The myth of small data

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The myth of small data

How to produce small area estimates regarding lifestyle, health and healthcare to support an integrated population-based healthcare

Methods and outcomes

Willemijn de Graaf-Ruizendaal

Colofon

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The myth of small data

How to produce small area estimates regarding lifestyle, health and healthcare to support an integrated population-based healthcare

Methods and outcomes

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te Bunschoten-Spakenburg

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Spreuken 19:8

Wie zijn verstand gebruikt, heeft zijn leven lief,
wie zich laat leiden door inzicht, is geluk op het spoor.

CONTENTS

What is this thesis about?

Local health data necessary for a good healthcare system
This thesis shows how to produce data on lifestyle, health and healthcare at a local level, in order to achieve a better match between healthcare supply and the healthcare needs of a population.

Data at the local level (i.e. small area estimates) on the lifestyle, health and healthcare of a population are essential for local governments, health organizations, insurance companies and other stakeholders to support a good healthcare system. A good healthcare system should strive for better care for individuals, better health for populations and lower healthcare costs. However, data on lifestyle, health and healthcare are often not available for populations at a local level, and therefore, a perfect match between healthcare needs and healthcare supply is difficult to accomplish.

How to produce health data at a local level?
In this thesis, it is investigated how local data on lifestyle, health and healthcare could be generated for each four-digit postcode area in the Netherlands by means of an innovative strategy using national sample data and auxiliary data. Figure 1 presents a flowchart of the innovative strategy developed in this thesis.

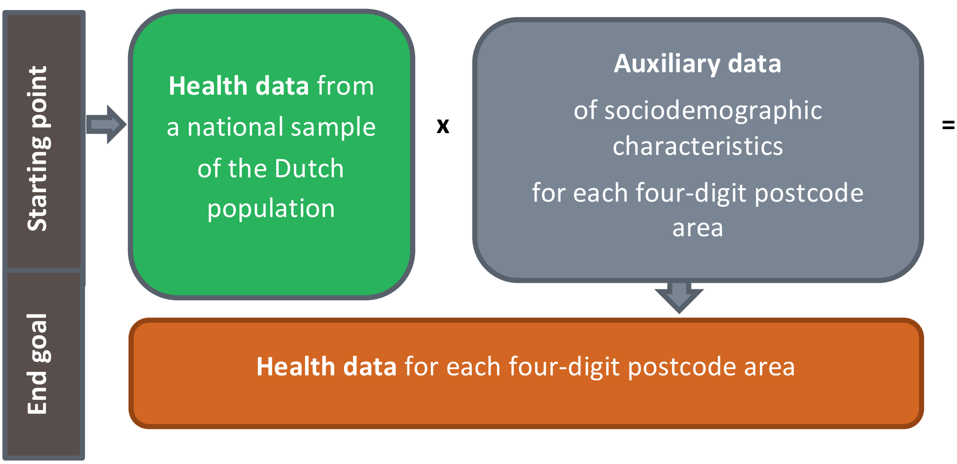

Figure 1: Flowchart of the innovative strategy

An innovative strategy could generate local data on lifestyle, health and healthcare

This thesis describes the development of an innovative strategy which produced local data on lifestyle, health and healthcare for each four-digit postcodes area in the Netherlands. The innovative strategy comprised a simple and robust statistical model. Only seven sociodemographic characteristics at the area level (age, sex, one-person households, low-income households, non-Western immigrants, status score and urbanization level) as well as health data from national sample data were needed to generate estimates at the local level. A model with unit-level and area-level sociodemographic predictors produced more accurate estimates. A drawback of the model is that it demands more data requirements, advanced statistical knowledge and advanced software programs. Moreover, models like this require extensive user-specific explanation to support the interpretation of the estimates in order to achieve a better match between healthcare needs and healthcare supply.

Estimates supporting health promotion and workforce planning

The applications of the generated estimates on lifestyle, health and healthcare are manifold. They hold particularly important information for supporting integrated population-based healthcare. For example, the estimates provide insight into the predicted mean number of contacts with general practice care per inhabitant, the mean number of contacts with general practice care for chronic conditions, the percentage of people in good health and the percentage of smokers for every four-digit postcode area in the Netherlands. These data are useful not only to target preventive interventions and health promotion, but also to support health workforce planning. The estimates on lifestyle, health and healthcare were presented in tables and maps in a freely accessible Internet application with approximately 2,500 unique monthly visitors (Figure 2).

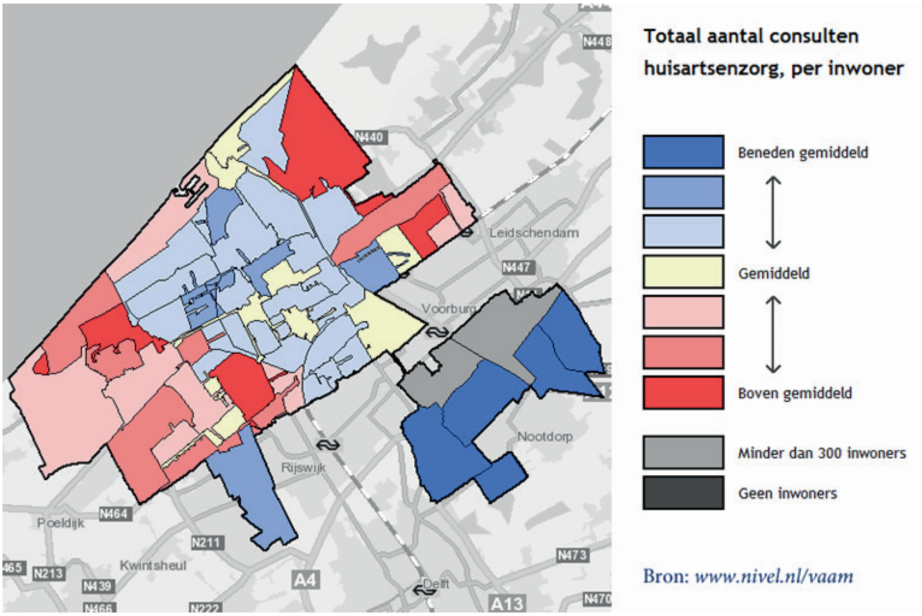

Figure 2: An example of a map in the Internet application on the mean estimated number of GP contacts.

Practice organization characteristics influence the gap between estimated GP utilization rates and actual utilization rates

Local estimates of the need for general practice care were compared with the actual use of general practice care for the general practices for which we had data in the NIVEL Primary Care Database. The difference between the estimated need for general practice care and the actual use can be explained by practice organization characteristics. This difference was primarily influenced by the presence of female GPs in a general practice, other medical providers in the practice, the disease management measures and dual practices. Practices with these characteristics have significantly higher GP utilization rates than estimated based on the sociodemographic profile of the area.

The quality and effectiveness of the local data were influenced by the data, statistical models and communication issues

The constructed innovative strategy described in this thesis requires health data from national sample data or registered data as well as auxiliary data at the unit or area level. Although these data are available in the Netherlands, availability and quality issues influence the validity, actualization and the effectiveness of the generated estimates. The availability of the data is affected by privacy and competition issues in particular. National investment in the coordination, availability and quality of such health data is needed to construct valid estimates on lifestyle, health and healthcare.

Chapter 1

General introduction & research questions

This thesis aims to produce small area estimates regarding lifestyle, health and healthcare, which are essential data at a local level that support the process of integrated population-based healthcare. The general introduction describes the background to the thesis, presents the research problem and the research questions, and discusses the methodological approach. Finally, the introduction presents the outline of the thesis.

Aim of the introduction

Matching primary healthcare to the healthcare needs of local populations is a complex and time-consuming process. However, it is a necessary process to keep healthcare both cost-efficient and of high quality, especially with an ageing population and an increasing number of chronically ill people. Unfortunately, the lack of local data on lifestyle, health, healthcare needs and healthcare use hampers the discussion by stakeholders about the perfect match between healthcare needs and healthcare supply at a local level. This thesis addresses the lack of local data, i.e. small area estimates on lifestyle, health and healthcare, and investigates how small area estimates can be produced for each four-digit postcode area in the Netherlands. Small area estimates provide insight into the spatial distribution of lifestyle, health and healthcare needs, based on the sociodemographic profile of an area, and they constitute important input for the discussion by stakeholders about the perfect match between supply and demand of primary healthcare.

BACKGROUND

Two challenges of the Dutch healthcare system

High costs

For several decades, the organization of healthcare has been changing [1]. As healthcare costs are high, healthcare should be organized more cost-efficiently and effectively without affecting the quality of healthcare. The cost of the Dutch health and welfare system grew enormously between 1999 and 2011, from 44 billion euros to almost 90 billion euros. 18% of this increase could be explained by sociodemographic developments, such as an ageing population [2]. Elderly people often suffer from chronic conditions and multi-morbidity, resulting in high healthcare utilization [3]. Moreover, there is an association between increased healthcare costs and the use of more specialized care. Around one quarter of the healthcare costs in 2014 could be ascribed to specialized and highly specialized care. This proportion is expected to rise in the future as a result of technical developments. In contrast, primary care is less expensive and uses up only 10% of the total healthcare budget. If no changes are made in the way healthcare is organized, the costs are expected to rise every year [2]. Health insurance premiums of families with an average income now constitute a quarter of their income; it is projected this will rise to 30-45% of their income in 2040 [4].

Quality of care

In addition to the increasing cost of the Dutch healthcare and welfare system, attention should also be paid to the quality of healthcare, and to whether changes in health policy are required. At present, the Dutch healthcare sector is of good quality, which is evidenced by international research. For instance, the Dutch healthcare sector scores high on the accessibility of care, the accessibility outside office hours and the low financial barriers to care [4, 5]. Nevertheless, if no changes are made in the way healthcare is organized, the quality of healthcare may be jeopardized for future generations. Savings in healthcare costs should not affect the quality of healthcare [6]. Such savings should go hand in hand with the necessary changes in health policy, not only to guarantee the quality of healthcare but also to enhance it.

Healthcare is ‘the combined functioning of public health and personal healthcare services’ [7]. According to the WHO, a *health system* refers to ‘all the activities whose primary purpose is to promote, restore or maintain health’ [8]. The quality of healthcare entails all these activities and can be measured by many dimensions, such as efficiency, safety, continuity, appropriateness, accessibility and patient-centeredness [7]. To ensure lower costs but a higher quality of care, national governments may focus on all these dimensions for all healthcare activities. To this end, in 2001 the Dutch national government formulated a healthcare policy striving for a healthcare system which has a better match with the demand for care, is less provider-centred, has shorter waiting lists, provides more patient information, offers more choice in healthcare providers and treatments, and is more patient-centred [9].

Solution: stronger primary care

Internationally, several national governments have implemented potential solutions for decreasing the healthcare costs without affecting the quality of care. The Dutch government proposed two changes, namely a more demand-driven healthcare system and an adaptation of the insurance system [9]. Even though the second change is vital for the success of the first, this thesis focuses only on the first change, a more demand-driven healthcare system.

In many countries, the main focus is on strengthening primary healthcare, with a central role for general practice care, aiming to reduce the use of secondary care [10-13] and to focus healthcare more on the needs of local populations [6, 13]. In the literature, this is often referred to as *population-based healthcare*, aiming for better care for individuals, better health for populations and lower healthcare costs [14]. The health of populations should be enhanced with a greater focus on preventive interventions, health promotion and public health planning. If people eventually become ill, primary healthcare must be strengthened in such a way that fewer people are referred to secondary care. In addition, substitution from secondary care to primary care is a potential solution to reduce healthcare costs [15]. The motto of the Dutch government is 'health close to the people and as their own responsibility if possible; specialized care when necessary, concentrated care if there is no alternative' [16]. In this thesis, this will henceforth be called 'an integrated population-based healthcare'.

The importance of primary healthcare to the health system has already been recognized for several decades [17, 18]. However, a stronger primary healthcare 'can be expected to lower the cost of care, improve health through access to more appropriate services and reduce the inequities in the population's health' [19]. In the literature, positive effects of a strong primary healthcare are reported [19, 20] on health [19, 21], quality of care [22] and cost [23].

Primary healthcare can be defined as 'the provision of integrated accessible healthcare services by clinicians who are accountable for addressing a large majority of personal healthcare needs, developing a sustained partnership with patients and practising in the context of family and community'[18]. Primary healthcare can be provided by several care providers, such as general practitioners, midwives, psychologists, physiotherapists, pharmacists and social workers. The primary healthcare provider acts as the patients' first contact, provides continuing care, and coordinates the referral to a specialist. The general practitioner (GP) is the central care provider in primary healthcare. General practitioners provide care for specific, defined populations and communities, and they provide care from the cradle to the grave. In the Netherlands, every resident is listed with a GP to ensure access for every patient [24]. Dutch GPs are able to meet more than 90% of all new healthcare demands which are presented in general practice care [25]. General practice care operates at the neighbourhood level and residents are usually registered with a general practice close to their home. The mean distance to a GP is 2.7 kilometres [26] and the mean number of inhabitants per FTE GP is 2,350. The Dutch government does not actively intervene to realize this standard. The above-mentioned characteristics make GP care the perfect means to ensure that healthcare is more integrated, population-based and patient-focused.

Health and healthcare needs differ as a result of sociodemographic characteristics

The process of more integrated population-based healthcare is hampered by great disparities in the health status, healthcare needs and healthcare usage of different sociodemographic and socioeconomic groups [27-30]. Age is associated with the highest variations in health, chronic conditions and mortality. However, gender, marital status and level of education are also important contributors [30]. For instance, diabetes is most prevalent in the lower education group and allergies are most prevalent in the higher education group [31]. In the Netherlands, patients visit their GP on average four times per year. However, patients older than 85 years visit their GP on average 13 times per year [32]. Healthcare use is also influenced by ethnicity, income and education. These particular sociodemographic characteristics differ enormously between populations and areas (see Figures 1 and 2; differences in age and ethnicity at the four-digit postcode level in the Netherlands).

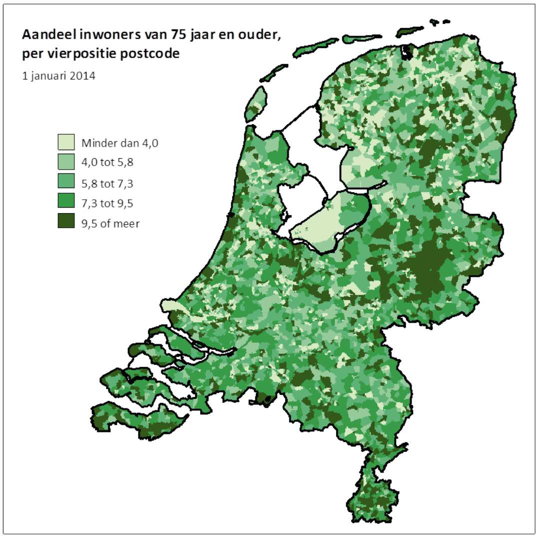

Figure 1: Differences in age at the four-digit postcode level in the Netherlands

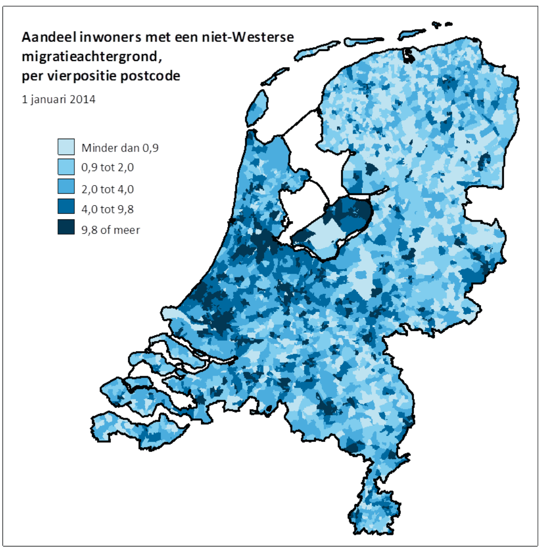

Figure 2: Differences in ethnicity at the four-digit postcode level in the Netherlands

Local differences in health, healthcare needs and healthcare use should lead to adjustments in the local organization of primary healthcare. However, the organization of healthcare is preliminary based on historical assumptions, such as the assumption of 1 FTE GP for 2,350 patients for every area (Box 1). Unfortunately, supply-driven primary care based on historical assumptions will not be able to keep healthcare sustainable for future challenges [33, 34].

BOX 1

From a historical point of view, 1 FTE GP should have a health service area of 2,350 patients. However, in an area of 2,350 residents with a large percentage of patients between 18-30 years old, it may be expected that the patients visit their GP less often than in an area with a large percentage of older people. Nevertheless, more contacts for psycho-social diseases are to be expected in such a younger population, and as a result, fewer GP hours may be needed but more hours for practice support for psycho-social diseases.

The necessity for local data about lifestyle, health and healthcare

Local data about a population's health, lifestyle and healthcare needs are necessary to obtain a better match between healthcare needs and healthcare supply. Local data are data for a geographically small domain, such as at the neighbourhood level or at the four-digit postcode level; in the literature these are referred to as 'small area estimates' [35]. It is important to consider which small area estimates are required by healthcare providers, local governments and other stakeholders in order to support the process towards an integrated population-based healthcare. In a pilot project in cooperation with the Dutch National Institute for Public Health and Environment (RIVM) and one Regional Public Health Service, we concluded that there are large differences between local governments regarding the small area estimates they need, and these differences depend on the stage of integrated population-based healthcare at which each local government operates [36]. In general, local governments required data about the supply, demand, and the match between supply and demand of not only GP care but also other primary care disciplines. They required data about the prevalence of chronic diseases, comorbidity and multimorbidity, as well as data related to the legislation of social support (in Dutch *Wet Maatschappelijke Ondersteuning*). Local governments were also interested in small area estimates about health and lifestyle, which they could use to implement and target preventive interventions [36].

The VTV model is another source of information about the small area estimates necessary to support an integrated population-based healthcare [37]. This model shows the complex relationships between healthcare use, prevention, external developments, policy, health determinants and health (Figure 3). The VTV model was the starting point of our research into which small area estimates on lifestyle and health hold important information that supports local governments in implementing an integrated population-based healthcare. This research is discussed in Chapter 3 of this thesis.

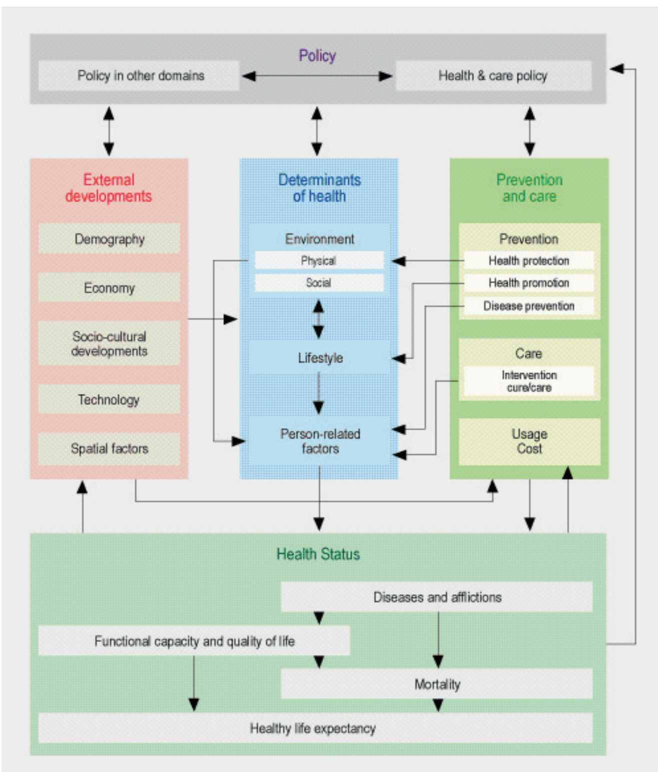

Figure 3: The VTV model: a future exploration model of public health (*Volksgezondheid Toekomst Verkenning model*).

METHODOLOGY

Small area estimates are difficult to obtain

It is necessary to adapt the organization of primary healthcare to the needs of a population, and this results in the need for more small area estimates. Unfortunately, it is difficult to obtain small area estimates and there are several reasons for this. First, most national health surveys are not designed to generate direct survey estimates for small areas: national survey data either do not contain respondents for every small area, the sample size is too small to generate valid estimates, or the sample is stratified to larger areas [38]. Second, local health surveys are costly and as a result they are not routinely updated [39, 40]. Third, if small area estimates are available for some local areas, they are often distributed over fragmented data sources, which makes it difficult to combine and interpret them. Finally, privacy and competition issues play a key role in the availability of small area estimates.

> Different reasons hinder the availability of small area data regarding health

Indirect small area estimates are a powerful alternative

There are two broad methodologies to produce small area estimates, namely direct and indirect estimations. Direct estimations are based on survey samples. However, as stated above, there are some problems inherent to survey samples as they produce small area estimates without sufficient statistical precision, especially for smaller areas. A powerful alternative is the use of indirect small area estimations, which can be calculated using a statistical model or a geographical approach [41, 42]. This thesis focuses on indirect small area estimates based on a statistical model. A statistical model uses auxiliary data at a small area level 'to construct predictor variables for use in a statistical model that can be used to predict the estimate of interest for all small areas' [43 p. 18]. In Chapters 2, 3 and 4 of this thesis, different statistical models are examined to produce small area estimates for four-digit postcode areas in the Netherlands.

In Chapter 2, it is investigated whether a statistical model can be used to generate small area estimates regarding the need for GP care at the four-digit postcode area level. Using auxiliary data at the four-digit postcode level and GP-registered data for a sample of general practices, research was conducted into the question whether it is possible to estimate the need for GP care for every four-digit postcode area in the Netherlands. Can a statistical estimation model turn a small set of data into a large dataset with healthcare estimates for all the four-digit postcode areas in the Netherlands? Figure 4 presents a flow diagram of the innovative strategy.

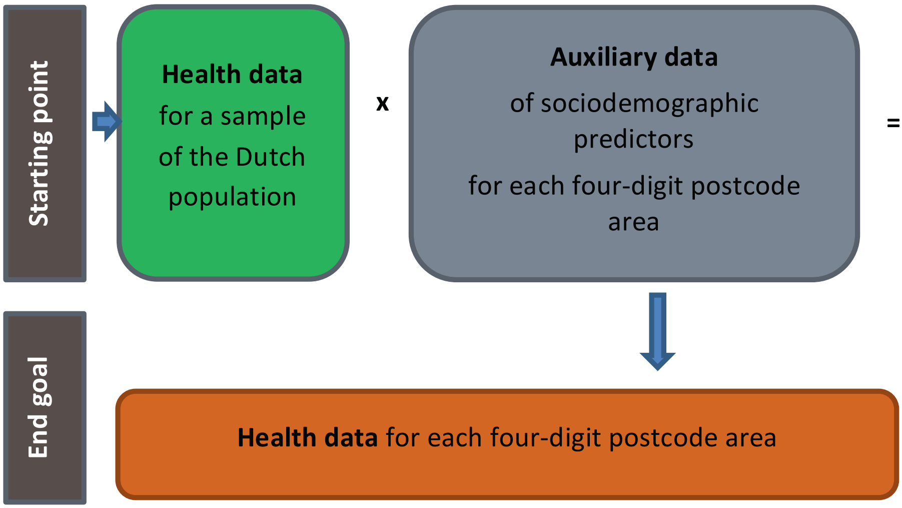

Figure 4: Flowchart of the innovative strategy.

Two main issues were investigated. First of all, research was conducted into whether the two necessary data sources were available and suitable, namely the sociodemographic characteristics at the four-digit postcode area, i.e. auxiliary data, and the healthcare data from national survey data or registered data. In addition, other data requirements that are necessary for small area estimation were researched, including the number of cases needed, the relationship between the auxiliary data and the healthcare data, and whether the data were regularly updated. Second, it was investigated which statistical estimation method was best suited within the technical and statistical constraints of the study. Finally, to study the match between supply and demand, the estimates for GP contact rates were compared with GP supply at the four-digit postcode area. The statistical model was a linear regression model with sociodemographic predictors at the individual and area level. This study was the first in the Netherlands to present an overview, based on a statistical model, of local areas with a higher or lower estimated demand for GP care compared to the local supply of GPs.

Small area estimates regarding lifestyle and health

In Chapter 3, the statistical estimation model is further developed. It was investigated to what extent auxiliary data on sociodemographic characteristics and national survey data on health can be used to calculate small area estimates on lifestyle and health to support local health policy. This study was based on data from the Health Monitors of the Regional Public Health Services in the Netherlands, which provide insight into the lifestyle and the health situation of large geographical areas [44]. If small area estimates on lifestyle and health can be generated from the National Health Monitor, this national monitor can be a useful data source for local governments in their growing role of prevention and health promotion for geographical small areas.

Improving small area methodologies both statistically and technically

As a consequence of an increasing demand for small area estimates and statistical and technical improvements in small area estimation, small area methodologies have been developed extensively in the past decades. Figure 5 presents an overview of the different techniques for small area estimation. Particularly the techniques for indirect model-based estimations are very extensive and advanced [45]. Within the scope of this thesis, it was not possible to apply every new methodological approach due to data and time constraints. In Chapter 4, the statistical estimation model from Chapter 2 and 3 is further developed into a multilevel regression model. It was investigated whether a multilevel regression model could generate more valid small area estimates than the statistical model used in the previous studies. The multilevel model uses two-level predictors, interaction effects and post stratification. This statistical model is an advanced model which requires more advanced data sources, as well as additional time and money. Estimates were validated internally and externally to compare this more advanced method with the simpler statistical models used in the earlier studies of this thesis.

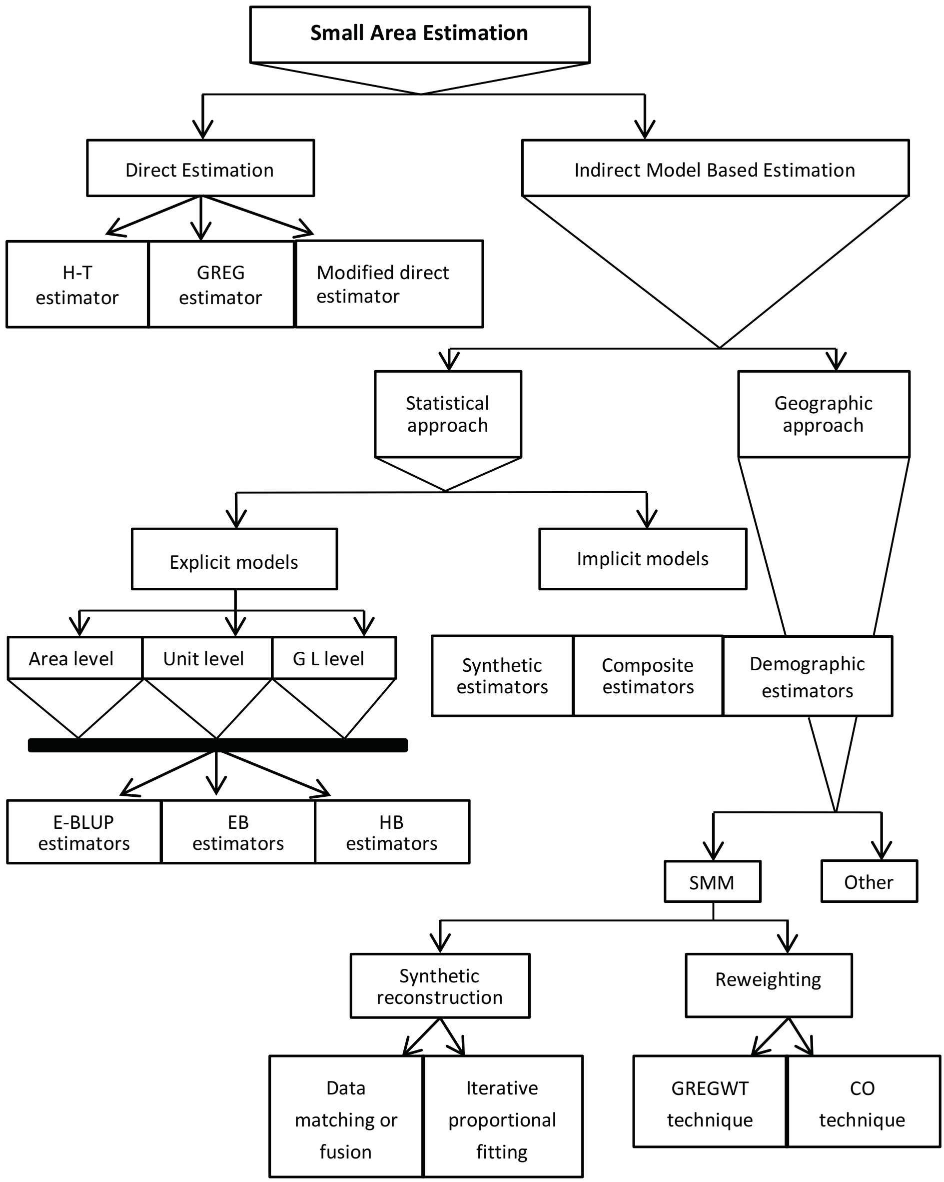

Figure 5: The different small area estimation techniques (Rahman, 2008a).

The influence of practice characteristics on healthcare utilization

It is known from the literature that contributors at the area level and the patient level influence the use of GP care [28, 32]; this may explain the difference between the estimated demand for GP care and the actual use of GP care. However, in addition to area and patient characteristics, supply characteristics also influence healthcare use. Therefore, the discrepancy between the estimates of healthcare needs and the actual healthcare use may also be explained by supply characteristics. In this thesis, it was assumed that a GP's management style also influences the utilization of GP care [46]. For instance, large practices were assumed to be technically better equipped and have more human resources to provide consultation for small surgery than smaller practices, leading to higher utilization rates. In Chapter 5, it is investigated which practice organization characteristics influence the differences between the estimated GP utilization rates and the actual utilization rates of GP care. The small area estimates of the utilization of GP care were again generated with a small area estimation technique.

Small area estimates about the quality of care

Small area estimates on lifestyle, health and healthcare needs provide useful information to match healthcare supply to the healthcare needs of the population. However, this leads to the question whether it is also necessary to match the quality of care to the needs of local populations. Are differences in the preferences regarding the quality of care also based on the sociodemographic characteristics of patients? It is known that the elderly have more GP contacts; however, are their preferences regarding other quality issues in GP care also different to those of younger people? Substantial research has been conducted into patient preferences regarding the quality aspects of GP care [47-53]. The influence of age on the preferences regarding GP care showed different magnitudes [48, 50, 54]. Moreover, one study did not find any relationship at all between age and preference scores and concluded that 'the reason for this is unclear and may relate to a number of factors' [51]. To shed more light on this issue, in Chapter 6 it is investigated whether elderly patients have different preferences than younger patients concerning 58 quality statements regarding GP care, and whether gender, education, perceived health status, healthcare use and degree of urbanization may confound the relationship between age and preference score [55]. The results of this study indicate whether the quality of GP care should be addressed in the production of small area estimates on healthcare needs.

The Demand Supply Monitor for primary care

The small area estimates produced in the different studies of this thesis had to be usable and useful for the Demand Supply Monitor for Primary Care (in Dutch *VAAM*)[56].

Figure 6: The homepage of the Demand Supply Monitor for Primary Care.

In 2005, the Netherlands Institute for Health Services Research (NIVEL) and the Dutch Patient and Consumer Federation (NPCF) initiated an online application with small area estimates regarding the estimated demand, the supply and the match between supply and demand of different primary healthcare disciplines. The main goal of this online application was to give stakeholders insight into the local need for primary healthcare, so as to provide information-input for the discussion about demand-driven primary care. The online application had to be freely accessible with small area estimates at the neighbourhood or four-digit postcode level, its data had to be routinely updated, and it needed to be usable for all the stakeholders in the field of primary care [56-58].

As a result, the generated small area estimates had to be transformed from data into information, eventually creating knowledge for stakeholders in the field of primary healthcare. It was therefore investigated how to present small area estimates in an online application such that it creates value for the people who need it: how could the small area estimates set things in motion? How should the user interface be designed? Would it be necessary to include maps, illustrations and manuals? The answers to these questions were not scientifically investigated; instead, they were based on trial and error, user group feedback and the large number of emails from the users over the past seven years.

MAIN RESEARCH QUESTION

There is a need to strengthen primary care but also an absence of small area estimates regarding lifestyle, health, healthcare needs and healthcare use that can provide crucial information for the discussion between stakeholders. This is why the main focus of this thesis was to calculate, using a statistical approach, small area estimates for every four-digit postcode area in the Netherlands that are useful for the Demand Supply Monitor for Primary Care. The statistical approach needed to take into account the sociodemographic differences between local areas and the influence of these differences on lifestyle, health, healthcare needs and healthcare use. The statistical approach had to be reliable, robust for every data source, as well as understandable, interpretable and reproducible for stakeholders. The necessary data had to be available within the time and financial constraints of the research and had to be routinely updated. The main research question of this thesis was:

Research question

How can we produce reliable and interpretable small area estimates regarding lifestyle, health, healthcare needs and healthcare use for every four-digit postcode area in the Netherlands, based on a statistical approach which takes into account the sociodemographic differences between local areas and the influence of these differences on lifestyle, health and healthcare, in order to support an integrated population-based healthcare?

Sub questions and outline of the thesis

This thesis consists of three parts. The first part, Chapters 2, 3 and 4, discusses the calculation of small area estimates, using different statistical estimation models.

In **Chapter 2**, small area estimates regarding the need for GP care are calculated based on the sociodemographic profile of the area. Second, the estimations are compared with the supply of general practitioners at the four-digit postcode level. It is investigated whether reliable estimates regarding GP care can be calculated using a statistical model, and to what extent the supply of GP care matches the need for GP care in four-digit postcode areas in the Netherlands. This chapter discusses the general statistical estimation method which is also used in the other studies.

In **Chapter 3**, a large national database of lifestyle and health indicators is used to investigate to what extent this database can be used to calculate small area estimates regarding lifestyle and health at the four-digit postcode level by means of a statistical estimation method. These small area estimates regarding lifestyle and health hold necessary information to support local governments and health organizations in preventive interventions, health promotion and healthcare planning.

In **Chapter 4**, a more advanced method is investigated to produce small area estimates regarding the need for GP care. The advanced method is compared to the general statistical estimation method in terms of validity of the estimates and the resources needed to produce the estimates.

The following **sub-questions** are answered in the studies above:

1. Which robust statistical model can be used to calculate reliable estimates regarding lifestyle, health, healthcare need and healthcare use, so as to support an integrated population-based healthcare?
2. Which data and predictors can be used to calculate reliable estimates regarding lifestyle, health, healthcare need and healthcare use, so as to support an integrated population-based healthcare?
3. To what extent does the supply of GP care match the estimated need for GP care at the four-digit postcode level in the Netherlands?
4. What was the validation method used for the calculated small area estimates?
5. Which method was most suitable to produce small area estimates in terms of validity and resources needed?

The second part of this thesis investigates which healthcare organization characteristics influence the discrepancy between the estimated need for healthcare and the actual healthcare use.

In **Chapter 5**, it is investigated which general practice characteristics influence the discrepancy between the need for general practice care, estimated on the basis of the sociodemographic profile of an area, and the actual use of general practice care at the practice level. It is discussed whether variables other than the sociodemographic profile of an area are important contributors to healthcare use and should therefore be considered in the discussion on how to match primary healthcare to the needs of the population. The following sub-questions are addressed in this study:

1. Do practice organization characteristics influence the difference between the estimated need for general practice care and the actual use of general practice care?
2. Should practice organization characteristics be considered in the discussion of an integrated population-based healthcare?

The third part of this thesis investigates whether the quality of healthcare should be adjusted to the characteristics of the population, in the same way as the supply of healthcare is adjusted to the characteristics of the population in quantitative terms .

In **Chapter 6**, it is investigated whether elderly patients have different preference scores regarding the quality aspects of general practice care, and which factors influence the relationship between age and preference score. The results of this study provide information on whether the quality of general practice care, just as the supply of general practice care, should be adjusted to the characteristics of the population. The following sub-question is addressed in this study:

1. Should the quality of general practice care be adjusted to the sociodemographic profile of the patients, so as to support an integrated population-based healthcare?

The final chapter, **Chapter 7**, presents the summary of this thesis and discusses its results, its shortcomings and some recommendations for future research.

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Chapter 2

A decision tool to analyse local demand and local supply for GP care using a synthetic estimation model

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ABSTRACT

Background

This study addresses the growing academic and policy interest in the appropriate provision of local healthcare services to the healthcare needs of local populations to increase health status and decrease healthcare costs. However, for most local areas information on the demand for primary care and supply is missing. The research goal is to examine the construction of a decision tool which enables healthcare planners to analyse local supply and demand in order to arrive at a better match.

Methods

National sample-based medical record data of general practitioners (GPs) were used to predict the local demand for GP care based on local populations using a synthetic estimation technique. Next, the surplus or deficit in local GP supply were calculated using the national GP registry. Subsequently, a dynamic internet tool was built to present demand, supply and the confrontation between supply and demand regarding GP care for local areas and their surroundings in the Netherlands.

Results

Regression analysis showed a significant relationship between socio-demographic predictors of postcode areas and GP consultation time (F [14, 269,467] = 2,852.24; P <0.001).The statistical model could estimate GP consultation time for every postcode area with >1,000 inhabitants in the Netherlands covering 97% of the total population. Confronting these estimated demand figures with the actual GP supply resulted in the average GP workload and the number of full-time equivalent (FTE) GP too much/too few for local areas to cover the demand for GP care. An estimated shortage of one FTE GP or more was prevalent in about 19% of the postcode areas with >1,000 inhabitants if the surrounding postcode areas were taken into consideration. Underserved areas were mainly found in rural regions.

Conclusions

The constructed decision tool is freely accessible on the Internet and can be used as a starting point in the discussion on primary care service provision in local communities and it can make a considerable contribution to a primary care system which provides care when and where people need it.

INTRODUCTION

Responsive primary care

There is a growing academic and policy interest in the appropriate provision of primary healthcare services to the population of local areas to increase health status and decrease healthcare costs [1-3]. Governments and healthcare organisations aim for primary care services that are demand-driven, are easily accessible, locally available and established in accordance with the health criteria of the local population [1,3,4]. However, there are great disparities in the healthcare use of different socio-demographic and socioeconomic groups [5-7]. Therefore, it is a great challenge to match primary healthcare services to the healthcare needs of the local population. Local information on healthcare needs is necessary to gain more insight into these disparities in order to arrive at a better match between demand and supply.

Unfortunately, it is impossible to acquire local health-related data for every local area, and there are several reasons for this. First, most national health surveys are not designed to generate estimates for small areas; national survey data either do not contain respondents for every small area or the sample size is too small to generate valid estimates [8]. Second, local health surveys are costly and, as a result, they are not routinely updated [9,10]. Third, if local health data are available for some local areas, they are often distributed over fragmented data sources, which makes it difficult to combine and interpret them [11].

Spatial microsimulation models

To assist organisations and healthcare providers in the supply of local health-related data, spatial microsimulation models can be used. Spatial microsimulation models have a long history in economics and are increasingly used in epidemiology as an alternative to local health surveys [12]. In short, such models construct large synthetic micro data at the small area level on the attributes of individuals or households by combining different sources of information to 'estimate geographical distributions of variables which were previously unknown' [13], p 1128. There are various types of spatial microsimulation models, varying from models which only construct micro datasets to models which use the constructed micro dataset to build future micro datasets and consider future policy changes [14].

Regarding healthcare issues, micro datasets have been generated for issues such as obesity, mental disorder, access to general practitioner (GP) services and lifestyle behaviour such as smoking and alcohol consumption [9,13,15,16]. Datasets of local health-related data can be used to identify local areas where, for example, the number of people smoking is higher or lower than the national average [9]. These local data could assist policymakers in their decisions regarding the implementation of interventions.

However, for planning purposes it would be more effective if a model incorporated not only the expected demand for care but also the spatial distribution of health services, and thus identified potentially underserved or overserved areas. With this in mind, Morrissey et al. (2008) estimated GP visits in a rural district of Ireland, using a spatial microsimulation model [16]. They assessed whether the spatial distribution of GP services matched the demand at a local level, and they concluded that the demand for GP care was much higher in rural areas than urban areas. However, surprisingly, the accessibility of GP care services was the lowest in these rural areas [16].

In the present study, the work of Morrissey et al. (2008) was expanded [16]. It was investigated to what extent a spatial microsimulation model can be developed and expanded into a dynamic Internet decision tool which can be used to fine-tune the provision of primary care to the demand of the local population for all the local areas in the Netherlands. Not only were underserved or overserved areas identified, but the deficits and surpluses in the number of physicians for the specific areas were also calculated. This article describes how the model was built, what data were used and which method was applied. Moreover, the results of the model are presented and the possible consequences for health policy are discussed. The model generates data regarding almost all primary care disciplines, however, this article focuses on the description of the method and the results in general practice care.

METHODS

Design

As discussed above, local information on the demand of primary care is often missing. One possible solution is to calculate synthetic estimates of local health demand figures by means of a spatial microsimulation model that uses a synthetic estimation technique. This general technique produces health estimates for local areas for which health data are unknown by using health data from other local areas using a model-based approach [8]. For this technique two datasets are necessary: a national census dataset which includes socio-demographic characteristics of local area, and a national sample-based dataset which includes medical record of GPs for a number of local areas. A synthetic estimation technique was used to estimate local demand for GP care. These estimations were subsequently compared to actual GP supply from the national GP registry to assess the match between supply and demand for local areas and their surroundings.

Data collection

Sample based medical record data of GPs from 2008 were obtained from the National Information Network of General Practice (LINH) from the Netherlands [17]. This network is a dynamic pool of practices, geographically well-distributed across the Netherlands, with yearly changes in composition. The data used contain approximately 350,000 patients from 85 general practices. Patients listed in the LINH practices are representative of the Dutch population regarding gender and age. The LINH database contains frequency of GP contacts, gender, age and the postcode of each patient registered by GPs. Of the 85 general practices, 13 were excluded because of incomplete data.

National census data were obtained from *Statistics Netherlands* by postcode [18]. For the present study, postcode area was chosen as geographical unit, because postcode area comes closest to the neighbourhood at which primary care services operate. The average population size of a postcode area is 5,771 inhabitants. Data were collected regarding the total population, the numbers of male and female inhabitants in age categories, the number of one-person households, the number of non-Western immigrants: at least one parent is born in Africa, Latin America or Asia, the number of low-income households: households with a purchasing power of <€9,250 a year, and the degree of urbanisation of the area divided into five categories from rural (<500 addresses per km^2) to very highly urbanized (>2,500 addresses per km^2) [18]. These area characteristics were selected as predictors because they are known to be important determinants of healthcare use [19]. For instance, women visit their GP more often than men and older people also have a higher GP contact rate [20], as do non-Western immigrants [21] and people with a low income [22]. In addition, people living in rural areas make use of healthcare services more frequently [23]. Other important determinants, such as education, are not available by postcode. The area characteristics were linked to patients by patient's postcode.

Information on GP supply in the Netherlands was obtained from the national GP registry for the year 2009 [24]. The GP registry contains characteristics for every GP and GP practice in the Netherlands. The number of GPs, the number of full-time equivalents (FTEs) and the postcodes of the general practices were extracted from this database.

Statistical analysis

To obtain a spatial micro dataset regarding the estimated demand for care, a synthetic estimation technique was used consisting of two main stages (Figure 1). The first stage involved generating a statistical model which represents the relationship between the demand for GP care and the socio-demographic predictors. GP registration data on patient level were linked to national census data by postcode. In the second stage, the statistical model was applied to national census data in order to estimate the demand for GP care for every postcode area.

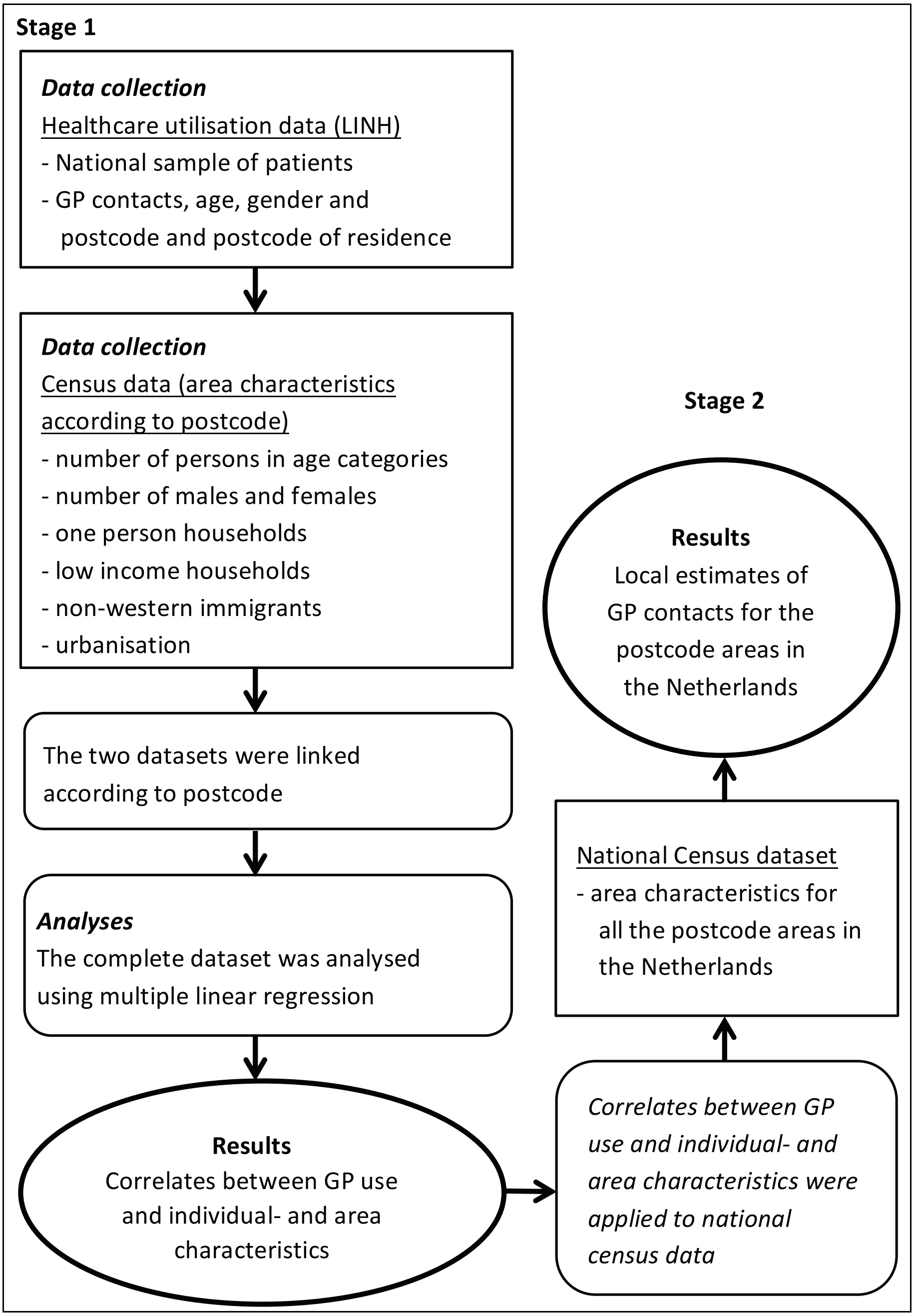

Figure 1. Flow diagram of the methodological approach.

Subsequently, multiple linear regression analysis was conducted between the number of contacts with the GP per listed patient and dummies for 'patients gender and age' (female = 1, male = 0; 0-4 years old, 5-14 years old, 15-24 years old, 25-39 years old = reference category, 40-64 years old, 65-74 years old and 75 years and older), 'proportion one-person households', 'proportion low-income households', 'proportion non-Western immigrants', and dummies for 'urbanisation' of the area (reference category = rural). The annual number of GP contacts was converted into GP consultation time by multiplying it by 10, because an average GP contact takes about 10 min in the Netherlands [25].

Next, the coefficients from the multiple linear regression for the different predictors were multiplied by the number of these predictors in the area to estimate GP consultation time for all the postcode areas in the Netherlands (*n* = 4,033; Figure 2). No results are presented for the 1,260 postcode areas with <1,000 inhabitants. Estimations based on <1,000 inhabitants are not considered reliable. The included postcode areas still covered 97% of the total population. The analyses were performed with STATA 10.0 [26].

> Box 1:
>
> General practice is the formal point of entry into the healthcare system and GPs function as gatekeepers; specialist and hospital care can only be accessed by referral from a GP. In the Netherlands, GP care operates at a neighbourhood level. All residents are registered with a GP practice usually closest to the residence or on a very small distance. The mean distance to a GP is 2.7 kilometres [27]. The mean number of inhabitants per FTE GP is 2,350. the Dutch government does not intervene actively to realize this standard.

$$C_{consultation\ times} = a^* X_0 + b_1 X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6 X_6 + b_7 X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_0 * X_{12} + b_{13}X_0 * X_{13} + b_{14}X_0 * X_{14}$$

$C_{consultation\ time}$	= the number of GP contacts minutes
X_0	= the number of people in the population
X_1	= the number of women in the population
X_2	= the number of 0–4 years old in the population
X_3	= the number 5–14 years old in the population
X_4	= the number 15–25 years old in the population
X_5	= the number 40-64 years old in the population
X_6	= the number 65–74 years old in the population
X_7	= the number 75-years old and older in the population
X_8	= the number non-Western immigrants in the population
X_9	= the number of one-person households in the population
X_{10}	= the number of low-income households in the population
X_{11}	= low urbanisation
X_{12}	= moderately urbanised
X_{13}	= strongly urbanised
X_{14}	= very strongly urbanised

$C_{consultation\ time} / X_0$ = the number of GP contact minutes per inhabitant

Figure 2. Mathematical model for the expected GP consultation time in minutes per inhabitant.

Confronting supply and demand

Two parameters were computed as indicators for the match between demand and supply:

1. The expected consultation time per available GP; this indicates the amount of work for the GPs in the postcode area given the local population.

2. The number of FTE GP too much/too few to reach the national average of 7,743 contacts per FTE GP per year. This is an indicator for under- and oversupply. According to the norm, the average FTE GP in the Netherlands has approximately 2,350 patients [24] and the average patient has a GP consultation time of 31.8 min per year [17]. This results in a standard workload for an FTE GP of 74,730 min consultation time.

The two parameters were computed at the level of the postcode area itself and at the level of the postcode area including surroundings. This has been done because not everyone visits the GP in his own postcode area. Therefore, undersupply in the postcode area can be compensated by oversupply in the surrounding area. For this reason, the surrounding postcode areas situated at 3 km or less by road were also analysed for the supply and demand of GP care. In 2004, the mean distance from a patient to his own GP practice was 2.7 km in the Netherlands [27]. This number was rounded up to 3 km because this distance was not measured from the patients' actual addresses but from the centre of their postcode area. The analysis was conducted with Mapinfo Professional. In the Netherlands, general practice is the formal point of entry into the healthcare system and GPs function as gatekeepers; specialist and hospital care can only be accessed by referral from a GP. In the Netherlands, GP care operates at a neighbourhood level. All residents are registered with a GP practice usually closest to the residence or on a very small distance. The mean distance to a GP is 2.7 kilometres [27]. The mean number of inhabitants per FTE GP is 2,350. the Dutch government does not intervene actively to realize this standard.

RESULTS

The results of the multiple regression analysis are presented in Table 1. The regression analysis showed a significant relationship between the predictors of the model and GP consultation time (F [14, 269,467] = 2,852.24; P <0.001). The model explained 12.9% of the variation in the dependent variable. The results revealed that 11 variables were significant predictors of GP consultation time. The strongest predictors of the number of GP contact minutes were '75 years and older' (B = 55.1, P <0.001) and '65-74 years old' (B = 25.5, P <0.001).

Table 1. Regression coefficients for annual GP consultation time in minutes.

	b	Lower bound 95% CI	Upper bound 95% CI
Constant[a]	15.33892[b]	14.42749	16.25035
Female	11.92347[b]	11.59783	12.2491
0-4 years	0.411849	-0.354851	1.178549
5-14 years	-9.006723[b]	-9.596515	-8.416931
15-24 years	-3.599869[b]	-4.183009	-3.016729
40-64 years	7.796694[b]	7.345136	8.248252
65-74 years	25.50999[b]	24.814	26.20598
75 years and older	55.09777[b]	54.35037	55.84517
Proportion non-Western immigrants	9.313317[b]	7.663707	10.96293
Proportion one-person households	-2.330715	-4.831568	0.170138
Proportion persons in low-income households	18.94194[c]	15.96651	21.91738
Low urbanisation	-1.031837[b]	-1.567949	-0.495726
Moderately urbanised	0.153963	-0.426263	0.734188
Strongly urbanised	-0.579397[c]	-1.158326	-0.000468
Very strongly urbanised	-3.874945[b]	-4.837014	-2.912876

[a]Constant = male, 25-39 years, no non-Western immigrants, more person household, no low income, no urbanisation.
[b]*P* <0.01.
[c]*P* <0.05. CI, Confidence intervals; r^2 = 12.9%.

GP demand

The results of the mathematical model (Figure 2) showed an average GP consultation time per postcode area of χ = 183,650 (SD = 122,944) and per inhabitant per year of χ = 31.9 (SD = 3.6). The postcode area with the lowest expected GP consultation time (χ = 21.6) had a low percentage of low-income households, a low percentage of one-person households, a low percentage of people older than 65 years and a low level of urbanisation.

GP supply rates

The mean number of FTE GPs was highest in strongly urbanised postcode areas (χ = 3.8; SD = 3.0) and lowest in rural postcode areas (χ = 1.8; SD = 1.9).

Confronting supply and demand

The comparison between expected GP consultation time based on the socio-demographic profile of the postcode areas and actual GP supply revealed a shortage of GP supply for 54% of the postcode areas, if an average workload of 74,730 contact min per FTE GP was assumed. The total shortage for these areas was 1,653 FTE GP. A GP shortage >1 FTE was prevalent for about 20% of the postcode areas with a total of 4 million inhabitants.

The results of the surrounding analysis showed a shortage of GP supply for 46% of the areas, so for 8% of the postcode areas there is compensation. A shortage >1 FTE was indicated in 19.0% of the postcode areas. Together, these areas had a total shortage of 1,417 FTE GPs for >3 million people.

The expected workload per FTE GP in the Netherlands was 76,360 contact min a year (SD = 47,869). When the surrounding areas were taken into consideration the mean expected workload per FTE GP was 75,617 contact min per year (SD = 40,754). Table 2 relates different classes of GP workload to the proportion of the Dutch population and shows a large variation in the workload of GPs. The majority of the Dutch population lives in a postcode area with a workload of 50,000-100,000 GP contact min. However, the surrounding analysis showed that, respectively, 8.6%, 3.0% and 0.4% of the Dutch population live in a postcode area with a higher workload than the norm workload. Moreover, 4.9% of the Dutch population have no GP in their postcode area and surrounding area.

Table 2. Distribution of Dutch postcode areas and population over classes of expected workload.

	For postcode areas with >1,000 inhabitants (*n* = 2,773)		For postcode areas (*n* = 2,773) and their surrounding areas	
Workload: Annual GP consultation time (min)	Postcode areas (%)	Inhabitants of the total Dutch population (%)	Postcode areas (%)	Inhabitants of the total Dutch population (%)
8,000-50,000	21.0	17.9	13.2	8.6
50,000-100,000[a]	40.0	47.1	62.6	71.5
100,000-150,000	9.4	12.9	7.2	8.6
150,000-300,000	4.4	5.7	2.9	3.0
300,000-500,000	0.4	0.7	0.4	0.4
No GP	24.8	12.7	13.7	4.9

[a] The norm workload for a Dutch GP is 74,730 min per year

The average shortage/surplus in FTE GP per postcode area including surroundings was 0.67 (SD = 3.4). So, overall there was no shortage in FTE GP supply when GP supply was confronted with the estimated GP consultation time based on the socio-demographic composition of the postcode areas. However, GP supply was unequally dispersed over the expected demand for GP care. Table 3 shows the percentage of the shortage or surplus in FTE GPs related to the number of FTE GPs needed to cover the expected demand in postcode areas and their surroundings. The resulting shortage or surplus is represented for areas with different population sizes. The mean percentage surplus in FTE is 0.23%. Areas with the fewest inhabitants showed the largest percentage of shortage in FTEs. Most of these areas were rural areas. In contrast, areas with the highest numbers of inhabitants had the largest percentage of surplus in FTE GPs. This indicated that urban areas probably compensate the shortage in rural areas.

Table 3. The percentage shortage/surplus in FTE GPs for different area sizes including the surrounding areas (*n* = 2,773).

Residents class	Mean FTE GP needed based on the expected demand for GP care	Actual mean FTE GP supply	Mean % shortage/surplus in FTE GP based on needed GP care*	Postcode (*n*)
1,000-2,500	0.70	0.60	-18.9	553
2,500-5,000	1.58	1.67	5.89	372
5,000-7,500	2.66	2.68	-0.23	251
7,500-10,000	3.84	3.87	0.19	199
10,000-15,000	5.38	5.69	5.19	289
15,000-20,000	7.54	7.91	4.93	200
20,000-30,000	10.49	10.75	2.93	340
>30,000	25.74	28.59	9.59	569

Mean percentage shortage/surplus in FTE GP = ((FTE GP - needed FTE GPs)*100)/FTE GPs needed for every postcode area including the surrounding areas.

DISCUSSION

The distribution of GPs is usually based on the number of inhabitants in an area, on the attractiveness of the area for GPs regarding work opportunities or personal factors. However, this may lead to underserved or overserved areas [29], while governments aim for primary care services which are locally available and accessible. This study presents the method and the results of a decision tool which not only makes it possible to analyse the estimated demand and the supply of GP care, but also the confrontation between supply and demand for GP care for local areas in the Netherlands. The results showed that the constructed model could estimate GP consultation time for every area with >1,000 inhabitants in the Netherlands covering 97% of the total population. Confronting these estimated figures with the actual GP supply resulted in the average GP workload and the number of FTE GP too much/too few for local areas to cover the demand for GP care. If the surrounding postcode areas were taken into consideration, 19% of the areas had a shortage of 1 FTE GP or more. According to our results, underserved areas were mainly found in rural regions. Our findings confirm previous research which concluded that rural areas often suffer from a lack of primary care [30,31]. A surplus in the number of FTE GPs was prevalent in areas with the highest numbers of inhabitants. This indicates that urban areas probably compensate the shortage in rural areas.

Unmet healthcare leads to undesirable consequences: patients are forced to travel greater distances to a GP practice and/or experience longer waiting times before they are seen by a physician. Accessibility problems of GP care may lead to higher utilisation of hospital care, which is more specialised and more expensive, without seeing a GP first [32]. Teljeur et al. (2010) reported that a 1% shortage in GP care supply may result in a 2.4% increase in the demand for hospital care [32]. Therefore, governments and healthcare organisations are being stimulated to promote and facilitate local GP care. Primary care that is available locally enables people to control their own health conditions and prevent diseases; eventually, this may lead to a lower demand for healthcare [33]. Moreover, Pierard (2009) concluded that a larger number of GPs was positively correlated with better health outcomes [34]. However, it needs to be mentioned that a higher supply of physicians may also lead to unnecessary healthcare use.

A flexible GP care system, which is responsive to the demand of the population, is essential to overcome the health problems related to an ageing population and an increase in chronic diseases (National Health Reform, Commonwealth of Australia, 2011). The decision tool presented here is a powerful tool to make both GP care and other primary care disciplines more responsive to the demand of the population. At present, healthcare planners usually base their interventions on national or regional data. The micro level is often overlooked, simply due to a lack of data. Our decision tool can expose geographical differences in the demand for and the supply of primary care; thus, our tool provides health planners with information for the design and implementation of their interventions, like the geographical position of a general practice or a disease specific health plan for a local area. The decision tool also exposes local areas with an expected oversupply or undersupply of healthcare providers. The tool is freely accessible on the Internet and provides demand estimates for GP care, chronic disease care, physiotherapy, dietetics, psychological care, pharmaceutical care and midwifery care. It also provides supply figures for GPs, physiotherapists and midwiferies. Users can select different areas for which they search information and they are also able to download reports. The tool has an average of 2,000 visitors a month. Most users work for regional facility organisations for primary care, local governments, healthcare centres or insurance companies. The usefulness of the decision tool is influenced by the validation of the model. The constructed model could explain almost 13% of the variance in GP consultation time. It should be noted that the dependent variable was only specified by predictors that are available at a local level for every postcode area in the Netherlands and are updated regularly by *Statistics Netherlands*. The construction as well as the validation of the model is thus restricted by the availability of local predictors. The explained variance could be increased if, for example, information about level of education and lifestyle factors is gathered at a local level and added to the model. Despite the absence of these predictors, the level of explained variance for the number of GP contact minutes can be regarded as acceptable. A previous version of the decision tool has been validated externally using local health survey data from the city of Utrecht from 2003-2006. The study concluded that the Pearson correlation between the two datasets on GP contact was 0.68 [28]. This is a reasonable degree of conformity, especially considering the fact that previous research concluded that the two methods could lead to substantial differences [35].

In our study, the analysis of the geographical differences in the demand for GP care is based on estimated rather than real data, because GP registration data are only available for a small sample of the postcode areas in the Netherlands. In our method, the local demand was estimated based on the composition of the population. So, differences in the estimated demand for GP care between areas could only be explained by the population demographics and the urbanisation of the area and not by GP supply, such as availability and accessibility of GP practices or quality of services. This may be seen as an advantage, because actual healthcare use is influenced by health supply issues. For instance, a large number of GPs in the area may induce healthcare use.

Moreover, not only supply issues may influence actual healthcare utilisation but also different barriers for subgroups in the population to access healthcare such as financial or geographical issues. However, the GP registration data used in this study reflects the national average for healthcare demand for those different subgroups. Still, when interpreting the results of the decision tool, users should always take into account both the local context and their own experience. The decision tool must be seen as a starting point for analysing supply and demand in a region. Additional data should be added to analyse the situation more deeply.

The level of analysis for the present study was postcode level. The classification in postcode areas has been chosen because the supply rates for GPs could only be obtained at postcode level and patients could only be linked to the area characteristics using the postcode of the area. In addition, a study by Reijneveld et al. (2000) showed that there was hardly any difference between the health requirements in deprived and non-deprived areas, regardless of the geographical classification used [36]. In short, we do not believe that the use of postcode level has had a substantial influence on our results.

To decrease the influence of border-crossing to visit a GP, the demand and supply figures of the postcode areas within 3 km of the practice were included in the analysis. However, the distance of 3 km may be considered arbitrary, especially as there are substantial differences between rural and urban areas in the distances between residents and their healthcare providers [37]. In the next update of the decision tool, different distances will be used for urban and rural areas in the analysis of the surrounding areas.

Our study also has some clear strong points. No self-reported data about GP contact were used in the analysis as these may bias the number of visits to the GP. Moreover, the level of analysis of the present study was at micro level. Other studies often analyse at regional or even at national level and extrapolate the means to lower geographical levels, thus neglecting local differences. Furthermore, the method of our study makes it possible to estimate future ratings for the demand for GP care (results not shown in this article). For this reason, the socio-demographic profile of the postcode areas was compiled using predicted figures.

Another clear strong point of the constructed decision tool is the way in which data about primary care are combined, analysed, enriched and made freely accessible. This makes it possible to have an informed discussion about primary care workforce planning in the Netherlands. Moreover, in other countries where local health data are not readily available, the method of the decision tool can also be used. National health and census data should be available and the assumed average workload must be adapted to the country in question.

For further improvements to the constructed decision tool, research needs to be conducted into the factors that could explain the differences between estimated and actual GP contact. Possible explanations may be found at the individual level of patients, the individual level of the healthcare provider, but also at the organisational level of the practice or even in the infrastructure of the practice area; a lack of public transport and/or safe pedestrian walkways may influence access to the GP practice for elderly people. Moreover, to cope with the differences between estimated and actual GP contact, the variable 'perceived health of the population' could be used as a measure of the need for healthcare. Adding this measure to the decision tool in the future may give more insight into accessibility and availability issues regarding healthcare. Furthermore, plans have been made to integrate other models of healthcare services into the decision tool, such as elderly care and the shift from secondary care to primary care. Also, the statistical analysis can be improved by using a hierarchical regression model, a count model and only using local variables to predict the local demand for care. In the future, we are able to use a more sound statistical model because we are then in the possession of a larger dataset with more respondents per postcode area. Despite the fact that our statistical method can be improved in the future, we do not believe that our method resulted in unreliable outcomes, as the validation study did show [28].

Finally, further research should be undertaken into the implementation of the decision tool and its effect on the way GP care and other primary care disciplines have been organised and whether the amount of underserved areas have diminished as a result.

Conclusions

This study addresses the growing academic and governmental interest in the appropriate provision of healthcare services to the population of local areas. The constructed decision tool can make a considerable contribution to a primary care system which provides care when and where people need it.

For the results in the other disciplines, the reader is referred to www.nivel.nl/vaam (a website in Dutch) or to the report with an extensive description of the method used [38-39].

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Chapter 3

Supporting local health policy by using small area estimates about health and lifestyle

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ABSTRACT

Background

In the Netherlands, the Health Monitors of the Public Health Services mainly give insight into the health and lifestyle situation of large geographical areas, such as regions and municipalities. However, due to changes in health policy, there has been a shift in focus towards care and support in smaller areas. As a result, small area data are required regarding health and lifestyle. This study investigated the extent to which census data can be used to estimate small area data on health and lifestyle, so as to support local health policy.

Method

Local health surveys collected by 24 Public Health Services in the Netherlands were used to obtain data on the respondents' health, lifestyles and four-digit postcodes. From this dataset, 16 health and lifestyle indicators were selected. The mean score for each indicator was calculated at the four-digit postcode level for areas with at least 100 respondents. Subsequently, census data (e.g. gender, age, low-income status, household, degree of urbanization) were matched with the postcode. Regression analyses were used to investigate to what extent the 16 indicators at the four-digit postcode level were associated with census data for the four-digit postcode. The explained variance of the models and the correlations between the predictions and the sample data were used to analyse the usefulness of the small areas estimates.

Results

The regression models showed an average explained variance of 25%. The indicator 'moderate/poor perceived health' had the highest explained variance. The correlations between the small area estimates and the direct estimates from the health survey at the postcode level was r=0.51 (min=0.27; max=0.63).

Conclusion

Small area estimates provide the possibility to make a first draft of the local health and lifestyle situation, based on the sociodemographic composition of an area. The census data explained approximately 25% of the variation in

the local health and lifestyle situation. Local governments may use these estimates to identify small areas with a possible low health status and inhabitants with an unhealthy lifestyle, and subsequently focus more on these areas in their health policy.

MAIN FINDINGS

- The sociodemographic profile of an area, such as the percentage of low-income households, the percentage of one-person households and the percentage of non-Western immigrants, account for approximately 25% of the variation in the health and lifestyle situation among different four-digit postcode areas.
- Census data could be used to calculate small area estimates regarding health and lifestyle in a relatively straightforward manner.
- Small area estimates regarding health and lifestyle at the four-digit postcode level are useful to support local health policy.

BACKGROUND

There are geographical variations in health characteristics [1], which is why healthcare and health support services should be organized and focussed on the healthcare needs of local populations, i.e. there should be population-based healthcare [2, 3]. The overarching goals of population-based healthcare include better care for individuals, better health for populations, and lower costs [4]. In addition, a better balance between cure and prevention is desired to keep healthcare cost-effective and of good quality [2, 3]. To support the goals of population-based healthcare, small area data about health and healthcare needs are becoming increasingly important [1].

In the Netherlands, local health policy should be based on epidemiological analyses [5, 6], which are conducted by Public Health Services and presented in a Health Monitor [7]. The Health Monitor presents health figures for large geographical areas such as municipalities and regions. As a result, the data in the Health Monitor are not specific enough to support the goals of population-based healthcare. Sample designs are a well-known method for producing small area data. However, such designs are exceedingly expensive and privacy issues often hamper the use of these data for local health policy.

A powerful alternative to sample designs is the small area estimation method (SAE), which is a general technique used to calculate small area estimates based on a statistical model [8]. The SAE method uses census data at an individual or aggregated level as predictors of the estimate of interest for all local areas [9]. In the Netherlands, the SAE method has been used to calculate estimates of the demand for primary care for every four-digit postcode area. The demand for care has been estimated based on the census data of an area and the national registration data of healthcare providers. The estimated small area data have been presented as the estimated contact rate per healthcare provider and the estimated contact rate by type of disorder in a monitor which is freely accessible [10, 11].

In the present study, we used a SAE method to investigate to what extent census data can be used to calculate small area estimates regarding health and lifestyle, using the data in the Health Monitor as an approximation of the healthcare needs in an area. Adding local level estimates regarding health and lifestyle to existing estimates of the demand for care provides local governments with useful information in their growing role in healthcare. Moreover, estimates regarding health and lifestyle can assist institutions that organize healthcare to make informed decisions about the best way to adjust the supply of care to the health situation of local populations.

METHOD

Design

Small area estimates regarding health and lifestyle were calculated using the SAE method, which is a model-based approach. Linear regression analysis was used to calculate the association between on the one hand health and lifestyle indicators and on the other hand the sociodemographic profile for the smallest geographical area for which this is possible, taking into account the numbers in the sample of the Health Monitor. The geographical level in this study was the four-digit postcode area. Subsequently, the health and lifestyle situation for all four-digit postcode areas was estimated by extrapolating the model coefficients to the sociodemographic profile of all four-digit postcode areas. The usefulness of the estimates was tested by the explained variances of the models as well as the Pearson correlations between the survey direct estimates from the Health Monitor and the small area estimates calculated using the SAE method.

Data

From Statistics Netherlands, the census data for the year 2013 were obtained at the four-digit postcode level. Data were collected for the following categories: total population; male and female in different age categories; one-person households; non-Western immigrants; at least one parent born in Africa, Latin America and or Asia; low-income households; households with a purchasing power of less than €9,250 euros a year; and the urbanization level of the area divided into five categories. These area characteristics were selected as explanatory variables, because they are available at the four-digit postcode level but especially as they are important determinants of healthcare use [12].

Data on health, lifestyle and four-digit postcode were derived from local health surveys collected by 24 Public Health Services in the Netherland and presented in a Health Monitor. The local health surveys were sent to random samples, mostly stratified to municipalities of residents aged 19-65 years selected from the municipal administrations in 2008 or 2009. In a previous study, 16 health and lifestyle indicators were selected from this dataset [13] (Table 1). These indicators are all dichotomous variables. Subsequently, the mean score for every indicator was calculated at the four-digit postcode level, based on the respondent's four-digit postcode. Next, census data were matched to postcode level. In the end, there were 3,086 postcode areas with health, lifestyle and census data. In 2009, there were a total of 4,018 four-digit postcode areas in the Netherlands.

Analyses

The analyses were conducted using STATA 13.1. Linear regression analysis was used to establish the associations between the health and lifestyle indicators and the census data, i.e. the sociodemographic predictors at the four-digit postcode level. For this reason, the dependent variables were transformed to the logit scale. The dependent variables are proportions with values ranging from 0 to 1, for which the values 0 and 1 hardly occur. Four-digit postcode areas were analysed as to whether they had at least 1,000 residents and whether data of at least 100 respondents were available per indicator, so that reliable proportions of the dependent variables could be analysed. The regression models included all the sociodemographic predictors: the percentages of males and females in different age groups (19-25, 40-54, 55-64), the percentages of one-person households, non-Western immigrants, low-income households, as well as urbanization level, which was dummy-coded. No selection procedure was applied. The predictor male aged 25-39 was excluded from the model due to collinearity. The explained variance of the models shows the extent to which the sociodemographic predictors can explain the variability of the transformed dependent variables between the four-digit postcode areas.

The model coefficients of the linear regressions were applied to the sociodemographic profile of all four-digit postcode areas, in order to estimate the health and lifestyle indicators for all postcode areas (see Box 1 for the formula). Subsequently, an inverse logit transformation was used to transform the estimations back. The coefficients can be interpreted as odds ratios. The odds ratio is the number by which the estimated odds for an area will be multiplied if the predictor increases by one percentage and all the other predictors stay the same. For the predictor 'urbanization', the odds ratios show the numbers by which the odds will be multiplied if one of the categories is compared to the reference category and all the other predictors stay the same. Then, Spearman correlations were calculated between the direct estimates from the health survey and the small area estimates for the four-digit postcode area.

To gain a better understanding of the results, they were also analysed using linear regression with no transformed dependent variables. The coefficients are then the difference in percentage per unit of the predictor (see Box 2 for the formula).

RESULTS

For the indicators 'physically disabled' and 'drug use', there were too few observations for analysis. Table 2 presents the results of the linear regression analysis for the indicator 'moderate/poor perceived health' (*F* [14, 399] = 27.04 p<0.001), a summary measure of the subjective health status of a population [13]. The coefficients are presented per percentage. The predictors 'non-Western immigrants' (*B*=0.013, *p*=0.00, 95% CI [0.008, 0.018]), 'one-person households' (*B*=0.013, *p*=0.00, 95% CI [0.007, 0.019]) and 'low-income households' (*B*=0.44, *p*=0.00, 95% CI [0.036, 0.053]) have a significant relationship with the dependent variable. It could be concluded from the other models that the predictors 'non-Western immigrants', 'low-income households', 'one-person households' and the various gender-age categories are significant predictors of the health and lifestyle status at the four-digit postcode level (Table 3).

Table 3 also shows the explained variance for the different indicators and the Spearman correlations. The explained variance ranges from 3.5% to 46.9%, with a mean variance of 25.5%. The indicator 'moderate/poor perceived health' has the highest explained variance (r^2=46.9). The indicators 'chronic conditions', 'more than one chronic condition', 'smoking', 'overweight' and 'a high risk of anxiety or depression' have an explained variance of more than 30%. The indicators 'physical inactivity', 'hypertension', 'asthma', 'heavy smoking' and 'underweight' have an explained variance of less than 20%. In particular 'physical inactivity' and 'underweight' are barely associated with the sociodemographic predictors in this study. The mean correlation between the direct estimates from the health survey and the small area estimates at the four-digit postcode level is *r*=0.51.

The results of the linear regression without transformed dependent variables are shown in Tables 4 and 5; these are similar to the results of the linear regression with logit transformed variables. The same predictors are significant for the indicator 'moderate/poor perceived health'. The mean explained variance is 28% instead of 25%. The mean Pearson correlation between the direct estimates from the survey and the small area estimates at the four-digit postcode level is *r*=0.51, which is equal to the Pearson correlation of the first analysis.

CONCLUSION

Main findings

In the present study, we used the SAE method to investigate the extent to which census data could be used to calculate small area estimates regarding health and lifestyle based on data from the Health Monitor, a database which presents data only for larger geographical areas such as municipalities and regions. We used linear regression models to establish the relationship between census data and health and lifestyle indicators at the four-digit postcode level. The mean explained variance for the 14 analysed indicators was approximately 25%. The models of nine indicators had an explained variance ranging from 20% to 47%; these indicators yield a moderate to good association between the sociodemographic profile and the health and lifestyle situation of an area. The highest explained variances were for the indicators 'moderate/poor perceived health', 'one chronic condition', 'more than one chronic condition', 'smoking', 'overweight' and 'a high risk of anxiety or depression'. There was a weak association between the indicators 'physical inactivity' and 'underweight' and the sociodemographic profile of an area. Apparently, there are other predictors outside the investigated sociodemographic profile that influence these indicators. The mean correlation between the survey direct estimates and the small area estimates for the four-digit postcode level was *r*=0.51.

Discussion

There are great sociodemographic inequalities between areas, which in turn lead to large health differences between areas and populations [14, 15]. It is necessary to obtain more detailed data and knowledge about these health disparities in order to support local governments in their growing role in healthcare and social support services. In the Netherlands, local governments are more than ever responsible for preventive care, social support, care for younger people and the availability and organization of primary care [16]. The results of this study indicate that there is a moderate association between most of the investigated health and lifestyle indicators and the sociodemographic profile of an area. Census data at the four-digit postcode level, which are relatively easy to acquire, can be used to calculate health and lifestyle estimates for four-digit postcode areas. If there are no small area data on health status and lifestyle, the small area estimates based on the sociodemographic profile are a first indication of possible health inequalities between four-digit postcode areas. Moreover, if such small area data are available, the comparison with the small area estimates indicates whether a four-digit postcode area scores better or worse than expected based on the sociodemographic profile of an area. As such, the estimates can be the start of a discussion between local governments, Public Health Services and primary care organizations about the supply of healthcare, preventive care and social support at a local level. Therefore, here we present the estimates for the four-digit postcode level, a small geographical level similar to the geographical level of neighbourhoods and districts.

Strengths and limitations

The census data investigated explained approximately 25% of the variance in health and lifestyle among local areas. This is acceptable if we take into consideration that our method is relatively easy to apply. However, a large part of the variance is still left unexplained. Besides the fact that social behaviour such as drinking, smoking and inactivity is difficult to predict, our model could be extended with other predictors to explain more of the variance. For instance, our model does not contain all the sociodemographic predictors which are associated with health and lifestyle. One important missing predictor is the level of education. Winkelby and Jatulis (1992) concluded that education is the strongest social economic status predictor of cardiovascular disease risk factors [17]. However, educational level is not available at the four-digit postcode level in the Netherlands. Also, other predictors regarding the physical environment, such as the amount of greenery in the neighbourhood, influence health and lifestyle and are not included in the model. For further research into the calculation of small area estimates we should investigate more sources for predictors at the four-digit postcode level. Another limitation was that our health data sample consisted only of respondents aged 19-64 years. To support local governments, for instance, in their role of care provider for younger people, it would have been desirable if our sample had also included respondents younger than 19 years old.

Our study is one of the first studies in the Netherlands that has investigated the calculation of small area estimates for all the four-digit postcode areas and that can provide organizations with important data about health and lifestyle at a small geographical level, presented in a freely accessible monitor. In addition, our study used two large datasets, which is another strong point. The first dataset was a national survey on health and lifestyle at a regional level. These data could, without any extra cost, be transformed into small area estimates. The second dataset is a national census dataset, which is updated annually by Statistics Netherland. Moreover, we were able to investigate as many as 14 indicators regarding health and lifestyle, rather than just a few indicators. In sum, the small area estimates about health and lifestyle calculated in this study are an important source of information which can support local health policy, especially because small area data are not always available. Health survey data which are normally presented at a large geographical level can now be used to calculate estimates for smaller geographical areas, such as the four-digit postcode level.

Table 1. The 16 selected health status and lifestyle indicators from the Health Monitor.

Category	Indicators
Health status	Moderate /poor perceived health
	Self-reported high risk of anxiety and depression
	Self-reported chronic condition; diagnosed or not diagnosed by a physician
	Self-reported two or more chronic conditions; diagnosed or not diagnosed by a physician
	Self-reported diabetes; diagnosed or not diagnosed by a physician
	Self-reported hypertension; diagnosed or not diagnosed by a physician
	Self-reported asthma; diagnosed or not diagnosed by a physician
	Self-reported disability in daily life; diagnosed or not diagnosed by a physician (hearing problems, sight problems, and mobility problems and restrictions ADL selection)
	Underweight (BMI <= 18)
Lifestyle indicators	Overweight (moderate BMI> = 25)
	Obesity (BMI> = 30)
	Current smoker
	Heavy smoker (more than 21 cigarettes per day)
	Excessive alcohol consumption (men drink more than 21 glasses of alcohol per week, women drink more than 14 glasses of alcohol per week)
	Physical inactivity (the norm: 5 days a week 30 minutes of moderately intense activity)
	Drug use (hard and soft drugs)

Box 1. Mathematical model for linear regression analysis with logit transformation.

y= proportion moderate/poor perceived health

The dependent variables are transformed to the logit scale:

$$y' = logit(y) = ln\left(\frac{y}{1-y}\right)$$

(ln= natural logarithm)

Next, the association between the transformed dependent variables (y') and the predictors are calculated using linear regression.

The estimated value for the dependent variable for a four-digit postcode area (y') is calculated by entering the coefficients from the model and the corresponding x-scores for a particular four-digit postcode area in the formula:

$\hat{y}'=b_0+ b_1 * X1 + ... +b_{14}*X14$

b_0	constant			-4.267	=	-4.267
X_1=	percentage of males 20-24 years	6.1	x	-0.039	=	-0.2379
X_2 =	percentage of females 20-24 years	8.2	x	-0.03	=	-0.246
X_3=	percentage of females 25-39 years	10	x	0.002	=	0.02
X_4=	percentage of males 40-54 years	13.8	x	-0.007	=	-0.0966
X_5=	percentage of females 40-54 years	14.7	x	0.01	=	0.147
X_6=	percentage of males 55-64 years	18.3	x	0.017	=	0.3111
X_7=	percentage of females 55-64 years	19	x	-0.006	=	-0.114
X_8=	percentage of non-Western immigrants	24.4	x	0.013	=	0.3172
X_9=	percentage of one-person households	62.6	x	0.013	=	0.8138
X_{10}=	percentage of persons in low-income households	40.9	x	0.044	=	1.7996
X_{11}=	low urbanization	0	x	0.009	=	0
X_{12}=	moderately urbanized	0	x	0.041	=	0
X_{13}=	strongly urbanized	0	x	-0.008	=	0
X_{14}=	very strongly urbanized	1	x	-0.062	=	-0.062
						-1.6148= $\hat{y}'$

The result (Y') is converted by means of an inverse logit transformation to the predicted proportion.

Predicted proportion = exp(-1.6148)/(1+exp-1.6148))

$\hat{y}$=16.6

Box 2. Mathematical model for linear regression analysis without logit transformation

y= proportion moderate/poor perceived health

The association between the transformed dependent variables (y') and the predictors are calculated using linear regression.

The estimated value for the dependent variable for a four-digit postcode area (y') is calculated by entering the coefficients from the model and the corresponding x-scores for a particular four-digit postcode area in the formula:

Formula $\hat{y} = b_0 + b_1 * X1 + ... + b_{14} * X14$

	constant			-0.136	=	-0.136
X_1=	percentage of males 20-24 years	6.1	x	-0.004	=	-0.0244
X_2 =	percentage of females 20-24 years	8.2	x	-0.002	=	-0.0164
X_3=	percentage of females 25-39 years	10	x	0.001	=	0.01
X_4=	percentage of males 40-54 years	13.8	x	0	=	0
X_5=	percentage of females 40-54 years	14.7	x	0.001	=	0.0147
X_6=	percentage of males 55-64 years	18.3	x	0.001	=	0.0183
X_7=	percentage of females 55-64 years	19	x	0	=	0
X_8=	percentage of non-Western immigrants	24.4	x	0.002	=	0.0488
X_9=	percentage of one-person households	62.6	x	0.001	=	0.0626
X_{10}=	percentage of persons in low-income households	40.9	x	0.005	=	0.2045
X_{11}=	low urbanization	0	x	0	=	0
X_{12}=	moderately urbanized	0	x	0.005	=	0
X_{13}=	strongly urbanized	0	x	-0.002	=	0
X_{14}=	very strongly urbanized	1	x	-0.005	=	-0.005
						0.1771*100
						17.7= $\hat{y}$

Table 2. Unstandardized linear regression coefficients for associations between the transformed dependent variable 'proportion moderate/poor perceived health' and socio-demographic predictors at the four-digit postcode level[a] (n=414).

Variables	B[d]	Lower limit 95% CI[c]	Upper limit 95% CI	Odds Ratio's
Age groups (percentage)				
Males 20-24 years	-0.039	-0.106	0.029	0.96
Females 20-24 years	-0.030	-0.079	0.019	0.97
Females 25-39 years	0.002	-0.060	0.064	1.00
Males 40-54 years	-0.007	-0.055	0.042	0.99
Females 40-54 years	0.010	-0.028	0.048	1.01
Males 55-64 years	0.017	-0.046	0.079	1.02
Females 55-64 years	-0.006	-0.052	0.041	0.99
Percentage of non-Western immigrants	**0.013**	0.008	0.018	1.01
Percentage of one-person households	**0.013**	0.007	0.019	1.01
Percentage of persons in low-income households	**0.044**	0.036	0.053	1.05
[b] Degree of urbanization				
Low urbanization	0.009	-0.127	0.146	1.01
Moderately urbanized	0.041	-0.128	0.210	1.04
Strongly urbanized	-0.008	-0.188	0.173	0.99
Very strongly urbanized	-0.062	-0.268	0.145	0.94

[a] For four-digit postcode areas with at least 1,000 residents and at least 100 respondents.

[b] Reference category of degree of urbanization is rural.

[c] CI = Confidence interval.

[d] Statistical significance. **Bold** if $P<=0.05$.

Adjusted R^2 = 46.9%

Table 3. Results of linear regression analyses of logit-transformed dependent variables: estimated averages, minimums and maximums of small area estimates at the four-digit postcode level for residents between 20-64 years old; significant predictors, explained variance and Spearman correlations between direct survey estimates and small area estimates.

Indicators	Mean per postcode[a]	Min	Max	Significant predictors[b]	Adjusted R^2	N postcodes per analyse	R Spearman
Physical inactivity	40.2	34.1	45.4	-male 40-54 year, +female 40-54 year,	3.5%	232	0.32
Diabetes	3.5	1.9	7.5	+non-Western, +low income	21.3%	321	0.50
Hypertension	12.6	7.6	17.6	+male 55-64 year, +non-Western, -low income	19.8%	323	0.47
Asthma	7.6	5.2	12.2	+non-Western, +low income	16.9%	325	0.45
1 Chronic condition	51.3	41.0	61.2	+non-Western, +low income, +moderately urbanized	30.9%	329	0.57
>1 Chronic condition	25.1	15.6	36.4	+non-Western, +low income	37.3%	329	0.61
Current smoker	23.7	17.7	36.3	+non-Western, +one-person household, +low income	33.4%	440	0.61
Heavy smoker	2.2	1.0	5.1	+non-Western, +one-person household, +low income, +low urbanized, +moderately urbanized	19.0%	412	0.46

- table 3 continues -

Indicators	Mean per postcode[a]	Min	Max	Significant predictors[b]	Adjusted R^2	N postcodes per analyse	R Spearman
Underweight	1.5	1.1	2.9	+female 20-24 year	4.1%	384	0.26
Overweight	46.5	32.0	58.0	+non-Western, -one-person household, +low income	31.4%	439	0.52
Obesity	11.6	5.8	23.0	+non-Western, -one-person household, +low income	29.2%	439	0.53
Moderate/poor perceived health	11.6	6.0	24.4	+non-Western, +one-person household, +low income	46.9%	414	0.68
High risk of anxiety and depression	4.2	2.0	14.6	+non-Western, +one-person household, +low income	36.7%	391	0.61
Excessive alcohol use	29.6	16.4	42.1	-female 25-39 year, -female 40-54 year, +male 55-64 year, -female 55-64 year, -non-Western, +one-person household, -low income	26.7%	420	0.54

[A] Mean estimation for four-digit postcode areas with at least 1,000 residents and at least 100 respondents.
[b] + significant positive relationship between dependent variable; - significant negative relationship (P<= 0.05).

Table 4. Unstandardized linear regression coefficients for association between the dependent variable moderate/poor perceived health and socio-demographic predictors at a four-digit postcode level[a] (n=414).

Variables		Coefficient	Lower limit 95% CI[c]	Upper limit 95% CI
Age groups (percentage)	Males 20-24 years	-0.004	-0.011	0.003
	Females 20-24 years	-0.002	-0.007	0.002
	Females 25-39 years	0.001	-0.005	0.007
	Males 40-54 years	0.000	-0.005	0.004
	Females 40-54 years	0.001	-0.002	0.005
	Males 55-64 years	0.001	-0.005	0.007
	Females 55-64 years	0.000	-0.004	0.005
	Percentage non-Western immigrants	**0.002**	0.001	0.002
	Percentage one-person households	**0.001**	0.001	0.002
	Percentage persons in low-income households	**0.005**	0.004	0.006
	Degree of urbanization[b]			
	Low urbanization	0.000	-0.013	0.013
	Moderately urbanized	0.005	-0.012	0.021
	Strongly urbanized	-0.002	-0.019	0.016
	Very strongly urbanized	-0.005	-0.025	0.015

[a] For four-digit postcode areas with at least 1,000 residents and at least 100 respondents.
[b] Reference category of degree of urbanization is rural.
[c] CI = Confidence interval.
[d] Statistical significance. **Bold** if *P*<=0.05 .
Adjusted R^2 = 53.4%

Table 5. Results of linear regression analyses: estimated averages, minimums and maximums of small area estimates at the four-digit postcode level for residents between 20-64 years old; significant predictors, explained variance and Spearman correlations between direct survey estimates and small area estimates.

Indicators	Mean per postcode[a]	Min	Max	Significant predictors[b]	Adjusted R^2	N postcodes per analyse	R spearman
Physical inactivity	40.3	34.1	45.4	-male 40-54 year, +female 40-54 year	3.7%	232	0.32
Diabetes	3.8	1.6	7.2	+non-Western, +low-income	27.1%	324	0.51
Hypertension	12.9	7.1	17.4	+male 55-64 year, +non-Western	19.9%	323	0.47
Asthma	7.9	5.0	12.1	+non-Western, +low-income	19.2%	325	0.45
1 Chronic condition	51.2	41.3	61.2	+non-Western, +low-income, +moderately urbanized	31.0%	329	0.57
>1 Chronic condition	25.3	14.7	35.9	+non-Western, +low-income	37.8%	329	0.61
Current smoker	24.0	17.7	35.2	+non-Western, +one-person household, +low-income	35.7%	440	0.62
Heavy smoker	2.3	0.9	4.6	+non-Western, +one-person household, +low-income	19.5%	439	0.44

- table 5 continues -

Indicators	Mean per postcode[a]	Min	Max	Significant predictors[b]	Adjusted R^2	N postcodes per analyse	R spearman
Underweight	1.6	1.0	3.1	+female 20-24 year, +one-person household	8.7%	439	0.30
Overweight	46.6	31.7	57.8	+non-Western, -one-person household, + low-income	30.9%	439	0.52
Obesity	12.0	5.4	21.0	+non-Western, -one-person household, + low-income	30.5%	439	0.53
Moderate/poor perceived health	11.9	5.3	23.4	+non-Western, +one-person household, +low-income	53.4%	414	0.68
High risk of anxiety and depression	4.6	1.3	12.3	+ non-Western, +one-person household, +low-income	49.7%	397	0.62
Excessive alcohol use	29.9	14.7	41.3	-female 25-39 year, -female 40-54 year, +male 55-64 year, -female 55-64 year, -non-Western, +one-person household, -low-income	26.7%	420	0.54

[A] Mean estimation for four-digit postcode areas with at least 1,000 residents and at least 100 respondents.
[b] + significant positive relationship between dependent variable; - significant negative relationship (P<= 0.05).

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Chapter 4

The validation of small area estimates regarding GP care utilization based on a multilevel regression model

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ABSTRACT

Introduction

The organisational changes to a more integrated population-based healthcare system requires small area estimates on healthcare use, especially on GP care utilization. However, small area estimates are often not available. In this study, a multilevel approach is investigated to calculate small area estimates on GP care utilization. These estimates are validated, and the results of the multilevel model are compared to a linear model on aggregated data.

Method

The estimated GP care utilization rate was calculated using a multilevel negative binominal model of patients within postcodes with predictors at the unit-level and the area-level for each four-digit postcode area in the Netherlands. Concordance statistics and Pearson correlations between predictions and external data on the costs of GP care were used to test the validity. Subsequently, the results of the multilevel model were compared to a linear model on aggregated data at the four-digit postcode level.

Results

Sex, age and ethnicity as unit-level covariates and low-income households, status score, urbanization level and declining level as area-level covariates have positive significant relationships with utilization rates. A multilevel model fits the data significantly better than a linear model on aggregated data at the area level. The predicted values correlated r=0.66 with utilization rates from the NIVEL Primary Care database at the four-digit postcode level and were concordant for 81%. When postcode areas were excluded with less than 10 patients, correlation was r=0.91 and the Concordance statistic was 0.88. The correlation between the predicted utilization rates aggregated to the municipal level and the GP care costs at the municipal level was r=0.51. The external validity increased to r=0.70 when smaller municipals were excluded.

Conclusion

Small area estimates on GP care utilization could be calculated by means of a multilevel model for every four-digit postcode areas in the Netherlands. The internal and external validity of the multilevel model was higher than the linear model on aggregated data, but not as high as expected. In further research, the effect of additional predictors in the model should be investigated.

INTRODUCTION

The importance of small area estimates increased over the last decades. Small areas are areas at a geographical small level, such as neighbourhoods or four-digit postcode areas [1, 2]. Especially, the interest for small area estimates on health and healthcare has grown, due to the changes in the organization of primary healthcare and the need to plan and evaluate healthcare. Primary healthcare should be more focused on the needs of local populations to be more cost-effective and efficient. It should strive the principles of Triple Aim; improve populations' health, improve individuals' experience of care and reduce costs [3]. These organisational changes demand for small area estimates for research and allocation of healthcare according to health, lifestyle and healthcare needs.

There are two broad methods to produce small area estimates on health and healthcare issues. First, the use of sample surveys which produce direct small area estimates. Second, the use of a statistical model-based methods or geographical approaches to calculate indirect small area estimates [4, 5]. Sample surveys often produce unreliable small area estimates, because for small areas they often do not contain enough observations [6]. Surveys with sufficient observations at the small area level, are very costly and time consuming. Indirect small area estimates based on a statistical model-based method or geographical approach can be a better alternative [5].

The use of statistical estimation models is well accepted in the field of public health and epidemiology [7]. For instance, small area estimates (SAE's) have been calculated using different model-based approaches on coronary heart disease prevalence [8, 9], diabetic prevalence [10], life expectancies estimates [11], institutional births [7], smoking and drinking prevalence [12-14] and COPD prevalence [15]. In a previous study, we calculated small area estimates on the utilization of general practitioners care (GP care) using a linear model on aggregated data [16]. GP care plays a central role in strengthening primary care and in reducing the use of secondary care [17-20]. SAE's on GP care utilization are essential to better match the demand and the supply for GP care. In the present study, we want to investigate whether a multilevel approach with unit-level and area-level predictors, and a random effect at the area-level could calculate better small area estimates on the utilization of GP care than a linear model on aggregated data.

METHOD

Study design

A study was conducted in which for each four-digit postcode area in the Netherlands the estimated GP care utilization rate was generated using a small area estimation technique (SAE)[21]. This general technique is a model-based approach which uses a regression model to assess the relationship between our variable of interest and predictors at the unit-level and at the area-level; i.e. the relationship between GP care utilization and sociodemographic predictors is assessed for four-digit postcode areas for which we have patients registered. Subsequently, predictions are calculated for each four-digit postcode area in the Netherlands. Sociodemographic characteristics are used as predictors of GP care utilization because great disparities exist in the healthcare use of different sociodemographic and socio-economic groups [22-24]. A multilevel regression analysis is used with sociodemographic predictors both at the unit and the area-level to generate small area estimates on GP care utilization. The generated small area estimates on GP care utilization are validated internally, and externally by aggregating them to the municipal level and comparing them with the costs for GP care at the municipal level. Subsequently, the results of the multilevel model are compared to those from a linear model on aggregated data.

We followed the small area estimation method by Zhang et. al. (2014) [15]. They developed a flexible unit-level multilevel model with both individual-level fixed effects and county-level and state-level random effects to calculate small area estimates on chronic obstructive pulmonary disease prevalence at the census-block-level, the smallest geographical level in America. For the present study, this multilevel approach has the advantage of taking into account postcode area contextual effects which still exist after controlling for individual-level demographic factors. We investigated whether the method by Zhang et. al. (2014) is an useful and valid method to produce small area estimates on GP care utilization in the Netherlands.

Data sources

Dependent variable

The variable of interest is GP care utilization rate, because small area estimates on GP care utilization inform the discussion between stakeholders about how to match GP care to the needs of the population.

Utilization rates were derived from medical record data obtained from routine electronic health records of 399 general practices in the Netherlands participating in the NIVEL Primary Care Database in 2013. The database contains 1,277,689 listed patients which are representative of the Dutch population regarding sex and age in 3,488 four-digit postcode areas. Utilization rate is the sum of the different contacts per patient per year, weighted by the costs rate ratio for the different contacts (Table 1). For instance, a short contact with the GP has a costs rate ratio of 1 and a long visit from the GP has a costs rate ratio of 2.5. Utilization rate is weighted by the costs rate ratio, because for the external validation they are compared to data about the costs of GP care. The dependent variable is therefore not an integer.

Table 1. The different contact types for GP care, the costs in euros and the costs rate ratio.

Contact types	Costs in euros	Costs rate ratio
Short consultation GP[A]	9.01	1.0
Long consultation GP	18.02	2.0
Short visit	13.51	1.50
Long visit	22.52	2.50
Telephone consult	4.50	0.50
Email consult	4.50	0.50
Short consultation MDS[B]	9.43	1.05
Long consultation MDS	18.86	2.09
Short visit MDS	14.15	1.57
Long visit MDS	23.58	2.60
Telephone consult MDS	4.72	0.52
Email consult MDS	4.72	0.52

[A] GP = general practitioner
[B] MDS = Mental disorder supporter

Predictors at the unit-level

Predictors at the unit level were derived from NIVEL Primary Care Database which contains next to GP utilization rates also sex and age of the patient. Age was categorized into 7 categories (0-4, 5-14, 15-24, 25-39, 40-64, 65-74, 75 years and older). The ethnicity of the patient was added to the database by Statistics Netherlands. Ethnicity was categorized as being a non-Western immigrant or not, with non-Western immigrants being defined as having at least one parent born in Africa, Latin America and or Asia. Patients' age, sex and ethnicity were covariates at the unit-level and due to all the interactions they resulted in 28 different unit-level combinations.

Predictors at the area level

Next to unit-level covariates, the multilevel model included covariates at the area-level, the four-digit postcode level. Sociodemographic predictors at the four-digit postcode level were the percentage of low-income households: households with a purchasing power of less than <€9,250 euros a year, the percentage of one-person households, the percentage of non-Western immigrants, urbanization level of the area, divided into five categories from rural: less than <500 addresses per km2 to very strongly urbanized, more than >2,500 addresses per km2 (Statistics Netherland, 2014), status score which is a common indicator for neighbourhood socioeconomic status (SES) (The Netherlands Institute for Social Research, 2014) and the variable 'declining area'. Declining areas have a lower expected number of households in 2040 compared to 2013. Population decline is associated with an ageing population which results in different health care needs of the population and also a decline in health supply services. The variable declining area was derived from NIVEL (2014). The total number of four-digit postcode areas in the Netherlands in 2014 was 4,038 with on average 4,167 inhabitants per postcode area (SD=4,152; min=0; max=28,480).

Census data at the four-digit postcode level (n=4,038) for age x sex x ethnicity cross-tabulated categories were derived from Statistics Netherlands (2014). The data resulted in 28 demographic categories. The fraction for each of these 28 categories were known at postcode level.

External dataset; declaration data

The small area estimates on utilization rates at the four-digit postcode level were validated with declaration data on GP care costs at the municipal level (n=390) from VEKTIS (2014). VEKTIS collects and standardise declaration data from all the health insurance companies in the Netherlands.

Analyses

Multilevel negative binominal model

The dependent variable was GP care utilization rate per patient per year at the unit-level. Utilization rate was supposed to be related with two-level related factors, the individual level and the four-digit postcode level. To accommodate the large variability of the dependent variable, a multilevel negative binominal model was used to establish the relationships between utilization rate and predictors at the unit and the area-level. This model accepted the non-integers for the dependent variable. The period the patient was registered within the general practice for the year 2013 (1= for the whole year; 0.75= for maximum 9 months; 0.5= for maximum 6 months; 0.25 for maximum 3 months) was added as an exposure variable to the model.

Equation 1 shows the equation of the model. The log of the outcome is predicted with a linear combination of sex, gender and ethnicity with all their two-way and three-way interactions (bX_{ij}). The area covariates at the four-digit postcode level were also entered into the model (cZj): the percentage of low-income households, the percentage of one-person households, urbanization level into 5 dummies, status score as a continuous variable and the variable declining area. The random intercept at the four-digit postcode level models the influence of all postcode characteristics that were not incorporated in the model. Analyses were conducted using STATA 14 [25].

Equation 1: log(utilization rate) = intercept + random area effect + individual variables + area variables + error

log(Yij)= a+uj+bXij+cZj+eij

The above model was used for the complete NIVEL Primary Care Database which includes data for 3,488 four-digit postcode areas and 1,277,689 patients.

Predictions

Predictions were calculated for all the four-digit postcode areas in the Netherlands (n=4,037), including the ones for which we had no sample data. A postcode prediction is calculated based on the fraction of the 28 individual unit-level covariates combinations, the sociodemographic area covariates, and the random effect at the four-digit postcode level. For postcodes for which we had no sample data, the random effect was calculated as the mean of the neighbouring postcodes. The random effect was zero, when there were no neighbours with a calculated random effect. For the total NIVEL Primary Care Database 3,488 random effects were calculated; 507 random effects had to be calculated as the mean random effect of their neighbouring postcodes and 43 random effects were zero (Table 2). Predictions were calculated for each four-digit postcode area as a weighted mean of the unit-level predictions.

Table 2. The calculated random effects for the total dataset and selections of the dataset.

N PCs in Primary Care Database	Total dataset N=3,488	Without PCs < 10 patients N=2,451	Without PCs < 20 patients N=2,063	Without PCs < 30 patients N=1,856	Without PCs < 40 patients N=1,707	Without PCs < 50 patients N=1,595
Random effects calculated by model	3488	2,451	2,063	1,856	1,707	1,595
Random effects calculated by the neighbouring PCs	507	1,018	1,099	1,134	1,199	1,221
Random effects are zero	43	569	900	1,048	1,132	1,222
Total number of PCs in the Netherlands	**4,038**	**4,038**	**4,038**	**4,038**	**4,038**	**4,038**

*PCs= postcode areas

Model validation

Predictions for GP care utilization rates were calculated for the patients in the NIVEL Primary Care Database. The internal validation of the predictions was assessed by comparing the predicted value for utilization rates with those from the NIVEL Primary Care Database. The predictions at the individual level were therefore aggregated to the 3,488 four-digit postcode areas for which data was available in the NIVEL Primary Care Database. The internal validity was assessed by Pearson correlations and the Concordance statistic. The Concordance statistic describes the relationship between pairs of observations. A pair of observations are concordant when prediction and factual score for one are both higher, or both lower than for the other.

Predictions were also calculated for all the 4,038 four-digit postcode area in the Netherlands using census data and postcode area characteristics from Statistic Netherlands (2014). The external validation of the predictions was assessed by comparing the predicted values for utilization rates with declaration data on GP care costs at the municipal level from VEKTIS (2014). Therefore, utilization rate was calculated for each municipal as a by population size weighted mean of the predictions of its postcodes. Correlations were calculated between the predicted value for utilization rates and GP care costs at the municipal level.

Comparison multilevel model vs linear regression
The results from the multilevel negative binominal model were compared to a linear regression model on aggregated data at the four-digit postcode level that we used in a previous study. This linear model did not include the predictor 'declining area', and the predictor 'non-Western immigrant' was only added as an area predictor. The linear model was fitted to the data of NIVEL Primary Care Database. Therefore, the data at unit-level was aggregated to the four-digit postcode level. The analysis was conducted on four-digit postcode areas with 100 or more patients and for postcodes with 300 or more inhabitants (n=1,243). The explained variance of the linear regression model was given by R-squared. Pearson correlations were calculated between the predictions on GP utilization rates and the actual GP utilization rate from the NIVEL Primary Care database aggregated to the four-digit postcode level (n=1,243 postcodes) and between the predictions and the declared GP care costs.

RESULTS

NIVEL Primary Care direct estimates
The NIVEL Primary Care dataset contained 1,277,689 patients with a mean GP utilization rate of 3.98 (SD=5.70). Utilization rates differ between the different groups defined by sex, age and ethnicity (Table 3).

Multilevel negative binominal model
The three unit-level covariates and four of the six area-level covariates have a significant relationship with the mean utilization rate per patient per year (Table 4). Females in every age category have higher utilization rates than males, except for 0-5 years. There is a significant three-way interaction effect of age x gender x ethnicity on utilization rates. The percentage low-income households, status score of an area and urbanization level are positively related to utilization rates (Table 4). A multilevel model fits the

data significantly better than an ordinary least square model without postcode level ($p<=0.00001$), so there is a significant variability between postcode areas after controlling for the covariates.

Table 3. GP care utilization rates among patients by sex, age and ethnicity.

Characteristics at unit level	Number of patients	Utilization rate		
		Mean	95% CI	
Total	1,277,689	3.98	3.98	3.98
Sex				
Male	626,501	3.16	3.15	3.17
Female	651,188	4.77	4.75	4.79
Age groups , years				
00-04	65,103	2.68	2.65	2.70
05-14	149,739	1.90	1.89	1.91
15-24	147,119	2.64	2.62	2.66
25-39	219,319	3.16	3.14	3.17
40-64	457,446	3.92	3.90	3.93
65-74	132,500	5.57	5.54	5.61
≥75	106,463	9.57	9.50	9.63
Ethnicity (4 missing)				
Non-Western immigrant	137,297	3.70	3.68	3.73
No Non-Western immigrant	1,140,388	4.01	4.00	4.02

Table 4. Regression coefficients for fixed effects in the multilevel model for GP utilization rate, n=1,277,682.

Effect and subgroup	Estimate (B)	Standard Error	P value
Age groups , years			
00-04 (Reference group)	-	-	-
05-14	-0.545	0.009	0.000
15-24	-0.567	0.009	0.000
25-39	-0.417	0.008	0.000
40-64	0.004	0.008	0.643
65-74	0.477	0.008	0.000
≥75	1.056	0.009	0.000
Sex			
Male (Reference group)	-	-	-
Female	-0.095	0.010	0.000
Age groups x sex			
05-14 x female	0.191	0.013	0.000
15-24 x female	0.843	0.012	0.000
25-39 x female	0.819	0.012	0.000
40-64 x female	0.486	0.011	0.000
65-74 x female	0.311	0.012	0.000
≥75 x female	0.289	0.012	0.000
Ethnicity			
No NWI (Reference group)	-	-	-
NWI	0.115	0.017	0.000
Age groups x ethnicity			
05-14 x NWI	0.018	0.021	0.386
15-24 x NWI	-0.073	0.022	0.001
25-39 x NWI	0.068	0.020	0.001
40-64 x NWI	0.085	0.019	0.000
65-74 x NWI	0.041	0.029	0.151
≥75 x NWI	-0.338	0.041	0.000
Sex x NWI			
Sex x NWI	-0.014	0.025	0.565
Age groups x sex x NWI			
05-14 x female x NWI	-0.029	0.030	0.341
15-24 x female x NWI	-0.059	0.030	0.052

- table 4 continues -

Effect and subgroup	Estimate (B)	Standard Error	P value
25-39 x female x NWI	-0.003	0.028	0.905
40-64 x female x NWI	0.101	0.028	0.000
65-74 x female x NWI	-0.009	0.041	0.817
≥75 x female x NWI	0.046	0.056	0.411
Area covariates			
% Non-Western immigrant	0.001	0.000	0.251
% Low income household	0.003	0.001	0.000
% One-persons household	-0.001	0.001	0.103
Status score	-0.031	0.005	0.000
Degree of urbanization			
Rural (Reference category)	-	-	-
Low urbanisation	0.040	0.014	0.004
Moderately urbanised	0.072	0.014	0.000
Strongly urbanised	0.069	0.015	0.000
Very strongly urbanised	0.074	0.022	0.001
Declining area	0.059	0.015	0.000

Model validation

Internal validation

The predicted utilization rates at the four-digit postcode level correlated *r*=0.66 with the factual scores from the NIVEL Primary Care database and 81% of the pairs were concordant.

External validation

Pearson correlation between the predicted utilization rates at the municipal level and GP care costs at the municipal level from VEKTIS 2014 for all the 390 municipals in the Netherlands was *r*=0.51.

Results for data selections

The model was also fitted on data selections of the NIVEL Primary Care database, to exclude four-digit postcode areas with few data. Postcode areas were excluded with less than 10 patients (n postcode areas=2,451), with less than 20 patients (n postcode areas =2,063), with less than 30 (n postcode areas = 1,856), 40 (n postcode areas = 1,707) or with less than 50 patients (n postcode areas=1,595). When four-digit postcode areas were excluded with less than 10 patients, correlation between the predicted values for utilization rates and the utilization rates from the NIVEL Primary Care database at the four-digit postcode level went up from *r*=0.66 to *r*=0.91 and the Concordance statistic went up from 81% to 88%. When postcode area were excluded with less than 50 patients correlation increased to *r*=0.97 and the Concordance statistic to 93%.

The external validity was also tested when smaller municipals were excluded from the VEKTIS data. Municipals were excluded with less than 10,000 residents (n=366), with less than 20,000 residents (n=268), 30,000 residents (n=163), 40,000 residents (n=115) and with less than 50,000 residents (n=76). When municipals were excluded with less than 10,000 residents, Pearson correlations between the predicted utilization rates at the municipal level and GP care costs at the municipal level went up from *r*=0.51 to *r*=0.58. Pearson correlation increased to *r*=0.70 when municipals were excluded with less than 50,000 inhabitants.

Comparison multilevel model vs linear regression

The linear regression model of the utilization rate on individual data aggregated at the four-digit postcode level and sociodemographic characteristics of four-digit postcode areas explains 25.9% of the variance at the four-digit postcode level (Table 5). Two of the 21 area-level predictors have a significant relationship; 'females of 75 years and older' has a positive relationship and 'status score' has a negative relationship. Pearson correlation between the predictions on GP utilization rates and the actual GP utilization rate from the NIVEL Primary Care database at the four-digit postcode level (n=1,243 postcodes) was r=0.51. The model predicts a mean utilization rate per patient per year of 4.05, which is 36.5 consultation costs in euros. The mean consultation costs per patient per year is 38.05 euros (VEKTIS, 2014). Pearson correlation between the predicted utilization rates at the municipal level and GP care costs at the municipal level from VEKTIS 2014 was *r*=0.47. Pearson correlation for municipals with 10,000 inhabitants or more is also *r*=0.47 and increased to *r*=0.53 for municipals with 50,000 inhabitants or more.

Table 5 Model estimates for the regression of the mean utilization rate on sociodemographic characteristics of four-digit postcode areas (data aggregated on four-digit postcode area.

	Estimate (B)	Standard error	P-value
Percentage Sex x Age categories			
Males 00-04	-0.046	0.059	0.442
Females 00-04	-0.082	0.063	0.191
Males 05-14	-0.048	0.039	0.216
Females 05-14	0.031	0.041	0.455
Males 15-24	-0.037	0.035	0.296
Females 15-24	-0.010	0.028	0.710
Males 25-39	-	-	-
Females 25-39	0.018	0.039	0.652
Males 40-64	-0.017	0.032	0.582
Females 40-64	0.021	0.024	0.384
Males 65-74	0.003	0.048	0.948
Females 65-74	0.031	0.046	0.498
Males ≥75	-0.067	0.055	0.221
Females≥75	0.132[b]	0.030	0.000
Percentage of one-person households	-0.001	0.005	0.912
Percentage of non-Western immigrants	0.002	0.003	0.495
Status score	-0.157[b]	0.052	0.003
Percentage of people in low-income households	0.006	0.009	0.557
Degree of urbanization			
Rural	-	-	-
Low urbanisation	0.104	0.089	0.242
Moderately urbanised	-0.016	0.094	0.860
Strongly urbanised	-0.062	0.105	0.556
Very strongly urbanised	-0.053	0.138	0.700
Constant	3.763	-0.018	7.543

[b] $p<0.05$. R^2=25.9%, Adjusted R^2=24.6%

DISCUSSION

A multilevel regression model with unit-level and area-level predictors and a random effect at the postcode level was used to calculate small area estimates (SAE's) on GP care utilization for all the four-digit postcode areas in the Netherlands. The internal validity of the SAE's was tested, next to the external validity using data on GP care costs at the municipal level. The comparisons between the predictions for GP utilization rates and utilization rates from NIVEL Primary Care database for areas with 10 or more patients correlated *r*=0.91 and were concordant in 88% of the cases. When the analyses were repeated on areas without 50 patients correlation increased to *r*=0.97 and 93% of the comparisons were concordant. The external validity of the model also increased when smaller municipals were excluded from the analysis. The correlation between the predicted GP utilization rate and GP care costs was *r*=0.51 and increased to *r*=0.70 when municipals were selected with 50,000 inhabitants or more. This may be explained by the fact that practice variation exists in utilization rates and this effect is ruled out in larger municipals which have more general practices in their region. In sum, the multilevel model with unit-level and area-level predictors, and random effects was effective in producing small area estimates on GP care utilization. These SAE's are useful information on the geographical differences in GP care utilization and useful data to better match demand for care and supply of care in small geographical areas.

The validity of the multilevel model for GP utilization rate was reasonably good because the model produced useable SAE's. The external validity was *r*=0.70 when municipals were excluded with less than 50,000 residents, which is equal to an explained variance of 49%. Thus, with sociodemographic predictors at the unit- and area-level and a random effect at postcode level, 49% of the variance in GP are utilization rates between postcode areas could be explained. This is almost double the explained variance (25,9%) of the linear model with aggregated data. Small area estimates based on a model which is able to explain almost 50% of the explained variance in the dependent variable are more useable than small area estimates based on a model which could explain 25% of the variance. However, the validity of the multilevel model is not a high as Zhang who also used a multilevel approach to estimate the prevalence of COPD for counties and states in America [9]. The differences in results may be explained by the fact that the model of Zhang is disease specific and could be more precisely fitted due to a more homogeneous research population and more specific data on COPD prevalence.

The validity of the model was tested with data on the cost of GP care. GP care utilization rates were therefore used to calculate the costs in euros. However, inequalities between the two variables are expected, especially because the VEKTIS data did not include declaration data for about 250,000 inhabitants in the Netherlands.

Data selection on the number of patients per four-digit postcode area or the number of inhabitants per municipal influenced the results of the multilevel model. The decision to leave out areas with a small number of patients in the analysis is a trade-off between a better fitted model and the number of random effects that have to be imputed. We recommend to fit the model on data without areas with a maximum of 10 patients, because in this case the correlation increased from r=0.66 to 0.91.

In the present study, we would have preferred to use a crossed-effects model with practices as another source of variation. From our previous study, it became clear that practice characteristics accounted for approximately 20% of the GP utilization rates [16]. However, a crossed-effects model was not feasible due to the large amount of data and the estimation time needed to fit such a model. Therefore, users of the calculated small area estimates should be aware of the fact that practice characteristics significantly influence utilization rates above the sociodemographic unit-level and area-level predictors.

The results of the multilevel model were compared to a linear model with only aggregated data, as used in our previous studies. About 25% of the variance in GP utilization rate could be explained with only seven area predictors. However, analyses showed better results for the multilevel model. Unit-level predictors and random effects contribute significantly to GP utilization rates. Despite the fact that the linear model is much more easier to conduct: it needs less data resources, data preparation and time. Nevertheless, the multilevel model is preferred because of a better internal and external validity.

Our results are based on three large datasets. GP record data were used from GPs in 399 general practices with more than 1,2 million patients. This data is representative for the Dutch population regarding age and gender. However, GP record data may be registered with some errors. Moreover, the sample of general practices is not a random sample, but comes from a historical grown register for which practices were selected, which hampers the generalizability of our findings. Our multilevel model based on the NIVEL Primary Care Database predicts a lower mean consultation rate than based on the declaration data from VEKTIS. This may be due to the fact that general practices in our sample have lower utilization rates. Moreover, the declaration data from VEKTIS do not include data on 250,000 insured persons. The multilevel model was fitted on data of the year 2013 and applied to sociodemographic data of the year 2014. However, we do not think this effected our SAE's, because sociodemographic characteristics of an area change markedly over time, whereas the influence of sociodemographic characteristics on health does not change [1].

In the present study, we used the method of Zhang et. al to calculate SAE's on GP care utilization to better match the need for GP care to the supply of GP care [15, 26]. The multilevel model produced useable estimates. However, the three unit-level predictors could be expanded with other predictors, such as level of education and religion to predict utilization rates. Adding predictors to the model should be investigated in future research.

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Chapter 5

Are low and high utilization related to the way GPs manage their practices?

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ABSTRACT

Background

General practice care plays a key role in keeping healthcare effective and cost-efficient. However, variation in the utilization rates of practices may reveal variation in practice performance. Our research goal is to investigate whether the sociodemographic profile of the patients' area of residence and practice organization characteristics influence the low or high utilization of general practice care.

Methods

Data on the utilization of general practice care were derived from the electronic health records of 232 general practices participating in the NIVEL Primary Care Database for the year 2013. Census data for the year 2013 were matched with the postal code of the patients. A small area estimation (SAE) technique was used to calculate the estimated utilization rate for general practice care per practice based on the sociodemographic profile of the patients' area of residence. Subsequently, the actual utilization rates were compared to the estimated rates per practice. Linear regression analysis was used to link the differences between the actual and estimated utilization rates to practice organization characteristics.

Results

The sociodemographic profile of the patients' area of residence accounted for 25.7% of the estimated utilization rates per practice. Practice organization characteristics accounted for 19.3% of the difference between the actual utilization rates and the estimated rates. Practices had higher utilization rates than estimated when a practice was a dual practice, when it employed female GPs, when it employed other healthcare providers and/or when it offered more services related to a disease management programme.

Conclusion

We found that utilization rates of general practice care can be partially explained by the sociodemographic profile of the patients' area of residence, but also by practice organization characteristics. Insight into these factors provides both GPs and the other stakeholders involved in the

organization of general practice care with information to help reflect on the utilization of care.

BACKGROUND

General practice care plays a central role in healthcare. In the Netherlands, the general practitioner (GP) has a strong position: every resident is listed with a GP, and the GP deals with most of the health problems and coordinates the referral to specialized care [1]. Moreover, general practice care is covered by compulsory insurance and is the only health service exempt from cost sharing, which makes it accessible to everyone [2]. Many European countries regard strengthening the role of primary care, particularly general practice care, as a way to combat high healthcare costs and to meet the complex healthcare needs of the population [3-6].

Given the vital position of general practice care, it is important to study variation in utilization rates among general practices and especially the contributors to low and high utilization. Low utilization may not only indicate poor access and thus poor performance, but it could also indicate efficient use of healthcare services [7]. High utilization rates may indicate both good access and good performance, as a larger part of care is handled by the GP and less is referred to other healthcare providers. However, high utilization rates may also indicate inefficient use of healthcare services.

In the literature, the concepts underuse and overuse of healthcare services are often studied [8-11]. Underuse is 'the lack of provision of necessary care' and overuse is 'the provision of care for which harms outweigh the benefits' [9, 11]. To assess underuse and overuse, it needs to be determined whether the use of care was appropriate, i.e. whether the provision of medical services was beneficial or whether it had no or little benefit [11]. However, such methods are both time-consuming and expensive [10].

In the present study, we do not focus on the appropriateness of general practice care, but rather on high or low utilization rates at general practice level. High or low utilization rates at practice level were determined by the comparison of the actual utilization rates with the estimated rates based on the sociodemographic profile of the patients' area of residence. From the literature, it is known that the sociodemographic characteristics of an area influence the use of general practice care [12]. For instance, areas with a high underprivileged index: a high percentage of the elderly living alone, children under 5 years, in single parent families, unskilled workers and unemployed adults were more likely to report a GP consultation [13].

However, differences are to be expected between the actual utilization rates of general practice care and the estimated rates based on a limited set of sociodemographic variables, because many more factors do influence healthcare utilization. We want to explore to what extent differences between the actual utilization rate and the estimated rate based on a limited set of sociodemographic variables can be related to practice organization characteristics. From the literature, it is know that service provision or general practice characteristics influence consultation rates [12]. For example, variation in frequent attendance in general practice care could for 3% be attributed to the age of the GP and the use of an appointment system [14]. Cervical smear uptake rates were substantially higher in practices with a female partner [15], and the number of partners in a practice positively influenced breast cancer screening rates [16]. Practice organization characteristics include the human resources available, specific services offered (e.g. diagnostic equipment), organization of consultation hours, participation in disease management programmes, physical accessibility of the practice and information dissemination.

In the present study, we investigated to what extent practice organization characteristics, next to sociodemographic characteristics at the four-digit postcode level, influence the utilization of general practice care. Our goal is to provide stakeholders who are involved with the organization of general practice care with useful insight into the practice organization characteristics that influence high or low utilization, to help them reflect on the organization and the utilization of general practice care.

METHODS

Study design

An observational study was conducted in which for each practice the actual utilization rates of general practice care, based on medical record data, were compared with an estimated utilization rate for this practice, based on the sociodemographic profile of the patients' area of residence. Using an SAE technique, estimates were made for every four-digit postcode area in the dataset, and based on these estimates, practice estimates were calculated as a weighted average of patients' postcodes. The difference between the actual utilization rates and the estimated rates based on the sociodemographic profile of the patients' area of residence were linked to practice organization characteristics using linear regression analysis. Furthermore, practices with the largest positive difference were compared with the largest negative difference using t-tests and proportion tests.

Data

Utilization rates

Utilization rates of general practice care were derived from medical record data obtained from routine electronic health records from 240 general practices in the Netherlands participating in the NIVEL Primary Care Database for the year 2013 [17]. The database contains the utilization records, gender, age and four-digit postcodes of approximately 1 million listed patients who are representative of the Dutch population regarding gender and age. We selected general practices which had registered for a complete year and selected patients who had been registered at the same general practice for a complete year. This resulted in a dataset of 851,891 patients and 232 general practices, because 8 practices were excluded.

Practice organization characteristics

Practice characteristics were derived from the NIVEL database of health professionals (2013), which contains the characteristics of every general practice in the Netherlands (n=5,008) and which annually collects its data by means of surveys. Per practice, items were selected related to practice organization, such as type of practice (solo, dual, or group practice), human resources in practice (regarding GPs: number, FTE GP, age, gender, number of self-employed GPs, employed by another GP and locums, and the availability of different care providers in practice), list size (number of patients in practice) and number of patients in practice per FTE GP. Urbanization level of the practice was determined and divided into five categories from rural (less than <500 addresses per km^2) to very strongly urbanized (more than >2,500 addresses per km^2). Subsequently, items were selected from the survey and categorized into five practice organization measures, regarding the number of medical services offered, consultation profile of the practice, physical accessibility of the practice, participation in disease management programmes, and the availability of patient information material. A higher score for a category refers to a higher occurrence of the category. The description of the measures and the items are presented in Table 1.

Sociodemographic profile of the patients' area of residence

Statistics Netherlands provided national census data at the four-digit postcode level from the year 2013 [18]. The data collected included the total population, the number of males and females in different age categories, one-person households, non-Western immigrants (at least one parent born in Africa, Latin America and/or Asia), low-income households (households with a purchasing power of less than <€9,250 a year) and urbanization level of patients' area, divided into five categories. Additionally, status score was obtained from the Netherlands Institute for Social Research. Status score is an indicator of the socioeconomic status of an area [19]. The area characteristics were selected as explanatory variables of the utilization of general practice care, because they are available at the four-digit postcode level and are important determinants of healthcare use [20].

Outcome measures

The first outcome variable was the actual GP utilization rate per listed patient per practice, which was the sum of all declared consultations, such as consultations (including by email), telephone consultations, home visits and consultations involving minor surgery. The second outcome variable was the estimated GP utilization rate per listed patient per practice based on the sociodemographic profile of patients' area. The third outcome variable was the difference between the actual GP utilization rate and the estimated rate per listed patient per practice. This continuous variable was analysed as such and also defined into categories by ranking. The first 40 scores made up the category 'low utilization', in which the actual utilization rate was lower than the estimated rate. The final 40 scores made up the category 'high utilization', in which the actual utilization rate was higher than the estimated rate.

Data analyses

First, descriptive analyses were calculated to describe the sample and the explanatory variables at practice level.

Second, linear regression was used to analyse whether practice organization characteristics could explain the actual utilization rate aggregated at practice level.

Third, on the same data but now aggregated at the four-digit postcode level a linear regression model was estimated for utilization on sociodemographic characteristics of patients' area of residence. Only four-digit postcode areas with at least 100 listed patients contributed to the model. Predictions were made for all four-digit postcodes in the dataset. Subsequently, a utilization rate was calculated for each general practice as a weighted mean of the predictions of the patients' postcodes. In the model the next sociodemographic predictors were used: the percentages of male and female in seven different age categories (0-4, 5-14, 15-24, 25-39, 40-64, 65-74, 75 and older), the percentages of one-person households, non-Western immigrants, low-income households, urbanization level (which was dummy-coded) and status score.

Fourth, this estimated utilization rate per practice was compared with the actual utilization rate. Linear regression was used to analyse whether the difference could be explained by practice organization characteristics, on aggregated data at practice level. The explained variance of the linear regression models was given by R-squared.

In addition, t-tests and proportion-tests were conducted to contrast practices with the highests positive difference with those with the highest negative difference on practice characteristics. Analyses were conducted using Stata version 14.1.

RESULTS

Sample characteristics and practice organization measures

Table 1 presents the mean of the five practice organization measures and the percentages of the underlying items. Scheduled consultation hours, minor surgery and an emergency line are the three most frequent practice organization characteristics in general practice. Table 2 shows the distribution of the practice organization characteristics of the general practices in the sample (n=232). The mean number of GPs per practice is 2.32.

Mean actual utilization rate per practice

The regression coefficients for the different practice organization characteristics on the mean actual utilization rate per practice are depicted in Table 3, F (17, 206) = 3.12; p=0.0001). The results show that three practice characteristics are statistical significant positive predictors of the mean actual utilization rate, namely 'disease management programme', 'the presence of other medical providers in practice' and 'dual practices'. The model explains 20.5% of the variation in the dependent variable.

Mean estimated utilization rate per postcode

The mean estimated utilization rate was calculated at the four-digit postcode level using linear regression analysis. The results of the linear regression analysis are given in Table 4, with the mean utilization rate as dependent variable and the sociodemographic characteristics of patients' area as independent variables, F (21, 871) = 14.33, p<0.0001. The model explains 25.7% of the variation in the dependent variable. Seven predictors are statistical significant. The predictors 'females of 75 years and older', 'persons in a low-income household', 'low urbanized areas', 'moderately urbanized areas', 'strongly urbanized areas' and 'very strongly urbanized areas' have a positive association. The predictor 'one-person households' has a negative association with the dependent variable.

Difference between actual and postcode-based estimated utilization rate

The results of the linear regression analysis are shown in Table 5, with the difference between the actual and the estimated utilization rate as dependent variable and practice organization characteristics as independent variables, $F(17, 206) = 2.89$, $p=0.0002$. The results show four practice characteristics with a statistical significant positive influence on the difference between the mean actual utilization rate and the mean estimated utilization rate, namely 'percentage of female GPs', 'disease management programme', 'the presence of other medical providers in practice' and 'dual practices'. The model explains 19.3% of the variation in the dependent variable.

In addition to the analysis of practice organization characteristics on the difference between the actual utilization rate and the postcode-based estimated utilization rate, we also analysed 'the postcode-based estimated utilization rate' as a predictor for the mean utilization rate per practice. The results show that on its own, the 'postcode-based estimated utilization rate' ($B=0.93$) accounts for 9.2% of the variation in the mean utilization rate per practice.

T-tests and proportion tests on low versus high utilization practices

Table 6 illustrates the distribution of practice characteristics for the total sample of general practices and for the general practices divided into two categories: low utilization and high utilization. Table 6 also shows the results of the t-tests and the proportion-tests between the practices with the 40 highest positive and the 40 highest negative differences. Compared to practices with high utilization, practices with low utilization are significantly more often solo practices, less often dual practices, have lower numbers of GPs, female GPs, as well as GPs younger than 40 years old. They also score significantly lower on the practice organization measure 'consultation profile'.

DISCUSSION

The present study, is a first exploration on the extent to which differences between the actual utilization rate and the estimated rate based on a limited set of sociodemographic variables can be related to practice organization characteristics. The sociodemographic profile of the patients' area of residence accounted for approximately 26% of the actual GP utilization rate at the four-digit postcode level. The investigated practice organization characteristics accounted for approximately 20% of the actual GP utilization rates. Three practice organization characteristics were statistically significant. The mean actual utilization rate per patient increased by 0.6 contacts when a 'other medical provider' was present in the general practice, increased by 0.3 when the practice was a dual practice instead of a solo practice, and increased by 0.05 with every added disease management programme.

Practice organization characteristics accounted for 19% of the difference between the actual GP utilization rates and the estimated rates based on the sociodemographic predictors. The practice characteristics mentioned above were also statistical significant here: 'the presence of other medical providers', 'dual practice' and 'the availability of a disease management programme'. Additionally, the employment of female GPs significantly increased GP utilization rates. Every extra percentage of female GPs added 0.003 to the utilization rate per patients. Together with the results of the t-tests and proportion-tests, these results indicate lower utilization rates than estimated for solo practices, with fewer GPs, female GPs, GPs younger than 40 years, and for practices which offer fewer consultation types. The actual utilization rates of these practices are lower than expected based on the sociodemographic profile of the practice population.

The present study, cannot comment on the quality of general practice care for high or low utilization practices. Huygen et. al. (1992) found that patients from a doctor with an integrated practice style, which is regarded as good quality of care, have a better health and visited their doctor less frequently. Moreover, those doctors kept the referrals to a specialist to a minimum [7]. So, low utilization practices can provide good quality of care. Low utilization practices may also keep the quality of care high by the employment of more experienced GPs who need fewer follow-up consultations. The age of the GP may be seen as an indicator for experience. We found a significant lower percentage of GPs younger than 40 years in practices with low utilization. However, Kersnik found that frequent attenders were more likely to visit an experienced GP and found no differences in the age of the GP between frequent attenders and infrequent attenders [21]. In further research, the relationship between quality of care, the experience of GPs and high or low utilization should be investigated.

Provider characteristics interact with patient characteristics to influence utilization of care [22]. One important result of our study is that a higher utilization rate is found more often in practices with a higher number of female GPs. In a Dutch study, Bensing found gender differences in practice style: female GPs spend more time with their patients, female patients tend to choose female GPs and female GPs see more gynaecologic problems and consults for family planning [23]. Also, Majeed et. al. (1994) found higher cervical smear uptake rates in practices with a female partner and in larger practices. Thus, hiring female GPs will probably attract more female patients, who are more frequent attenders in general practice care for female related health problems which result in higher practice consultation rates. However, in a study of Kernsik, it was found that frequent attenders were more likely to visit a male GP. So, in future research the relationship between the use of GP care and the gender of the GP has to be further investigated.

High or low utilization of general practice care can be seen as an indicator for the accessibility of general practice care, because utilization of care is influenced by the availability and accessibility of health care services, next to health status and health related behaviour [24]. Accessibility of health care is a multidimensional concept. Elements such as geographical accessibility, availability, affordability, acceptability and accommodation can be distinguished [25-27]. A Danish study by Heje on the accessibility of general practice care found that patients experienced better accessibility in solo practices, with a short patient list and with a few employees [28]. We found that low utilization practices are more often solo practices with less FTE GP. In the study by Heje, patients may have reported better accessibility of care in these smaller solo practices because they experienced more continuous care in the doctor-patient relationship [29]. Moreover, a better perceived accessibility of care may not always lead to high utilization rates. However, we found no influence of our accessibility measure. Our accessibility measure only existed of three accessibility issues and was not based on a theoretical framework. Thus, the relationship between the accessibility measure and utilization rates should be interpreted with caution. In further research, the accessibility of low and high utilization practices should be further investigated.

To the best of our knowledge, our study is one of the first to assess low utilization or high utilization of general practice care using an SAE method, which is a relatively easy, robust and inexpensive method. Our findings indicate that high utilization was found more often in general practices that employ other medical providers and that offer a disease management programme. Our assumption is, that larger practices have more human resources and are technically better equipped to provide consultations for minor surgery or for specific diseases, resulting in higher utilization rates than solo practices. GPs in practices with high utilization rates and probably a high workload may keep their practices accessible by task shifting, task delegation, work efficiency and shorter patient time, as was concluded by Van den Berg for practices with a higher workload in the Netherlands [30, 31]. However, our study is a first exploration and future research is needed to investigate the exact influence of practice organization characteristics and their interactions.

Strengths and limitations

We would have preferred to use a crossed-effects multilevel model with practices as one source of level two variation and four-digit postcodes as the other. However, this was not feasible due to the long estimation time, because of the high number of level two units: 232 general practices and 893 four-digit postcode areas.

Our results are based on three large datasets of routinely registered data. One contains data on the characteristics of all the practices and GPs in the Netherlands, the other contains health record data of approximately 1 million patients who are representative of the Dutch population regarding age and gender, and the last dataset contains census data which are routinely updated by Statistics Netherlands. However, these datasets entails also limitations. GP record data may be registered with some errors. The practice characteristics are expected to be updated by the GPs yearly, however it is not known for sure whether a change in the practice organization is also being registered. Our 232 general practices are not a random sample, but comes from a historical grown register for which practices were selected. Thus, the representativity of our findings is unclear.

A strength of our study was the large number of practice characteristics, including the five practice organization measures, that we have investigated as potential factors of low or high utilization. Third, we used a powerful alternative to costly designs, i.e. the small area estimation method [32, 33]. This method has been applied in several policy areas around the world, including health. In previous research, we calculated estimates on the need for general practice care in all the local areas in the Netherlands [34].

However, the use of the SAE method also has a disadvantage. The SAE method gives the expected value for an area based on the sociodemographic predictors included in the model and not the real value for the construct. Therefore, results which are based on SAE measures are "...usually at pains to stress that it is reporting estimates all with a degree of uncertainty and not a direct measure of the construct of concern" [35]. This degree of uncertainty may be enhanced by the fact that the model incorporates the mean value of a sociodemographic predictor for an area, such as the percentage of low income households, while the patients belonging to a practice are a selection from this area and may in fact belong to a higher income category.

CONCLUSIONS

The contributors to the utilization of general practice care are manifold and can be found at different levels. We found contributors at the four-digit postcode level and at the general practice level. The presence of other medical providers in the practice, the presence of female GPs and the number of disease management programmes influenced the difference between the actual utilization rate and the estimated rate based on the sociodemographic profile of an area. Our findings provide stakeholders who are involved with the organization of general practice care with useful insight into the practice organization characteristics that influence high or low utilization, in order to help them reflect on the organization and utilization of general practice care.

Table 1. Presence of the practice organization measures and underlying items for the sample of general practices (n=232).

Measures	Items	%	Mean	SD
Medical service profile	Sum score of the 9 underlying items		2.99	1.50
The practice offers the	Deliveries	1.3		
following medical services:	Pharmacy	3.9		
	Minor surgery	89.7		
	ECG equipment	50.4		
	Spirometry	81.5		
	Audiometry	44.4		
	Teleconsultation	22.4		
	Medical equipment	0.9		
	Other medical services	4.3		
Consultation profile	Sum score of the 7 underlying items		4.11	1.54
The practice offers the	Scheduled consultations	91.8		
following consultation	Walk–in hours	13.8		
types:	Call back consultations	76.7		
	Evening consultations	15.1		
	Email consultations	47.4		
	Emergency line	89.2		
	Prescription line	77.2		
Accessibility	Sum score of the 3 underlying items		1.44	0.75
The practice offers the	Parking for disabled people within 100 metres	64.7		
following:	Bus stop within 300 metres	78.5		
	Other accessibility services	0.4		

- table 1 continues -

Measures	Items	%	Mean	SD
Disease management	Sum score of the 14 underlying items		4.18	3.25
The practice offers special	Diabetes	79.3		
consultation hours	Asthma	23.7		
for the following diseases/	COPD	34.1		
categories:	Cardiovascular diseases	62.1		
	Minor surgery	45.7		
	Pre- and post-natal care	2.2		
	Pap-smear	52.2		
	Mental healthcare	35.8		
	Geriatric care	30.2		
	Allergy/Dermatology	6.9		
	Osteoporosis	10.8		
	Immigrants	1.7		
	Travellers	25.9		
	Other special consultation hours	7.3		
Patient information	Sum score of the 6 underlying items		3.32	1.27
material	Leaflets	85.8		
The practice has the	Leaflets in different languages	3.0		
following	Website	76.7		
communication	Patient letters	86.6		
channels/ materials:	Leaflet on complaint procedure	79.3		
	Other patient informational material	0.4		

Table 2. Distribution of the selected practice characteristics for the total sample of general practices (n=232).

Practice characteristics	N	%
Solo practices	88	37.9
Dual practices	91	39.2
Group practices	53	22.8
Practices in rural areas	37	16.0
Practices in low urbanized areas	42	18.1
Practices in moderately urbanized areas	47	20.3
Practice in highly urbanized areas	45	19.4
Practices in very highly urbanized areas	61	26.3
Support staff per practice	**N**	**%**
Doctor's assistant	213	91.8
Practice nurse somatic disorders	85	36.6
Practice nurse mental disorders	146	62.9
Pharmacist	9	3.9
Other medical providers	25	10.8
Other non-medical providers	54	23.2
GP characteristics per practice	**M**	**SD**
GPs	2.32	1.49
FTE GP	1.62	1.12
Female GP	1.09	1.05
GPs younger than 40 years old	0.47	0.73
GPs 40-55 years old	1.18	1.10
GPs 56-65 years old	0.63	0.83
GPs 65 years or older	0.05	0.22
Self-employed GPs	1.84	1.29
GPs employed by GP	0.26	0.50
Locums	0.17	0.43

Table 3. Model estimates for the regression of mean actual utilization rate on practice characteristics. (Data aggregated on practice level, n=224)

	B	P-value	Lower bound 95% CI	Upper bound 95% CI
Practice organization measures				
Medical service profile	0.048	0.33	-0.049	0.145
Consultation profile	0.070	0.22	-0.041	0.182
Accessibility	0.156	0.05	-0.001	0.312
Disease management	0.048[b]	0.04	0.001	0.094
Patient information material	-0.074	0.23	-0.196	0.048
Human resources in practice				
Doctor's assistant	-0.456	0.18	-1.125	0.212
Practice nurse somatic disorders	-0.265	0.07	-0.553	0.024
Practice nurse mental disorders	0.047	0.70	-0.188	0.281
Pharmacist	0.145	0.60	-0.403	0.694
Other medical providers	0.618[b]	0.00	0.298	0.938
Other non-medical providers	-0.141	0.24	-0.375	0.094
Type of practice; reference is solo practice				
Dual practices	0.283[b]	0.02	0.040	0.525
Group practices	0.141	0.32	-0.136	0.419
GP characteristics per practice				
Percentage of female GPs	0.003	0.10	-0.001	0.006
Percentage of GPs younger than 40 years	0.002	0.28	-0.002	0.006
Percentage of self-employed GPs	-0.001	0.66	-0.005	0.003
Number of patients per FTE GP	0.000	0.82	-0.000	0.000

[b] $p<0.05$. CI=Confidence interval, R^2=20.5%; Adjusted R^2=13.9%

Table 4 Model estimates for the regression of mean utilization rate on Sociodemographic characteristics of four-digit postcode areas (data aggregated on four-digit postcode area, n=893).

	B	P-value	Lower bound 95% CI	Upper bound 95% CI
Percentage gender age categories; reference category is proportion of males 25-39 years old				
Males 0-4 years old	-0.085	0.23	-0.225	0.055
Females 0-4 years old	0.028	0.68	-0.106	0.162
Males 5-14 years old	-0.014	0.74	-0.099	0.070
Females 5-14 years old	-0.069	0.14	-0.161	0.023
Males 15-24 years old	-0.042	0.38	-0.135	0.052
Females 15-24 years old	-0.028	0.38	-0.092	0.035
Females 25-39 years old	0.035	0.53	-0.074	0.145
Males 40-64 years old	-0.024	0.55	-0.102	0.054
Females 40-64 years old	0.044	0.14	-0.014	0.103
Males 65-74 years old	0.053	0.35	-0.058	0.163
Females 65-74 years old	-0.064	0.24	-0.171	0.043
Males 75 years or older	0.096	0.10	-0.019	0.212
Females 75 years or older	0.080[b]	0.04	0.005	0.156
Percentage of one-person households	-0.012[b]	0.03	-0.023	-0.001
Percentage of non-Western immigrants	0.005	0.12	-0.001	0.012
Percentage of people in low-income households	0.030[b]	0.00	0.012	0.047
Status score	0.045	0.34	-0.048	0.139
Degree of urbanization; reference category is rural				
Low urbanisation	0.387[b]	0.00	0.191	0.583
Moderately urbanised	0.302[b]	0.00	0.099	0.505
Strongly urbanised	0.381[b]	0.00	0.161	0.600
Very strongly urbanised	0.345[b]	0.02	0.059	0.631

[b] $p<0.05$. CI=Confidence interval, R^2=25.7%, Adjusted R^2=23.9%

Table 5 Model estimates for the regression of difference between the actual and estimated utilization rate on practice characteristics (data aggregated on practice level, n=224).

	B	P-value	Lower bound 95% CI	Upper bound 95% CI
Practice organization measures				
Medical service profile	0.055	0.24	-0.038	0.148
Consultation profile	0.081	0.14	-0.026	0.188
Accessibility	0.107	0.16	-0.043	0.257
Disease management	0.051[b]	0.03	0.007	0.095
Patient information material	-0.052	0.38	-0.170	0.065
Human resources in practice				
Doctor's assistant	-0.500	0.13	-1.142	0.141
Practice nurse somatic disorders	-0.269	0.06	-0.546	0.008
Practice nurse mental disorders	0.000	1.00	-0.225	0.225
Pharmacist	0.183	0.49	-0.343	0.710
Other medical providers	0.463[b]	0.00	0.156	0.770
Other non-medical providers	-0.139	0.23	-0.364	0.087
Type of practice; reference is solo practice				
Dual practices	0.253[b]	0.03	0.021	0.486
Group practices	0.138	0.31	-0.129	0.404
GP characteristics per practice				
Percentage of female GPs	0.003[b]	0.04	0.0001	0.007
Percentage of GPs younger than 40 years	0.002	0.27	-0.002	0.006
Percentage of self-employed GPs	0.000	0.89	-0.004	0.004
Number of patients per FTE GP	0.000	0.42	0.000	0.000

[b] $p<0.05$. CI=Confidence interval, R^2=19.3%; Adjusted R^2=12.6%

Table 6. Differences on practice organization characteristics between the 40 lowest and 40 highest scoring practices on the difference between mean actual utilization rate and the postcode-based estimate.

	Total GP practices in sample (N=232)		Practices with utilization lower than predicted N=40		Practices with utilization higher than predicted N=40		Results t-tests/pr-tests between low and high utilization practices
	Mean	*SD*	Mean	*SD*	Mean	*SD*	*P-value*
GP characteristics per practice							
GPs per practice	2.32	*1.50*	**1.73**	*0. 88*	**2.40**	*1.60*	*0.02**
Female GPs per practice	1.09	*1.05*	**0.60**	*0.60*	**1.28**	*1.13*	*0.00***
GPs younger than 40 years	0.47	*0.73*	**0.20**	*0.41*	**0.53**	*0.72*	*0.02**
GPs 40-55 years	1.17	*1.10*	0.98	*1.00*	1.13	*0.94*	*0.49*
GPs 56-65 years	0.63	*0.83*	0.50	*0.60*	0.63	*0.87*	*0.46*
GPs 65 years or older	0.05	*0.22*	0.05	*0.22*	0.13	*0.34*	*0.24*
Self-employed GPs per practice	1.84	*1.29*	1.38	*0.81*	1.68	*1.00*	*0.14*
GPs employed by GPs per practice	0.26	*0.51*	0.18	*0.39*	0.30	*0.61*	*0.28*
Locums per practice	0.17	*0.43*	0.18	*0.39*	0.25	*0.44*	*0.42*
Missing	0.05	-	-	-	0.17	-	-
FTE GP per practice	1.62	*1.12*	1.28	*0.70*	1.59	*1.14*	*0.15*

- table 6 continues -

Practice characteristics							
List size per practice	3,671	*2,384*	2,767	*909*	3,502	*2,233*	*0.06*
Utilization rate per patient	4.05	*0.75*	**3.18**	*0.35*	**5.21**	*0.63*	*0.00***
Solo practices	0.38	*0.49*	**0.60**	*0.50*	**0.30**	*0.46*	*0.00***
Dual practices	0.39	*0.49*	**0.30**	*0.46*	**0.58**	*0.50*	*0.01**
Group practices	0.23	*0.42*	0.10	*0.30*	0.13	*0.34*	*0.72*
Urbanization	3.22	*1.42*	2.90	*1.50*	3.23	*1.39*	*0.32*
Practice organization measures							
Medical service profile	2.99	*1.50*	2.75	*1.43*	3.35	*1.55*	*0.08*
Consultation profile	4.11	*1.54*	**4.03**	*1.54*	**4.73**	*1.40*	*0.04**
Accessibility	1.44	*0.75*	1.33	*0.80*	1.63	*0.67*	*0.07*
Disease management	4.18	*3.25*	3.75	*2.89*	5.18	*3.74*	*0.06*
Patient information material	3.32	*1.27*	3.30	*1.27*	3.53	*1.20*	*0.42*
Support staff per practice							
Doctor's assistant	0.92	*0.27*	0.90	*0.30*	0.95	*0.22*	*0.40*
Practice nurse somatic disorders	0.37	*0.48*	0.38	*0.49*	0.48	*0.51*	*0.37*
Practice nurse mental disorders	0.63	*0.48*	0.43	*0.50*	0.63	*0.49*	*0.24*
Pharmacist	0.04	*0.20*	0.03	*0.16*	0.00	*0.00*	*0.31*
Other medical providers	*0.11*	0.31	0.05	*0.22*	0.18	*0.39*	*0.08*
Other non-medical providers	0.23	*0.42*	0.25	*0.44*	0.20	*0.41*	*0.39*

* The score for low utilization practices is significantly different from high utilization practices; $P<0.05$; $**P<0.01$

Bold The numbers in bold are practice characteristics which differ significantly between low and high utilization practices

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Chapter 6

Do patient and practice characteristics confound age-group differences in preferences for general practice care?

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ABSTRACT

Background
Previous research showed inconsistent results regarding the relationship between the age of patients and preference statements regarding GP care. This study investigates whether elderly patients have different preference scores and ranking orders concerning 58 preference statements for GP care than younger patients. Moreover, this study examines whether patient characteristics and practice location may confound the relationship between age and the categorisation of a preference score as very important.

Methods
Data of the Consumer Quality Index GP Care were used, which were collected in 32 general practices in the Netherlands. The rank order and preference score were calculated for 58 preference statements for four age groups (0–30, 31–50, 51–74, 75 years and older). Using chi-square tests and logistic regression analyses, it was investigated whether a significant relationship between age and preference score was confounded by patient characteristics and practice location.

Results
Elderly patients did not have a significant different ranking order for the preference statements than the other three age groups (r = 0.0193; p = 0.41). However, in 53% of the statements significant differences were found in preference score between the four age groups. Elderly patients categorized significantly less preference statements as 'very important'. In most cases, the significant relationships were not confounded by gender, education, perceived health, the number of GP contacts and location of the GP practice.

Conclusion
The preferences of elderly patients for GP care concern the same items as younger patients. However, their preferences are less strong, which cannot be ascribed to gender, education, perceived health, the number of GP contacts and practice location.

BACKGROUND

In the next 30 years, an increase in the demand for primary care is to be expected due to an ageing population [1-3]. Already, elderly patients have a substantially higher contact rate with general practice care than younger patients [4]. Primary healthcare must be able to adapt to the healthcare needs of the elderly, which are different from younger patients, to ensure the well-being of older people [1].

Moreover, primary care should address the preferences and the views of older patients [1,5], as differences in healthcare needs may lead to differences in preferences regarding healthcare [6]. Indeed, De Boer et al. found that patient groups categorised by health problem differed in their preferences for quality aspects of care [7]. Greater insight into elderly people's preferences regarding primary care can help to make primary care more responsive to the needs of the elderly [5,6].

Substantial research has been conducted into the preferences of patients regarding quality aspects of GP care [5,6,8-13]. The influence of age on the preferences regarding GP care showed different magnitudes [6,9,10]. Moreover, one study did not find any relationship between age and preference scores. This study concluded that the results for patients' preferences are mixed and that 'the reason for this is unclear and may relate to a number of factors' [11].

Even though the outcomes regarding the influence of age on preference scores differ widely, little research has been conducted into the factors which may influence these differences. In a Dutch study, Jung et al. stated that it was not age but the number of GP contact moments which had the greatest influence on preference scores. Other direct effects on preference scores were found for level of education, gender, and health status [9]. In addition to age, a systematic literature review identified a direct effect on preferences of level of education, health status, gender, family situation and utilisation of healthcare services [6]. Despite these direct effects on preference scores, the review did not elaborate on the possible effects on the relationship between age and preferences. To our knowledge, only two studies have elaborated on the influence of some of the above factors on the relationship between age and preference score [10,12]. However, they did so only for three preference statements regarding GP care.

In this study, we investigate whether elderly patients have different preferences concerning 58 preference statements for GP care than younger patients and examines whether gender, education, perceived health, healthcare use and degree of urbanisation may confound the relationship between age en preference score. These characteristics have been shown to have a major influence on the preferences for GP care [6,9]. The relationship between age and preferences regarding GP care is of special interest because older patients are more dependent on others, have a higher healthcare use, have a lower health status, and suffer more from chronic diseases than younger patients [3].

METHODS

Data collection and response

Data of the Consumer Quality Index GP care (CQI GP care) were used, which were collected for the development of this instrument between 2005–2007 in 32 GP practices in the Netherlands with a total of more than 16,000 patients [14]. The practices involved were located in both rural and urban areas. Every resident in the Netherlands is registered with a GP. For all patients registered at one of these practices, name, address, date of birth and gender were extracted. Using random sampling a questionnaire was sent in name of the GP to patients from every GP practice (n = 32). One practice was situated in an disadvantage area. To compensate for the expected low response rate for this practice, 150 questionnaires were sent. One practice had a very small patient population and therefore no questionnaires were sent. The total amount of questionnaires sent was n = 3,150.

The CQI is a Dutch valid instrument to measure patient experiences and preferences regarding healthcare [15]. It is based on two other types of surveys: the American CAHPS (Consumer Assessment of Healthcare Providers and Systems) [16,17] and the Dutch QUOTE (QUality Of care Through the patients' Eyes) [18-20]. The CQ-index is characterized by its disease-specific and provider-specific focus as well as the assessment of patient priorities, which both derive from the QUOTE. The lay-out, response scales and standardized sampling, data collection, analysis and presentation adopted for the QC-index were taken from CAHPS. The CQ-index has been declared to be the national standard for measuring patient experiences and performance indicators of quality of care are frequently based on the CQ-index [21,22].

The questionnaire contained questions regarding the respondents' characteristics according to the CQI method [15] and 58 preference statements regarding GP care and the other healthcare providers (OHCP) in the GP practice, such as the practice nurse. The statements covered subjects such as communication, accessibility, affection, care from other healthcare providers such as an assistant, specialised or diabetes nurse and/or practice nurse), organisation, patient-centred care, cooperation and expertise [14]. Patients could answer on a four-point scale which ranged from 'not important', 'reasonable important', 'important' to 'very important'. To address avoidance of scale extreme, especially amongst the oldest age group, the response scale are small and value labels were added to the response categories.

The questionnaire was filled in both by patients who had and by patients who had not visited a GP in the previous year. Despite the fact that those patients did not visit the GP in the previous year, they presumably have experiences with visiting the GP and therefore their preferences regarding GP care remain relevant and important.

Statistical analysis

Patients were categorised in four age groups (0–30, 30–51, 51–75 and 75 years and older). Subsequently, a rank order was calculated for every preference statement based on the mean score of the preference statements for every age group (scores 1–4). Next, the percentage of patients who found a preference statement 'very important' (preference score) was calculated for every preference statement for the four age groups. Therefore, the 58 preference statements were dichotomised (0 = 'not very important' to' important', 1 = 'very important'). The mean number of statements which were categorized as 'very important' was calculated for every age group. Using Students' t-test it was calculated whether the mean preference score differed significantly between the age groups and with spearman correlation the association between the different age groups and the rank order was calculated.

To analyse whether there were significant differences in the percentage of patients who found a statement 'very important' (preference score) between the four age groups, a chi-square test was conducted for every statement (n = 58). To analyse which age groups differed significantly on 'preference score', the chi-square tests were repeated for the statements with a significant *p*-value ($p < 0.05$) for every possible combination of two age groups.

Subsequently, logistic regression was used to analyse whether there was still a significant relationship between age and preference score after gender (1 = female) and education (1 = low, 2 = average, 3 = high), perceived health (0 = less than good health and 1 = good health) and GP contact (0 = less than 5 contact moments and 1 = 5 or more contact moments), and degree of urbanisation (0 = rural, 1 = urban) had been entered. If in the fourth model there was still a significant relationship between age and preference score, we defined that the above-mentioned factors did not confound the significant relationship between age and preference score. We were interested on the effects of the factors on the relationship between age and preference score and not on their main effects. The analyses were carried out using STATA (version 10, 2009, STATACorp, College Station Texas).

RESULTS

Response and demographics of the subgroups

The number of questionnaires sent amounted to 3,150. A total of 89 questionnaires were returned undeliverable. The net response was 60.7% (n = 1,858). For 35 respondents age was unknown and they were therefore excluded from the analysis (n = 1,823). The patient characteristics and the practice characteristic for the four age groups are shown in Table 1. For the four age groups, the chi-square tests showed significant differences in education ($p < 0.001$), gender ($p < 0.001$), perceived health ($p < 0.001$), number of GP contacts ($p < 0.001$) and urbanisation of the practice location ($p < 0.001$).

Table 1 Patient and practice characteristics for the respondents (n = 1,823) in the four age groups.

	Patients 0–30 years (n = 283)		Patients 30–51 years (n = 633)		Patients 51–75 years (n = 700)		Patients 75 years and older (n = 207)	
Mean age	21.4	SD = 6.3	40.8	SD = 5.9	60.8	SD = 6.5	80.74	SD = 4.4
	n	%	n	%	n	%	n	%
Education								
- unknown	14	5.0	17	2.7	47	6.7	21	10.1
- low	84	29.7	152	24.1	300	42.9	128	61.8
- medium	128	45.2	259	46.6	256	36.6	47	22.7
- high	57	20.1	169	26.7	97	13.9	11	5.3
Gender								
- unknown	2	0.7	0	0	1	0.1	0	0
- male	182	64.3	223	35.2	319	45.6	70	33.8
- female	99	34.9	410	64.8	380	54.3	137	66.2
Perceived health								
- unknown	0	0	6	0.9	13	1.9	2	1.0
- bad	2	0.7	13	2.1	22	3.1	8	3.9
- reasonable	27	9.5	94	14.8	176	25.1	85	41.1
- good	156	55.1	377	59.6	409	58.4	100	48.3
- very good	66	23.3	106	16.7	57	8.1	10	4.8
- excellent	32	11.3	37	5.8	23	3.3	2	0.1
GP contact rate								
- unknown	8	2.8	27	4.3	52	7.4	15	7.2
- 0	55	19.4	68	10.7	82	11.7	11	5.3
- 1	51	18.0	94	14.8	82	11.7	9	4.3
- 2-4	108	38.2	254	40.1	243	34.7	55	26.6
- 5-9	51	18.1	144	22.7	166	23.7	81	39.1
- 10 or more	10	3.5	146	7.3	75	10.7	36	17.4
Urbanisation practice location								
- unknown	0	0	11	1.7	23	3.3	7	3.4
- rural	152	53.7	341	53.9	301	43.0	80	38.6
- urban	131	46.3	281	44.4	376	53.7	120	58.0

Preference scores and rank order

Table 2 shows the different preference statements (n = 58), the percentage of respondents from the four age groups who found the preference statements 'very important', the rank order and significant differences between the age groups in the preference scores. The preference statements were ranked according to the rank score of the patient group ‘75 years and older’. In general, the preference statements with the ten highest and lowest scores were the same for the four age groups. There was no significant difference in rank order between the four age groups. According to the Spearman rank test, the relationship between the respondents’ age and the mean score given to the preference statements was non-significant ($r = 0.0193$; $p = 0.41$). The preference statements with the three highest scores for patients ‘75 years and older’ were ‘good expertise of GP’, ‘no conflicting information from OHCP and GP’ and ‘good cooperation between OHCP and GP’.

Table 2. Preference scores and ranking order for the 58 preference statements for the four age groups.

	1.Patients 0–30 years		2.Patients 30–51 years		3.Patients 51–75 years		4.Patients 75 years and older	
Preference statements	% Very important	Rank order	% Very important	Rank order	% Very important	Rank order	% Very important	Rank order
Good expertise of GP	68.9	2	74.0	1	73.6	1	67.8	1
HCP does not give conflicting information*	59.2 ^{4}	5	60.3 ^{4}	4	58.5 ^{4}	4	48.3 $^{1 2 3}$	2
Good cooperation between O*HCP* and GP*	56.1 ^{4}	7	56.4 ^{4}	5	58.0 ^{4}	3	44.9 $^{1 2 3}$	3
GP gives understandable explanation regarding results	55.1 ^{4}	6	53.1 ^{4}	6	54.1 ^{4}	5	44.9 $^{1 2 3}$	4
GP takes me seriously**	64.0 $^{3 4}$	3	60.4 $^{3 4}$	3	51.6 $^{1 2 4}$	6	43.2 $^{1 2 3}$	5
Privacy in examination room**	69.9 ^{4}	1	66.7 ^{4}	2	64.8 ^{4}	2	47.1 $^{1 2 3}$	6
GP must give information on side-effects medicine**	26.2 $^{2 3 4}$	30	34.4 $^{1 4}$	30	37.3 ^{1}	20	44.2 $^{1 2}$	7
OHCP redirects in time**	54.5 ^{4}	9	53.0 ^{4}	7	54.1 ^{4}	7	38.8 $^{1 2 3}$	8
GP listens carefully**	55.1 $^{3 4}$	4	50.5 $^{3 4}$	8	41.1 $^{1 2 4}$	10	32.7 $^{1 2 3}$	9

- table 2 continues -

	1.Patients 0–30 years		2.Patients 30–51 years		3.Patients 51–75 years		4.Patients 75 years and older	
GP must give information regarding different treatments	43.3	13	42.9	10	44.5 ^{4}	8	34.6 ^{3}	10
OHCP must have good expertise	40.9	18	42.2	15	43.1 ^{4}	13	34.3 ^{3}	11
Good diagnosis of assistant	39.9	17	45.7	12	44.2	12	39.1	12
Good accessibility of practice	46.6 ^{3}	15	39.8	18	39.3 ^{1}	15	38.8	13
Treatment should reduce problems	33.0	21	30.9 ^{3}	29	36.8 ^{2}	16	30.7	14
GP gives understandable explanation**	42.8 ^{3,4}	14	40.2 ^{4}	13	35.8 ^{1}	14	28.8 ^{1,2}	15
GP needs to tell me what I want to know**	50.2 ^{3,4}	10	43.6 ^{4}	9	42.0 ^{1,4}	9	32.4 ^{1,2,3}	16
Helpful staff	33.6	19	33.5	17	30.3	17	26.2	17
GP Practice must be clean**	40.1 ^{2,4}	20	31.5 ^{1}	24	35.6 ^{4}	18	26.2 ^{1,3}	18
Quick consult with own GP	21.9 ^{3}	33	27.1	32	28.7 ^{1}	27	26.1	19

- table 2 continues -

	1.Patients 0–30 years		2.Patients 30–51 years		3.Patients 51–75 years		4.Patients 75 years and older	
OHCP must take me seriously**	39.2 [3 4]	16	35.2 [3 4]	16	29.1 [1 2 4]	19	19.8 [1 2 3]	20
GP has attention for personal situation	31.5	32	33.3 [4]	27	30.6	31	25.0 [2]	21
OHCP must give understandable explanation	28.6 [4]	22	25.8	28	23.5	29	19.0 [1]	22
Possibility to call *AHGPC**	16.3 [2 3 4]	39	22.8 [1 3]	38	30.4 [1 2]	34	27.7 [1]	23
Consultation within 24 hours**	30.0 [3]	24	36.2 [3 4]	22	43.7 [1 2 4]	11	27.1 [2 3]	24
Good assistance on telephone	24.4	23	25.0 [4]	26	22.8	38	18.4 [2]	25
Respect of GP for patient**	54.4 [2 3 4]	8	43.1 [1 3 4]	11	30.2 [1 2 4]	24	22.6 [1 2 3]	26
GP is prepared to talk regarding mistakes*	24.4 [2 3]	29	32.0 [1]	23	35.4 [1]	22	30.9	27
GP must motivate advice	22.1	34	21.6	34	24.1	35	23.5	28
Good cooperation GP and OHCP	21.6	37	23.9 [3]	36	27.5	30	23.8	29

-table 2 continues -

	1.Patients 0–30 years		2.Patients 30–51 years		3.Patients 51–75 years		4.Patients 75 years and older	
Privacy at desk	25.2	38	27.3	40	29.1	40	29.3	30
GP must help me find my way in healthcare**	17.3 [3 4]	45	19.0 [3 4]	42	25.7 [1 2]	38	25.9 [1 2]	31
Respect of assistant**	44.2 [2 3 4]	11	32.9 [1 3 4]	20	26.8 [1 2]	31	20.9 [1 2]	32
OHCP listens carefully	25.5 [4]	27	23.2 [4]	33	22.1	36	15.7 [1 2]	33
Respect of *HCP* for patient **	42.1 [3 4]	12	37.1 [3 4]	14	28.1 [1 2 4]	23	16.3 [1 2 3]	34
GP must have sufficient time for patient**	29.1 [4]	24	28.0 [4]	25	23.3	28	17.6 [1 2]	35
GP attention for emotional causes of health problems	31.5	25	35.4 [4]	19	34.6 [4]	21	25.6 [2 3]	36
GP must help prevent disease	18.4	49	17.7 [3]	43	22.2 [2]	43	17.1	37
GP gives room for participation in decision-making**	28.3 [2]	28	35.7 [1 4]	21	32.3 [4]	25	22.9 [2 3]	38
Enough practice information available *	17.0 [3]	35	21.0	31	24.2 [1 4]	33	17.4 [3]	39
OHCP has information on disease history	19.6	44	18.7	47	22.2	46	17.4	40

- table 2 continues -

	1.Patients 0–30 years		2.Patients 30–51 years		3.Patients 51–75 years		4.Patients 75 years and older	
GP pays attention to emotional problems*	15.9 [2 3]	43	22.0 [1]	35	23.2 [1]	37	17.6	41
OHCP must spend sufficient time	20.1 [4]	31	18.1 [4]	39	16.4	41	10.8 [1 2]	42
OHCP wants to talk regarding mistakes *	18.9	43	24.0 [4]	37	24.2 [4]	39	15.8 [2 3]	43
OHCP must help prevent disease**	17.4	47	15.1 [3]	50	23.3 [2 4]	47	14.8 [3]	44
OHCP must motivate advice **	17.7 [4]	36	15.9 [3 4]	44	22.2 [2 4]	42	8.5 [1 2 3]	45
GP must redirect when I think it is necessary *	18.4 [3]	51	18.3 [3]	48	24.2 [1 2]	50	23.3	46
OHCP gives room participation in decision making*	18.1	40	22.3 [4]	41	21.0 [4]	44	12.5 [2 3]	47
Assistant must spend enough time	16.3 [4]	42	14.0	45	14.6	49	9.7 [1]	48
Good (fast) contact on telephone **	12.0 [3 4]	54	13.0 [3 4]	49	22.5 [1 2]	48	22.3 [1 2]	49
Enough seating in general practice	9.3	53	8.1	51	8.4	52	6.8	50

- table 2 continues -

	1.Patients 0–30 years		2.Patients 30–51 years		3.Patients 51–75 years		4.Patients 75 years and older	
Quick access to consultation *	11.7 [3]	48	17.4	43	18.7 [1]	25	13.1	51
OHCP must pay attention to emotional problems**	12.2 [3]	52	12.0 [3]	53	18.3 [1 2 4]	50	9.6 [3]	52
Direct contact with GP	12.8	55	12.5	56	15.3	54	15.1	53
Information on health problems available in practice	14.1 [4]	50	11.3	54	13.1	53	8.00 [1]	54
Helped within 15 minutes after the agreed time**	17.3 [2 3 4]	46	12.3 [14]	52	9.5 [1]	55	7.3 [1 2]	55
Favourable practice hours	5.7	56	7.2	55	6.6	56	8.0	56
GP prescribes medicine when I think it is necessary	8.8	58	6.9	58	9.4	57	9.2	57
Possibility to go to *AHGPC*	7.1	57	6.9	57	7.8	58	8.6	58

OHCP = the Other Healthcare Provider within the general practice.
AHGPC = After Hours General Practitioner Clinic.
* = $p < 0.05$; ** = $p < 0.01$.

The chi-square tests showed a significant difference in preference score between two or more different age groups for 53.4% (n = 31) of the preference statements. In most cases, patients ’75 years and older’ had the lowest preference score. The results of the chi-square tests, which compare two groups separately, showed for the group of ‘0-30 years old’, the most significant differences in preference scores (n = 26) with the group of ‘75 years and older’. For the group of ‘30-50 years old’, the most significant differences (n = 28) were also with the group ’75 years and older’ and the same yields for the group of ‘50-75 years old’ (n = 23).

Table 3 shows the mean number of preference statements which are categorised as ‘very important’ for the different age groups. The results showed that the group of ‘50-75 years old’ had the largest number of preference statements which were categorised as ‘very important’ (mean = 18.1) and the group of ‘75 years and older’ had the lowest mean number of preference statements that were categorised as ‘very important’ (mean = 14.2). This difference was significant ($t(688) = 3.13$; $p < 0.001$).

Table 3. Mean number of statements which are ‘very important’ for the different age groups.

Age groups	Mean number of statements which are ‘very important’	SD	N
0-30 years	17.2	12.1	233
30-51 years	17.7	13.9	514
51-75 years	18.1	14.0	542
75 years and older	14.2	11.2	148

Logistic regression; controlling for gender, education, perceived health, GP contacts and urbanisation of the practice location

Logistic regressions were conducted for the 31 statements for which the chi-square tests showed a significant difference in the preference scores between the age groups. For most of the statements, the significant relationship between age and preference score did not disappear after the confounders were entered in the logistic regression model. The significant influence of age on preference score disappeared for only five statements after entering the factor education; most of these preference statements concerned the other healthcare provider. Table 4 shows the five preference statements for which the significant relationship disappeared. The other confounder variables; perceived health, number of GP contacts and GP practice location did not influence the significant relationship between age and preference score.

Table 4. Results nested logistic regression analyses for 5 preference statements for which confounders influence the relationship between age and preference score.

	Odds ratio	Std. err.	z	95% Conf.	Interval
Preference statement 36: GP must redirect me to a medical specialist when I think it is necessary					
Reference category 51–75 years					
Model 1					
75 years and older	0.97	0.2	0.87	0.65	1.44
30-51 years	0.72	0.1	0.02	0.55	0.95
0-30 years	0.7	0.13	0.05	0.49	1.00
Model 2					
75 years and older	0.9	0.18	0.61	0.6	1.35
30-51 years	0.77	0.11	0.06	0.58	1.02
0-30 years	0.72	0.13	0.08	0.5	1.04
Gender	0.93	0.12	0.58	0.73	1.19
Education	0.81	0.07	0.02	0.68	0.96
Preference statement 57: The OHCP must assist me to prevent diseases or to improve my health*					
Reference category 0–30 years					
Model 1					
75 years and older	0.9	0.26	0.7	0.51	1.57
51-75 years	1.57	0.31	0.03	1.06	2.33
30-51 years	0.94	0.2	0.77	0.62	1.42
Model 2					
75 years and older	0.76	0.22	0.35	0.43	1.35
51-75 years	1.46	0.3	0.07	0.98	2.17
30-51 years	0.97	0.21	0.9	0.64	1.48

- table 4 continues -

	Odds ratio	Std. err.	z	95% Conf.	Interval
Gender	1.14	0.16	0.35	0.87	1.49
Education	0.73	0.07	0	0.6	0.89
Preference statement 59: The OHCP must pay attention to emotional problems					
Reference category: 0–30 years					
Model 1					
75 years and older	0.87	0.29	0.68	0.45	1.67
51-75 years	1.71	0.39	0.02	1.09	2.68
30-51 years	1.1	0.26	0.69	0.7	1.76
Model 2					
75 years and older	0.69	0.23	0.28	0.36	1.34
51-75 years	1.57	0.36	0.05	1	2.47
30-51 years	1.16	0.28	0.54	0.72	1.86
Gender	0.99	0.15	0.97	0.74	1.34
Education	0.64	0.07	0	0.51	0.79
Preference statement 62: The OHCP must collaborate well with GP					
Reference category 51–75 years					
Model 1					
75 years and older	0.7	0.13	0.047	0.49	0.99
30-51 years	0.97	0.12	0.82	0.77	1.23
0-30 years	0.96	0.15	0.78	0.71	1.3
Model 2					
75 years and older	0.74	0.13	0.1	0.52	1.06
30-51 years	0.9	0.11	0.39	0.7	1.15
0-30 years	0.91	0.14	0.53	0.67	1.23
Gender	0.91	0.09	0.4	0.74	1.13
Education	1.23	0.1	0.01	1.07	1.43
Preference statement 63: The OHCP must not give conflicting information					
Reference category 0–30 years					
Model 1					
75 years and older	0.66	0.12	0.02	0.46	0.95
51-75 years	0.91	0.11	0.43	0.71	1.16
30-51 years	0.95	0.15	0.73	0.7	1.29
Model 2					
75 years and older	0.75	0.14	0.12	0.52	1.08
51-75 years	0.98	0.12	0.86	0.76	1.25
30-51 years	0.97	0.15	0.84	0.71	1.32

- table 4 continues -

	Odds ratio	Std. err.	z	95% Conf.	Interval
Gender	0.89	0.1	0.27	0.72	1.1
Education	1.2	0.09	0.01	1.04	1.4

*OHCP = The other healthcare provider.

DISCUSSION

Healthcare for the elderly has become an essential part of GP care. In the future, the number of elderly patients with complex healthcare needs as a result of multi-morbidity, disability, vulnerability, and loss of control will grow [13,23,24]. Despite the complex healthcare needs of elderly patients, the present study showed no significant difference in the rank order of the 58 preference statements regarding GP between elderly patients and younger patients. Elderly patients find 'good expertise of GP', 'no conflicting information' and 'good cooperation' important quality aspects, just as the other age groups. In this perspective, GPs must pay attention to the same quality aspects for the elderly patients as for the youngest patients.

However, the present study showed differences in the number of preference statements which are categorized as 'very important' between the age groups. The elderly patients categorised the lowest number of preference statements as 'very important'. The fact that the oldest patients are milder has been confirmed by previous research [25] and may be attributed to an age effect. As the life-cycle theory states, age can influence people's beliefs, values and attitudes regarding healthcare. The oldest patients become dependent, disabled and develop a loss of self-confidence, which may result, for instance, in less motivation to participate in shared decision making or active information seeking [26]. As a consequence, it may not be necessary to prepare healthcare providers for an upcoming critical patient group as younger patients grow older.

The present study demonstrated that patient characteristics and practice location did in most cases not confound the significant relationship between age and preference score. Only for five preference statements the factor 'education' confounded the relationship between age and preference score. This finding may indicate that older patients with a higher level of education, in some cases, have other preferences regarding quality of GP care than older patients with a lower education level. This may mean that as highly-educated patients grow older, GPs have to be aware of their divergent needs and desires. In this sense, the difference in preference score for the different age groups can be a cohort effect. In the future, GPs may encounter more well-educated elderly people with preferences comparable to those of younger patients [12]. However, education only influenced the relationship for 5 of the 31 preference statements entailing redirection to medical specialists, assistants to prevent diseases, cooperation between health-care providers, conflicting information and attention for emotional problems.

Not only the mean age of the GP's patient population will change, but also the healthcare offered by the GP. As patients grow older, GP care will shift from cure to care. Also, the GP care in the Netherlands for patients with a chronic disease will shift to a more patient-centred focus and different disciplines and health-care organisations will be stimulated to cooperate. These changes may change patients' opinions regarding GP care in the future [27]. Therefore, research into the preferences regarding GP care for different patient groups should be repeated in the future.

A limitation of this study, given the number of comparisons made and statistical tests performed, is the issue of multiple testing. In short, the multiple testing issue entails that when a series of comparisons are performed while in reality there are no differences, 5% of these test will show a significant difference solely due to chance. Statistical solutions to this problem, such as the Bonferroni correction for example, generally reduce power. Accordingly, we chose not to apply a statistical correction for multiple comparisons, but to address this issue when interpreting the results. In this context, it is worth noting that although we found much more significant results than could be expected based on chance alone, a small number of the significant results may potentially be a result of the number of tests performed.

A second limitation is the arbitrary approach by which the age groups have been categorised, especially, the age group 0–30 years old which include preferences from parents with young children with preferences from young adults. Nevertheless, our data show that the group of '0-30 years old' had the most significant differences in preference scores (n = 26) with the group of '75 years and older'. For the group of '30-50 years old', the most significant differences (n = 28) are also with the group '75 years and older' and the same is true for the group '50-75 years old' (n = 23). So, the most divergent group is the age group ‘75 years and older’. Previous research using other age groups confirmed that preference scores differ between age groups. In addition, we found that generally the relationship between age and preference score is not significantly influenced by patient and practice characteristics.

Another aspect which has to be taken into account is the fact that patient preferences are influenced by the length of time that elapsed between the consultation and filling in the survey [28]. We have no information regarding the length of time elapsed between the consultation and the survey. However, our sample contained people who had visited their GP in the year preceding the survey and people who had not visited their GP in that year. Therefore, the preference scores were not only influenced by recent experiences of our sample.

Lastly, our study did not investigate every possible patient or practice characteristic. For example, patients’ religion may also influence the relationship between age and preference score. According to a systematic review, religion is most frequently found to influence patients’ preferences [6]. However, our data set did not include this variable.

One of the strengths of our research is the large number of preference statements which were investigated, that these preference statements were based on interviews and focus groups with patients and were approved by different health-care organisations. Moreover, our survey was developed using widely known and tested CQI-methodology [15] and also included preference statements regarding the other healthcare provider in GP care which is rather unique.

Conclusion

The present study investigated the preferences regarding general practice care of elderly patients and whether patient characteristics and practice location may confound the relationship between age and the categorisation of a preference score as very important. This study demonstrated that the preferences of elderly patients concerning GP care concern the same items as younger patients. However, their preferences are less strong, which cannot be ascribed to gender, education, perceived health, the number of GP contacts and practice location.

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Chapter 7

Summary and general discussion

The aim of this thesis was to investigate how small area estimates regarding lifestyle, health and healthcare can be generated using a statistical estimation model in order to support the process of integrated population-based healthcare in the Netherlands. Chapter 7 provides a summary of the study and discusses the meaning of the results, the lessons learned and the implications for further research.

WHAT WAS INVESTIGATED?

Small area estimates are needed for an integrated population-based healthcare

The thesis investigated how small area estimates regarding lifestyle, health and healthcare can be generated using a statistical estimation model. Small area estimates of lifestyle, health and healthcare generate data on a geographically small level, and such data are essential to support changes in the healthcare system aiming to keep healthcare cost-effective and of good quality. These changes are directed at making healthcare more demand-driven and at adapting it to the needs of local populations. The small area estimates contribute to the so-called 'triple aim' of improving the populations' health, improving individuals' experience of care, and reducing healthcare costs [1, 2]. They also fit in with the health policy of the Dutch government, which is aimed at matching the supply of primary care to the needs of local populations, strengthening primary care and decentralizing health policy [2-6].

The transition to an integrated population-based healthcare at both the national and local level is a complex process. The lifestyles, health and healthcare needs of populations differ greatly between small geographical areas [7], as do their determinants, such as gender, age, social economic status, income, type of household and other sociodemographic characteristics [8-11]. Therefore, local and integrated population-based healthcare requires estimates "at a finer level of geographical detail than the broad regions that were commonly used in the past" [12, p.17]. In this thesis it is shown that for the Netherlands, small area estimates on lifestyle, health and healthcare needs generate the data that are key to determining the necessary healthcare provision.

Strategies to calculate small area estimates

Small area estimates on lifestyle, health and healthcare are not readily available and require advanced models as well as suitable data. In principle, small area estimates could be based on sample surveys. However, sample surveys are costly, rapidly become outdated, are not available for every small area, and have insufficient statistical precision at the small area level [13-15]. A small area may be a neighbourhood, a four-digit postcode area, a municipality or a health region. This thesis focused on finding a solution for the problem of costly and limited sample surveys. It was investigated to what extent a statistical estimation model can produce small area estimates on lifestyle, health and healthcare. A statistical estimation model is an innovative strategy, as it can convert estimates for only a sample of areas into estimates for every area. In other words, a statistical estimation model uses "*auxiliary data available at the small area level, such as administrative data or data from the last census. These data are used to construct predictor variables for use in a statistical model that can be used to predict the estimate of interest for all small areas*" [12, p.19].

An innovative strategy for small area estimations in the Netherlands

Several statistical estimation techniques were studied that are used in countries such as the United States, Canada and the United Kingdom. Next, the question was addressed whether a statistical estimation technique could also be used to calculate small area estimates for small areas in the Netherlands. This led to other questions. Can health, lifestyle and healthcare be predicted by sociodemographic characteristics at the small area level within the Dutch health care system? What is the availability of sociodemographic data and national survey or registered data on lifestyle, health and healthcare needs? Can a robust, general, valid and efficient model be developed, given all the necessary indicators? And, finally, what is the acceptability of small area estimates in the context of the Dutch policy discussion towards achieving an integrated population-based healthcare?

The research for small area estimation in the Netherlands started in 2005, when a project was initiated to create an Internet application called 'the Demand Supply Monitor for primary care' (in Dutch: VAAM). The main goal of the 'Demand Supply Monitor for primary care' was to provide stakeholders with insight into the local need for primary care and to support local, demand-driven primary care. The Internet application was designed to be freely accessible for all the stakeholders in the field of primary care, and it was based on small area estimates that could be routinely updated [16]. The underlying statistical estimation model was developed to calculate small area estimates of primary care demand for all the four-digit postcode areas in the Netherlands. This thesis describes the development and deployment of the Demand Supply Monitor for primary care, addressing the following central research question.

RESEARCH QUESTION

How to produce reliable and interpretable small area estimates regarding lifestyle, health, healthcare needs and healthcare use for each four-digit postcode area in the Netherlands, based on a statistical approach which takes into account the sociodemographic differences between local areas and the influence of these differences on lifestyle, health and healthcare to support an integrated population-based healthcare?

The studies in this thesis have been categorized into **three parts.**

In **Part 1** (Chapters 2, 3 and 4), three studies are described that investigate different statistical estimation models to calculate small area estimates regarding lifestyle, health and healthcare. These chapters describe the search for the most effective and efficient statistical estimation model for calculating small area estimates. The estimates had to be valid, but also needed to be constructed with a minimum number of resources. There are two reasons why the small area estimates were focused on general practitioner care. First, the general practitioner is the central care provider of primary care in the Netherlands (as in many other countries). Secondly, general practitioners act as the first contact for patients, provide continuing care and coordinate specialist care if the patient needs it [17].

Part 2 of the thesis (Chapter 5) describes a study into the discrepancy between the small area estimates of the need for general practitioner care and the actual utilization of general practitioner care, for the small areas in which this comparison could be made. Specifically, it was analysed which healthcare organization characteristics influence this discrepancy.

Part 3 of the thesis investigated whether differences in patient preferences regarding GP care should be included, so as to improve the statistical models used to generate small area estimates, in addition to the indicators regarding the local population and healthcare supply.

In summary, the findings of the studies have provided insight into the following:

- the data sources needed to optimally calculate small area estimates on lifestyle, health and healthcare;
- the design choices to be made for the construction of a statistical estimation model;
- the type of statistical model (linear or multilevel) that is most effective and efficient to produce small area estimates;
- the question whether a robust statistical estimation model can be constructed to calculate estimates on lifestyle, health and healthcare;
- the question whether the match between general practitioner healthcare demand and supply can be calculated for all four-digit postcode areas in the Netherlands;
- the practice characteristics which influence the gap between small area estimates on the need for GP care and the actual utilization of GP care;
- the question whether the quality of GP care (as experienced by patients) should also be included in the small area estimate model to support the process of an integrated population-based healthcare.

THE MEANING OF THE FINDINGS OF THIS THESIS

This thesis described and explained the construction of a statistical estimation model to generate small area estimates on lifestyle, health and healthcare for all the four-digit postcode areas in the Netherlands. The main result of the thesis is that collecting and preparing the necessary data sources for the construction of a valid, robust, effective and efficient statistical estimation model is a lengthy but rewarding process. The studies also prove that small area estimates can be calculated for most of the indicators under study, i.e. the supply and demand of general practitioner healthcare at postcode level in the Netherlands. In the next sections, the meaning of the findings are discussed.

Part 1 (Chapter 2): Statistical models can generate small area estimates on GP care

In Part 1 (Chapters 2, 3 and 4), three studies were conducted to investigate different statistical estimation models to calculate small area estimates regarding lifestyle, health and healthcare. The general methodological approach of all the statistical estimation models in this thesis consisted of two stages. The first stage involved collecting data and generating a statistical model which represents the relationship between the dependent variable and the sociodemographic predictors. In the second stage, the correlates from the statistical model were applied to national auxiliary data in order to estimate the dependent variables for every postcode area. The general methodological approach is presented as a flow diagram in Figure 1.

In Chapter 2, it was investigated how small area estimates of general practice care could be calculated using registered data from medical records of general practices and census data on sociodemographic characteristics. The small area estimates had to represent the need for GP care in a four-digit postcode area. The number of GP consultations – based on registered data from about 80 general practices – were transformed into the time the GP spent with patients, i.e. GP consultation time. The statistical estimation model used was a linear regression model with sociodemographic variables of the patient and of the area in which the patient lived.

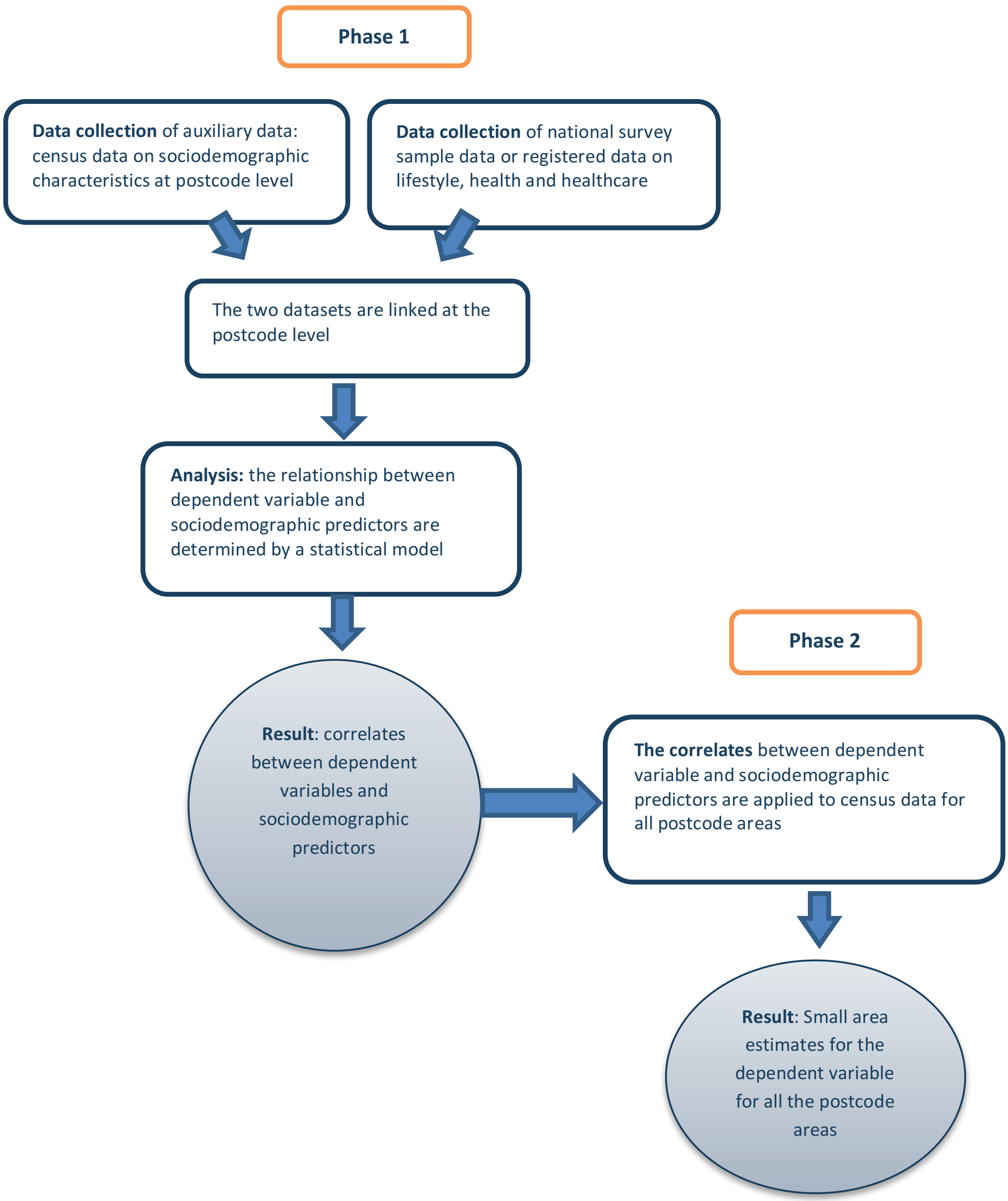

Figure 1: The general methodological approach

The linear regression model showed significant relationships between the sociodemographic predictors and GP consultation time at the patient level. The model explained 12.9% of the variance in the dependent variable. The model could estimate GP consultation time for every four-digit postcode area with more than 1,000 inhabitants in the Netherlands, covering 97% of the total population. The postcode area with the lowest expected GP consultation time per patient had a low percentage of low-income households, a low percentage of one-person households, a low percentage of people older than 65 years and a low level of urbanization.

The match between the need and supply calculated at postcode level

In Chapter 2, the estimation model constructed was able to generate small area estimates regarding the need for GP care based on the sociodemographic profile of the patient and patient's area of residence for most of the four-digit postcode areas in the Netherlands. For integrated population-based healthcare, it is also important to have insight into the match between the supply and demand of primary care. Therefore, small area estimates were also calculated for the match between supply and demand at the four-digit postcode level. To this end, the small area estimates of the need for GP care were compared with the number of GPs in an area, based on the national GP register [18]. Two indicators were computed. The first indicator represented the estimated consultation time per full time equivalent (FTE) GP necessary to meet the need for GP care. To calculate this, the estimated consultation time for a four-digit postcode area was divided by the number of full time equivalent GPs for that area. The second indicator was the shortage or surplus for a specific area in the FTE GPs necessary to reach the national average of 7,743 consultations per FTE GP per year (Box 1). The two indicators were computed at the level of the postcode area itself and for the postcode area including surrounding areas (Box 2), as many patients visit a GP in another four-digit postcode area [19].

BOX 1: A full time equivalent (FTE) working GP served approximately 2,350 patients in the Netherlands for the year 2009 [18]. The Dutch government does not intervene actively to realize a standard number of patients per GP. The mean number of consultations per patient was 3.18 [19]. The number of consultations per year for the Dutch population divided by the number of full time equivalent GPs resulted in a standard workload of 7,473 consultations per FTE GP.

The results of Chapter 2 show large variations in GP workload among the four-digit postcode areas. GP supply is unequally dispersed over the estimated need for GP care at the four-digit postcode level. The majority of the Dutch population (71.5%) live in a postcode area with a workload of 5,000-10,000 GP consultations per FTE GP, and 12% of the Dutch population live in a postcode area with a higher workload than the norm workload of 7,743 consultations. 4.9% of the Dutch population have no GP in their postcode area or the surrounding area. An estimated shortage of one FTE GP or more was prevalent in about 19% of the four-digit postcode areas with more than 1,000 inhabitants, if supply from the surrounding postcode areas was taken into consideration. Together, these areas had a total shortage of 1,417 FTE GPs to serve about 3 million people. There appeared to be a direct relationship between the number of inhabitants and the level of GP shortage. Areas with the fewest inhabitants showed the largest percentage of shortage in FTE GP. Most of these were located in rural regions. Areas with the highest numbers of inhabitants had the largest percentage of surplus of FTE GP.

A better match between supply and demand is essential for integrated population-based healthcare

In Chapter 2, indicators were calculated for the match between supply and demand of general practice care for the year 2009. The demand for general practice care was estimated based on patients' sociodemographic characteristics and their area of residence. The calculated indicators for the match between supply and demand provide important information for supporting the process towards more demand-driven primary care. The indicators give insight into areas with potential undersupply or oversupply of general practitioners and could provide important information for the discussion about the distribution of GPs. In an ideal world, the number and the distribution of general practitioners should be based solely on the demand for care. However, Chapter 2 shows that the distribution of general practitioners is not equal to the need for GP care based on the

> **BOX 2**: In the Netherlands, general practice is the formal point of entry into the health care system and GPs function as gatekeepers; specialist and hospital care can only be accessed by referral from a GP. In the Netherlands, GP care operates at a neighbourhood level. All residents are registered with a GP practice usually closest to their residence or on a very small distance. The mean distance to a GP is 2.7 kilometres [19].

sociodemographic profile of an area. In fact, other mechanisms outside the need for care influence the distribution of GPs, such as the historical assumption of 2,500 patients per full time equivalent GP and the attractiveness of an area regarding professional opportunities, medical training opportunities, physical environment or personal preferences [20]. These mechanisms impose problems for the distribution of GPs. For instance, most GPs see more work opportunities in urban areas, leaving rural areas often underserved [21, 22].

Health workforce planning to obtain 'the right skills, at the right time, at the right place' is at the top of the policy agenda in many countries. The findings of this thesis confirm previous research which concluded that rural areas often suffer from a lack of primary care [23, 24]. The inverse care law still exists: "the availability of good medical care tends to vary inversely with the need for it in the population served" [25]. Both supply-induced demand and unmet demand lead to highly undesirable consequences. Undersupply leads to poor access and health risks. Patients are forced to travel greater distances to a GP practice and/or experience longer waiting times before they are seen by a physician. Accessibility problems of GP care may lead to higher utilization of hospital care, i.e. more specialized and more expensive care [26]. Teljeur et al. (2010) reported that a 1% shortage in GP care supply may result in a 2.4% increase in the demand for hospital care [26].

For this reason, governments and healthcare organizations promote and facilitate local GP care. Locally available primary care enables people to control their own health conditions and helps prevent diseases; eventually, this should lead to a lower demand in healthcare [27]. Moreover, Pierard (2009) concluded that a larger number of GPs per 1,000 inhabitants was positively correlated with better health outcomes [28]. Oversupply of health workers may increase access to healthcare, but most likely also leads to high utilization of care and thus to inefficient use of healthcare resources. The main challenge of every healthcare system is therefore to allocate the right number and the right type of healthcare providers to respond to a population's healthcare needs [29]. The estimations of the match between supply and demand at the four-digit postcode level in the Netherlands provide useful information to avoid oversupply or undersupply, based on the sociodemographic characteristics of the population of the areas.

The first constructed estimation model calculates small area estimates of the need for GP care and of the match between supply and demand at the postcode level, but this model can only explain 13% of the variance in GP consultation time. Obviously, an explained variance of 100% would be ideal, as such a model fits the data completely and no other predictors outside the model influence the dependent variable. However, an explained variance of 100% is not feasible in social science research as it is based on limited measurements of human behaviour; such behaviour is characterized by poor predictability, unintended macro consequences and imperfect market mechanisms. Therefore, the models developed for this thesis can merely aim at reaching an explained variance that is as high as possible. In this thesis, we showed that the internal validity of our models can be considered 'high' or 'satisfactory' if an explained variance of 50% is reached. An explained variance of 13% means that the internal validity and statistical precision of the estimates is lower and can be improved. Thus, it was considered necessary to develop the statistical model further.

Part 1 (Chapter 3): The constructed statistical model can generate lifestyle and health estimates

It was investigated whether the statistical model from Chapter 2 could be further developed to calculate more valid and more informative small area estimates. The statistical model was further tested on health and lifestyle data to calculate small area estimates on lifestyle and health indicators. Several adjustments to the statistical estimation method were studied: the model was fitted to a larger dataset, it was tested for multiple outcome variables and it was extended with other predictor variables.

In the Netherlands, small area estimates on health and lifestyle are not readily available, even though health risks, morbidity, mortality and subjective measures of health status in a population are important indicators for local health policy and health human resource planning [30]. In the Netherlands, health policy is preferably based on epidemiological analyses, which are conducted by Public Health Services and presented in a Health Monitor [31, 32]. However, the Health Monitor only presents health figures for large geographical areas such as municipalities and regions. As a result, the data in the Health Monitor are not specific enough to support the goals of an integrated population-based healthcare on a small-scale level.

The statistical estimation strategy from Chapter 2 was used to find out whether small area estimates on health and lifestyle indicators can be calculated in a satisfactory way based on the data from the Health Monitor. The data from the Health Monitor were used in this analysis as national sample survey data, to investigate if the constructed statistical estimation model can be used to calculate small area estimates on lifestyle and health at the four-digit postcode level. The statistical estimation model consisted of aggregated area-level predictors, including interaction effects. The model was also adjusted to the different dependent dichotomous or continuous variables and was fitted on a larger dataset.

The results showed that the statistical estimation model was indeed capable of producing small area estimates for 14 of the 16 indicators on health and lifestyle at the four-digit postcode level. The mean explained variance of the 14 indicators analysed was about 25%, which is a modest internal validity. The highest explained variances were found for the indicators 'moderate/poor perceived health', 'one chronic condition', 'more than one chronic condition', 'smoking', 'overweight' and 'a high risk of anxiety or depression'. The lowest explained variances were achieved for the indicators 'physical inactivity' and 'underweight'. Apparently, there are other predictors outside the investigated sociodemographic profile that determine these indicators.

For two indicators, 'drug use' and 'having a disability', the estimation model could not calculate small area estimates. For these two indicators there were too few observations in the data from the Health Monitor; drug use had a very low prevalence and items about 'having a disability' were only present in the sample survey of two regional Public Health Services. These findings indicate that an estimation model can only calculate small area estimates for indicators which have a substantial prevalence and hence provide sufficient observations per area. Based on the data and the results of the linear regression analysis, an indicator should have at least 60 observations.

It is concluded in Chapter 3 that census data on sociodemographic characteristics at the four-digit postcode level, which are relatively easy to acquire, and national survey data on lifestyle and health can be used to calculate health and lifestyle estimates for four-digit postcode areas. These small area estimates, based on the sociodemographic profile of an area, are a first indication of possible lifestyle and health inequalities between four-digit postcode areas if no small area data on lifestyle and health are available. However, if small area data on lifestyle and health are available, the comparison with the small area estimates can indicate whether a four-digit postcode area 'scores better or worse' than expected based on the area's sociodemographic profile. As such, the estimates can be the starting point of a discussion between local governments, public health services and primary care organizations about the need for healthcare, the need for preventive care, and the need for health promotion at a local level.

Part 1 (Chapter 4): A multilevel model generated more valid small area estimates than a linear model

In the studies described in Chapters 2 and 3, two statistical estimation models were constructed to calculate small area estimates. The two models were able to construct small area estimates on (1) GP care and (2) lifestyle and health for four-digit postcode areas in the Netherlands. However, the validity of the calculated small area estimates was limited. The explained variance of the first model was about 13% and for the second model the explained variance was on average 25%. For this reason, it was investigated in Chapter 4 whether the effectiveness of the small area estimation model could be further enhanced.

The estimation model was further developed into a multilevel model to determine whether a multilevel model with unit-level predictors, area-level predictors, interaction effects and a random effect at the four-digit postcode level can calculate more valid small area estimates on one specific indicator, namely the need for GP care. This dependent variable was measured by the GP care utilization rate. GP care utilization rates were derived from medical record data obtained from routine electronic health records of 399 general practices in the Netherlands that participated in the NIVEL Primary Care Database. The database contains information about 1.2 million patients. The multilevel approach was compared to a linear model on aggregated data.

The internal validity of the calculated estimates for the multilevel model was assessed by comparing the estimates of GP care utilization rates with the actual GP care utilization rates from the NIVEL Primary Care database. Consequently, the predictions at the individual level were aggregated to the 3,488 four-digit postcode areas for which data of at least 1 patient were available in the NIVEL Primary Care Database. The estimates from the multilevel model and the NIVEL Primary Care utilization rates were concordant in 81% of the comparisons; correlation was *r*=0.66.

The multilevel model was also fitted to data selections of the NIVEL Primary Care database, to exclude four-digit postcode areas with few data. When four-digit postcode areas with less than 10 patients were excluded (n postcode areas=2,451), correlation increased from *r*=0.66 to *r*=0.91 and the concordance statistic rose from 81% to 88%. When postcode areas with fewer than 50 patients were excluded (n postcode areas=1,595), correlation increased to *r*=0.97 and the concordance statistic to 93%.

The external validity of the estimates for the multilevel model was assessed by comparing the estimates on GP care utilization rates with declaration data on GP care costs at the municipal level as published by VEKTIS (2014). The correlation between the multilevel estimates and the declaration volumes was *r*=0.51, which increased to *r*=0.70 when municipalities with 50,000 residents or more were selected.

The linear model was fitted to the data of NIVEL Primary Care Database. To this end, the data at unit-level was aggregated to the four-digit postcode level. The analysis was conducted on four-digit postcode areas with 100 or more patients and for postcodes with 300 or more inhabitants (n=1,243). We based these thresholds on the data and the results of the linear regression analysis. The validity of the model was tested by the explained variance of the linear regression model, given by R-squared and Pearson correlations between the predictions on GP utilization rates and the actual GP utilization rate from the NIVEL Primary Care database aggregated to the four-digit postcode level (n=1,243 postcodes), and between the predictions and the declared GP care costs. For the linear regression model, a correlation of *r*=0.51 was found between the linear model estimates and the NIVEL Primary Care utilization rates. The explained variance was 25.9%, which is double the explained variance of the linear model (i.e. 12.9%) as described in Chapter 2. Pearson correlation between the predictions at the municipal level and GP care costs at the municipal level from VEKTIS 2014 was *r*=0.47. Pearson correlation for municipalities with 10,000 inhabitants or more was also *r*=0.47 and increased to *r*=0.53 for municipalities with 50,000 inhabitants or more.

The data selection based on the number of patients per four-digit postcode area or the number of inhabitants per municipality influenced the results of the multilevel model and the linear model. For the multilevel model, the decision to exclude areas with a small number of patients from the analysis is a trade-off between a better fitted model and the number of random effects that must be imputed. We recommend fitting the model to data of areas with at least 11 patients, because for such areas the correlation increased from r=0.66 to 0.91.

The results of Chapter 4 show more valid estimates for the multilevel model. Unit-level predictors, area-level predictors and a random effect at the four-digit postcode level correlate significantly with the actual GP care utilization rates. The construction of the linear model is more efficient, however, as it requires fewer data sources, less data preparation, and thus fewer budget resources than the multilevel model. Still, the multilevel model is to be preferred over the linear model as it calculates more valid small area estimates of the need for GP care. It can therefore be concluded that the construction of a statistical estimation model is a trade-off between effective small area estimates and the resources needed to calculate the small area estimates. Consequently, using small area estimates is a matter of weighing up the pros and cons of the method used and the statistical precision of the estimates, and clearly describing these design choices.

Part 2 (Chapter 5): GP practice characteristics influence the gap between estimated and actual GP care utilization

In Part 2 of this thesis, the calculated small area estimates of the need for GP care were compared with the actual utilization of GP care at practice level, based on the NIVEL Primary Care database. From the literature, it is known that the sociodemographic characteristics of a patient and of a patient's area of residence influence the use of general practice care. Still, differences were expected between the actual utilization rates of general practice care and the estimated need for GP care based on a limited set of the sociodemographic variables, as healthcare utilization is influenced by many more factors. For example, it is known from the literature that service provision and general practice characteristics also determine GP consultation rates [10]. In Chapter 5, it was investigated to what extent differences between the actual utilization rate and the estimated need for GP care can be related to practice organization characteristics.

The actual consultation rates for each general practice, based on medical record data collected in the NIVEL Primary Care database, were compared with the estimated need for GP care in this practice. Small area estimates on the need for GP care were calculated using a linear regression model on aggregated data for every four-digit postcode area in the dataset. Practice estimates on the need for GP care in an area were calculated as a weighted average of the estimates of patients' postcodes. Linear regression analysis was used to examine how the difference between the actual consultation rates and the estimated need for GP care based on the sociodemographic profile of the patients' area of residence was related to practice organization characteristics.

Practice characteristics were derived from the NIVEL database of health professionals (2013), which contains the characteristics of every GP practice in the Netherlands (n= 5,008). For each practice, characteristics were selected that were related to practice organization, such as type of practice, human resources in practice, number of patients per practice and number of patients per FTE GP. Urbanization level of the practice was also selected, as were items that were categorized into the following five practice organization measures: the number of medical services offered, the consultation profile of the practice, the physical accessibility of the practice, participation in disease management programmes, and the availability of information material for patients.

The results showed that together, all the practice characteristics explained 20% of the variance in the actual consultation rates between practices. The sociodemographic profile of patients' area of residence explained 25% of the variance in the actual consultation rates. Thus, the variance in consultation rates between practices can be explained not only by the sociodemographic characteristics of patients' area of residence, but for a large part also by the characteristics of a general practice. There were three practice characteristics that increased the consultation rate at general practice level, namely 'the presence of disease management programme', 'the presence of other medical providers in practice' and 'dual practices'.

Together, the practice characteristics accounted for 19% of the difference between the estimated need for GP care (based on the sociodemographic predictors of patients' area of residence) and the actual consultation rate of the general practice. Dual general practices had higher actual consultation rates than estimated. Higher consultation rates were also found in general practices that employed other medical providers and that offered a disease management programme. The 40 practices with the largest positive difference between the estimated need for GP care and the actual consultation rate were also compared with the 40 practices with the largest negative difference. These results revealed that practices with consultation rates lower than the estimated need for GP care were more often solo practices, practices with fewer active GPs, practices with fewer female GPs, practices with fewer GPs younger than 40, and practices that offer fewer consultation types. The results of Chapter 5 show that larger practices with more active GPs have additional marginal benefits ('economies of scale'), possibly because their human resources are technically better equipped to provide consultation for minor surgery or for specific diseases, resulting in a relatively higher production than solo practices.

The results of Chapter 5 raised some important questions for further research, for instance about the quality of care, about the accessibility of general practice care and potential healthcare risks for patients. These questions have also been addressed by other researchers. Huygen et al. (1992) found that patients who are registered with a GP with an integrated practice style, which is regarded as good quality of care, were in better health and visited their GP less frequently. Moreover, these GPs kept referrals to a specialist to a minimum [33]. It would therefore be interesting to explore whether the practices in our data with relatively higher and lower actual consultation rates than estimated differ in their practice style and the quality of care they provide.

For practices that have lower actual consultation rates than estimated, further research can be useful into the quality of care in relation to the employment of more experienced GPs. More experienced GPs may need fewer follow-up consultations to deal with the health questions of their patient population. The GP's age may be seen as an indicator for experience. In Chapter 5, a significantly higher percentage of GPs younger than 40 was found in practices with higher actual consultation rates than estimated, which may indicate that younger GPs do more follow-up consultations. However, Kersnik found that frequent attenders were more likely to visit an experienced GP and found no differences regarding GP age between frequent attenders and infrequent attenders [34]. Nonetheless, the results from Chapter 5 make clear that practice characteristics also influence the use of GP care. Therefore, practice characteristics should also be considered in the discussion about an integrated population-based healthcare. It is not sufficient to only focus on the patient population and the estimated need for this population.

Part 3 (Chapter 6): Are there differences in patient preferences regarding GP care that should be included in small area estimation?

In part 1, studies were conducted to construct statistical estimation models to calculate small area estimates on lifestyle, health and GP care. Part 2, investigated the influence of practice characteristics on the differences between the need for GP care and the actual consultation rate at practice level. These results revealed that, next to the sociodemographic profile of a patients' area of residence, the supply side also influence the use of GP care. In Part 3, it was investigated whether there are differences in patient preferences regarding GP care that should be included in a small area estimation on GP care.

An important patient group of general practice care are the elderly. This group is expected to grow in the future, and this rise will lead to an increase in the need for primary care [35, 36]. As a result, elderly people are likely to place a heavy burden on the allocation of health resources. Dutch GPs already claim a substantially higher contact rate for elderly patients than for younger patients [37], and this rate is likely to rise in the future.

To ensure the well-being of the elderly by means of health promotion, disease prevention and disease management, responsive primary healthcare is crucial. Primary healthcare must be able to adapt to the needs of the elderly, who generally have different needs than younger patients due to a higher risk of chronic disease and disability [35, 38]. However, primary healthcare must also be flexible in addressing the preferences and the views of older patients, as differences in healthcare needs may lead to differences in preferences regarding healthcare. Greater insight into elderly people's preferences regarding primary healthcare can help to make primary healthcare more responsive to the needs of the elderly [38, 39]. If there are differences in patient preferences regarding general practice care, these should be considered in small area estimations of general practice care.

Substantial research has been conducted into the preferences of different patient groups. However, the results are mixed and 'the reason for this is unclear and may relate to a number of factors' [40]. Even though the outcomes regarding the influence of age on preference scores differ widely, little research has been conducted into the factors which may influence these differences. In this thesis, it was investigated (1) whether there are relevant differences between different patient populations, older people versus younger people, in their preferences regarding general practice care, and (2) which factors influence the relationship between age and preference score. For example, it was investigated whether the elderly have different preference scores regarding ‘privacy at the reception of the general practice’, ‘good cooperation between the health care providers in the practice’ and ‘a short waiting list’.

The results of Chapter 6 indicate no significant differences in the rank order of the 58 preference statements regarding general practice care between elderly patients and younger patients. Elderly patients find ‘good expertise of GP’, ‘no conflicting information’ and ‘good cooperation’ important quality aspects, and so do the other age groups. However, elderly patients categorized significantly fewer preference statements as ‘very important’. In most cases, the significant relationships were not confounded by gender, education, perceived health, the number of GP contacts or the level of urbanization of the general practice location. Thus, even though the elderly are a group with complex healthcare needs due to multi-morbidity, disability, vulnerability and loss of control [41, 42], they gave the same rank order to the preference statements as younger patients. From this perspective, there are no differences between the older and younger patients in preference statements about quality of general practice care. Every age group found it important that the GP was competent, that the different healthcare providers in the general practice did not give conflicting information and that cooperation between the healthcare providers was good. Thus, differences in preference statements for older or younger patient groups on the quality of general practice care do not have to be considered in small area estimations of general practice care.

However, in the future, not only the mean age of the GP’s patient population will change, but also the healthcare offered by the GP. In the Netherlands, general practice care for patients with a chronic disease will shift to a more patient-centred focus and different disciplines and healthcare organizations will be stimulated to cooperate. These changes may alter patients’ opinions regarding general practice care in the future [43]. Therefore, research into the preferences regarding general practice care for different patient groups should be repeated in the future.

Conclusion

The main result of these five studies is that statistical estimation models can be constructed which are able to generate small area estimates regarding lifestyle, health, and healthcare for the four-digit postcode areas in the Netherlands. The construction of an effective small area estimation model was a lengthy process, especially for the multilevel model, which needed several data resources. From the estimation models generated in this thesis, it can be concluded that the sociodemographic characteristics of a patient or a patients' area of residence highly influence lifestyle, health and healthcare at the four-digit postcode level. In particular age and gender are strong predictors. The final statistical estimation model is a two-level model and is based on three patient-level predictors, seven area-level predictors and a random effect at postcode level.

The applications and the possibilities of the generated small area estimates at the four-digit postcode level are various. For instance, the small area estimates regarding the need for GP care have been applied to the general practice level and compared to the actual utilization of general practice care. Thus, practices with high or low utilization could be identified and it was possible to identify practice characteristics that influence the low or high utilization of general practice care. These results show that the need for GP care is not only influenced by sociodemographic characteristics, but also by general practice characteristics. The gap between the estimated need for GP care at practice level, based on the sociodemographic characteristics of patient's area of residence, and the actual consultation rate at practice level can be explained for 19% by practice characteristics. Dual practices, practices which offer a disease management programme and practices with female GPs are 'high production practices'. Thus, besides the sociodemographic characteristics of a population, practice characteristics should also be considered in the discussion towards a more integrated population-based healthcare.

Lessons learned and implications for future research

This thesis focuses on producing small area estimates for the four-digit postcode areas in the Netherlands using an innovative strategy. Studying small area estimation is not new. Small area estimation techniques have existed for several decades. The interest in small area estimates has grown tremendously over recent decades and is expected to continue growing, because of the increasing interest from policymakers and the private sector: policy is becoming ever more decentralized and business decisions are being increasingly influenced by local conditions [12]. In countries such as the Unites States, the United Kingdom and Canada, small area estimates have been produced and used for issues such as income, poverty, unemployment, agriculture and substance abuse. Despite the growing academic and political interest in small area estimates, the developments in estimation techniques and the efficient data infrastructure in the Netherlands, the studies in this thesis are the first to investigate the calculation of small area estimates using a statistical estimation model in the Netherlands.

The effectiveness of the calculated small area estimates

This thesis shows that statistical estimation models can be constructed to calculate small area estimates on lifestyle, health and healthcare. However, the constructed small area estimation models with sociodemographic predictors cannot explain 100% of the variance between four-digit postcode areas regarding lifestyle, health and healthcare. On average, the different models constructed explain 25% of the variance between postcode areas. In other words, small area estimates calculated with a small area estimation method provide the expected value for an area based on the sociodemographic predictors included in the model [44], but do not fully represent 'reality'. The performance of the statistical models to represent 'reality' appears to depend on the following three factors: the availability of good predictor variables that are uniformly measured over the total area, the choice of a good prediction model, and a thorough evaluation of the quality of the model [12]. However, this thesis also shows that the availability and quality of good national survey data or registered data on lifestyle, health and healthcare influence the effectiveness of the small area estimates. Below, the effectiveness of the small area estimates is discussed in the context of these prerequisites.

Prerequisite 1: The constructed model consisted of good predictor variables

Good predictor variables are essential for effective small area estimates. Good predictor variables are associated with the dependent variable, are systematically collected and are routinely updated. From the literature, it is known that health and healthcare use are influenced by sociodemographic variables at the unit level and the area level, such as gender, age, income, race and unemployment [8-11]. From the research in this thesis, it has become clear that a basic set of systematically collected and routinely updated census data on sociodemographic characteristics for all four-digit postcode areas in the Netherlands was freely and easily available from Statistics Netherlands. This basic set consisted of the number of male and female inhabitants in different age categories, the number of one-person households and the number of non-Western immigrants. These characteristics come from population registers and are reliable and valid. Moreover, these predictors were significantly associated with lifestyle, health and healthcare needs and acted as good predictor variables in the constructed estimation models.

The predictors used in the small area estimation models can be considered good predictor variables. However, the models investigated in this thesis do not contain all the sociodemographic predictors associated with lifestyle, health and healthcare. For instance, one important sociodemographic predictor that was missing is the educational level of a patient or an area. Educational level is the strongest socioeconomic status predictor of health status [45]. However, educational level is not available at the four-digit postcode level in the Netherlands and could therefore not be included in the model. In addition, other predictors that influence healthcare use, such as lifestyle, health and physical environment, are not available at the four-digit postcode level for all the areas in the Netherlands.

The small area estimates in this thesis are based on good predictor variables. Moreover, only seven sociodemographic predictors were used to calculate reasonable small area estimates. However, adding extra predictors to the model that are associated with the dependent variable will lead to even better estimates. Further research is necessary to investigate data sources for other good predictor variables and to investigate the association with the dependent variables.

Prerequisite 2: Well-chosen prediction models were used

The second prerequisite for effective small area estimates is a well-chosen prediction model. In this thesis, the choice for a prediction model was influenced (1) by the distribution of the dependent variable, (2) by whether the relations between the predictors and the dependent variable in the model 'borrowed strength' from areas/and or time periods, and (3) by whether the model used aggregated data and/or unit-level data [12]. The linear model constructed can be considered as robust and sparse. With only minor changes, the model was able to estimate a reasonably high level of variance in lifestyle, health and healthcare needs at the four-digit postcode level: about 25% of the variance in these independent variables could be explained by sociodemographic predictors. The constructed statistical models borrowed strength from areas, and most of the models used aggregated data. A clear advantage of aggregated data over unit-level data is that a basic set of aggregated data on sociodemographic predictors are easy and freely available from public sources, in this case Statistics Netherlands. A linear model with aggregated data was thus an efficient way to calculate small area estimates.

Over the years, the statistical estimation model has developed from a linear model to a multilevel model with unit- and area-level covariates, interaction effects and a random effect at postcode level. In the future, the model may be further developed into a cross-effects model with practice organization characteristics and sociodemographic predictors at the unit- and area-level. From Chapter 5, it has become clear that practice characteristics, just as sociodemographic characteristics, influence healthcare utilization and should ideally also be added to the model. However, within this thesis project, a crossed-effects model with practice characteristics required the processing of too much data and too long estimation times. Obviously, with the fast-increasing power and performance of hardware and software programs, it will be feasible in future to run such models and analyses.

To conclude, complex models with more predictors, predictors at different levels, and random effects lead to rapidly increasing data requirements, a need for better software programs and a need for more computing power to handle large amounts of data. This means that there is always a trade-off between simple statistical models and complex models. Complex models produce better estimates through their data fit, which will lead to more effective small area estimates. By contrast, simple models have modest validity but are easier to conduct and require fewer resources.

Prerequisite 3: The validity of the models was systematically tested

The third prerequisite for effective small area estimates is a thorough evaluation of the prediction model. Over the years, the internal validation of the constructed estimation model has systematically been tested with the explained variance of the models. The primary aim was to come up with a model with a ‘maximum’ percentage of explained variance in lifestyle, health and healthcare use. Alternatively, we discussed what a reasonable percentage of explained variance should be. This discussion could not be concluded. Many sources of variation, not necessarily related to area characteristics, were found to play a role. For instance, in the case of GP care, we observed that individual GP preferences, historically grown situations, location, and allocation policies of municipalities also contribute to differences between areas. Thus, despite our primary aim to come up with a model that achieves maximum explained variance, we had to curb our expectations in this regard.

The first model in Chapter 2 explains 13% of the variance between four-digit postcode areas regarding the need for GP care; this is only a small part of the variance between postcode areas. Therefore, the model was developed further. In Chapter 3, a model was used to calculate indicators on lifestyle and health. On average, this model could explain 25% of the variance on lifestyle and health between postcode areas. The model was better at calculating estimates regarding a state of being, such as 'perceived health' and 'having a chronic disease', than at calculating estimates regarding behaviour, such as 'exercising'. However, a large part of the variance between postcode areas on lifestyle and health was still left unexplained. The model was further developed into a multilevel model to estimate the need for GP care. The multilevel model produced more valid estimates than the models in Chapters 2 and 3. For the multilevel approach, the method of Zhang et al. was used. Zhang et al. used the multilevel approach to estimate the prevalence of COPD for counties and states in the United States and found an even higher internal and external consistency: r=0.88 and r=0.97. One possible explanation for this is the difference in dependent variable. A multilevel model with sociodemographic predictors is probably better able to predict the prevalence of COPD than GP care utilization at the small area level.

In this thesis, the internal validity of the constructed statistical estimation models was systematically tested. The external validity of the models could only be tested in one study, described in Chapter 4, because only then was an external dataset available. The multilevel model produced the most valid small area estimates of the need for general practice care. An external validity of r=0.70 was reached when the analysis was repeated on larger municipalities. A correlation of 0.70 is equal to an explained variance of 49% and indicates a modest to strong relationship between the predictors in the data and the dependent variable. However, it also indicates that 51% of the variance between postcode areas on the need for GP care is still left unexplained by the sociodemographic predictors in the model. Thus, GP care utilization is not solely influenced by the need for GP care based on the sociodemographic profile of a patient or a patient's area of residence; other predictors also influence GP care utilization. For instance, general practice characteristics are predictors of GP care utilization, as shown in Chapter 5.

Prerequisite 4: The need for good national sample survey data or registered data

In the above sections, three prerequisites for effective small area estimates were discussed. In addition, this thesis shows that an effective statistical estimation model also needs good data on lifestyle, health and healthcare from national sample survey data or registered data. Good data need to be available for a representative sample of the four-digit postcode areas in the Netherlands, and such data need to be systematically collected and routinely updated.

Two important datasets for the construction of the small area estimations models were the NIVEL Primary Care Database, which is updated annually, and the Health Monitor from the 24 Public Health organizations in the Netherlands, which is updated once every four years. Both datasets are systematically collected. However, they also have some limitations. For example, GP record data may have been registered with some errors. Moreover, GP record data are derived from a sample of general practices; this sample is not random but derived from a historically developed register of selected GP practices. The health and lifestyle indicators from the 24 Public Health organizations in the Netherlands are not systematically collected across all regions. Furthermore, privacy issues affected the availability and the usability of both datasets. Due to privacy issues, many precautions and actions had to be taken before data were released; for instance, data were encrypted and in some cases only available on highly secure computers. Moreover, competition issues influenced the availability of data. Some datasets were too costly to use or were simply not released for our research. The last data constraint is related to changes in the geographical borders. In the Netherlands, the number of municipalities and four-digit postcode areas has decreased over time, which sometimes makes the comparison of data sources from different years challenging.

Recommendations regarding data quality and availability

Despite the good data infrastructure in the Netherlands, several recommendations regarding data quality and availability can be formulated, based on the different studies in this thesis. Most of all, investment in data quality and availability should be made at the national level, and the coordination of data collection and data release should also take place at the national level. It is important to strive for a set of easily and freely accessible as well as routinely updated predictor variables at the level at which healthcare is organized. Investments should be made regarding national survey data on health, lifestyle, healthcare needs and healthcare supply, which should be routinely updated and available at the small area level. Data collection should be more standardized, and national sample data regarding lifestyle, health and healthcare should be made more publicly available. The Dutch national government aims for *open data* which are publicly accessible and reliable [46]. However, regarding health and healthcare data, the Dutch government remains rather reserved due to privacy issues. In a world where data is collected to a greater extent than ever before and where about 90% of the data has been collected in the past 2 years [47], we should especially invest in the quality and availability of national survey or registered data for good information provision at a local level to support healthcare in the neighbourhood for an efficient and effective healthcare system.

The small area estimates are important to show differences between the expected need for GP care and the actual utilization of such care

In the sections above, the effectiveness was discussed of the calculated small area estimates on lifestyle, health and healthcare. The multilevel model produced the most valid small area estimates on the need for general practice care. However, a large part of the variance between postcode areas on GP care utilization was left unexplained. The results of the calculated small area estimates on GP care indicate that the sociodemographic characteristics in the model are not the only predictors that influence GP care utilization, which implies that the healthcare system is not yet demand-driven. Moreover, practice organization characteristics largely influence the use of general practice care, and this is not desirable in a healthcare system which should only focus on the needs of a population.

The calculated small area estimates aim to estimate the need for GP care at local and regional levels to better match healthcare supply to the need for healthcare. The small area estimates based on medical record data on GP care utilization must be regarded as only an *indicator* for the need for GP care in a population. After all, the need for healthcare which actually results in healthcare utilization depends on many factors, such as societal determinants, the health services system and individual determinants [48]. For instance, there is a strong relationship between comorbidity and the volume and variety of health care utilization [49], and between provider characteristics and healthcare utilization (Chapter 5). For instance, female patients visit the GP more than male patients, and they tend to choose female GPs, which results in higher utilization rates for practices with female GPs [50]. Thus, healthcare utilization is influenced by several factors other than the need for healthcare.

In statistical estimation models, the effects of 'other' non-included factors are ruled out by definition. For example, the effects of practice characteristics and societal determinants on GP care utilization are ruled out in the constructed multilevel model. The multilevel model is based on GP utilization rates from 399 general practices and uses only sociodemographic predictors. Thus, the estimates of GP care utilization represent the expected need for GP care based on sociodemographic predictors of patients and their area of residence. In this sense, the small area estimates of GP care are measures of the need for GP care in a population *without* the influence of provider and practice characteristics. This is in line with the view that healthcare resource planning should be based on patient-centred needs for healthcare services rather than on the actual use of healthcare, as the latter is also influenced by the supply of healthcare. This 'supplier-induced demand' conflicts with estimating indicators for healthcare needs [51]. Future research should search for additional sociodemographic characteristics at the patient or area level that are significantly related to the need for general practice care, in order to calculate the true measure of the need for care.

The calculated small area estimates are a helpful instrument for national governments, local governments, healthcare planners and healthcare organizations for health human resource planning. However, users of the small area estimates of the need for GP care should be aware of the fact that health human resource planning depends on several factors and their dynamic interplay, such as supply factors, educational policies and social, political, geographical and economic contexts [30]. As a result, the calculated estimates are not the only essential information needed for health human resource planning.

Small area estimation techniques are not 'the second-best substitute for the real thing'

Due to the high interest in small area estimates around the world, the estimation techniques are rapidly developing further. Recent studies into small area estimates on subjects such as obesity, diabetes, rare diseases, vaccine coverage, cardiovascular disease, disparities in mammography, tobacco control efforts and public opinion [52] show the development in these estimation techniques. For instance, small area estimates on public opinion were generated by a multilevel regression and post stratification approach (MRP), developed by Gelman and Little [53], and Park, Gelman and Bafumi [54]. In the MRP approach, the estimate is the function of both demographics and state-specific effects. This multilevel modelling approach was compared to disaggregation by state of national surveys. Lax and Phillips concluded that 'multilevel modelling is clearly superior when samples are smaller – indeed, one can accurately estimate state opinion using only a single large national survey.' [55, p.107]. Moreover, they do not believe that simulation or estimation approaches are 'the second-best substitute for the real thing' as Erikson stated more than 40 years ago [55, 56, p. 25]. Since then, major developments have taken place in for example statistics, computers and computer software. Zhang et al. used the MRP approach for small area estimates on health indicators at the county and state level. They concluded that the small area estimation technique results in high internal consistency and good external consistency [57]. These are clear and positive conclusions on the validation of small area estimates and the developments in their technique, which will only boost the interest in and the use of small area estimates around the world.

The small area estimates were presented in a freely accessible Internet application

This thesis has a methodological focus. Nevertheless, the main focus was not on the methodological approach to produce small area estimates, but on how to produce small area estimates by means of a statistical model, so as to support an integrated population-based healthcare. In this sense, the methodology and the results of the small area estimates were not only published in scientific articles. The calculated small area estimates were also presented in a freely accessible Internet application, an information tool for health human resource planners. The goal was to support them in the design and implementation of their interventions, such as the geographical position of a general practice or a disease-specific health plan for a local area. The Internet application also provided supply figures for GPs; it had an average of 2,000 visitors each month. The high number of visitors clearly shows the need for small area estimates on lifestyle, health and healthcare in the Netherlands. Most users of the Internet application worked for regional facility organizations for primary care, local governments, healthcare organizations, insurance companies and banks.

During this research, it was often considered how we could present small area estimates in an Internet application such that they are useful for a diverse group of users. In other words, how could we convert the small area estimates into valuable information to support a more integrated population-based healthcare as well as to support regional and local organizations in achieving this? A web tool was developed in which the small area estimates were presented in tables and maps containing information about the methodology and the interpretation of the small area estimates. In addition, a user group and a group of experts were consulted, and the Internet application was presented at several conferences. Over the years, a great deal of feedback was received, especially in the form of numerous emails from users. Generally, the users were very positive about the availability of small area data about lifestyle, health and healthcare, and the Internet application was often called 'one of the main sources of small area health data' in the Netherlands.

Nevertheless, the users of the Internet application also had questions about the interpretation of the small area estimates. Despite the best efforts to explain the small area estimates as published by the Internet application, it remained difficult for users to understand that the data were *estimates*, i.e. predictions based on the sociodemographic profile of an area and not the real construct. It was difficult to communicate that the estimates were different from 'reality', as other factors next to the sociodemographic profile of an area influence lifestyle, health and healthcare. Moreover, it became clear that users did not always read the explanatory texts. The users were primarily interested in retrieving the regional and local data, and retrieving it fast. This is inherent to Internet users, who want to read, click and scroll as little as possible to find what they are looking for. However, for a good interpretation of the small area estimates, it is important that the user first reads the explanatory texts.

An effective communication strategy depends on to whom, where and how the message is sent. It is important to target the communication to a predefined receiver or user group. The users of the Internet application ranged from local governments and epidemiologists to healthcare providers. In hindsight, a general explanation about the methodology and the interpretation was not the best way forward; rather, the explanation should have been targeted at the different subgroups. Moreover, it is important to use the right terminology to describe the definition of small area estimates; however, this is easier said than done. The words 'prediction' and 'expectation' imply projections for the future and the word 'estimate' implies uncertainty. Thus, it is important not only to invest in good data and in the methodology of the small area estimation technique to produce the most valid estimates, but also to use the right terminology in the communication regarding the most effective small area estimates. In further research, the usability of the small area estimates should be further investigated.

Limitations and strengths of this research

In this section, some limitations and strengths of this research are discussed. During the years of research, the focus was on how to produce small area estimates on health, lifestyle and healthcare using a small area estimation technique for integrated population-based healthcare. From the start, this research had a strong societal relevance. Every year, we wanted to generate up-to-date small area estimates for all four-digit postcode areas in the Netherlands on several indicators of lifestyle, health and healthcare. First of all, health policy was studied and together with the consultative group it was decided which indicators were necessary or useful to support the organizational changes in healthcare. Subsequently, the search started for the right data on lifestyle, health and healthcare and on sociodemographic predictors. This was always a lengthy process, due to all the data restrictions and the constraints mentioned earlier in this thesis. Then, the statistical models were built and investigated and the Internet application was designed. This process was repeated every year. The experience increased our knowledge, and every year the small area estimates became more effective. In particular the methodology of the small area estimations developed over the years.

The studies in this thesis have some limitations

Small area estimation techniques require a thorough evaluation of the validity of the model. In the studies in this thesis, the internal validity of the statistical estimation models was systematically tested; however, the external validity was investigated less often. The reason for this was the lack of an external dataset on lifestyle, health and healthcare. Only the external validity of the multilevel model could be tested using declaration data from VEKTIS. The data from VEKTIS did not include declaration data for 250,000 insured persons, because these people could not be ascribed to a municipality. As a consequence, differences were to be expected between the generated estimates of GP care utilization and the cost of GP care utilization. Analyses showed a mean estimated cost of 36.50 euro per patient for the NIVEL Primary Care database and a mean cost of 38.05 euro per patient in the declaration data from VEKTIS. It can be concluded that the sample of general practices in the NIVEL Primary Care database has a lower declaration rate than the total sample of general practices in the Netherlands.

Most of the generated small area estimates were based on data from the NIVEL Primary Care Database. This database contains GP care utilization rates derived from medical record data obtained from routine electronic health records of general practices in the Netherlands. The sample of general practices is not random. It is a historically grown register for which practices were selected. Moreover, GP record data could have been registered with some errors. Therefore, the generalizability of the findings based on GP record data is not completely clear. As stated above, the sample of general practices had a lower declaration rate than the total sample of general practices. However, the group of patients from the general practices in the sample are representative regarding gender and age.

A limitation of the constructed small area estimation model is the limited set of sociodemographic predictors used. The model includes seven predictors, but some essential sociodemographic predictors of lifestyle, health and healthcare needs are missing in the model. One important missing sociodemographic predictor is educational level. The educational level of patients and/or areas influences GP care utilization and should therefore be included in the model. However, educational level was not available at the four-digit postcode level during this research. In future research, additional relevant predictors should be investigated.

The methodology of statistical estimation evolves quickly. During the studies in this thesis, it was not possible to keep up with the new developments in the methodology of small area estimation. This thesis is therefore not an outline of the new developments in small area estimation, but an overview of how small area estimates can be produced for all the four-digit postcode areas in the Netherlands using a small area estimation technique.

The strengths of the studies in this thesis

In the different studies of this thesis, a powerful alternative to costly survey samples was developed to calculate small area estimates on lifestyle, health and healthcare. Small area estimates are increasingly important for supporting an integrated population-based healthcare at the local and regional level. This method is being studied in several countries around the world. The studies in this thesis are the first to investigate the calculation of small area estimates using a statistical estimation model for the Netherlands. The steps that have been made to improve and develop valid small area estimates are described in this thesis. A strength is that the studies and models are based on large datasets that cover all areas within the Netherlands. The first statistical linear estimation model was based on patient data from 80 general practices, the next multilevel model was based on patient data from 399 general practices, covering more than a million patients evenly divided over the country. As the patient data are routinely and systematically collected, datasets can be updated for replicating and using the small area estimate model over time. In sum, the recruitment and preparation of large datasets in combination with the development of increasingly advanced statistical estimation methods formed the basis for a robust statistical estimation model able to calculate estimates on lifestyle, health and healthcare that can be used at all local levels in the Netherlands with minor adjustments to the model.

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Samenvatting

(summary in Dutch)

INTRODUCTIE

Het doel van dit proefschrift was het genereren van data op lokaal niveau (small area estimates, SAE's) over leefstijl, gezondheid en de gezondheidszorg. Deze lokale data is essentieel om het proces naar een meer geïntegreerde 'zorg in de buurt' te ondersteunen. Dit proefschrift beschrijft de ontwikkeling van deze methode.

De essentie van een meer geïntegreerde 'zorg in de buurt' is het aanpassen van de eerstelijnszorg aan de zorgbehoefte van een populatie om de gezondheid te verbeteren, de ervaren zorg te verbeteren en de kosten van de gezondheidszorg te reduceren. Zorg in de buurt moet op een klein geografisch niveau georganiseerd worden en maakt data op lokaal niveau noodzakelijk om dit proces te ondersteunen.

Echter, lokale data over leefstijl, gezondheid en de gezondheidszorg zijn niet (makkelijk) voorhanden. Er zijn vier redenen die de beschikbaarheid van deze data beïnvloeden. Allereerst, zijn landelijke vragenlijsten over gezondheid niet ontworpen om op lokaal niveau data te genereren. Ten tweede, zijn vragenlijsten over gezondheid voor alle lokale gebieden duur en worden daarom niet regelmatig herhaald. Ten derde, wanneer er lokale data beschikbaar zijn, zijn deze vaak gedistribueerd over verschillende databronnen en daardoor moeilijk te combineren en te interpreteren. En als laatste, spelen privacy en concurrentie issues een grote rol in de beschikbaarheid van lokale data.

Omdat lokale data over leefstijl, gezondheid en de gezondheidszorg essentieel zijn voor 'zorg in de buurt', maar niet makkelijk beschikbaar zijn, moet lokale data gegenereerd worden. Over het algemeen zijn er twee methodes om data op lokaal niveau te genereren; directe en indirecte schattingstechnieken. De directe schattingstechnieken zijn gebaseerd op vragenlijsten onder steekproeven van de bevolking. Echter, deze methode resulteert in schattingen op lokaal niveau met weinig statistische precisie. Het alternatief is een indirecte schattingsmethode, waarbij lokale schattingen gegenereerd worden op basis van een statistisch model. Echter, de vraag is of deze methode ook geschikt is voor het genereren van lokale data voor alle gebieden in Nederland? Daarom is in dit proefschrift onderzocht hoe lokale data over leefstijl, gezondheid en de gezondheidszorg gegenereerd kan worden op basis van een statistisch schattingsmodel voor alle viercijferige postcodegebieden in Nederland. De hoofdvraag van dit proefschrift was:

Hoe kan betrouwbare lokale data over leefstijl, gezondheid en de gezondheidszorg gegenereerd worden op basis van een statistisch schattingsmodel dat rekening houdt met de sociodemografische verschillen tussen lokale gebieden en de invloed van deze verschillen op leefstijl, gezondheid en de gezondheidszorg voor alle viercijferige postcodegebieden in Nederland om het proces van een meer geïntegreerde zorg in de buurt te ondersteunen?

De verschillende studies in dit proefschrift zijn gecategoriseerd in drie delen:

In deel 1, worden drie studies beschreven waarin onderzoek is gedaan naar verschillende statische schattingsmodellen om lokale data te genereren. Het was een zoektocht naar het meest effectieve en efficiënte statistische schattingsmodel. De schattingen moesten betrouwbaar zijn, maar ook gegenereerd worden met een minimale inzet van middelen.

In deel 2, wordt een onderzoek beschreven naar de discrepantie tussen de geschatte zorgvraag en het feitelijke zorggebruik op lokaal niveau voor kleine gebieden waar deze vergelijking voor kan worden gemaakt. Concreet werd geanalyseerd welke kenmerken van de zorgorganisatie deze discrepantie hebben beïnvloed.

In deel 3, wordt onderzocht of patiëntvoorkeuren met betrekking tot de kwaliteit van de huisartsenzorg tussen patiëntgroepen verschilt en meegenomen moeten worden in het statische schattingsmodel om de lokale schattingen te verbeteren.

METHODE EN RESULTATEN

Hoofdstuk 2

In hoofdstuk 2, werden lokale schattingen gegenereerd met betrekking tot de vraag naar huisartsenzorg. Deze studie richtte zich op de groeiende academische en beleidsmatige interesse om het zorgaanbod af te stemmen op de zorgbehoefte van de lokale bevolking om de gezondheidsstatus te verhogen en de kosten voor de gezondheidszorg te verlagen. Lokale schattingen van de vraag naar huisartsenzorg stellen zorgplanners in staat de lokale vraag te analyseren. Het confronteren van deze schattingen met het aanbod van huisartsenzorg geeft inzicht in de match tussen vraag en aanbod.

Methode

Een nationale steekproef van medische dossiergegevens van huisartsen werden gebruikt om de lokale vraag naar huisartsenzorg op basis van lokale populaties te schatten. Het schatten werd gedaan met behulp van een statistische schattingstechniek. Deze schattingstechniek bestond uit twee hoofdfasen. De eerste fase betrof het genereren van een statistisch model dat de relatie weergeeft tussen de vraag naar huisartsenzorg en de sociodemografische voorspellers met behulp van lineaire regressie. In de tweede fase werd het statistische model toegepast op nationale censusgegevens om de vraag naar huisartsenzorg in te schatten voor elk viercijferig postcodegebied. Voor deze techniek waren twee datasets nodig: een nationale census-dataset over sociodemografische kenmerken van lokale gebieden, en een nationale, op steekproeven gebaseerde dataset met een medisch dossier van huisartsen voor een aantal lokale gebieden. Vervolgens werd het overschot of tekort in lokale GP-aanbod berekend met behulp van het nationale GP-register.

Resultaten

Deze studie toonde een significante relatie aan tussen de sociodemografische voorspellers van viercijferige postcodegebieden en de spreektijd van de huisarts. De sterkste voorspellers waren 'mensen van 75 jaar en ouder' en '65-74-jarige mensen'. Het statistische model kan de spreektijd van de huisartsen schatten voor elk viercijferig postcodegebied met meer dan 1.000 inwoners, die 97% van de totale bevolking van Nederland beslaan. Het confronteren van de geschatte vraagcijfers met het feitelijke GP-aanbod, resulteerde in een geschatte tekort van één FTE huisarts of meer voor ongeveer 19% van de viercijferige postcodegebieden met meer dan 1.000 inwoners wanneer de omringende viercijferige postcodegebieden in overweging werden genomen. Deze gebieden werden voornamelijk gevonden in landelijke gebieden.

Hoofdstuk 3

In hoofdstuk 3 is een grote nationale database van leefstijl- en gezondheidsindicatoren gebruikt om te onderzoeken in welke mate deze database kan worden gebruikt om schattingen van leefstijl en gezondheid op het viercijferige postcodeniveau te berekenen met behulp van de statistische schattingstechniek die is ontwikkeld in hoofdstuk 2. Schattingen op lokaal niveau over leefstijl en gezondheid zijn noodzakelijke informatie om lokale overheden en gezondheidsorganisaties te ondersteunen bij preventieve interventies, gezondheidsbevordering en gezondheidszorgplanning.

Methode

Lokale gezondheidsenquêtes verzameld door 24 gezondheidsdiensten in Nederland werden gebruikt om gegevens te verkrijgen over de leefstijl en de gezondheid. De gemiddelde score voor elke indicator werd berekend op het viercijferige postcodeniveau waarvoor er gegevens beschikbaar waren. Vervolgens werden censusgegevens (bijvoorbeeld geslacht, leeftijd, lage inkomensstatus, huishouden, mate van verstedelijking) gekoppeld aan het viercijferige postcode. Regressieanalyses werden gebruikt om te onderzoeken in welke mate de gezondheids- en leefstijlindicatoren op het viercijferige postcodeniveau waren geassocieerd met de censusgegevens. De verklaarde varianties van de modellen en de correlaties tussen de schattingen op viercijferig postcodeniveau en de steekproefgegevens op viercijferig postcodeniveau waarvoor data beschikbaar was, werden gebruikt om de bruikbaarheid van de schattingen te analyseren.

Resultaten

Het in hoofdstuk 2 ontwikkelde statistische model was niet alleen in staat om schattingen te maken met betrekking tot de vraag naar huisartsenzorg, maar ook met betrekking tot gezondheid en leefstijl (hoofdstuk 3). De censusgegevens in het statistische model verklaarden ongeveer 25% van de variatie in de gezondheids- en leefsituatie van lokale populaties. De indicator 'waargenomen gezondheid' had de hoogste verklaarde variantie, bijna 50%. De correlaties tussen de schattingen op viercijferig postcodeniveau en de directe schattingen van de gezondheidsenquête op postcodeniveau waren r = 0,51 (min = 0,27; max = 0,63).

De schattingen van leefstijl en gezondheid op viercijferig postcodeniveau bieden de mogelijkheid om een eerste inzicht te verkrijgen in de lokale gezondheids- en leefsituatie op basis van de sociodemografische samenstelling van een gebied. Lokale overheden kunnen deze schattingen gebruiken om gebieden met een mogelijke lage gezondheidsstatus en inwoners met een ongezonde leefstijl te identificeren, en vervolgens meer aandacht te besteden aan deze gebieden in hun gezondheidsbeleid.

Hoofdstuk 4

In hoofdstuk 4 werd een meer geavanceerd statistisch schattingsmodel onderzocht om lokale schattingen te genereren met betrekking tot de vraag naar huisartsenzorg. Deze geavanceerde methode werd vergeleken met de algemene statistische schattingsmethode, ontwikkeld in hoofdstuk 2 en gebruikt in hoofdstuk 3, in termen van de betrouwbaarheid van de schattingen en de middelen die nodig zijn om de schattingen te produceren.

Methode

De geschatte vraag naar huisartsenzorg werd berekend met behulp van een multi-level negatief binominaal model van patiënten binnen postcodes met voorspellers op het niveau van patiënten en het gebied voor elk viercijferig postcodegebied in Nederland. Concordantiestatistieken en Pearson-correlaties tussen de schattingen en externe gegevens over de kosten van huisartsenzorg werden gebruikt om de validiteit van de schattingen te testen. Vervolgens werden de resultaten van het multi-level model vergeleken met een lineair model met voorspellers op het gebiedsniveau.

Resultaten

De patiëntkenmerken geslacht, leeftijd en niet-westerse allochtoon mede als de gebiedskenmerken huishoudens met een laag inkomen, statusscore, verstedelijkingsniveau en krimpgebieden hebben een positieve significante relatie met de vraag naar huisartsenzorg. Een multi-level model fits de data beter dan een lineair model met enkel voorspellers op het gebiedsniveau.

De schattingen correleren r=0,66 met de vraag naar huisartsenzorg uit de NIVEL Zorgregistraties huisartsenzorg op het viercijferige postcodeniveau waarvoor data beschikbaar was en de Concordantie statistiek was 0,81. Wanneer postcodegebieden werden uitgesloten met minder dan 10 patiënten, was de correlatie r=0,91 en de Concordantie statistiek was 0,88. De correlatie tussen de schattingen geaggregeerd naar het gemeentelijk niveau en de kosten voor de huisartsenzorg op het gemeentelijk niveau was r=0,51. De externe validiteit nam toe tot r=0,70 wanneer kleinere gemeenten werden uitgesloten van de analyses.

Lokale schattingen met betrekking tot de vraag naar huisartsenzorg konden worden berekend met behulp van een multi-level model voor elk viercijferig postcodegebieden in Nederland. De interne en externe validiteit van het multi-level model was hoger dan die voor het lineaire model op geaggregeerde gegevens, maar niet zo hoog als verwacht. In verder onderzoek moet het effect van extra voorspellers in het model worden onderzocht.

Hoofdstuk 5

In hoofdstuk 5 werd onderzocht of het sociaal-demografische profiel van het woongebied van de patiënt en organisatiekenmerken van de huisartsenpraktijk van invloed zijn op het gebruik van huisartsenzorg. Huisartsenzorg speelt een sleutelrol bij het effectief en kostenefficiënt houden van de gezondheidszorg. Echter, het verschil in het gemiddeld aantal consulten per patiënt per jaar tussen huisartsenpraktijken kunnen duiden op verschillen in de kwaliteit van huisartsenzorg. In hoofdstuk 5 werd onderzocht of praktijkkenmerken, naast het sociaal-demografische profiel van het woongebied van de patiënt, een belangrijke bijdrage leveren aan het gebruik van huisartsenzorg.

Methoden

Gegevens over het aantal consulten huisartsenzorg zijn verzameld uit elektronische huisartsendossiers van 232 huisartsenpraktijken die deelnamen aan NIVEL Zorgregistratie Huisartsenzorg voor het jaar 2013. Aan deze data zijn op postcodeniveau censusgegevens gekoppeld betreffende sociodemografische kenmerken van het woongebied van de patient voor het jaar 2013. De statistische schattingstechniek uit hoofdstuk 2 werd gebruikt om voor elk viercijferig postcodegebied het aantal consulten te schatten op basis van het sociodemografische profiel van het woongebied van de patiënt. Deze schattingen werden vervolgens berekend op praktijkniveau en vergeleken met het feitelijke zorggebruik voor de huisartsenpraktijken waarvoor data aanwezig was in NIVEL Zorgregistraties huisartsenzorg. Lineaire regressieanalyse werd gebruikt om te onderzoeken of het verschil in het feitelijke en het geschatte zorggebruik verklaard kan worden door praktijkkenmerken van de huisartsenpraktijk.

Resultaten

Het sociodemografische profiel van het woongebied van de patiënt kon 25,7% van het verschil in zorggebruik tussen huisartsenpraktijken verklaren. Praktijkkenmerken konden 19,3% van het verschil verklaren tussen het feitelijke en het geschatte zorggebruik. Huisartsenpraktijken hadden een hoger zorggebruik dan geschat wanneer een praktijk een duo praktijk was, wanneer het vrouwelijke huisartsen in dienst had, wanneer het andere zorgaanbieders in dienst had en wanneer het meer diensten aanbood in verband met een disease management-programma.

Het gebruik van huisartsenzorg kan gedeeltelijk worden verklaard door het sociodemografische profiel van het woongebied van de patiënten, maar ook door praktijkkenmerken. Inzicht in deze factoren biedt zowel huisartsen als andere belanghebbenden informatie voor de discussie over een goede afstemming tussen vraag en aanbod.

Hoofdstuk 6

In hoofdstuk 6 werd onderzocht of oudere patiënten verschillende preferentiescores hebben met betrekking tot kwaliteitsaspecten van de huisartsenzorg ten opzichte van jongere patiënten en welke factoren deze relatie beïnvloeden. Ouderenzorg is een essentieel onderdeel geworden van de huisartsenzorg. In de toekomst zal het aantal oudere patiënten met complexe zorgbehoeften als gevolg van multimorbiditeit, beperkingen, kwetsbaarheid en verlies van controle toenemen. Eerdere onderzoeken toonden inconsistente resultaten met betrekking tot de relatie tussen de leeftijd van patiënten en preferenties met betrekking tot kwaliteitsaspecten van de huisartsenzorg. De resultaten van dit onderzoek maken duidelijk of de kwaliteit van huisartsenzorg, net als het aanbod van huisartsenzorg, moet worden aangepast aan de kenmerken van de lokale bevolking.

Methode

Voor deze studie werden gegevens van de Consumer Quality Index Huisartsenzorg gebruikt, welke werden verzameld in 32 huisartspraktijken in Nederland. De rangorde en preferentiescore zijn berekend voor 58 kwaliteitsaspecten voor vier leeftijdsgroepen (0-30, 31-50, 51-74, 75 jaar en ouder). Met behulp van chi-kwadraattests en logistische regressieanalyses werd onderzocht of een significant relatie tussen leeftijd en preferentiescore werd beïnvloed door patiëntkenmerken en de locatie van de praktijk.

Resultaten

Ondanks de complexe zorgbehoeften van oudere patiënten, toonde deze studie geen significant verschil in de rangorde voor de 58 kwaliteitsaspecten tussen oudere en jongere patiënten. Oudere patiënten vinden 'goede expertise van de huisarts', 'geen tegenstrijdige informatie van verschillende zorgverleners' en 'goede samenwerking' belangrijke kwaliteitsaspecten, net als de andere leeftijdsgroepen. Voor 53% van de kwaliteitsaspecten werden echter significante verschillen gevonden in de preferentiescore tussen de vier leeftijdsgroepen. Oudere patiënten categoriseerden significant minder kwaliteitsaspecten als 'zeer belangrijk'. In de meeste gevallen werden de significante relaties niet beïnvloed door geslacht, opleiding, de ervaren gezondheid, het aantal huisartscontacten en de stedelijkheidsgraad van de locatie van de huisartspraktijk. In dit perspectief moeten huisartsen aandacht besteden aan dezelfde kwaliteitsaspecten voor oudere patiënten als voor de jongeren patiënten.

Hoofdstuk 7 (Betekenis van de resultaten, conclusie en discussie)

Dit proefschrift toont aan dat het verzamelen en voorbereiden van de benodigde gegevensbronnen voor de constructie van een valide, robuust, effectief en efficiënt statistisch schattingsmodel een langdurig, maar een lonend proces is. De verschillende studies tonen aan dat voor de meeste onderzochte indicatoren lokale schattingen kunnen worden berekend, namelijk voor de vraag naar huisartsenzorg, voor de afstemming tussen vraag en aanbod en voor verschillende leefstijl- en gezondheidsindicatoren voor viercijferige postcodegebieden in Nederland.

De lokale schattingen over de afstemming tussen vraag en aanbod, gebaseerd op de sociodemografische kenmerken van een gebied, bieden belangrijke gegevens voor een geïnformeerde discussie over de afstemming van het zorgaanbod op de vraag naar zorg. De lokale schattingen over leefstijl- en gezondheidsindicatoren, wederom gebaseerd op het sociodemografische profiel van een gebied, zijn een eerste aanwijzing van mogelijke ongelijkheden in leefstijl en gezondheid tussen viercijferige postcodegebieden, indien hier geen gegevens over beschikbaar zijn uit gezondheidsenquêtes. Als er wel lokale gegevens beschikbaar zijn over leefstijl en gezondheid, kan de vergelijking met de schattingen aangeven of een viercijferig postcodegebied 'beter of slechter scoort' dan verwacht op basis van het sociodemografische profiel van een gebied. Als zodanig vormen de schattingen het begin van een discussie tussen lokale overheden, volksgezondheidsdiensten en eerstelijnsgezondheidsorganisaties over de vraag naar zorg, de behoefte aan preventieve zorg en gezondheidsbevordering op lokaal niveau.

Het statistische schattingsmodel met sociodemografische voorspellers kan echter niet 100% van de variantie in leefstijl, gezondheid en gezondheidszorg tussen viercijferige postcodegebieden verklaren. Gemiddeld verklaart het model voor de verschillende indicatoren 25% van de variantie. De schattingen die zijn berekend op basis van het statistische schattingsmodel leveren daarom de verwachte waarde voor een gebied op basis van de sociodemografische voorspellers die in het model zijn opgenomen, maar geven niet volledig de 'realiteit' weer. De mate waarin het statistische model de 'realiteit' kan weergeven, wordt beïnvloed door drie zaken: de beschikbaarheid van goede voorspellende variabelen die uniform worden gemeten over het totale gebied, de keuze voor een goed schattingsmodel en een grondige evaluatie van de kwaliteit van het model. Daarnaast blijkt uit de verschillende studies dat de beschikbaarheid en de kwaliteit van goede data uit nationale enquêtes of geregistreerde gegevens over leefstijl, gezondheid en gezondheidszorg de effectiviteit van de lokale schattingen beïnvloeden.

Dankwoord

Het dankwoord. Als je het dankwoord mag schrijven ben je er bijna. Het langdurige proces resulterend in een ongeveer 200 pagina's tellend boekje kan dan bijna bestempeld worden als afgerond. Het proces heeft bij mij ongeveer 7 jaar geduurd. In die tijd bleek onderzoek doen leuk en interessant, maar het schrijven van artikelen moeizaam en langdurig. Er moet namelijk goed worden nagedacht over iedere zin, eigenlijk over ieder woord. Daarnaast hebben coauteurs allemaal een mening die meegenomen moet worden. Daarom leek mij het schrijven van het dankwoord een eitje. Die hoeft namelijk niet wetenschappelijk verantwoord te zijn en niemand hoeft of mag daar commentaar op hebben. Maar nu, aan het einde van het proces blijkt het schrijven van het dankwoord alles behalve makkelijk.

In de zomer van 2009 startte ik als assistent onderzoeker bij het NIVEL. Dinny de Bakker, hoofd van de onderzoeksafdeling 'organisatie van de eerstelijnszorg' zag in mij, een net afgestudeerde communicatie wetenschapper, voldoende potentie voor een onderzoeksfunctie in de gezondheidszorg. Hij was er aan het begin, coachte/begeleidde/motiveerde/inspireerde tijdens al die jaren, maar is er helaas niet meer bij aan het einde. Dinny de Bakker stierf op 31 december 2016. Dat moeilijke, verdrietige feit maakt het schrijven van het dankwoord misschien nog moeilijker dan het schrijven van al die artikelen samen.

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Nu rest alleen nog de promotieplechtigheid. Mijn man Mischa: ‘ik snap dat je zenuwachtig bent, maar het is eigenlijk gewoon een presentatie’. En zo is het maar net ☺ .

About the author

Willemijntje Albertha de Graaf-Ruizendaal was born in 1984 on the 28th of November in Bunschoten-Spakenburg, a village nearby Amersfoort, The Netherlands. She finished secondary school in 2003 and went to inholland University of Applied Science in Diemen to follow the study ‘Communication Studies’. She was very interested in communications and hoped to learn about marketing, public relations and writing. However, the study did not comply to her expectations and she switched to the Free University of Amsterdam after two months and started a study in Communication Science. She followed a broad spectrum of courses, such as philosophy, organizational communications, marketing and statistics. After a few years, she specialized in social communications. Her bachelor thesis was about the positive effects of watching television on the emotional and cognitive development and behaviour of children. She graduated in 2006.

In 2006, she started her ‘Masters in Communications’ at the University of Amsterdam and specialized in ‘Commercial communications and Health education’ and was most of all interested in persuasive communication and health education. Her master thesis was about the influences of habits on the theory of planned behaviour regarding smoking and drinking alcohol. She was also a teacher assistant at the university and performed research with her mentor. In this period, her interest for scientific research was aroused. She decided to extend her masters and went to the International School for Humanities and Social Science where she did the ‘Research Master Communication Science’. She followed courses on different methods of research and statistical analyses. She graduated in 2009.

In June 2009, she started working at NIVEL, the Netherlands institute for health services research, in Utrecht. She worked on developing an Internet application were users could consult data about the demand and the supply of primary care for all the four-digit postcode areas in the Netherlands. Health data at the four-digit postcode area are in most cases unavailable and, therefore, she developed and validated different estimation techniques for small area data. During this project, she wrote scientific articles and worked on other projects regarding the organization of primary care. Nowadays, she is studying at the Marnix Academy to become a primary school teacher.

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