 3.5.3. Health Expenditure data

The last dataset was obtained from Vektis, a platform that provides information on declared healthcare costs for different types of health care use. The data is derived from all healthcare claims and insurance information for a given year.
The dataset used in the research consists of medical expenses paid by health insurers for 2014, for different cost categories such as specialist medical care, pharmacy, mental health, primary care, dental care (for children), maternity care, etc. These care costs are disaggregated by sex and age, and the data is aggregated to postcode 3 level, to ensure confidentiality.
The challenge of this dataset was bringing it to a comparable unit, so that it can be analysed with other datasets.

## 3.6. Data Preparation

Since data used in the research comes from different sources, each of them was separately prepared and modified to fit the analysis (Figure 4).
The first decision to start the data preparation was determining the common unit of analysing the data. Postcode 4 was defined to be the unit of analysis. This decision was made considering the possibility of bringing all the datasets to this unit.

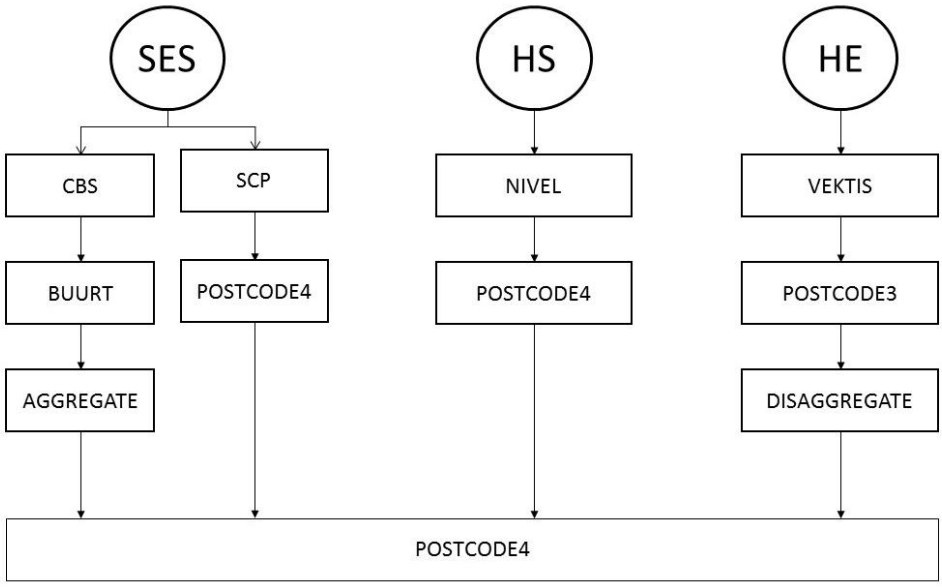


Figure 4. Steps followed in modifying the data to bring to a common unit of analysis

CBS Data from 2014 was downloaded from CBS website, and included an excel sheet with attributes of the social and economic indicators. The data is for the whole Netherlands. Apart from that, spatial attributes are available on shapefiles.
ArcGIS was used to visualize the data, and prepare them for further analysis, using different tools.
First step was cleaning the data and having only the indicators of socio-economic circumstances used in the research (Table 6). After that, the data was clipped using Twente region border and the table contained data for the 14 municipalities of the region after that.

Table 6. Indicators from CBS used for analysis and their explanation

| **Attribute** | **Definition** |
|---|---|
| *GM_NAAM* | Municipality name |
| *POSTCODE* | Postcode 4 |
| *AANT_INW* | Population number |
| *AANT_MAN* | Population number of men |
| *AANT_VROUW* | Population number of women |
| *P_00_14_JR* | Population 0-14 years old (%) |
| *P_15_24_JR* | Population 15-24 years old (%) |
| *P_25_44_JR* | Population 24-44 years old (%) |
| *P_45_64_JR* | Population 45-64 years old (%) |
| *P_65_EO_JR* | Population 65 years and older (%) |
| *INK_ONTV* | Average income per income receiver[x1000] |
| *P_WEST_AL* | South-western[1] (%) |
| *P_N_W_AL* | Non-Western[1] (%) |
| *P_MAROKKO* | Morocco[1] (%) |
| *P_ANT_ARU* | Netherlands Antilles and Aruba[1] (%) |
| *P_SURINAM* | Suriname[1] (%) |
| *P_TURKIJE* | Turkey[1] (%) |
| *P_OVER_NW* | Other non-Western[1] (%) |
| *NON_DUTCH* | Non-Dutch (%) |
| *P_LAAGINKP* | Individuals with low income (%) |
| *P_ACTIEF* | Individuals that are active- working (%) |
| *STATUSSCORES* | Index accumulated by education, income, and jobs (%) |
| *EDU_LOW* | Low level of education: primary and secondary schools in the first phase[2] (%) |
| *EDU_MEDUIM* | Secondary education: secondary education of the second phase[3] (%) |
| *EDU_HIGH* | High education: tertiary education[4] (%) |

[1] Appendix 3
[2] The first phase of secondary education includes vocational school junior general secondary education (up to grade 3) and MBO-1 programs
[3] To the second stage of secondary education include mbo2-, mbo3- and MBO 4 courses and upper general secondary education.
[4] To tertiary education among the college and university courses.

The shapefiles consist of three units, Buurt, Wijk and Gemente. The smallest unit is Buurt, and is smaller than Postcode 4. Therefore, this dataset needed to be aggregated to be compatible for analysis.
The aggregation was done using ArchGIS, where Postcode 4 was summarized and each indicator was either summed or averaged based on the relevant method.
These attributes then were converted to excel file to be combined with other datasets.
Next, the SES composite for the region of Twente was added to this dataset. The index includes values from -4.82 the lowest, to 2.09 the highest.

NIVEL-VAAM data of 2014 was downloaded from the NIVEL website, and included excel files with attributes of health for each municipality in postcode 4. These files were combined in one for the whole region, and the data was added to the file with CBS data, using Postcode attribute as common variable. Table 7 presents the attributes used in the research.

Table 7. Indicators from VEKTIS used for analysis and their explanation.

| **Attribute** | **Definition** |
|---|---|
| *CONSULTATIONS* | Consultation per inhabitant |
| *PRESCRIPTIONS* | Total number of prescriptions in general practice |
| *MODERATE_POOR_PERCEIVED_HEALTH* | Estimated percentage of people with moderate / poor perceived health |
| *AT_LEAST_2CHRONIC_ CONDITION* | Percentage of the population (20-64 years) with at least two self-reported chronic conditions |
| *DIABETES* | Percentage of the population (20-64 years) with self-reported diabetes |
| *ASTHMA_BRONC_EMPHYSE_ COPD_COPD* | Percentage of the population (20-64 years) with self-reported COPD |
| *OVERWEIGHT* | Percentage of the population (20-64 years) that are overweight |
| *OBESE* | Percentage of the population (20-64 years) that are obese |
| *HIGH_BLOODPRESSURE* | Percentage of the population (20-64 years) who have high blood pressure |
| *DOES_NOT_MEET_STANDARD_MOVE* | Percentage of the population (20-64 years) that does not meet the standard move |
| *SMOKING* | Percentage of the population (20-64 years) that smoke |
| *EXCESSIVE_USE_ALCOHOL* | Percentage of the population (20-64 years) that drink alcohol excessively |

Vektis data was downloaded from Vektis website, and consisted of an excel document with data on the costs of health for one year for the whole Netherlands. Data has municipal level and postcode 3 information and they are disaggregated in gender and age groups. They include data for both male and female in 19 age groups *(0-4, 5-9, 10-14, 15-19, 20-14, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, 85- 89, and 90+).* The first step involved the selection of expenditure items

to be analysed with other aspects and a selection of the indicators was made as shown in Table 8. The data was then disaggregated from municipal level to postcode 4. This was first done by categorizing the age groups into 5 sets from the CBS list. This is because population numbers for each age group were available on postcode level in the CBS data. Secondly, disaggregation was done by allocating costs based on population data.
The proportion of costs allocated to the postcodes was based on the proportion of each age group on the postcode level compared to the total population number per age group in municipal level.
For example:
Postcode 7621 in Borne has 1171 inhabitants of age group 0-14 and 4311 is the total number of inhabitants of that age group in the municipality. This age group spends 77765.5 euro on GP consultations per year on the municipal level.
To allocate the money age group 0-14 of postcode 7621 spends per GP consultations, these steps were followed:

$1171/4311 = 0.271 \rightarrow$ proportion of age group of postcode 4 compared to municipal level

$0.271*77765.5=21074.45 \rightarrow$ cost of GP consultations of age group 0-14 in Borne.

Later costs of all age groups were added to obtain information of GP consultation costs per postcode 4.
This procedure was done for all the indicators needed for the analysis and the data is added to the CBS data using Postcode 4 attribute as a common variable.

Table 8. Indicators from CBS used for analysis and their explanation

| **Attribute** | **Definition** |
|---|---|
| *KOSTEN_HUISARTS_CONSULT* | Cost of GP consults |
| *KOSTEN_GENERALISTISCHE_BASIS_GGZ* | Base cost of general mental health |
| *KOSTEN_TWEEDELIJNS_GGZ* | Cost of secondary mental health |
| *KOSTEN_MEDISCH_SPECIALISTISCHE_ZORG* | Cost of medical care specialist |

Last step in preparing the data indicated making them same type of data and ready for the method used to analyse. Two different data types were in the dataset. Absolute values, which included indicators like population number and money values, and relative values, which included percentages of different indicators from CBS and Vaam data. These data were converted into absolute values, either percentages using total population number, or values per inhabitant.
Apart from that, indicators like status score from SCP were continuous values. To turn them into SES classes Z-scores (standard deviation scores) are calculated, classifying by the probability of one postcode to occur within the normal distribution.
This is done by standardizing the values, and then categorizing them into five classes by equal break.
The standardization is done as follows:
(value – mean) / standard deviation

Additionally, dummy variables for each SES class are created to allow to but the variable in the regression model. These dummy variables are created with the assumption that if a neighbourhood fits in a particular class, then it gets 1, otherwise 0.

### 3.7. Data analysis

The analysis of the data for the research was done with the aim to answer the research questions, meanwhile exploring the relations and causalities. The hypothesis of the research coming from literature are considered as an initial idea to guide the focus of the analysis. The general approach of exploring the relations and influences was taken, moving to details, and focusing on the results that better explain them.
On the first part of the analysis SPSS was used to do the statistical analysis. After that, ArcGIS was used to visualise and interpret the relations spatially. A better overview of the results was gained when these two methods are combined and the whole picture is presented. The diagram in Figure 5 presents the steps taken to come to the results.

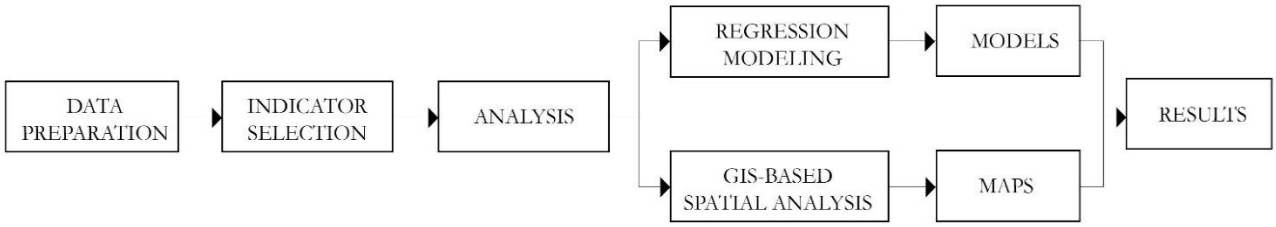


Figure 5. Diagram of the methodology of the research

#### 3.7.1. Statistical analysis

First, descriptive statistics were conducted to describe the basic features of the data. The calculations were done for all indicators to be used in the analysis by looking at min, max, mean, and standard deviation of each indicator. These tables are presented in Appendix 1.
After that, the variation for each variable was checked from the three concepts:

- *Socio economic circumstances*
- *Health status, and*
- *Health expenditure.*

This was done using variance inflation factor (VIF) tests. VIF tests were looked at to see whether there is a high linear relationship between predictors. Values between 0.2 (Menard, 1995) and 10 (Myers, 1990) were considered as not multicollinear. Furthermore, cross tables were produced to explore the data and see the relations between different variables.

To test the complete model and try to answer the research questions, multiple linear regression modelling was used. Following the conceptual framework (see Figure 1, p.17) each relation was examined.
This was done in two phases. In the first phase, the relationship between socio-economic circumstances and health status and health behaviour was analysed. Each of the health status and health behaviour

indicators (Table 7) was analysed separately and explained by socio-economic circumstances indicators (Table 6). Health status and health behaviour indicators were set as dependent variables one by one, while *status score index, age groups, gender and ethnicity* were set as independent variables. The models were run by adding all independent variables by forced entry, and then manually eliminating one by one the variable that is not statistically significant. This process was repeated until all the independent variables were statistically significant ($p<.001$) (Field, 2009). For the final model, the $R^2$ and Adjusted $R^2$ were reported to look at the proportion of variance accounted by the model. Also, residual plots were checked to look the normal distribution and heteroscedasticity (Field, 2009).

This entire procedure was repeated, but this time instead on putting social score index in the independent variables list, the indicator that composed it were used. So, the new list of independent variables consists of *income, jobs, education, age groups, gender, and ethnicity.*

In the second phase, the relationship of socio-economic circumstances, health status and health behaviour with health expenditure was analysed. The same method as in the first step was conducted, leading to the last relationship to be examined on the framework.

### 3.7.2. GIS -based spatial analysis

The spatial analysis to examine the relationship between indicators of socio-economic circumstances, health status, health behaviour and health expenditure was done using ESRI ArcGIS 10.4.1. The shapefiles obtained from the CBS were visualized, and out of all municipalities of the Netherlands, Twente region divided, using clip command. This data is at buurt level, so first the polygons are merged based on their postcode attribute by dissolve command. Then the excel dataset is added to the attribute table.

All indicators considered in the research are visualized separately. Values are categorized in five classes, using normal breaks and gradient colours are used to present them. In indicators like SES and high education, the gradient colours are flipped, in order to describe areas of low SES and less educated people with darker colour. This was done to allow easier identification of areas with low SES and b able to intuitively draw conclusions from the maps.

# 4. RESULTS

*This chapter gives an overview of results obtained through the analysis. First, the association of socio-economic circumstances with health status and heath behaviour are presented. Next, the association of health status and health behaviour with measures of health use. Finally, association of socio-economic circumstances, health status and health behaviour with health expenditure.*

## 4.1. Association of Socio-economic circumstances with Health status and health behaviour

The association of SES with health status and health behaviour was examined in two ways. First, by conduction multiple linear regression using SPSS, and second, by spatial visualization using ArcGIS.

As previously explained in methodology (Chapter 3), the statistical analysis implied of analysing the relation between SES indicators and health status and health behaviour indicators, by following the framework presented in the Chapter 2. The analysis consisted modelling each relation twice; first by looking at SES as a composite variable, further referred as first model, and second, by incorporating its individual indicators, further referred as second model. Both models are reported for all the cases, but depending on the outcomes, one or the other model is highlighted and discussed. A complete list of SES indicators is given previously in methodology, while the tables contain only the indicators that were statistically significant in explaining the variation for one of health status indicators. To evaluate the significance of the independent variables in the model, *p values* are checked, and all the reported variables have $p<0.001$.
These indicators are also visualized in maps in Figure 6 to 8. from where we can see the spatial association between socio-economic circumstances with health status and health behaviour.
GIS- based spatial analysis consisted of visualizing indicators of SES, health status, and health behaviour, and analysing the relationship between them by looking at the spatial variation of each indicator.
Sections below present results obtained from these visualizations.
Results for both, the statistical analysis and the spatial visualization will be discussed further in the next Chapter.

### 4.1.1. SES influence on health status

To explain the association SES has on health status, six variables were chosen to be analysed: *overweight, obese, high blood pressure, diabetes, asthma/bronchitis/emphysema/COPD, and at least two chronic diseases.*
Tables below show the results of linear regression modelling for each variable. Table 9 shows the results of the first models, where SES is put in the models as a composite index, while Table 10 shows the results when the models use individual indicators of SES.

Out of six variables modelled, for four of them the value of explaining the variation of the outcome is higher when modelled with individual indicators of SES. This means that using the independent variables of SES has explained a larger amount of the variation in the outcome in most of the models.
Nevertheless, even though the first models give lower predictive values ($R^2$), the power of the independent variables explaining the dependent one is higher. Thus, these models can be stronger in identifying a specific problem or area to intervene.
From the first model in Table 9 we see SES low consistently scoring high in explaining health status conditions like overweight, obese, diabetes, and at least one chronic condition. This relation can be further analysed by spatially analysing the areas with low SES and the conditions. In Figure 6 and 7 we see that postcodes with low SES are in the centre on Almelo and south of Enschede. These postcodes also score with the highest percentage of people with all six of the health status variables. Also, there is statistical and

spatial correlation between postcodes that have medium-low and medium SES with the HS indicators analysed. These areas are postcodes in different municipalities (Figure 6 and 7), but an accumulation can be noticed in Almelo, Hengelo, and Enschede.

When looking at the individual indicators of SES, high education is the one that is present in explain most of the health status variables, by inversely correlating with them. That indicates that the higher the percentage of highly educated people in one postcode, the lower the percentage of people with health conditions. Individuals with low income are also one of the variables that affect the HS variables and is positively correlated with them. Figure 7 shows that similarly with other variables, the postcodes from Almelo and Enschede that have the highest values in all HS variables are also high in percentage of people with low income.

Table 9. Linear regression modelling for health status determinants using SES as a composite index

| | Overweight | Obese | High Blood pressure | Diabetes | Asthma, bronchitis, emphysema, COPD | At least two chronic conditions |
|---|---|---|---|---|---|---|
| R Square | **0.666** | **0.750** | **0.815** | **0.888** | **0.773** | **0.926** |
| Adjusted R Square | **0.644** | **0.740** | **0.800** | **0.879** | **0.761** | **0.914** |
| | **B** | **B** | **B** | **B** | **B** | **B** |
| constant | 55.1619 | 11.9365 | 21.0436 | 5.8132 | 4.9910 | 33.9737 |
| SES_LOW | 15.1413 | 15.0635 | | 3.6722 | | 12.0118 |
| SES_MLOW | 8.2076 | 7.0635 | | | | 4.6760 |
| SES_MEDIUM | 2.8110 | 1.8235 | | | | 3.6155 |
| SES_HIGH | -2.5053 | -1.7600 | | | | -3.6446 |
| P_00_14_JR | 0.3233 | | | -0.1479 | | |
| P_15_24_JR | -0.4224 | | | | | |
| P_25_44_JR | -0.3260 | | -0.3942 | | | -0.3982 |
| P_65_EO_JR | | | | | 0.0995 | |
| Non-Western total | | | 0.3607 | | | |
| Turkey | | | | 0.1585 | 0.3099 | 0.5184 |

Table 10. Linear regression modelling for health status determinants using individual indicators of SES

| | Overweight | Obese | High Blood pressure | Diabetes | Asthma, bronchitis, emphysema, COPD | At least two chronic conditions |
|---|---|---|---|---|---|---|
| R Square | **0.902** | **0.859** | **0.842** | **0.843** | **0.903** | **0.892** |
| Adjusted R Square | **0.895** | **0.854** | **0.824** | **0.829** | **0.894** | **0.875** |
| | **B** | **B** | **B** | **B** | **B** | **B** |
| constant | 27.5233 | 17.7348 | 21.8789 | -4.4209 | -26.2750 | 28.5197 |
| Individuals with low income | | | | 0.1463 | 0.2187 | 0.2792 |
| Edu_high | -0.4289 | -0.2195 | -0.1543 | | | -0.2937 |
| Population women | | | | | 0.4894 | |
| P_00_14_JR | 0.4648 | | | | | |
| P_25_44_JR | | -0.1590 | -0.3502 | | | |
| P_45_64_JR | 0.4077 | | | | | |
| P_65_EO_JR | 0.3418 | | | 0.0816 | | 0.2623 |
| Western total | | | 0.2220 | | | |
| Non-Western total | 0.3049 | 0.3257 | | | | |
| Turkey | | | 0.2245 | 0.1495 | 0.1146 | |

This phenomenon is also observed when looking at the non-Dutch inhabitants in postcodes. Highest percentages with non-Dutch inhabitants are clustered in Almelo, Hengelo, and Enschede, including the two before mentioned postcodes. When analysed which specific ethnic group is significant in influencing health status variables, Table 9 and 10, shows Non-Western and Turkish to be explaining the variables. In the spatial analysis, these groups also result to accumulate in the three cities where the other variables do as well; Almelo, Hengelo, and Enschede.

Age groups is also one of the indicators that is significant to explaining the HS indicators, but it's more specific to different conditions. For overweight people, three age groups 0-14, 45-46, and 65 and older seem to be the influencing factors for the outcome. The higher the percentage of inhabitants within these age groups, the higher the percentage of overweight people. Additionally, age group 65 and more seems to be influencing the outcome of people with two or more chronic conditions.

For spatial visualization of specific age groups and ethnic groups, refer Appendix 3.

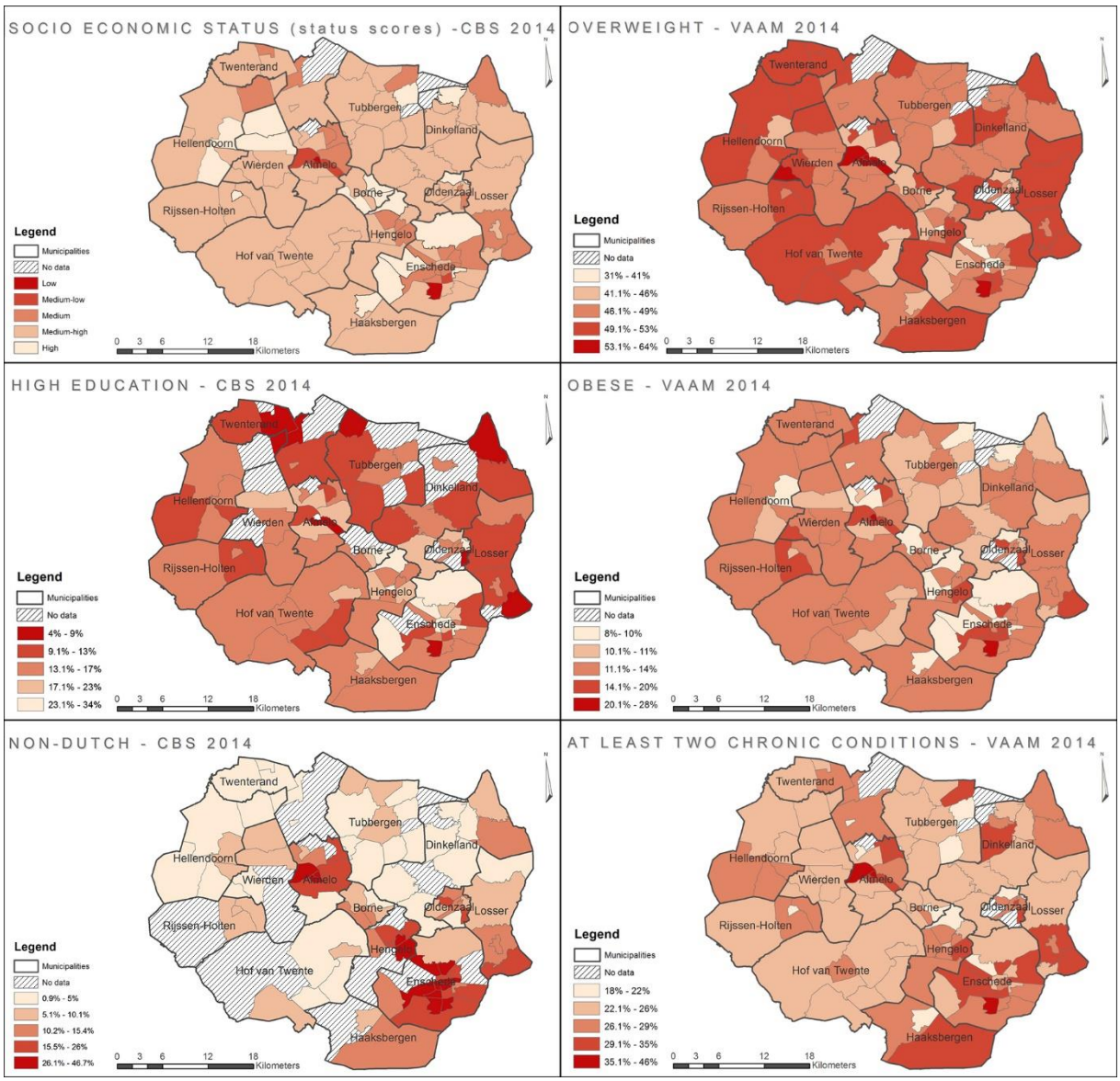


Figure 6. Spatial visualization of HS indicators and SES indicators that have an influence on them

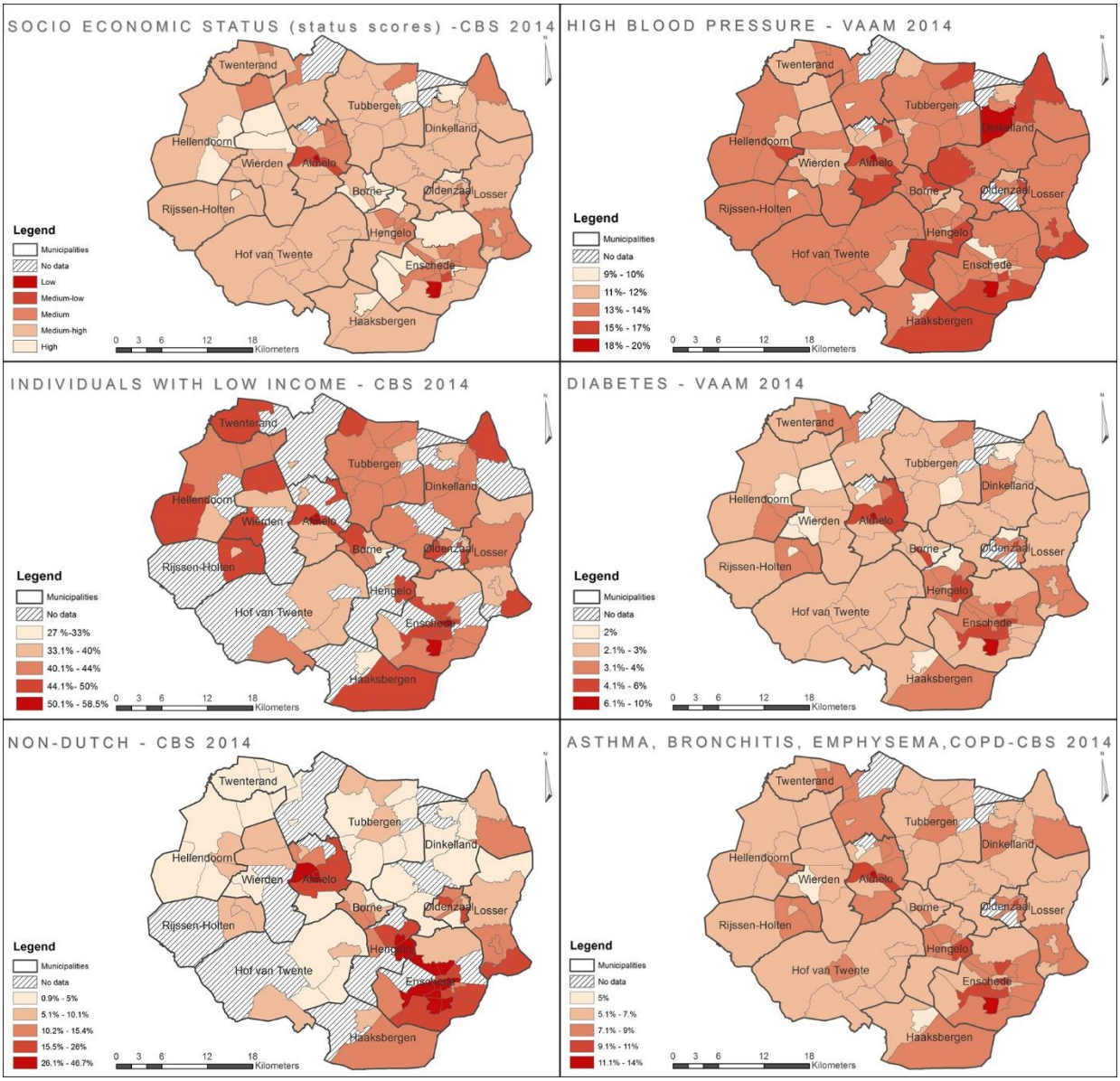


Figure 7. Spatial visualization of HS indicators and SES indicators that have an influence on them

### 4.1.2. SES influence on health behaviour

For analysing the influence of socio-economic conditions on health behaviour, three variables are chosen to analyse: *exercising, smoking, and use of alcohol.* In the three cases, the analysis has shown that using SES by including its individual indicators gives higher values of $R^2$ and Adjusted $R^2$. Nevertheless, even though the first models have lower explanatory values ($R^2$), the power of the independent variables explaining the dependent one is higher. Thus, this models can be stronger in identifying a specific problem or area to intervene. Tables below show the results of linear regression modelling for each variable. Table 11 shows the results of the first models, where SES is put in the models as a composite index, while Table 12 shows the results when the models use individual indicators of SES.

These indicators are also visualized in maps in Figure 8 from where we can see the spatial association between SES and health behaviour.

Table 11. Linear regression modelling for health behaviour determinants using SES as a composite index

| | Does not meet standard move | Smoking | Excessive use of alcohol |
|---|---|---|---|
| R Square | **0.214** | **0.934** | **0.702** |
| Adjusted R Square | **0.206** | **0.925** | **0.689** |
| | **B** | **B** | **B** |
| constant | 53.4304 | 35.3520 | 115.4750 |
| SES_LOW | | 12.0111 | |
| SES_MLOW | | 6.5588 | |
| SES_MEDIUM | | 3.5738 | |
| Population women | | | -1.3288 |
| P_15_24_JR | | | -0.4213 |
| P_45_64_JR | -0.4508 | | |
| Non-Western total | | | -0.2980 |
| Turkey | | 0.4023 | |

Table 12. Linear regression modelling for health behaviour determinants using individual indicators of SES

| | Does not meet standard move | Smoking | Excessive use of alcohol |
|---|---|---|---|
| R Square | **0.299** | **0.943** | **0.717** |
| Adjusted R Square | **0.285** | **0.937** | **0.702** |
| | **B** | **B** | **B** |
| constant | 61.9757 | -1.3599 | 78.0977 |
| Individuals with low income | | 0.8994 | |
| Active | | | 0.4645 |
| Population women | | | -1.4047 |
| P_15_24_JR | | -0.5047 | |
| P_45_64_JR | -0.3966 | | |
| P_65_EO_JR | | | 0.3382 |

When analysing health behaviour indicators, we can notice that they are influenced by different indicators of SES. For *smoking,* lower socio economic status is the indicator with the highest power of explaining the variable. Looking at which specific indicator of the composite index, we see that individuals with low income are explaining this relation, together with Turkish ethnic group. This can be seen in Figure 8, where postcodes that have the highest percentage of people smoking, also are on the lowest SES class and largest percentage of non-Dutch people. In the Appendix 3 we can see these postcodes have high percentage of Turkish people.

*Excessive use of alcohol* is influenced by the people working/active and older than 65 years old. On the other hand, it is negatively correlated with women, indicating that the higher the percentage of women in a postcode, leads to less people that use alcohol excessively. From the first model, we see that it is also negatively correlated with non-western ethnic group, which can also be observed when looking at the Figure 10. where we see a spatial correlation of postcodes with lowest percentage of excessive use of alcohol corresponding with the highest percentage of non-Dutch people. Also, a spatial correlation is seen with people who are working/active, where postcodes with highest percentages of people working, have the highest percentage of people using alcohol excessively.

Differently from these two behaviour variables, for *exercising-does not meet standard move*, lower scores of explaining its variation are achieved. The model shows influence only from age group 45-64, which is in an inverse correlation with the dependant, implying that the more people of this age group in a postcode, the less the percentage of people that don't meet the standard move.

For spatial visualization of specific age groups and ethnic groups, refer Appendix 3.

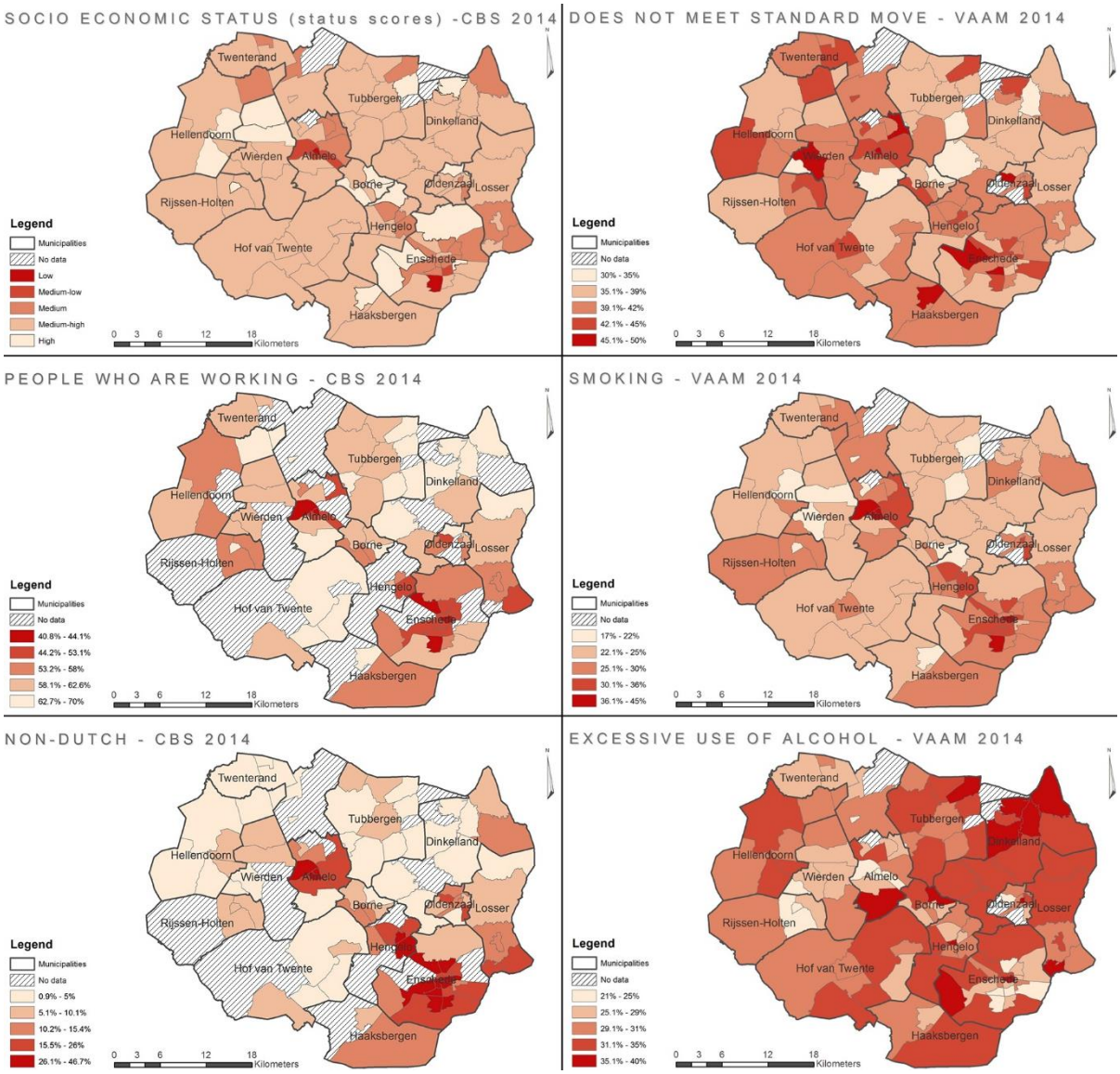


Figure 8. Spatial visualization of health behaviour indicators and SES indicators that have an influence on them

### 4.1.3. SES influence on objective and subjective measures of health

To analyse how different group of socio economic circumstances influences health utility three measures were chosen to be modelled. Two of them are objective: *consultations per inhabitant, and number of prescriptions per inhabitant*, while one is subjective: *moderate/poor perceived health.*

Tables below show the results of linear regression modelling for each variable. Table 13 shows the results of the first models, where SES is put in the models as a composite index, while Table 14 shows the results when the models use individual indicators of SES.

These indicators are also visualized in maps in Figure 9 from where we can see the spatial correlation.

When analysing measures of health, we can notice that they are influenced by different indicators of SES. From objective measures, *consultations per inhabitant* is explained by age group 65 and older, indicating that the more people of this age group in a postcode, the more the number of consultations. This can also be observed in Figure 9. where postcodes that have the highest percentage of population with 65+ years correlate with postcodes with higher consultations.

*Number of prescription* is inversely correlated with the indicators showing the percentage of women in a postcode. It has a high power of explaining the outcome. Age group 65 and older is one of the indicators affecting in higher number of prescriptions, while the second model shows that people that work and people with low education tend to also get more prescriptions. In Figure 9 we can see that postcodes with higher number of prescriptions correlate with postcodes with larger percentages of low educated people.

*Moderate/ poor perceived health* is the variable with high predictive value from the model, explaining 95% of the variation from SES indicators. It is influenced by lower SES classes, which can also be seen in Figure 9, where postcodes that score low in SES also perceive health as moderate or poor. These postcodes as previously mentioned are in Almelo, Hengelo, and Enschede. When looking at individual indicators, people that have high education seem to be the ones that don't perceive health as moderate or poor, while the opposite is for ages 65 and more, and Turkish and other non-Western ethnic groups.

For spatial visualization of specific gender, age groups, and ethnic groups, refer Appendix 3.

Table 13. Linear regression modelling for health status measures using SES as a composite index

| | **Consultations** | **Number of prescriptions** | **Moderate/poor perceived health** |
|---|---|---|---|
| R Square | **0.678** | **0.346** | **0.955** |
| Adjusted R Square | **0.675** | **0.334** | **0.947** |
| | **B** | **B** | **B** |
| constant | 291.807 | 1385.749 | 18.702 |
| SES_LOW | | | 13.119 |
| SES_MLOW | | | 4.882 |
| SES_MEDIUM | | | 2.852 |
| Population women | | -28.642 | |
| P_00_14_JR | | | -0.326 |
| P_15_24_JR | | | -0.209 |
| P_65_EO_JR | 8.906 | 4.291 | |
| Turkey | | | 0.363 |

Table 14. Linear regression modelling for health status measures using individual indicators of SES

| | **Consultations** | **Number of prescriptions** | **Moderate/poor perceived health** |
|---|---|---|---|
| R Square | **0.678** | **0.484** | **0.921** |
| Adjusted R Square | **0.675** | **0.456** | **0.912** |
| | **B** | **B** | **B** |
| constant | 291.807 | 945.036 | 8.123 |
| Active | | 3.111 | |
| Edu_low | | 2.596 | |
| Edu_high | | | -0.204 |
| Population women | | -26.429 | |
| P_65_EO_JR | 8.906 | 5.610 | 0.267 |
| Turkey | | | 0.384 |
| Other non-Western | | | 0.631 |

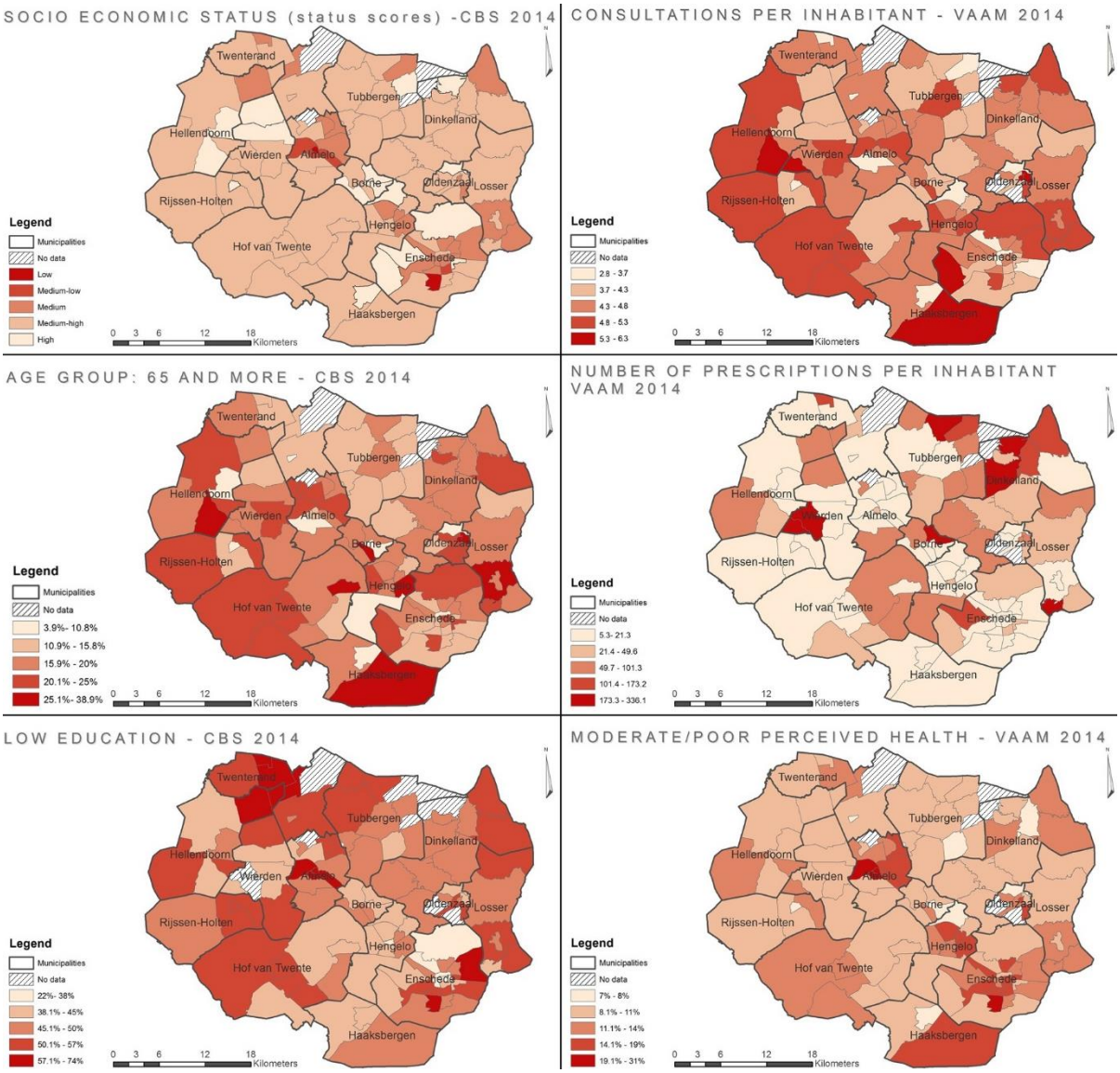

Figure 9. Spatial visualization of health status measures and SES indicators

## 4.2. Association of health status and health behaviour with measures of health use

The association between the determinants of health status and health behaviour and how they use health care was examined in two ways. First, by conduction multiple linear regression using SPSS, and second, by spatial visualization using ArcGIS. The relation was examined by looking how different health conditions and health behaviour can explain the use of health care.

Objective and subjective measures of health were the dependent variables for the models, and health conditions and behaviours are the independent variables explaining the variation in the outcome. As afore mentioned, the analysis consisted modelling each relation twice; first by looking at SES as a composite variable, further referred as first model, and second, by incorporating its individual indicators, further referred as second model.

A complete list of indicators used in the modelling is given previously in methodology, while the tables contain only the indicators that were statistically significant in explaining the variation for one of health measure indicators. To evaluate the significance of the independent variables in the model, *p values* are checked, and all the reported variables have $p<0.001$.

These indicators are also visualized in maps in Figure 10 from where we can see the spatial association between health status and health behaviour with health measures.
GIS- based spatial analysis consisted of visualizing indicators of HS, and analysing the relationship between them by looking at the spatial variation of each indicator.
Sections below present results obtained from these visualizations.
Results for both, the statistical analysis and the spatial visualization will be discussed further in the next Chapter.

#### 4.2.1. Objective and subjective measures

To examine the association between the determinants of health status and health behaviour and how they use health care two objective measures: *consultations per inhabitant, and number of prescriptions per inhabitant* and one subjective measures: *moderate/poor perceived health* are modelled. The table below show the results of linear regression modelling for each variable.

From Table 15 we see that overweight is the variable present in explaining the three of the dependents. It is positively correlated, leading to increase in *consultation* and *prescription number* as well as in percentages of people that *perceive health as moderate or poor.* This relation is partially present in spatial correlation too, with bigger emphasis on overweight- perceived health.
The other variable that explains both consultations and number of prescriptions is the variable describing respiratory conditions asthma, bronchitis, emphysema, COPD. Surprisingly, the variable is positively correlated to consultation, while negatively to number of prescriptions. This can be observed also spatially, where in Figure 10 we can see that there is a negative correlation in postcodes that have a bigger number of consultations with the number of prescriptions.
The other common variable that influenced the consultations and number of prescription is excessive use of alcohol, which is positively related to both, leading to increase in number of both consultations and prescriptions.
On the other hand, moderate/poor perceived health results to be influenced by percentages of people that smoke and in a smaller value by those that don't meet standard move.
For spatial visualization of at least two chronic condition, smoking, and does not meet standard move, refer Figure 10.

Table 15. Linear regression modelling for health status measures and health status and behaviour indicators

| | Consultations | Number of prescriptions | Moderate/poor perceived health |
|---|---|---|---|
| R Square | **0.342** | **0.410** | **0.964** |
| Adjusted R Square | **0.324** | **0.394** | **0.962** |
| | **B** | **B** | **B** |
| constant | -144.665 | -330.068 | -18.606 |
| Overweight | 5.305 | 20.497 | 0.1456 |
| At least two chronic conditions | | | 0.2263 |
| Asthma, bronchitis, emphysema, COPD | 14.269 | -33.565 | |
| Does not meet standard move | | | 0.0842 |
| Smoking | | | 0.5324 |
| Excessive use of alcohol | 7.477 | 12.225 | |

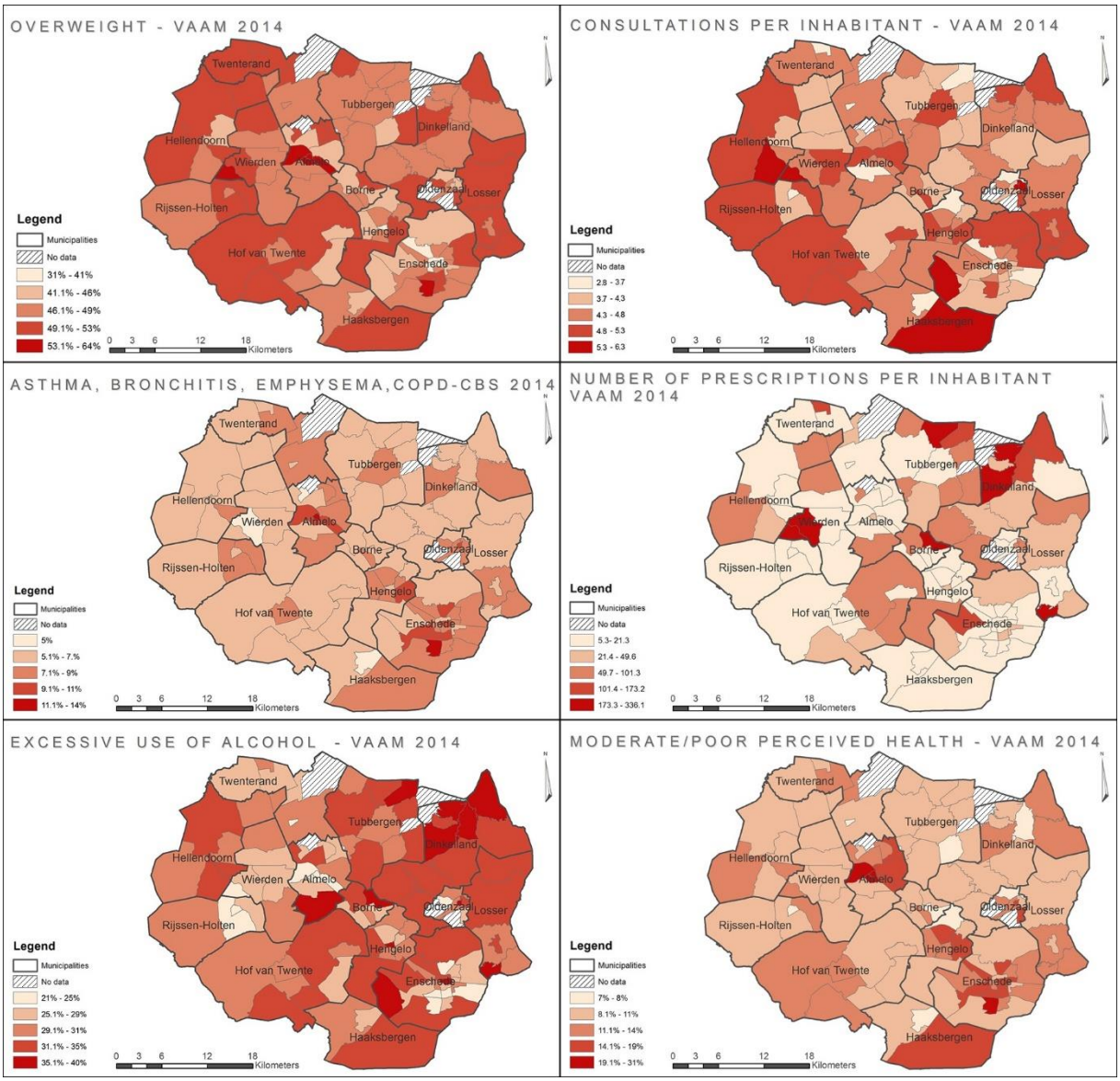


Figure 10. Spatial visualization of health status measures and health status and behaviour indicators

## 4.3. Association of SES, health status and health behaviour with Health expenditure

The association of SES and HS with HE was examined in two ways. First, by conduction multiple linear regression using SPSS, and second, by spatial visualization using ArcGIS.

As previously explained in methodology, the statistical analysis implied of analysing the relation between SES indicators and HS indicators with HE indicators, by following the framework presented in the Chapter 2. The analysis between SES and HE consisted modelling each relation twice; first by looking at SES as a composite variable, further referred as first model, and second, by incorporating its individual indicators, further referred as second model. Both models are reported for all the cases, but depending on the outcomes, one or the other model is highlighted and discussed. The analysis between HS and HE consisted on first, analysing the health status and health behaviour indicators and their influence on HE, and second, the health measure indicators and HE.
A complete list of SES and HS indicators is given previously in methodology, while the tables contain only the indicators that were statistically significant in explaining the variation for one of HE indicators. To evaluate the significance of the independent variables in the model, *p values* are checked, and all the reported variables have $p<0.001$.
These indicators are also visualized in maps in Figure 11 and 12 from where we can see the spatial association between socio-economic circumstances, health status and health expenditures.
GIS- based spatial analysis consisted of visualizing indicators of SES, HS and HE, and analysing the relationship between them by looking at the spatial variation of each indicator.
Sections below present results obtained from these visualizations.
Results for both, the statistical analysis and the spatial visualization will be discussed further in the next Chapter.

### 4.3.1. SES influence on HE

To explain the influence SES has on health expenditure, three variables were chosen to be analysed: *cost of GP consultation, cost of medical care specialist, and cost of mental health.*
The table below show the results of linear regression modelling for each variable. Since the modelling of using SES as a composite index resulted in none of the SES classes as significant to explain any of the outcome, only the second model is reported in this section. The table with first model can be seen in Appendix 4. Table 16 shows the results when the models use individual indicators of SES.
When analysing health expenditure indicators, we can notice that different indicators influence them.
The *cost of GP consultation* is explained by the people working, being in an inverse correlation. This indicating that the postcodes with more people working have lowers costs of consults per inhabitant. This can be spatially seen in Almelo and Enschede, where majority of postcodes have higher cost of consultations, while lower percentages of people that are working.
For *cost of medical care specialist*, the three variables that are significant in explaining the outcome are age group 65 and older, and two ethnic groups non-western and Turkish. The age group 65+ and non-westerns influence it by positively correlating, while Turkish group is negatively correlated, with the highest power in explaining the outcome. As seen in Figure11 the spatial correlation between non-Dutch and cost of medical care specialist is not clear, considering also the missing data for ethnic groups in some of the postcodes with higher values of medical care costs.
Cost of mental health care is the variable that is influenced by individual indicators of SES, specifically, average income per income receiver, and with a higher power of explanation tin, individuals with low income. High explanatory power also have the group age 65 and older and the southwestern. These relations can be spatially seen in Figure 11 where cities that have the highest cost of mental health are Almelo, Hengelo and Enschede, who also score high in percentage of people with low income, and non-Dutch inhabitants.

Table 16. Linear regression modelling for health expenditure indicators using individual indicators of SES

| | Cost of GP consultation | Cost of medical care specialist | Cost of mental health |
|---|---|---|---|
| R Square | 0.336 | 0.776 | 0.716 |
| Adjusted R Square | 0.328 | 0.751 | 0.701 |
| | B | B | B |
| constant | 56.7900 | 864.5320 | -811.2310 |
| Average income per income receiver | | | 0.0140 |
| Individuals with low income | | | 9.1950 |
| Active | -0.3720 | | |
| P_25_44_JR | | | 7.2520 |
| P_65_EO_JR | | 22.3260 | |
| Southwestern total | | | 5.8680 |
| Non-Western total | | 72.1290 | |
| Turkey | | -75.3900 | |

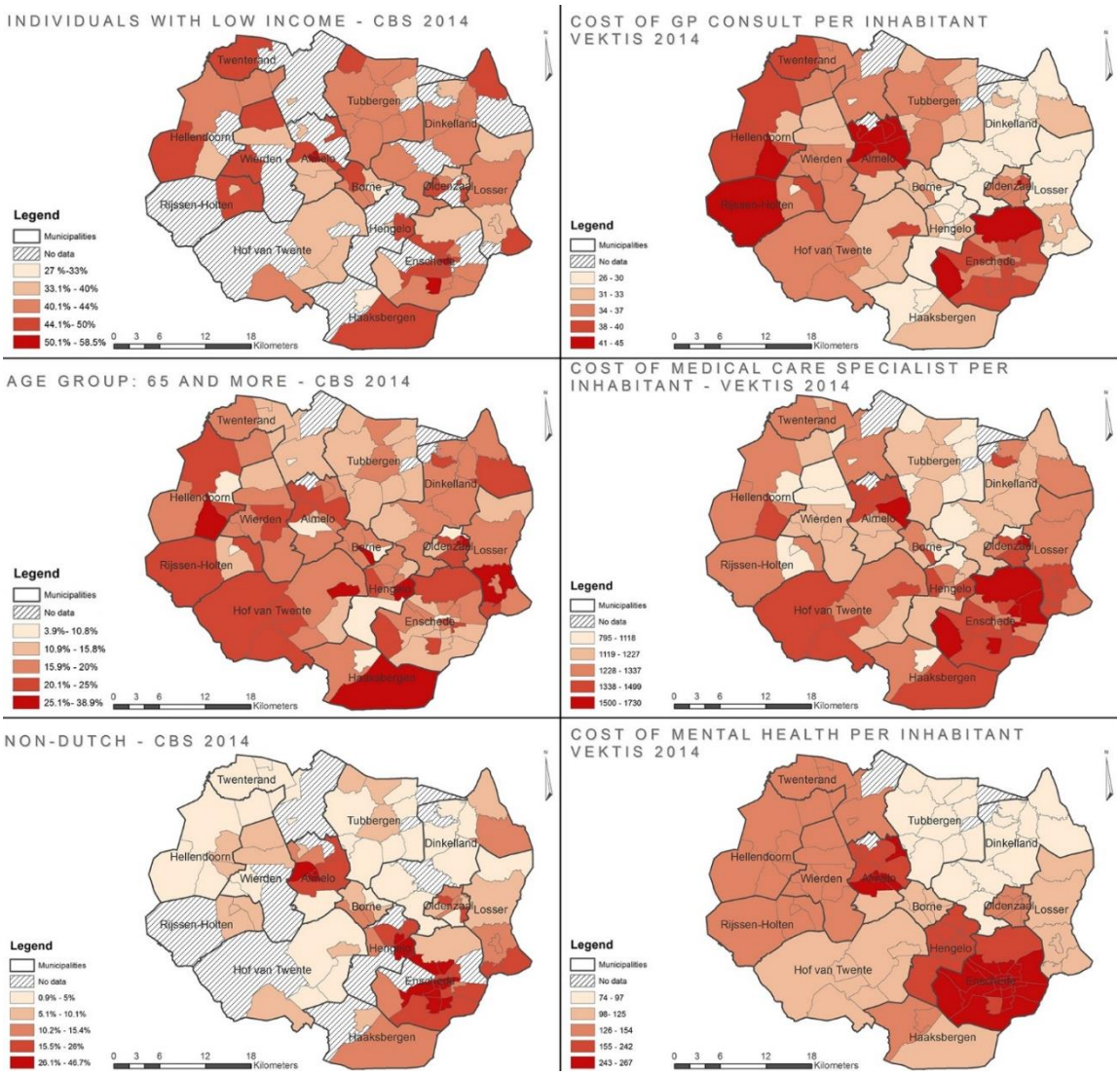


Figure 11. Spatial visualization of health expenditure indicators and SES indicators

### 4.3.2. Health status and health behaviour influence on HE

To explain the association between health status and health expenditure, three variables were chosen to be analysed: *cost of GP consultation, cost of medical care specialist, and cost of mental health.*
First the relation between health status and health behaviour with health expenditure was modelled, and second, health measures with health expenditure.
Tables below show the results of linear regression modelling for each variable. Table 17 shows the results for the first model, while Table 18 for the second.

From the first model, Table 17 smoking is the condition of health behaviour that has an influence in the three of health expenditure variables. It has the highest explanatory power in *cost of mental health*, while it is the only variable explaining both *cost of GP consultation* and *cost of medical care specialist*. This relation spatially can be seen in Figure 12.
For cost of mental health, differently from smoking having a positive correlation, overweight and excessive use of alcohol are negatively correlated to it.

Second model, examining the relationship of health measures and health expenditure is shown in Table 18. Moderate/poor perceived health is the variable that is present in explaining the model for the three of the variables of health expenditure. Consultations show to be negatively correlated with *cost of mental health*, while contact to physiotherapist has the highest power on influencing *cost of GP consults and cost of medical care specialist*.

Table 17. Linear regression modelling for health expenditure indicators

| | **Cost of GP consultation** | **Cost of medical care specialist** | **Cost of mental health** |
|---|---|---|---|
| R Square | **0.203** | **0.233** | **0.541** |
| Adjusted R Square | **0.196** | **0.226** | **0.500** |
| | **B** | **B** | **B** |
| constant | 23.913 | 853.994 | 502.9320 |
| Overweight | | | -7.2640 |
| Smoking | 0.417 | 15.930 | 7.7870 |
| Excessive use of alcohol | | | -6.3500 |

Table 18. Linear regression modelling for health expenditure indicators

| | **Cost of GP consultation** | **Cost of medical care specialist** | **Cost of mental health** |
|---|---|---|---|
| R Square | **0.262** | **0.578** | **0.322** |
| Adjusted R Square | **0.248** | **0.570** | **0.310** |
| | **B** | **B** | **B** |
| constant | 9.2460 | -459.5280 | 201.8300 |
| Consultations | | | -0.3660 |
| Contact physiotherapist | 1.0580 | 80.7100 | |
| Moderate/poor perceived health | 0.3880 | 10.8280 | 10.3050 |

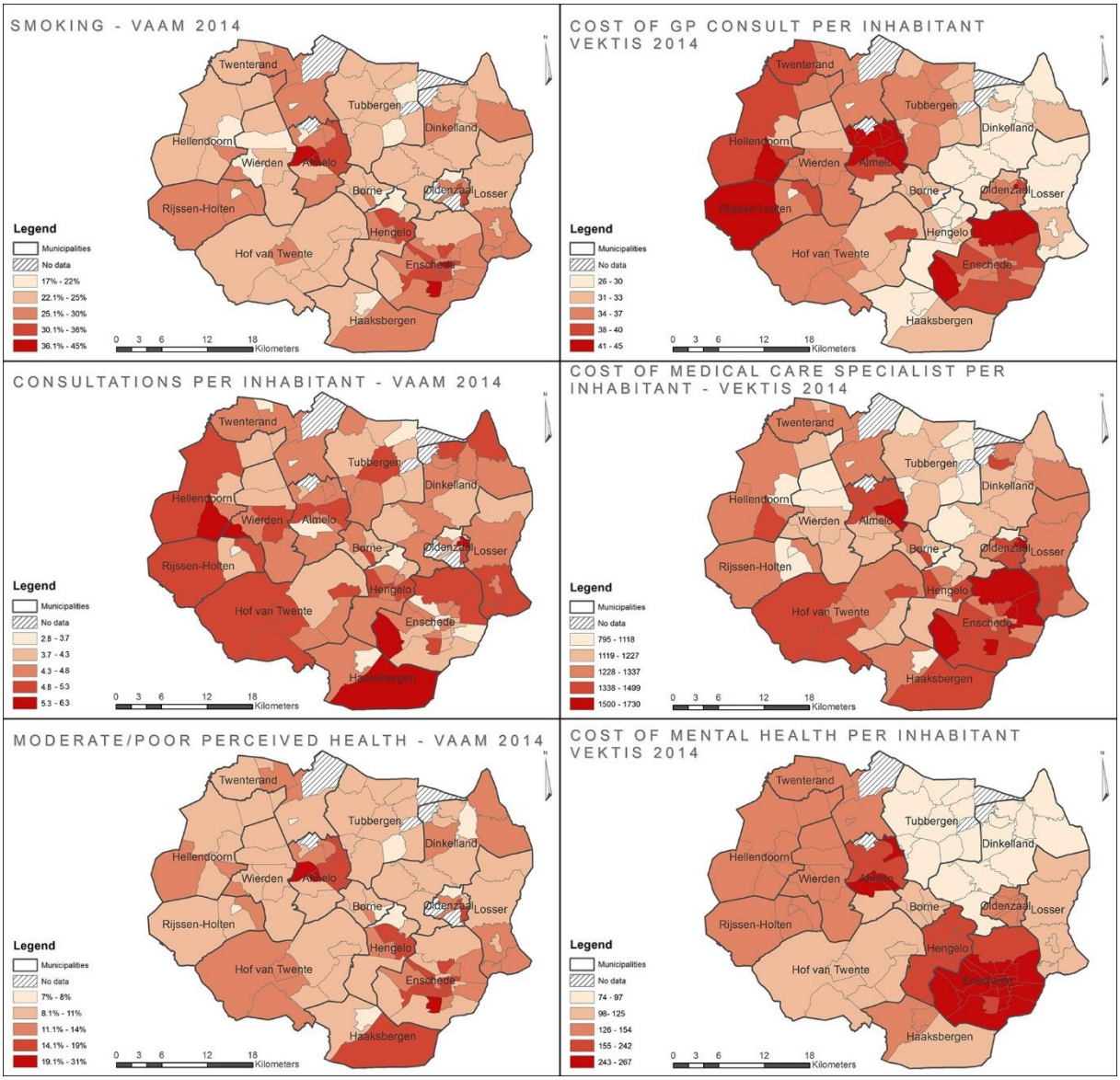


Figure 12. Spatial visualization of health expenditure indicators and health status measures

# 5. DISCUSSION

*This chapter includes the discussion and reflection on the results of the research. First, the association between socio-economic circumstances and health status is discussed. This is done by looking at the influence SES has on health status and health behaviour. The relation is discussed looking at the results from both statistical and spatial analysis. Next, the influence health status and behaviour has on health care use. Third, the influence SES and health status have on health expenditure is described by discussing the results from the previous chapter. Moreover, limitations of the study are presented at the end of this chapter.*

## 5.1. Association of Socio-economic circumstances with health status and health behaviour

Socio-economic circumstances have shown to be relevant influencers in the outcomes of health for postcode level 4 in the Twente region. Data of different sources, combined and analysed for this purpose has shown that there is a great importance in focusing on the indicators of SES when making intervention strategies and policies for health status improvement.

Using SES as a composite index and later as individual indicators has shown that both methods can be benefiting, depending on the indicator of health to be analysed, or the method of intervention needed to be planned. As composite index, SES has proven to be highly explanatory on most of the health status outcomes and behaviours, both in statistical and spatial analysis.
Postcodes of low SES have been consistently associated with worse health outcomes (i.e. overweight, obese, diabetes, and people with more than two conditions) and health behaviour (i.e. smoking, drinking, and exercising). Using GIS- based spatial analysis has resulted with identifying two postcodes 4 areas in the Twente region, which score low in SES, being ranked as areas with highest percentages on all six indicators of health status and two of the indicators of health behaviour analysed in the research. These two postcodes are located in Almelo (postcode 7605) and in Enschede (postcode 7544).
This finding is supported by the broad literature on the influence socio-economic circumstances have on health (Sommer 2015).
Moreover, analysing 22 European countries, Mackenbach et al., (2008) concluded that rates of death and perceived health are highly related with groups of low socio-economic status.
Furthermore, using individual indicators of SES has helped to get an insight on the specific aspects of socio-economic circumstances that influence health outcomes.
Health status indicators like diabetes, respiratory diseases, and chronic conditions, have been associated with groups of low income, while overweight, obese, and high blood pressure, with education.
Low income has been associated with low health outcomes (Muennig, Franks, Jia, Lubetkin, & Gold, 2005), and looking at the spatial distribution in Twente region, these areas tend to also be low in education, jobs, and higher number of non-Dutch inhabitants. While the health outcomes can be directly related to low income, that might be a result of multiple factors working together. People with low income can be associated with unemployment or lower earnings, thus it can be hypothesised that they come from groups with lower education. Similarly, with conditions linked with education, this can come from other reasons, apart from education as a numerical scale. Education has been widely evidenced for the effects it has in health (Grossman,1999).It can be connected to health literacy, where people missing information about health burdens and health care can result with higher chances of suffering from health conditions. Furthermore, education has been related to satisfaction with job, higher earning, and general well-being (Clark, 1996). It has also been one of the indicators of socio-economic circumstances in different studies to be considered in reducing differences in health outcomes and life expectancy (Mäki et al., 2014) Due to highlighted necessity for increasing health literacy for the purposes of improving general health of the

population, different countries, such as the United Kingdom, pay specific attention to education when developing goals and policies for health improvements.
In the report for a healthier Netherlands, National Institute for Public Health and the Environment (RIVM) 2014, acknowledge the role of education and the effect it has on health. In 2014, the difference between low and high educated people resulted in 6-year life expectancy difference. Therefore, education can be determined as one of the main indicators to be addressed for promoting better health.

Additionally, looking at the demographic structure of the population, specific groups appear to present related to health outcomes. Population above 65 has been associated with worst health outcomes, such as diabetes, overweight, and more than two chronic conditions. Researchers have been arguing constantly about the implications of longer life expectancy, and if this results with lower health status for the elderly. One of the aspects where this is visible is increased number in overweight and dementia in communities entering the older ages (Suzman & Beard, 2011). Twente region acclaims for around 14% people aged more than 65 years old (CBS), thus a particular attention should be addressed to this group when promoting health status improvement.
Furthermore, this age group has resulted to be linked to excessive drinking. This finding supports the latest trend where studied find western countries increasing rates of drinking, particularly elderly above 65 (Geels et al., 2013). In their study Geels et al. (2013) find that alcohol is highly consumed by Dutch elderly, in particular by women. However, this contradicts the results of this study, where women are identified as non-excessive drinkers of alcohol. This may come as a result particular to Twente region, considering other factors, such as ethnicity. Excessive use of alcohol has been inversely associated with non-western ethnic groups that live in the Twente region. Looking at the spatial distribution of non-Dutch inhabitants, there is an inverse correlation between excessive drinkers of alcohol and non- Dutch. Particularly, Turkish group results to locate highly in areas that score low in alcohol use. Other characteristics could explain this, such as religion and the culture of not drinking alcohol in these communities.
On the other hand, non-Dutch population has been associated with low health outcomes (i.e. diabetes, respiratory conditions, and hypertension) and smoking. Spatial accumulation of these groups has been identified in areas in Almelo and Enschede, considering a limitation presented by missing data on ethnicities, further discussed in the limitations section of this chapter.
Besides, non-Dutch population have been identified as people with perceived moderate or poor health. These areas have been spatially correlated also with low SES.

### 5.2. Association of SES, health status and health behaviour with measures of health care use

Health care use has shown to be related to both, socio-economic circumstances and indicators of health status and behaviour of people of the Twente region. For both consultations and number of prescriptions, health outcomes (i.e. overweight and respiratory conditions) and smoking have shown to be highly explanatory. Furthermore, the demographic structure of the region has a strong explanatory power. Population above 65 have shown to use care the most, scoring higher in consultations and prescription number. On the other hand, women are not getting prescriptions. This has been supported by literature
People with weight problems have been likened with health care use in many studies (Sturm, Roland, 2002). This can result also from the fact that these people might be linked to other health conditions, such as diabetes or hypertension (National Institutes of Health(NIH),1998)
To our surprise, people with respiratory conditions show to participate in consultations, but are not getting prescriptions. This relation is also not significant spatially, where mismatching of results are seen form consultations to number of prescriptions. This can be a problem of the nature of the data used in analysis. The statistical correlations might reflect the overall values of the region, while spatially the

postcodes don't correlate and reflect the same phenomena. This might be a result of using postcode 4 data, which are heterogeneous areas with different structures. The internal variation can result in shortcoming for the analysis.

### 5.3. Association of SES, health status and health behaviour with Health expenditure

The findings of this research suggest that, there indeed is a link between health expenditure with socio economic status, health status and health behaviour. Three dependent variables used: cost of GP, cost of medical care specialist and cost of mental health are common across all variables of health expenditure and avoids thus avoids specificity of assessment for a given variable (for example: some dependent variables may only be applicable to certain group, such as maternal care). The selected dependent variables give an overview of the potential relationship which is deemed a good starting point for investigating the potential relationships between these concepts.

Income levels which has shown in previous studies to influence health expenditure (Kapur et al., 2004) also explain it in our study, but only with cost of mental health (& individual with low income). Low income levels are associated with many long term illness as well as increased incidental mental disorder (Sareen, Afifi, McMillan, & Asmundson, 2011). This prolonged need for care as well as higher potential for psychiatric care thus result in higher costs for mental health. However, this cost is significant in age group 25-44 and not in 65. This variability is possibly explained by other factors such as ethnicity or origin of people as only south-western populace show this significance. Turkish people tend to spend less on medical care specialist which is perhaps due to cultural peculiarities but concrete conclusions cannot be drawn. The cost of medical cost also relatives positively with age group 65 and above. This is potentially due to higher tendency of having health conditions for the elderly. This is consistent with findings related to consultations and prescriptions, whereby older people tend to spend more on these services.

Influence of smoking on health expenditure is positive across all dependent variable and is one of the most significant predictor of health care expenditure. This is consistent with findings from literature (Chrisntiansen et al., 2006; Ke et al., 2011). People who tend to smoke are more susceptible to a variety of health conditions thereby increasing their health expenditure. However, in contrast alcohol is also is found to have negative relation with cost of mental health. The same literature also points out absence of relation with excessive alcohol consumption, but a negative relation is identified with mental health. Overweight variable also shows similar relation with health expenditure. An assumption is that people who consume a lot of alcohol do not want to participate in mental care due to social dogma associated with excess alcohol use. But concrete conclusions cannot be drawn and needs further research to validate these results.

### 5.4. Limitations

Using data from different sources, with different resolution can be challenging. This research has its limitation and, although some of them are briefly mentioned in previous sections, the ones that can be addressed and improved in future studies are presented.

The data used in analyses comes from different sources, all of them with different spatial unit. First, the data used for health status is aggregated before publishing, which itself loses details what can affect the results. Second, the data for health expenditure needed to be disaggregated, using population age groups to allocate the money in postcode 4 level. This was done under the assumption that every person of the

same age group in one postcode spends the same amount of money on health. This modification of data leads to dilutions, thus decreasing the certainty of the results.

Apart from that, the level of the analysis postcode 4 areas are not homogeneous units, so the internal variation within them is problematic to generate results. Different indicators such as income can be high, but others like education can be low. This might lead to contradicting forces within the same postcode, leading to shortcoming in the analysis. Data of smaller resolution cold help get more accurate results.
In addition, there are missing data on the indicators that are available. This limits the analysis to either include them, or to come to better conclusions.

# 6. CONCLUSION

The main objective of this study was to examine the relation between socio-economic circumstances, health status, health behaviour, and health expenditure in the Twente region on the basis of publicly available spatially disaggregate secondary data sources. A framework is developed to serve as a guideline for analysing the main concepts and help understand the relationship between them.

The Twente region is chosen as a case study based on the certain criteria, particularly having in mind local social-economic and demographic characteristics.

Methodological approach is designed to combine various data of different sources, and bring them together to capture the relationship between socio-economic circumstances, health status, health behaviour, and health expenditure in the Twente region in the Netherlands. This study showed the relevance of combining open source data at a disaggregate level into a unified database in order to do a comparative intra-urban analysis of the fourteen municipalities of the Twente region.
Research was conducted using statistical and spatial analysis. Statistical analysis was done using multiple linear regression. First, it examined how socio-economic circumstances relate to health status and health behaviour. Second, it analysed to what extent are variations in SES, health status and health behaviour connected with healthcare expenditure. A GIS-based spatial analysis was done to capture the presence of spatial accumulation of the problems and visualise spatial variation of health behaviour, health status, health utilization and health expenditure.

Three main conclusions are underlined. The first, there is strong association between SES, both as composite and multidimensional concept, with health behaviour and health status. The second, SES, health status and health behaviour can be linked with healthcare use and health expenditures. And, the third, using GIS- based analysis offers the possibility to spatially analyse the accumulation of problems and target specific areas for intervention.

## 6.1. Recommendations for future studies

This study provided a strong argument on the relevance of socio-economic circumstances on health outcomes and expenditure. However, it also left some place for the improvement and possibility to try different methodological variations to confirm or challenge the results.

The data used in the research was open source data, which had limited variation of spatial units. To be able to combine them, the lowest level was postcode 4. With the aforementioned limitations of this size unit, it is recommended that future studies look into the relation between SES and health using smaller units like buurt/neighbourhood, or even household level. This can be constricted due to availability of data that are public, so a collaboration with institutes in charge can bring to necessary results.

Another possibility for improvement is the selection of the indicators to be analysed. Due to data availability, at a certain moment in study a selection was made from the available data online. Later, one of the data sources (VAAM) changed their interface, including more indicators, and detailing the ones available. It is recommended to include and analyse these indicators in the first steps of the analysis, in order to improve the understanding of the relations between concepts.

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# APPENDIXES

## APPENDIX 1 – DESCRIPTIVE STATISTICS

| Descriptive statistics for indicators of Socio-Economic circumstances in Twente region | | | | | |
|---|---|---|---|---|---|
| **Variables** | N | Mean | SD | Min | Max |
| **Socio-Economic Status (dummy variables)** | | | | | |
| SES LOW | 115 | 0.0174 | 0.13130 | 0.00 | 1.00 |
| SES Medium LOW | 115 | 0.0348 | 0.18403 | 0.00 | 1.00 |
| SES MEDIUM | 115 | 0.2174 | 0.41428 | 0.00 | 1.00 |
| SES Medium HIGH | 115 | 0.5826 | 0.49529 | 0.00 | 1.00 |
| SES HIGH | 115 | 0.1478 | 0.35648 | 0.00 | 1.00 |
| **Income** | | | | | |
| Average income per income receiver (euro) | 115 | 24,850.1 | 4377.4 | 10500.0 | 34333.3 |
| Individuals with low income (%) | 83 | 43.30 | 4.854 | 27 | 59 |
| **Jobs** | | | | | |
| Active (%) | 84 | 58.23 | 6.779 | 41 | 70 |
| **Education** | | | | | |
| Education low (%) | 108 | 48.5741 | 7.05016 | 22.00 | 74.00 |
| Education medium (%) | 102 | 35.6569 | 3.42817 | 22.00 | 44.00 |
| Education high (%) | 95 | 15.8105 | 5.58740 | 4.00 | 34.00 |
| **Gender** | | | | | |
| Population men (%) | 115 | 50.69 | 1.536 | 47.67 | 55.69 |
| Population women (%) | 115 | 49.31 | 1.536 | 44.31 | 52.33 |
| **Age groups** | | | | | |
| 0-14 years old (~~%~~) | 115 | 17.98 | 3.722 | 6.97 | 30.99 |
| 15-24 years old (%) | 115 | 12.81 | 3.456 | 8.39 | 32.54 |
| 25-44 years old (%) | 115 | 23.41 | 4.295 | 16.36 | 33.45 |
| 45-64 years old (%) | 115 | 28.16 | 3.817 | 17.32 | 40.00 |
| 65+ years old (%) | 115 | 17.63 | 5.505 | 3.99 | 38.98 |
| **Ethnicity** | | | | | |
| Westerns total (%) | 99 | 7.03 | 4.400 | 0.80 | 18.60 |
| Non-Westerns total (%) | 99 | 5.99 | 7.789 | 0.00 | 35.21 |
| Morocco (%) | 41 | 0.58 | 0.814 | 0.00 | 3.28 |
| Netherlands Antilles and Aruba (%) | 41 | 0.34 | 0.421 | 0.00 | 1.38 |
| Suriname (%) | 41 | 0.53 | 0.654 | 0.00 | 2.35 |
| Turkey (%) | 41 | 4.65 | 5.254 | 0.00 | 23.19 |
| Other non-Western (%) | 41 | 3.92 | 3.435 | 0.00 | 18.37 |
| Non-Dutch total (%) | 99 | 13.02 | 11.113 | 0.97 | 46.70 |

| | Descriptive statistics for indicators of Health status in Twente region | | | | | |
|---|---|---|---|---|---|---|
| | **Variables** | N | Mean | SD | Min | Max |
| DETERMINANTS | **Personal** | | | | | |
| | **Weight** | | | | | |
| | Overweight (%) | 111 | 48.8 | 4.063 | 31.0 | 64.0 |
| | Obese (%) | 111 | 12.6 | 2.995 | 8.0 | 28.0 |
| | **High blood pressure (%)** | 111 | 13.5 | 1.757 | 9.0 | 20.0 |
| | **Diabetes (%)** | 111 | 3.6 | 1.268 | 2.0 | 10.0 |
| | **Chronic Conditions** | | | | | |
| | Least two chronic conditions (%) | 111 | 26.8 | 4.149 | 18.0 | 46.0 |
| | Asthma, bronchitis, emphysema, COPD / COPD (%) | 111 | 7.6 | 1.505 | 5.0 | 14.0 |
| | **Behavioral** | | | | | |
| | **Exercise** | | | | | |
| | Does not meet standard move (%) | 111 | 40.8 | 3.406 | 30.0 | 50.0 |
| | **Smoking (%)** | 111 | 26.8 | 4.872 | 17.0 | 45.0 |
| | **Drinking** | | | | | |
| | Excessive use of alcohol (%) | 111 | 30.6 | | 21.0 | 40.0 |
| MEASURES | **Objective** | | | | | |
| | Consultations | 111 | 4.5 | 0.581 | 2.8 | 6.3 |
| | Number of prescriptions | 111 | 48.2 | 64.313 | 5.3 | 336.2 |
| | **Subjective** | | | | | |
| | Moderate / poor perceived health (%) | 111 | 12.3 | 3.888 | 7.0 | 31.0 |

| Descriptive statistics for indicators of Health Expenditures in Twente region | | | | | |
|---|---|---|---|---|---|
| **Variables** | N | Mean | SD | Min | Max |
| Cost of GP consults | 115 | 35.102 | 4.429 | 26.040 | 45.413 |
| Cost of medical care specialist | 115 | 1280.311 | 159.150 | 795.055 | 1730.142 |
| Cost of mental health | 115 | 161.815 | 65.249 | 74.583 | 267.959 |

**P_WEST_AL: Southwestern total [%]**

The number of immigrants with a Western origin on January 1, expressed as a percentage of the entire population. This data is derived from the Structure Census Municipal Administration (GBA). Among the westerners among immigrants from Europe, North America, Oceania, Indonesia and Japan. When a neighbourhood has fewer than 50 people, this fact is kept secret (.). Non-Western Immigrants are divided into Western and non-Western by virtue of their birth. The category 'non-Western' are immigrants from Turkey, Africa, Latin America and Asia, excluding Indonesia and Japan. On the basis of their socio-economic and cultural position, immigrants from these two countries among the westerners. It mainly concerns people who Indies were born in the former Dutch and employees of Japanese companies and their families

**P_N_W_AL:.Non-Western total [%]**

The number of immigrants with non-Western origin on January 1, expressed as a whole percentage of the number of inhabitants. This data is derived from the Structure Census Municipal Administration (GBA). When a neighborhood has fewer than 50 people, this fact is kept secret (.). Until 2003, moreover, applied the additional requirement of the presence of at least ten non-western immigrants and the number before conversion was at a rate of only completed five numbers

**P_MAROKKO:.Morocco [%]**

The proportion of immigrants with ethnic background Morocco, Ifni, Spanish Sahara and Western Sahara on January 1, expressed as a percentage of the entire population. When has an area less than 50 people and less than 10 non-Western immigrants, has been kept secret this fact(.).

**P_ANT_ARU Netherlands Antilles and Aruba [%]**

The proportion of immigrants with ethnic background of to the Dutch kingdom belonging islands of Bonaire, Curacao, Saba, St. Eustatius, St. Maarten and Aruba on January 1, expressed as a percentage of the entire population. As of October 10, 2010, the Dutch Antilles are dissolved. The Kingdom of the Netherlands is made from that date from four countries: the Netherlands, Aruba, Curacao and Sint Maarten. All islands have a new status. Curacao and Sint Maarten are new countries within the Kingdom. With a separate status within the Kingdom, Curacao and Sint Maarten become autonomous countries. The countries have an independent board and are no longer dependent on the Netherlands. The public entities Bonaire, St. Eustatius and Saba, also known as the Caribbean Netherlands have deeper relationship with the Netherlands and act as a special municipality of the Netherlands. When a neighbourhood less than 50 people and fewer than 10 non-western immigrants, this information is kept secret(.).

**P_SURINAM Suriname [%]**

The proportion of immigrants with ethnic background Suriname on January 1, expressed as a whole percentage of the population. When a neighbourhood less than 50 people and less than 10 counts non-Western immigrants, this information is kept secret(.).

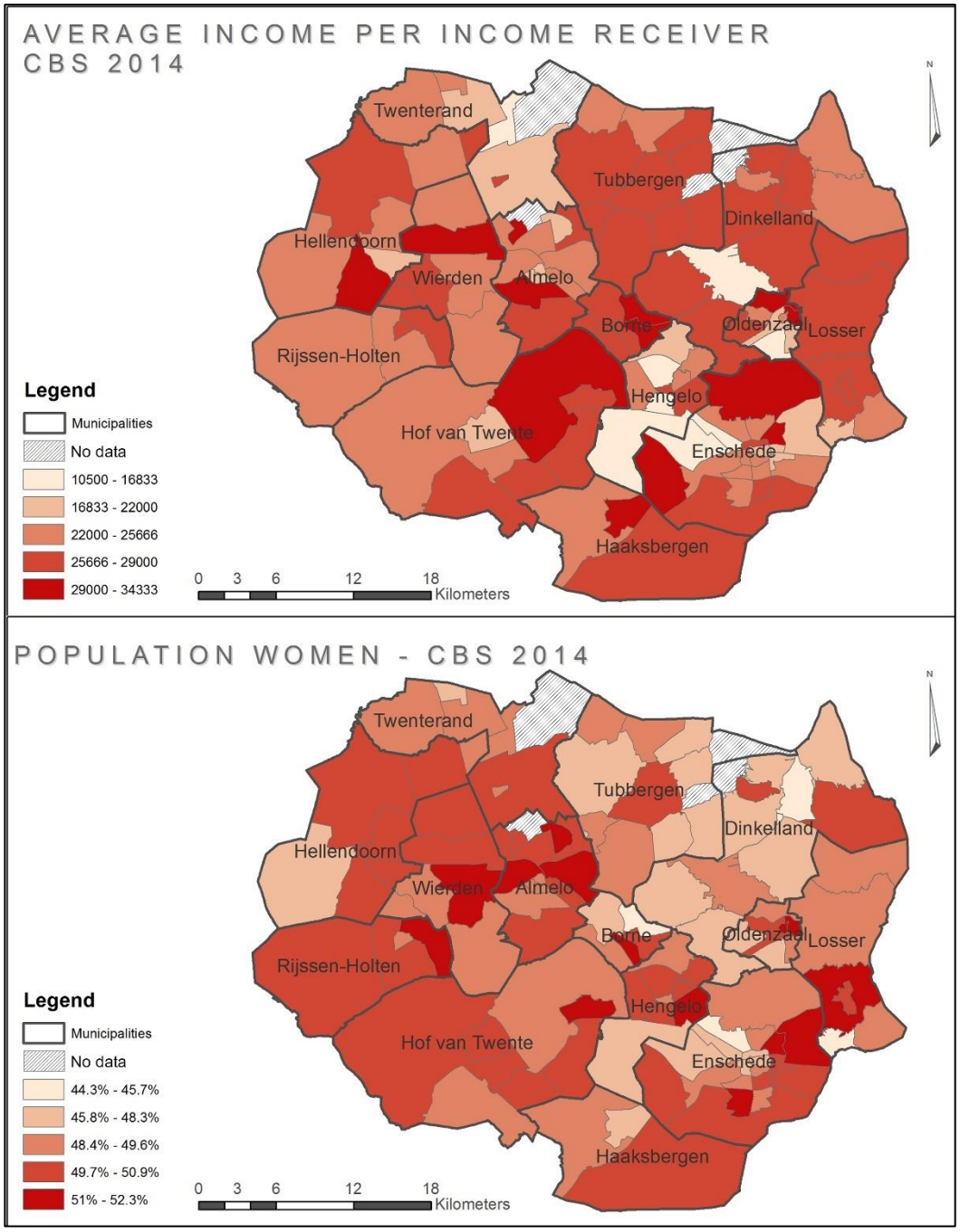
**P_TURKIJE Turkey [%]**

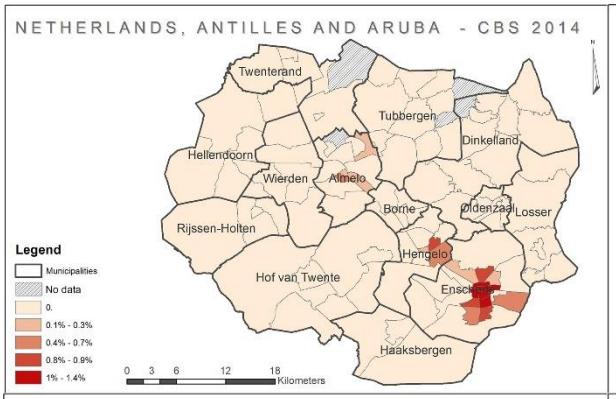
The proportion of immigrants with ethnic background Turkey on January 1, expressed as a whole percentage of the population. The percentage mentioned by 50 or more per area and at least 10 non-western immigrants by area.

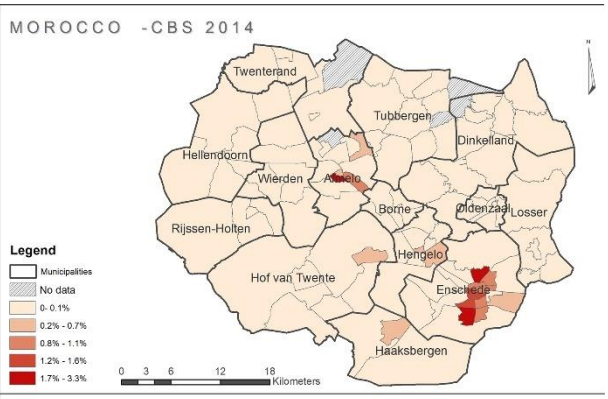
**P_OVER_NW:.Other non-Western [%]**

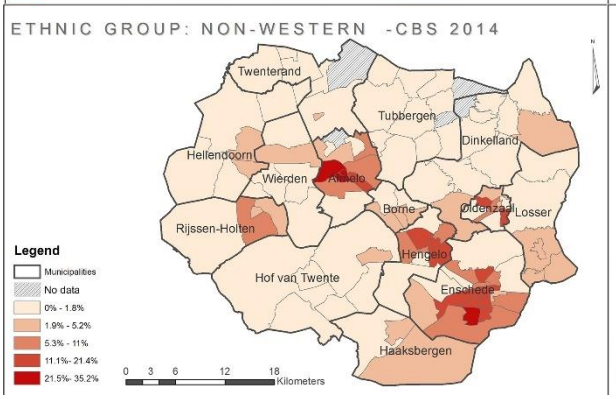
The proportion of immigrants with non-western origin on January 1, expressed as a whole percentage of the population. The percentage mentioned by 50 or more per area and at least 10 non-western immigrants by around CBS.

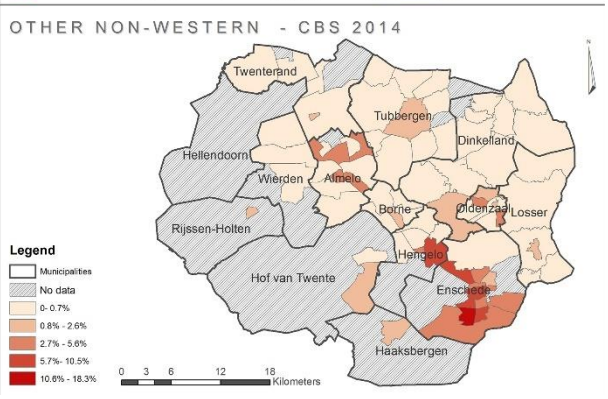
APPENDIX 3 – SPATIAL VISUALIZATION FOR SPECIFIC AGE GROUPS AND ETHNIC GROUPS

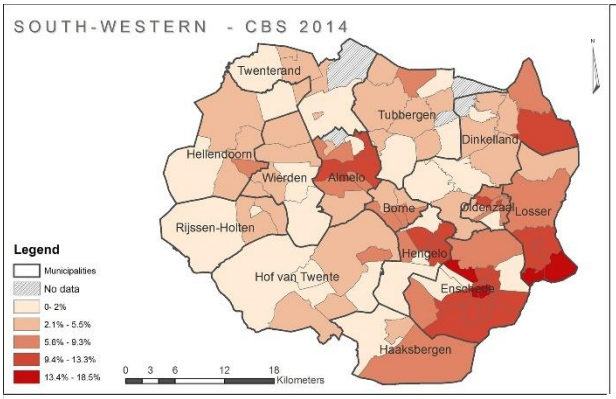


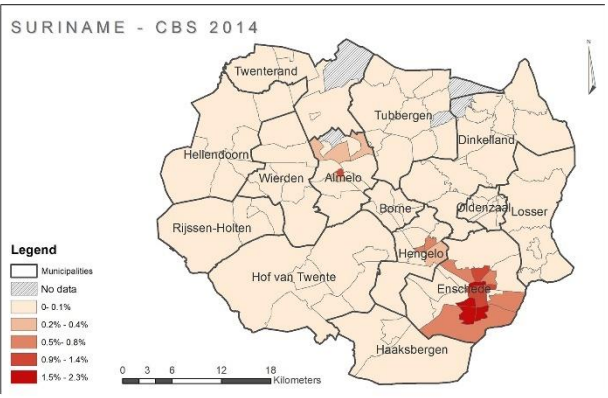

NETHERLANDS, ANTILLES AND ARUBA - CBS 2014
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
Legend
Municipalities
No data
0.
0.1% - 0.3%
0.4% - 0.7%
0.8% - 0.9%
1% - 1.4%
0 3 6 12 18
Kilometers

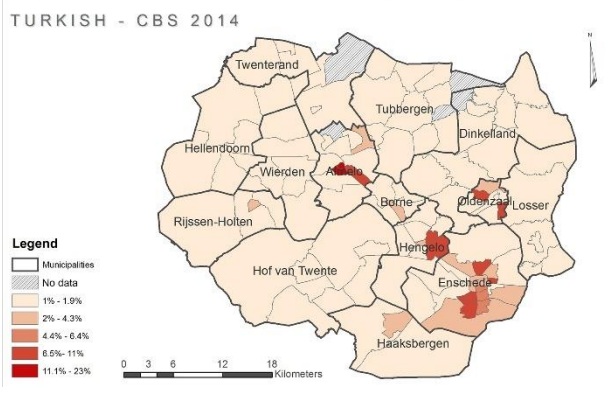

MOROCCO -CBS 2014
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
Legend
Municipalities
No data
0- 0.1%
0.2% - 0.7%
0.8% - 1.1%
1.2% - 1.6%
1.7% - 3.3%
0 3 6 12 18
Kilometers

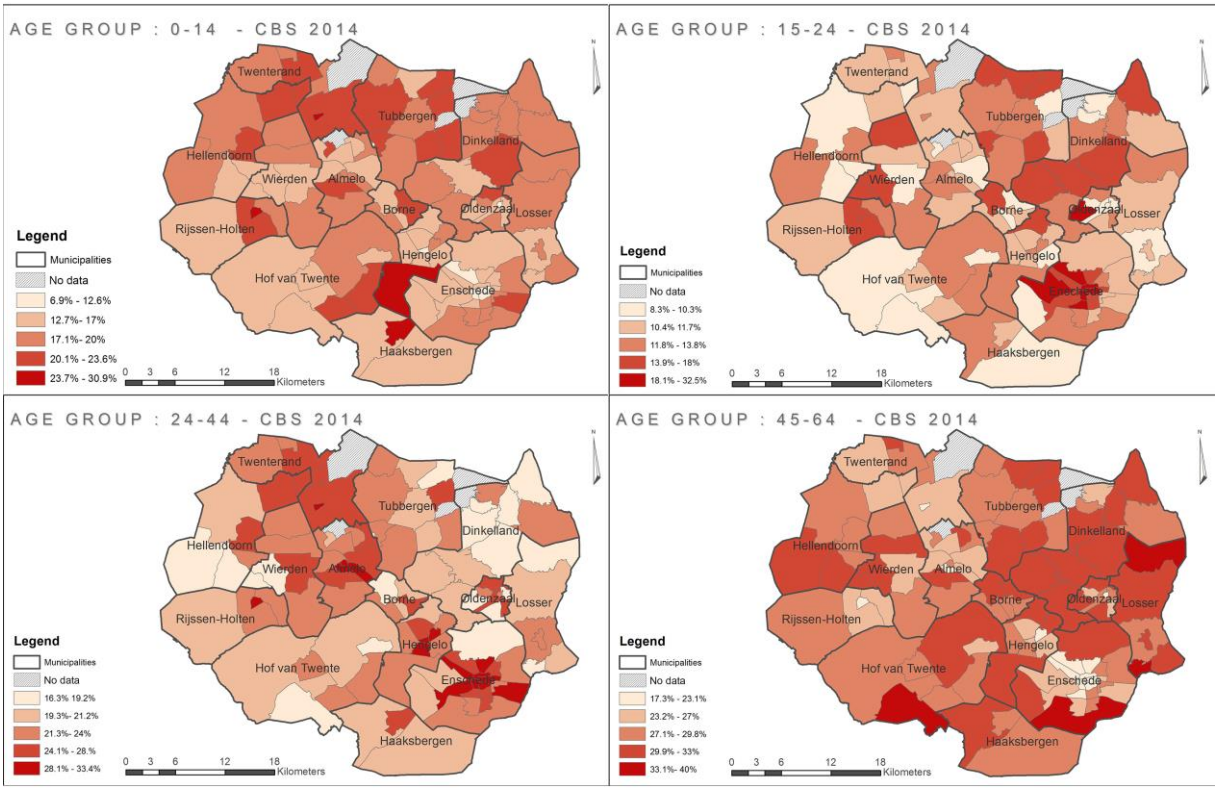

ETHNIC GROUP: NON-WESTERN -CBS 2014
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
Legend
Municipalities
No data
0% - 1.8%
1.9% - 5.2%
5.3% - 11%
11.1%- 21.4%
21.5%- 35.2%
0 3 6 12 18
Kilometers


OTHER NON-WESTERN - CBS 2014
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
Legend
Municipalities
No data
0- 0.7%
0.8% - 2.6%
2.7% - 5.6%
5.7%- 10.5%
10.6% - 18.3%
0 3 6 12 18
Kilometers


SOUTH-WESTERN - CBS 2014
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
Legend
Municipalities
No data
0- 2%
2.1% - 5.5%
5.6% - 9.3%
9.4% - 13.3%
13.4% - 18.5%
0 3 6 12 18
Kilometers


SURINAME - CBS 2014
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
Legend
Municipalities
No data
0- 0.1%
0.2% - 0.4%
0.5%- 0.8%
0.9% - 1.4%
1.5% - 2.3%
0 3 6 12 18
Kilometers


TURKISH - CBS 2014
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
Legend
Municipalities
No data
1% - 1.9%
2% - 4.3%
4.4% - 6.4%
6.5%- 11%
11.1% - 23%
0 3 6 12 18
Kilometers


AGE GROUP : 0-14 - CBS 2014
Legend
Municipalities
No data
6.9% - 12.6%
12.7%- 17%
17.1%- 20%
20.1% - 23.6%
23.7% - 30.9%
0 3 6 12 18 Kilometers
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
AGE GROUP : 15-24 - CBS 2014
Legend
Municipalities
No data
8.3% - 10.3%
10.4% 11.7%
11.8% - 13.8%
13.9% - 18%
18.1% - 32.5%
0 3 6 12 18 Kilometers
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Haaksbergen
AGE GROUP : 24-44 - CBS 2014
Legend
Municipalities
No data
16.3% 19.2%
19.3%- 21.2%
21.3%- 24%
24.1% - 28.%
28.1% - 33.4%
0 3 6 12 18 Kilometers
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen
AGE GROUP : 45-64 - CBS 2014
Legend
Municipalities
No data
17.3% - 23.1%
23.2% - 27%
27.1% - 29.8%
29.9% - 33%
33.1%- 40%
0 3 6 12 18 Kilometers
Twenterand
Tubbergen
Dinkelland
Hellendoorn
Wierden
Almelo
Borne
Oldenzaal
Losser
Rijssen-Holten
Hengelo
Hof van Twente
Enschede
Haaksbergen

APPENDIX 4 – LINEAR REGRESSION MODELING RESULTS FOR HEALTH EXPENDITURE AND SES

| | Cost of GP consultation | Cost of medical care specialist | Cost of mental health |
|---|---|---|---|
| R Square | **0.250** | **0.776** | **0.453** |
| Adjusted R Square | **0.236** | **0.751** | **0.447** |
| | **B** | **B** | **B** |
| constant | -7.3850 | 864.5320 | 89.3050 |
| Population women | 1.0040 | | |
| P_00_14_JR | -0.3930 | | |
| P_65_EO_JR | | 22.3260 | |
| Southwestern total | | | 10.0700 |
| Non-Western total | | 72.1290 | |
| Turkey | | -75.3900 | |