Vitamin G:
Green environments - Healthy environments

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For my parents

Contents

1

Introduction and research questions

Introduction

The shortest summary of this thesis is in its title "Vitamin G", where the G stands for the green space around us and Vitamin stands for the possible positive relationship between green space and people's health. The aim of this thesis is to investigate whether green space in people's living environment is positively related to their health.
In the first part of this thesis we investigate the direct relationship between green space and health. Once a link can be established between green space and health, the next question is what mechanisms exist through which green space might exert a beneficial effect on health. In the second part of this thesis, therefore, we examine possible explanations for the relationship between green space and health. The third part focuses on exploring the relationship between green space and feelings of social safety, because green spaces are sometimes regarded as unsafe places. The fourth part of this thesis examines the question of whether health benefits conferred by green space are used in the health care sector, in order to find out whether the beneficial influence of green space is put into practice.

Background

Green space and health

In our society which is becoming increasingly densely populated and in which large numbers of people live in urban areas, green space is no longer an obvious component of the direct living environment. According to a United Nations report, the urban population now amounts to 50% of the world population and this figure will have risen to about 70% by 2030. At the same time, urban green space is under pressure (De Vries, 2001). According to the Dutch National Spatial Strategy (Ministerie van VROM, 2004), the quality and quantity of green in and around cities has diminished noticeably. Due to increasing urbanisation, combined with a spatial planning policy of densification, more people are facing the prospect of living in less green residential environments. If the availability of green space positively influences health, living in less green residential environments could have health consequences. People with a low socio-economic status, who do not have the resources to move to greener (often more expensive) areas outside cities, will be particularly affected by these

developments, which may lead to environmental injustice with regard to the distribution of (access to) public green spaces.

Notions about the beneficial effects of green space have persisted throughout history (Van den Berg and Van den Berg, 2001). However, scientific evidence of a direct relationship between the amount of green space in the living environment and health is scarce. Only two epidemiological studies had investigated the direct relationship when the Vitamin G programme started (Takano et al., 2002; De Vries et al., 2003). These studies suggested a positive link between the amount of green space in the living environment and health. A number of questions remain unanswered, however. First of all, little is known about the strength of the relationship between green space and health. Secondly, it is not known whether the relationship between green space and health differs for specific health outcomes, such as cardiovascular disease or depression. Thirdly, more knowledge is needed on whether the relationship between green space and health differs between sub-groups of the Dutch population. Fourthly, it is unclear if the relationship between green space and health differs for various types of green space (Health Council of the Netherlands and RMNO, 2004) and fifthly, it is unknown whether the relationship depends on the proximity of green space. In other words, the relationship between green space and health needs to be investigated more thoroughly. These areas of research are investigated in the first part of this thesis.

We hypothesise for sub-groups of the Dutch population that the relationship between green space and health is stronger for people who spend more time in the vicinity of their homes, which results in higher exposure to green space in their living environment. We expect stronger relationships for elderly people and children (as compared to adults), because they are likely to spend more time in the vicinity of their home as a result of their lower mobility. Furthermore, we expect the relationship to be stronger for people with a lower socio-economic status, whose activities and social contacts are often situated closer to their homes (Harms, 2006; Schwanen et al., 2002).

Mechanisms behind the relationship

Once a link between green space and health can be established, the next question is through which mechanisms green space might exert a beneficial effect on health. In the second part of this thesis we investigate mechanisms related to exposure and behaviour. These mechanisms were chosen because of their relevance to contemporary health problems, such as chronic stress,

burn-out, depression, lack of physical activity and obesity. Furthermore, these mechanisms were chosen because of data availability.
Most research on the beneficial health effects of green space was substantiated in controlled experimental studies, which focused mainly on demonstrating the direct relationship between exposure to green environments and recovery from stress and mental fatigue (Hartig et al., 2003; Health Council of the Netherlands and RMNO, 2004; Van den Berg et al., 2007). Scientists selected experimental settings to maximize effects and concentrated on stress reduction and attention restoration as the most notable outcomes. Theoretical developments followed this empirical focus, and the dominant theories in the field (Kaplan and Kaplan, 1989; Ulrich, 1993) consider stress reduction and restoration to be a central causal mechanism. Although the focus on extreme settings and restorative effects has highlighted the importance of green space to health, it potentially obscures the scope and underlying mechanisms of these effects. Very little is known about the role of a behavioural mechanism that is based on the general idea that green space could increase and prolong physical activity (Pikora et al. 2003; Giles-Corti and Donovan, 2002) and improve social contacts (Kawachi and Berkman, 2000; Kuo et al., 1998a). We also examine in this thesis, therefore, whether the amount of green space in the living environment encourages these two forms of behaviour.
Apart from the causal mechanisms, the relationship may partly be the result of direct or indirect selection, which could lead to a spatial redistribution of health, rather than an overall change in public health. Selection may lead to environmental injustice, especially when considering the availability of green spaces.

By taking a broad perspective on the relationship between green space and health that takes a wide range of settings, health outcomes and underlying mechanisms into account, the present thesis supplements earlier experimental research and provides indications of the size of the effects of (long-term) exposure.
The relationship between green space and health is significant for different disciplines. For sociology first of all, because it discusses whether the distribution of green space has health consequences for different population groups. For environmental psychology secondly, because it investigates the relationship between the environment and psychological health. For health sciences thirdly, because this thesis discusses environmental influences on

health and fourthly, for social and/or health geography. In this last field, regional differences in health, especially urban/rural health differences have seldom been related to the amount of green space within the environment. This thesis aims to fill this gap.

Green space and feelings of social safety

There may be another side to the possible positive relationship between green space and health, as green spaces are sometimes regarded as unsafe places that may facilitate crime by providing a hiding place for perpetrators and criminal activity (Herzog and Flynn-Smith, 2001; Winsum-Westra and Boer, 2004). Studies from the US suggest on the other hand that exposure to natural environments may reduce feelings of anger, frustration and aggression (Kuo and Sullivan, 2001a), which may in turn enhance feelings of social safety, and even reduce actual rates of aggressive behaviour and criminal activity (Kuo and Sullivan, 2001b). In the third part of this thesis, therefore, we investigate the relationship between green space and feelings of social safety. In addition to investigating the general relationship, we will also study whether this relationship varies between urban and rural areas, between different population categories (men/women, old/young) and for different kinds of green spaces (open/closed).

Use of green space in health care settings

If there is a positive relation between green space and health, it would be interesting to study how these findings are applied in health care settings. People have traditionally ascribed healing powers to nature and used nature in health care facilities, but rapid technological advances in the health care sector meant that healthcare settings were no longer concerned with the healing effects of the environment (van den Berg 2005). In the last part of this thesis, we investigate the extent to which the health benefits of green space are used in the health care sector. More specifically, we investigate whether health benefits conferred by nature are used in patient consultations by Dutch general practitioners.

Research questions

The following research questions will be addressed.

1 *'How strong is the relationship between the amount of green space in people's living environment and their health?'*
   a *To what extent is this relationship dependent on the type of health-related outcome measure involved (self-reported health, depression, cardiovascular diseases)?*
   b *To what extent is this relationship dependent on the categories of the population involved (e.g. the elderly, children, low socio-economic status groups)?*
   c *To what extent is this relationship dependent on the type of green space involved (e.g. urban green, agricultural green)?*
   d *To what extent is this relationship dependent on the proximity of green spaces?*

2 *'Can the relationship between the amount of green space in people's living environment and their health be explained by mechanisms of exposure and behaviour?'*

3 *'Does the amount of green space in people's living environment positively or negatively affect feelings of social safety?'*

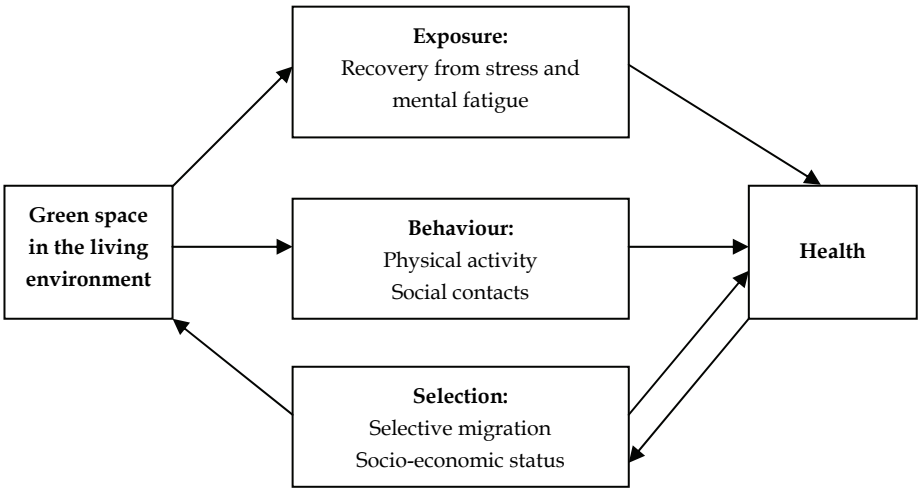
4 *'To what extent are the health benefits of natural environments used in the health care sector in the Netherlands?'*

This thesis is part of a larger research programme called Vitamin G. The general question studied in the Vitamin G programme is as follows: what is the direction and strength of the relationship between the amount of green space in people's living environment and their health, well-being and perceived safety, how can this relationship be explained, and how can the results be made useful for policy intervention? This general question will be answered in three projects on three different scales: on a macro scale using data on the Netherlands as a whole (this thesis); on an intermediate scale looking into the specific effects of green space in the urban environment; and on a micro scale investigating the effects of allotment gardens (Groenewegen et al., 2006; Maas et al., 2005).

Theoretical consideration

Our approach to answering these questions is based on analysing the multilevel relationships between environment and people (Groenewegen and Huigen, 1992; Groenewegen, 1997). People live in a shared environment that influences their health in a general sense. Figure 1.1 shows the conceptual model for the relationships between green space, health and the explanatory mechanisms. The mechanisms will be discussed in the following sections.

Figure 1.1 Conceptual model



Exposure

The first mechanism that will be investigated is exposure to green space. A small but growing body of well controlled empirical research speaks directly to the restorative effects of green space (Health Council of the Netherlands and RMNO, 2004; Van den Berg et al., 2007). In general, this research has shown more positive affective, cognitive, and physiological responses to natural settings as compared to built settings.

The restorative effects of green space have generally been explained from an evolutionary perspective. What most of these explanations have in common is the argument that, from a remnant of two or three million years of evolution in natural environments, modern humans have developed a partly

genetic readiness to respond positively to habitable settings that were favourable to well-being and survival for pre-modern people (Appleton, 1975; Orians, 1986; Kaplan and Kaplan, 1989; Ulrich, 1993). Notably, this readiness to respond positively to habitable settings is assumed to be triggered by natural environments alone; humans do not possess such a disposition for most built environments and materials (Ulrich, 1993). An important implication of people's readiness to respond positively to nature is that their attention is easily and almost effortlessly held by natural scenes. This attention-drawing quality of natural settings is referred to as 'soft fascination' (Kaplan and Kaplan, 1989), which is assumed to play an important role in the restorative quality of nature. When nature captures people's attention, executive systems that regulate directed attention are allowed to rest, pessimistic thoughts are blocked, and negative emotions are replaced by positive ones (Hartig et al., 1996; Parsons, 1991).

According to the dynamic stress-vulnerability (DSV) model (Heady and Wearing, 1989; Ormel and Neeleman, 2000), the prospect of living in an environment with limited access to green resources may increase the vulnerability to the impact of stressful life events on mental and physical health. In general, residents of neighbourhoods with abundant green space have more opportunities to visit and contemplate nature and profit from its restorative effects than residents in neighbourhoods that lack green space (Kaplan and Kaplan, 1989), which means that the availability of green space in the living environment may be an important environmental factor that moderates the impact of stressful life events on health. As a consequence, we investigated the extent to which the presence of green space close to and further away from home can buffer the adverse impacts of stressful life events on self-reported mental and physical health.

Behaviour

The second mechanism behind the relationship between green space and health that will be investigated is the behavioural mechanism. The general idea behind this mechanism is that green space may promote two forms of behaviour, viz. physical activity and social contacts; these two forms of behaviour are discussed in the following two sections.

Physical activity

Green space can have beneficial effects on health in so far as green space promotes physical activity. The relationship between physical activity and health has increasingly come under the spotlight in recent years. Physical activity is seen to have a key role in the promotion of good health and the prevention of disease, such as type II diabetes, obesity, cardiovascular diseases and hypertension (US Department of HHS, 1996; Booth et al., 2000; Pate et al., 1995; NIH Consensus Development Panel on Physical Activity and Cardiovascular Health, 1996; Paffenbarger et al., 1993).

Research based on the social ecological model (Sallis and Owen, 1996; Giles-Corti and Donovan, 2002) explores possible barriers to and facilitators of physical activity. The social ecological model considers an interplay between individuals and their social and physical environment and it suggests that there are multiple determinants of whether people are physically active or not. Some of these are related to the individual, namely biological characteristics (i.e. age, gender) and psychological characteristics (i.e. attitudes and beliefs towards physical activity). Other important determinants, which are external to the person, are the physical and social environment (Sallis et al., 1998; King et al., 2002; Giles-Corti and Donovan, 2005; Giles-Corti and Donovan, 2002).

One of the characteristics of the physical environment that could influence physical activity is the amount of green space in the living environment. Green environments are perceived as more attractive than built environments (Van den Berg et al., 2003) and because some bodily movement (walking or cycling, for example) is often necessary to experience them, it may be that they do inherently promote physical activity. Furthermore, green environments are multifunctional and can be used for different kinds of physical activity.

Social contacts

Besides influencing physical activity, green space might also stimulate social contacts. Social contacts can take many forms, including having a conversation, undertaking joint activities and paying visits. It is widely recognised that social relationships can influence a variety of health outcomes (e.g. Berkman et al., 2000; Hawe and Shiell, 2000). Persons actively involved in communities or socially engaged with others tend to live longer (Kawachi et al., 1997) and are healthier both physically and mentally (e.g. Kawachi and Berkman, 2000; Leyden, 2003).

Attractive green areas in the neighbourhood may serve as a focal point of tacit coordination for positive informal social interaction, strengthening social ties and social cohesion by extension (Kweon et al., 1998). One of the conditions that stimulate the creation of neighbourhood community is meeting opportunities, because people have to be able to meet to establish relationships (Flap and Völker, 2005; Völker et al., 2007). Green common space could offer interesting opportunities for meeting, because they can provide shadow and privacy for example, as well as sound buffering from surrounding environments (Hartig et al., 2003; Coley et al., 1997; Kaplan and Kaplan, 1989). Besides offering opportunities for meeting, green spaces can also promote a general sense of community by increasing feelings of emotional attachment to a neighbourhood and people's identification with a place, which could in turn decrease feelings of loneliness and increase social support (Prezza et al., 2001; Pretty et al., 1994).

Selection

Apart from these causal mechanisms, the relationship may partly be the result of direct or indirect selection. Direct selection occurs when people's health influences their chances of living in a favourable environment. The neighbourhood in which people live may not only influence their health, but the health of individuals may also influence the area where they will live. Several studies have observed that residential mobility is associated with individual health. Positive health is correlated with greater residential mobility among younger adults in particular (Bentham, 1988; Boyle et al., 2004; Van Hooijdonk, et al., 2007). On the other hand, longitudinal studies of health-related migration show that direct selection cannot be held responsible for geographical differences that remain if socioeconomic and demographic factors are taken into account (Verheij et al., 1998; Van Lenthe et al., 2007).

Indirect selection takes place when people with certain characteristics that are related to health, such as income, can afford to live in a favourable environment (Verheij, 1999). Migration flows are related to such socio-demographic characteristics as age, income and education (Heins, 2002). We control statistically for the possibility of indirect selection by taking socio-demographic and socio-economic characteristics of people into account when analysing the relationship between green space and health and the causal mechanisms behind this relationship.

Data sources and methods

Several existing large-scale survey data and land-use data are used for the purposes of this thesis. Table 1.1 provides an overview of the data sources used, which are discussed below.

Table 1.1 Data used to answer the research questions

	Subjects	Variables used	Geo coding	Source
Dataset 1 Green space	The Netherlands, 25 by 25 metre grid cells	Land use data (type of green, water surface, built-up area)	x- and y-coordinates grid cells	LGN4 data
Dataset 2 General Health	All people registered with 104 GP practices n=400,000 Representative of Dutch population	• Perceived general health • Basic socio-economic and demographic variables, including level of education • All diagnosis-coded contacts and interventions in general practice during 12 months in 2000/1	6-digit postal code	Second National Survey of Morbidity and Interventions in General Practice, 2001
Dataset 3 Behaviour	Random sample of people registered with 104 GP practices n= 13,000 Representative of Dutch population	As dataset 1, *plus:* • Extensive health information • Behaviour (e.g. physical activity and social contacts) • Extensive socio-economic and demographic characteristics (e.g. income) • Other relevant control variables (e.g. number of persons in the household)	6-digit postal code	Second National Survey of Morbidity and Interventions in General Practice, 2001
Dataset 4 Feelings of social safety	Random population sample n=90,000	• Feelings of safety • Socio-economic and demographic characteristics	4-digit postal code	Police Population Monitor 2001

- table 1.1 continues -

- table 1.1 continued-

	Subjects	Variables used	Geo coding	Source
Dataset 5 Characteristics of the living environment		• Socio-economic characteristics • Number of buildings • Mobility	4-digit postal code	Living Environment Database 2001
Dataset 6 Characteristics of the living environment		• Urbanity • Demographic characteristics	Municipal level 4-digit postal code	Statistics Netherlands
Dataset 7 Use of health benefits of physical activity and green space in patient-general practitioner communication	Random sample of videotaped consultations between patient and general practitioners n=2,784	• Whether or not a lifestyle recommendation on physical activity was discussed during consultations		Second National Survey of Morbidity and Interventions in General Practice, 2001

Health data: Second Dutch National Study of General Practice

The health data originate from the Second Dutch National Study of General Practice (DNSGP-2). The DNSGP-2 included a representative nationwide sample of 104 general practices in the Netherlands, comprising 195 GPs and including approximately 400,000 patients. DNSGP-2 data collection mainly took place between April 2000 and April 2002, with approximately 85% of the dates in the calendar year 2001. The total population of the participating practices was comparable to the population of the Netherlands with respect to sex, age and type of health care insurance (Schellevis and Westert, 2006; Westert et al., 2005). The GP setting is an optimal one for providing information on population health because it is accessible to all, is close to the community and is usually the first point of contact with the health care sector. The important epidemiological criterion of covering the whole population at risk is met, since almost all non-institutionalised Dutch citizens are registered with a GP (Westert et al., 2006).

A number of data collections took place within different (sub) populations in the general practices. Several of these data collections were used for the purposes of this thesis, viz. a census of the total practice population, a health interview survey among a random sample of 5% of the total practice

population, data from the electronic medical record from people registered with a GP, and data from videotaped consultations between patients and general practitioners. These data collections will be discussed briefly in the next sections.

Census

A written one page questionnaire with 14 items was sent to all people registered with the participating practices at the start of the study (n=385,461). The following items were included in the questionnaire: marital status, household composition, living arrangements, health insurance, ethnic origin (based on country of birth of the respondent and both parents), number of years resident in the Netherlands, educational level, occupation, work status and one question on perceived general health. Data for 294,999 persons were available for analysis, representing a response rate of 76.5%. These data were used to study the relationship between green space and perceived general health.

Data from electronic medical record

Data on morbidity were derived from the electronic medical records. These data were used to study the relationship between green space and morbidity. Data on people's contacts with the general practice were derived from the routine registration in the electronic medical records (n=1.5 million contacts). The data were collected over a 12-month period, most of the data being collected in 2001; 96 of the 104 practices recorded morbidity for a full period of 12 months (Schellevis and Westert, 2006).

Health Interview Survey

We used data from the health interview survey to investigate the mechanisms behind the relationship between green space and health. A 5% random sample of the practice population was invited to participate in an extensive health interview, which comprised a computer-assisted face-to-face interview carried out at the person's home by a trained interviewer. The average interview duration was 90 minutes. The interviews were randomly distributed over the calendar year 2001 to avoid seasonal patterns in morbidity. A total number of 19,685 persons were invited to participate and it was possible to use data from 12,699 valid interviews for the analyses (response=64.5%). Some questions were only answered by a random sample

of half the study population, to shorten the length of the questionnaire (Schellevis and Westert, 2006).
The interview included validated instruments to measure the level of physical activity, social support, loneliness, number of stressful life events experienced, number of health complaints experienced in the last 14 days, and mental health.
In the case of children aged under 12 years, a limited proxy interview was held with one of the parents; a parent was nearby during the interviews with children aged between 12 and 18 years.
The socio-demographic characteristics of the people who participated in the health interview survey were highly comparable to those of the total Dutch population, although men, younger age groups and migrants were slightly underrepresented (Westert et al., 2005).

Videodata
Within the framework of DNSGP-2, 2,784 consultations with general practitioners were videotaped with the objective of gaining more insight into the communication between general practitioners and their patients. The videotaped consultations were observed by trained observers using standardised observation schemes (Roter Interaction Process Analysis System [Roter, 1991]) and additional checklists. One aspect observed was whether or not a lifestyle recommendation concerning physical activity was discussed during the consultation.

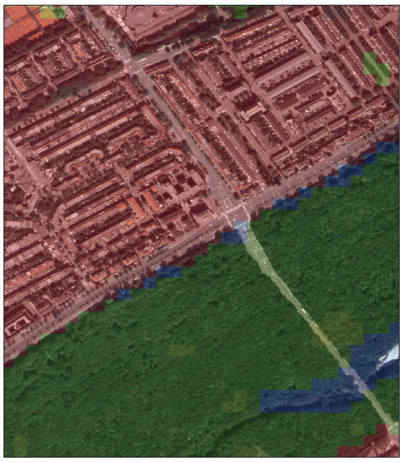
Data on feelings of social safety
The data on feelings of social safety originate from the Police Population Monitor 2001 (n=88,607; non-response 28%), which is a representative nationwide telephone survey commissioned by the Netherlands Ministry of the Interior and Kingdom Relationships, and the Ministry of Justice. It is held every two years among a randomly selected sample of approximately 90,000 people and focuses on differences in crime rates, feelings of social safety and opinions on the police (Projectbureau Politiemonitor, 2001) .

Green space data: National Land Cover Classification database
Data on the distribution of green space in the Netherlands were derived from the National Land Cover Classification database (LGN4). This database contains the dominant type of land use for each 25 by 25 metre grid cell in the whole of the Netherlands and distinguishes 39 classes of land use,

including crop types, forest types, water, various urban classes and semi-natural classes (De Wit and Clevers, 2004; Thunnissen and De Wit, 2000). See figure 1.2 for some examples of how areas are classified in LGN.

Figure 1.2 Examples of how areas are classified in LGN

The Hague (PBL)



Wageningen (Alterra)

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The Hague (de Scheveningse Bosjes)

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The database was created using a methodology that integrates satellite images from 1999 and 2000, the digital 1:10,000 topographic map of the Netherlands (TOP10vector) from the Netherlands Topographic Service, and

agricultural statistics from Statistics Netherlands (De Wit and Clevers, 2004). In the TOP10vector, houses are buffered by a 10-metre buffer to compensate for ground around houses, which often means that gardens are not included in the green space variable. Only gardens that extend beyond the 10-metre buffer are regarded as green space.

The total percentage of green space, which includes all urban green, agricultural green, forests and nature conservation areas, was calculated from the dataset. Only green spaces that have a dominant position in the 25 by 25 metre grid cell are regarded as green space in the dataset. Small-scale green spaces, like street trees and green roadsides for instance, are not regarded as green space because they have no dominant position in the grid cell.

Methods

The datasets on health were matched with the green space data on the basis of x and y coordinates of the respondent's six character postal code (the same six character postal code is shared by no more than about 15 to 20 households) and the percentage of green space within a 1km radius and a 3km radius was calculated around these coordinates. The total percentage of green space includes all urban green space, agricultural green space, forests and nature conservation areas. To discover which types of natural surroundings particularly foster health, stress, physical activity and social contacts, we calculated the percentages of the following categories within both a 1km and a 3km radius: the percentage of agricultural green space, the percentage of natural green space (forests, peat grassland, etc.), and the percentage of urban green space (woodland and grassy areas in built-up environments, which also include urban parks).

The datasets on feelings of social safety and green space were geographically linked on the basis of 4-digit postal codes. The Netherlands is divided into 4,000 4-digit postal codes with a 4-digit postal code in the Netherlands representing an average of 1,772 households. The 4-digit postal codes often correspond with neighbourhoods in urban areas, whereas they often represent a whole village in rural areas.

Statistical analysis

The research questions were assessed using multivariate multilevel methods, controlling for demographic and socio-economic characteristics and level of urbanity. The multilevel analyses were performed with MLwiN. Most studies included two levels, viz. the practice and individual levels, because of the hierarchical structure of the data. Data on individuals were gathered through general practices in order to study the relationship between green space and health, and individuals clustered between practices as a result. We included three levels in order to study the relationship between green space and feelings of social safety, viz. item level, individual level and postal code level.

Outline of the thesis

The answers to the research questions are presented in parts I to IV inclusive (chapters 2 to 8). In part I (chapters 2 and 3) issues related to the relationship between green space and health are investigated. Chapter 2 studies the relationship between green space and perceived general health. Chapter 3 explores the relationship between green space and morbidity in the Dutch population. The second part of this thesis (chapters 4 to 6) focuses on answering the second research question and investigates if the relationship between green space and health can be explained by mechanisms related to exposure and behaviour. Chapter 4 focuses on investigating the extent to which green space can buffer the adverse impact of experiencing stressful life events on health. Chapter 5 explores whether physical activity is a possible mechanism behind the relationship between green space and health, while chapter 6 examines whether social contacts are a possible mechanism. Part III (chapter 7) investigates the relationship between green space and feelings of social safety. Part IV of this thesis (chapter 8) focuses on the question of whether the health benefits of green space are used in the health care sector. Chapter 9 provides a summary of the conclusions of chapters 2 to 8 and an overall discussion.

Part I

Green space and health

2

Green space, urbanity and health

How strong is the relation?

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Abstract

Aim of this study is to investigate the strength of the relationship between the amount of green space in people's living environment and their perceived general health. This relationship is analysed for different age and socio-economic groups. Furthermore, it is analysed separately for urban and more rural areas, because the strength of the relationship was expected to vary with urbanity.

The study includes 250,782 individuals registered with 104 general practices who filled in a self-administered form on socio-demographic background and perceived general health. The percentage of green space (urban green space, agricultural space, natural green space) within a 1km and 3km radius around the postal code coordinates was calculated for each household.

Multilevel logistic regression analyses were performed at three levels, viz. individual level, family level and practice level, controlled for socio-demographic characteristics.

This study showed that the percentage of green space inside a 1km and a 3km radius had a significant relationship to perceived general health. The relationship was generally present at all degrees of urbanity. The overall relationship is somewhat stronger for lower socio-economic groups. Elderly, youth and secondary educated people in large cities seem to benefit more from presence of green areas in their living environment than other groups in large cities.

This research shows that the percentage of green space in people's living environment has a positive association with the perceived general health of residents. Green space appears to be more than just a luxury and consequently the development of green space should be allocated a more central position in spatial planning policy.

Introduction

Many people experience nature as an environment where they can rest and recover from daily stress. In the hectic society in which we live there is a growing need for nature as a source of relaxation and recreation (Health Council of the Netherlands and RMNO, 2004). But the enjoyment of nature is not obvious anymore. Urban areas have recently experienced a decline in the quality and quantity of their green space (RIVM, 2002; Ministerie van VROM, 2004). The United Nations Population Division notes that, although just under half of the world's current population lives in urban areas, nearly two-thirds of the world's populations will live in urban areas within the next 30 years (Vlahov and Galea, 2002).
Because of increasing urbanisation, combined with a spatial planning policy of densification, more people face the prospect of living in residential environments with fewer green resources. Especially people from low socio-economic strata without resources to move to greener areas outside the cities will be affected. This may lead to environmental injustice with regard to the distribution of (access to) public green spaces.

Although notions of the beneficial effects of nearby green space have persisted throughout history (Smyth, 2005; Van den Berg and Van den Berg, 2002; Maller et al., 2002), these notions have only recently been substantiated in controlled, experimental research (Ulrich, 1984). Research has focused mainly on demonstrating the relationship between exposure to green environments and well-being (Hartig, 2003).
There are only a few epidemiological studies on the relationship between nature and health. An epidemiological study performed in the Netherlands by our group showed that residents of neighbourhoods with abundant green space tend, on average, to enjoy better general health. This positive link was found to be most apparent among the elderly, housewives and people from lower socio-economic groups (Health Council of the Netherlands and RMNO, 2004; De Vries et al., 2003). A Japanese longitudinal study showed that living in a neighbourhood with relatively plentiful walkable green space correlated with a lower mortality risk (Health Council of the Netherlands and RMNO, 2004; Takano et al., 2002).
Outside these studies, little is known about the strength of the relationship between nearby green space and health. This is also shown by a recent report from the Health Council of the Netherlands and the RMNO (2004),

which concludes that there are important lacunae in current knowledge about the relationship between green space and health and the mechanisms underlying this relationship. In this present study we attempt to fill up the lacunae in current knowledge about the strength of the relationship between green space and health.

The aim of the present study was to investigate the strength of the relationship between the amount of green space in people's living environments and perceived general health.

The relationship was analysed separately for different socio-economic groups and different age groups, because it is hypothesised that the relationship is likely to be stronger for groups that spend more time in the vicinity of their homes: youth and the elderly as opposed to adults, and people with a lower socio-economic status as opposed to people with a high socio-economic status.

Furthermore, the relationship was analysed for urban and more rural areas separately, because it was expected that the strength of the relationship might vary with urbanity. It has long been known that health differs between urban and rural areas. These differences are often ascribed to factors such as pollution and lifestyles that co-vary with level of urbanity and with selective migration (Verheij, 1996; Verheij et al., 1998). But these urban–rural differences in health have seldom been related to the amount of green space in the environment.

Methods

Population

The data were derived from two different datasets that were combined for this study. The health data originate from the Second Dutch National Survey of General Practice (DNSGP-2) (Westert et al., 2005). The GPs and patients in this survey are representative of the Dutch population. The practice population from 104 general practices in the Netherlands filled out a one page self-administered questionnaire on socio-demographic background and perceived general health (n=400,000, response 76.5%). Each individual in the Netherlands is registered with a GP.

Environmental data were derived from the National Land Cover Classification database (LGN4), which contains the dominant type of land

use of each 25 by 25 metre grid cell in the whole of the Netherlands (De Wit and Clevers, 2005).
The two datasets were matched on the basis of x and y coordinates of the respondent's six character postal code. The percentage of green space within a 1km radius as well as within a 3km radius was calculated around these coordinates.

A selection was made on the basis of the assumption that it would take some time for a new living environment to affect a person's health. As a consequence, we only included respondents who had been registered with their current GP for longer than 12 months, thus excluding respondents with a high chance of having moved recently, partly because they might suffer from stress related to moving. After this selection, 250,782 respondents remained with valid values on all of the relevant variables.

Perceived general health
Perceived general health was self-rated by respondents by replying to the following statement: "In general, would you say that your health is…"
They could respond by one of the following categories: very good/good/neither good nor poor/poor/very poor. The scores were dichotomised, with 'neither good nor poor' (0) as the cut-off point. This kind of operationalizations has shown to be valid and predictive of health indicators in numerous studies (Rütten et al., 2001; Simons, 2002).

Characteristics of respondents' living environment
The information on the environmental characteristics was derived from the LGN4 database. The total percentage of green space in the respondents' living environment was measured within a 1km radius and within a 3km radius around a respondent's home, to see whether green space close by has a stronger or weaker effect than green space further away. The total percentage of green space includes all urban green, agricultural green, forests and nature conservation areas.
To discover which types of natural surroundings are particularly good for people's subjective health, we calculated the percentages of the following categories inside both a 1km and a 3km radius, viz. the percentage of agricultural green, the percentage of natural green (forests, peat grassland, etc.), and the percentage of urban green.

Level of urbanity

Another environmental characteristic is level of urbanity. This variable consists of five categories ranging from very strongly urban (1) to non-urban (5), and was measured at municipal level. The indicator is based on the number of households per square km and is widely used in the Netherlands (Den Dulk et al., 1999).

Demographic and socio-economic characteristics

Part of the relation between green space and health may be the result of direct or indirect selection. Direct selection takes place when people's health influences their chances of living in a favourable environment. Indirect selection takes place when people with certain characteristics related to wellbeing (such as income) can afford to live in a favourable environment (Verheij, 1996). Migration flows are related to such socio-demographic characteristics as age, income and education (Heins, 2002). It is important when analysing the strength of the relationship, to take the possibility of selection into account and to control for this.

We tried to rule out these selection effects by controlling statistically for relevant demographic and socio-economic characteristics.

The demographic characteristics taken into account were gender (female=1) and age (in years).

Socio-economic status (SES) was measured by the highest level of completed education, the work situation and ethnicity. In addition, socio-economic status was also measured by type of health insurance (public=0, private=1), because the type of health insurance can be regarded as an indicator of SES in the Dutch context.

When testing the relation between green space and different SES groups, SES was operationalised as the level of education and was divided into three categories, viz. higher education (university or higher education), secondary education and no/primary education.

Statistical analyses

The relationship between nature and health was assessed by multilevel logistic regression analyses, controlling for socio-demographic characteristics. The logistic multilevel analysis was performed with MLwiN. We included three levels, viz. individuals, family and practices. These three levels were included because of the structure of the data within DNSGP-2 and also because families and practices could influence the health of the

individual. Because we wanted to compare the relation for different subgroups we used interaction effects between the subgroup variable and the green indicator.

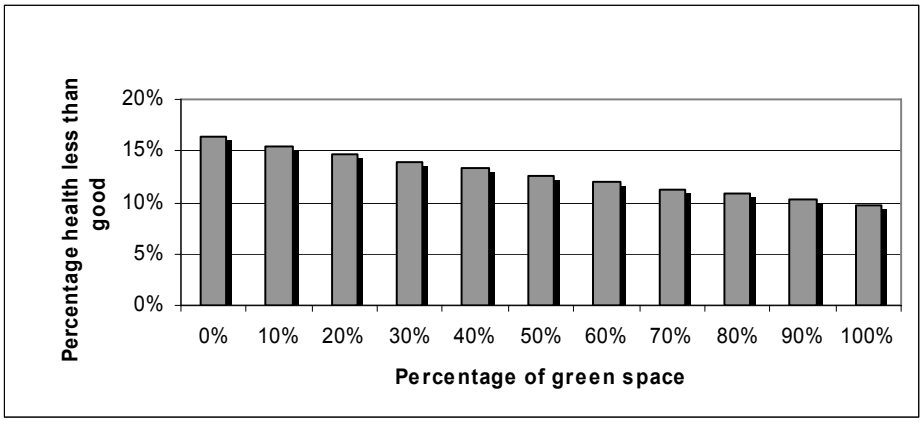
Results

The strength of the relationship between green space and health

The basic model includes all socioeconomic and demographic characteristics. In the second model urbanity is added, and one of the percentages of green space in the living environment is added in the third model (see table 2.1).

Given the other parameters in the model, perceived general health appears to be better in people living in a greener environment (see table 2.1, step 3a, step 3b). Figure 2.1 shows that the relationship between green space and health is considerable. In areas where 90% of the environment around the home is green, only 10.2% of the residents feel unhealthy, as opposed to areas in which 10% of the environment is green, where 15.5% of the residents feel unhealthy. The relationship is equally strong for the 1km and the 3km radius.

Figure 2.1 Relationship between amount of green space (in a 3km radius) and self-reported health (percentage stating their health is less than good) based on the logistic multilevel model of table 2.1, step 3b (controlled for urbanity, socio-demographic and socio-economic characteristics)



We also analysed the relationship between health and different types of green space (not in table). These analysis show that there appears to be a positive relationship between perceived general health and both agricultural green (1km: ß=0.004, s.e.=0.000/3km: ß=0.004, s.e.=0.001) and natural green (1km: ß=0.004, s.e.=0.001/3km: ß=0.006, s.e.=0.001) in a person's living environment. Urban green within a 3km radius around the home appears to be negatively related to people's health (ß=-0.008, s.e.=0.002), which is caused by the fact that urban green can only be found in urban areas which have a lower total amount of green space.

Table 2.1 Regression analysis of the total sample (n=250,782) for perceived general health: parameters and standard errors

	Perceived general health ('good/very good'=1)			
	Step 1	**Step 2**	**Step 3a**	**Step 3b**
Age	-0.039 (.000)***	-0.039 (.000)***	-0.039 (.000)***	-0.039 (.000)***
Gender (woman)	-0.134 (.013)***	-0.133 (.014)***	-0.130(.014)***	-0.132 (.014)***
Health insurance (private)	0.308 (.015)***	0.308 (.015)***	0.302 (.015)***	0.307 (.015)***
Level of education (high)	0.262 (.019)***	0.266 (.019)***	0.267 (.019)***	0.268 (.019)***
Attending school/studying	0.030 (.028)	0.032 (.028)	0.038 (.028)	0.034 (.028)
Unemployed/job-seeker	-1.118 (.041)***	-1.117 (.041)***	-1.111 (.041)***	-1.115 (.041)***
Housewife/houseman	-0.350 (.020)***	-0.352 (.020)***	-0.354 (.020)***	-0.352 (.020)***
Incapacitated	-2.403 (.026)***	-2.408 (.026)***	-2.408 (.026)***	-2.410 (.026)***
Retired	-0.362 (.022)***	-0.362 (.022)***	-0.360 (.022)***	-0.362 (.023)***
Job unknown	-0.443 (.034)***	-0.444 (.034)***	-0.443 (.035)***	-0.442 (.035)***
Ethnic minority	-0.450 (020)***	-0.446 (020)***	-0.439 (020)***	-0.443 (.020)***
Very strongly urban		-0.309 (.054)***	-0.102 (.057)	-0.070 (.062)
Strongly urban		-0.173 (.049)**	0.010 (.052)	-0.015 (.053)
Moderately urban		0.070 (.046)	0.081 (.048)	0.013 (.047)
Slightly urban		0.014 (.046)	0.079 (.046)	0.031 (.045)
Percentage of green (1km)			0.005 (.000)***	
Percentage of green (3km)				0.006 (.001)***

* p≤0.05; ** p≤0.01; *** p≤0.001

Urbanity, health and green space

Table 2.1 (step 2) shows that urbanity makes a significant contribution to perceived general health, given respondents' demographic and socio-economic characteristics. The perceived general health of people living in less urban areas tends to be better.

The addition of one of the percentages of green space renders the very strongly and strongly urban areas insignificant (table 2.1; step 3a, 3b). This illustrates the high (negative) correlations between amount of green space and degree of urbanity. It also indicates that the amount of green space is more strongly related to perceived general health than the degree of urbanity is.
This suggests that the amount of green space may have an independent effect on people's health at all degrees of urbanity. If this were true, the relation between green space and health should also occur when the different degrees of urbanity are examined separately.

Table 2.2 shows that the relation between green space and health is apparent in all degrees of urbanity, although in the very strongly urban areas only green space within a 3km radius around the home is related to perceived general health.

Table 2.2 Regression analysis for perceived general health by level of urbanity modelled as interaction effects: parameter and standard error[1]

	Perceived general health ('good/very good'=1)	
	Step 1	**Step 2**
Very strong urban * % of green space (1km)	0.001 (.001)	
Strong urban * % of green space (1km)	0.004 (.001)***	
Moderately urban * % of green space (1km)	0.006 (.001)***	
Slightly urban * % of green space (1km)	0.006 (.000)***	
Non urban * % of green space (1km)	0.004 (.001)***	
Very strong urban * % of green space (3km)		0.003 (.001)**
Strong urban * % of green space (3km)		0.006 (.001)***
Moderately urban * % of green space (3km)		0.006 (.001)***
Slightly urban * % of green space (3km)		0.006 (.001)***
Non urban * % of green space (3km)		0.006 (.001)***

* p≤ 0.05; ** p≤ 0.01; *** p≤ 0.001

[1] all analyses were controlled for socio-demographic and socio-economic characteristics

Where the type of green space is concerned, the amount of agricultural green is in all degrees of urbanity strongest related to perceived general health (not in table). Urban green in a 3km radius is negatively related to people's health in all degrees of urbanity (not in table). This is probably caused by the fact that people who have a lot of urban green space nearby, are living at the edge of their municipality (or in a small municipality) and

close to stronger urban municipalities; their own municipality itself is unlikely to contain much urban green space. This is supported by the fact that the amount of urban green space is negatively related to the total amount of green space within 3km.

To further investigate the strength of the relationship between green space and health, we tested the impact of a green environment on the perceived general health of people with different socio-economic statuses and people in different age groups.

The relation for socio-economic status groups

A greener environment appeared to be positively related to health in all education groups. People with a secondary education level benefit most from green space. (table 2.3; step 1 and step 2).

Table 2.3 Regression analysis for perceived general health by level of education modelled as interaction effects characteristics: parameter values and standard errors[1]

	Perceived general health ('good/very good'=1)	
	Step 1	**Step 2**
Very strong urban	-0.111 (.056)	-0.073 (.062)
Strongly urban	0.003 (.051)	-0.019 (.052)
Moderately urban	0.077 (.048)	-0.012 (.046)
Slightly urban	0.078 (.046)	0.032 (.045)
Higher education * % of green space (1km)	0.002 (.001)*	
Secondary education * % of green space (1km)	0.006 (.000)***	
Primary/no education * % of green space (1km)	0.003 (.000)***	
Higher education * % of green space (3km)		0.003 (.001)**
Secondary education * % of green space (3km)		0.007 (.001)***
Primary/no education * % of green space (3km)		0.004 (.001)***

* p≤ 0.05; ** p≤ 0.01; *** p≤ 0.001

[1] all analyses were controlled for socio-demographic and socio-economic characteristics and level of urbanity

Analyses (see table 2.4) for the different education groups in the different degrees of urbanity show that a greener environment is only related to health in all degrees of urbanity for people with a secondary level of education. People who are highly educated only benefit from green space in

strongly and moderately (only just significant within a 1km radius) urban areas.
The analyses suggest that the lower educated groups are more sensitive to the physical environmental characteristics.

Table 2.4 Regression analysis for perceived general health by level of urbanity and level of education modelled as interaction effects: parameter and standard error[1]

	Perceived general health ('good/very good'=1)				
	Very strong	**Strong**	**Moderate**	**Slight**	**Non urban**
Higher education*	0.001	0.005	0.004	0.000	0.002
% of green space (1km)	(0.002)	(0.002)**	(0.002)*	(0.002)	(0.004)
Secondary education*	0.005	0.006	0.007	0.008	0.006
% of green space (1km)	(0.001)***	(0.001)***	(0.001)***	(0.002)***	(0.002)**
Primary/no education*	0.002	0.000	0.002	0.004	0.004
% of green space (1km)	(0.002)	(0.001)	(0.001)*	(0.001)***	(0.002)*
Higher education*	0.000	0.007	0.004	0.002	0.001
% of green space (3km)	(0.003)	(0.002)***	(0.003)	(0.003)	(0.006)
Secondary education*	0.004	0.008	0.008	0.008	0.007
% of green space (3km)	(0.002)*	(0.001)***	(0.002)***	(0.002)***	(0.003)**
Primary/no education*	0.001	0.004	0.004	0.005	0.006
% of green space (3km)	(0.002)	(0.002)*	(0.002)*	(0.002)**	(0.003)*

* p≤0.05; ** p≤0.01; *** p≤0.001

[1] all analyses were controlled for socio-demographic and socio-economic characteristics

The relation between green space and health by age

Analyses of the relation between green space and health in the different age groups (youth: 0-24, adults: 25-64, elderly: 65 or older) show that the health of all age groups benefit significantly from green space (see table 2.5). The self-reported health of all age groups is better when there is more green space.

When the relation between the amount of green space and health is analysed for different age groups in the different degrees of urbanity, it appears that the relationship is most consistent for the elderly (see table 2.6). The elderly benefit from green space in all urban areas. Only the elderly and the youth seem to benefit from green space in very strongly urban areas. This relationship is stronger for green space within a 1km radius.

In the strongly, moderately and slightly urban areas all age groups benefit from green space.

Table 2.5 Regression analysis for perceived general health by age modelled as interaction effects: parameter values and standard errors[1]

	Perceived general health ('good/very good'=1)	
	Step 1	**Step 2**
Very strong urban	-0.102 (0.057)	-0.071 (0.062)
Strongly urban	0.010 (0.052)	-0.016 (0.053)
Moderately urban	0.080 (0.048)	0.012 (0.047)
Slightly urban	0.078 (0.046)	0.031 (0.045)
Youth * % of green space (1km)	0.006 (0.001)***	
Adults * % of green space (1km)	0.005 (0.000)***	
Elderly * % of green space (1km)	0.004 (0.001)***	
Youth * % of green space (3km)		0.006 (0.001)***
Adults * % of green space (3km)		0.006 (0.001)***
Elderly * % of green space (3km)		0.005 (0.001)***

* p≤0.05; ** p≤0.01; *** p≤0.001

[1] all analyses were controlled for socio-demographic and socio-economic characteristics and level of urbanity

Table 2.6 Regression analysis for perceived general health by level of urbanity and by age modelled as interaction effects: parameter and standard error[1]

	Perceived general health ('good/very good'=1)				
	Very strong	**Strong**	**Moderate**	**Slight**	**Non urban**
Youth * % of green space (1km)	0.006 (0.002)**	0.010 (0.002)***	0.004 (0.002)*	0.006 (0.001)***	0.002 (0.002)
Adults * % of green space (1km)	0.002 (0.001)	0.004 (0.001)***	0.005 (0.001)***	0.006 (0.001)***	0.004 (0.002)*
Elderly * % of green space (1km)	0.006 (0.002)**	0.002 (0.001)*	0.004 (0.001)***	0.005 (0.001)***	0.006 (0.002)**
Youth * % of green space (3km)	0.004 (0.002)*	0.012 (0.002)***	0.006 (0.002)**	0.006 (0.002)**	0.004 (0.003)
Adults * % of green space (3km)	0.001 (0.002)	0.007 (0.001)***	0.007 (0.002)***	0.007 (0.002)***	0.006 (0.003)*
Elderly * % of green space (3km)	0.004 (0.002)*	0.004 (0.002)*	0.005 (0.002)**	0.006 (0.002)**	0.007 (0.003)**

* p≤0.05; ** p≤0.01; *** p≤0.001

[1] all analyses were controlled for socio-demographic and socio-economic characteristics and level of urbanity

Discussion

Statement of principal findings

The percentage of green space in people's living environment showed a positive association with the perceived general health of residents. People with a greener environment within a 1km or 3km radius around their homes have better self-reported health than people living in a less green environment. The relations inside a 1km or 3km radius were equally strong, and it is only in the very strongly urban areas that the proximity of green space becomes more important. The amount of agricultural and natural green in the living environment was positively related to perceived general health. As shown in figure 2.1, the relationship between green space and health is considerable.

We hypothesised that the relationship between green space and health would be stronger for people who are assumed to spend more time in the vicinity of their homes. This study shows that this hypothesis can be corroborated; the relationship between green space and health is stronger for people with a lower SES as opposed to people with a high SES, and is stronger for youth and elderly compared to adults.

Our analyses show that health differences in residents of urban and rural municipalities are to a large extend explained by the amount of green space. The coefficients of the level of urbanity are strongly reduced and no longer significant when the amount of green space is taken into account. The amount of green space was not taken into account in previous research on the relationship between the level of urbanity and health. Our analyses show that green space is important in explaining the health differences between urban and rural residents. Furthermore, the analyses show that the amount of green space is more strongly related to perceived general health than urbanity.

The fact that the relationship was found at all levels is an indicator of the general character of the relationship. The Netherlands is a very densely populated country and this might affect the generalization of our results to other countries. On the other hand, the fact that we found the relationship at different levels of urbanity (which is measured as address density) suggests that the relationship would also be found in less densely populated countries.

Strengths and weaknesses of the study

This is the first epidemiological study to use such a large dataset. The health data and the land use data were derived from different databases and there is no single source bias as a consequence.

The observed relations between green space and health could be caused by selection effects. We tried to rule out this possibility by taking the socio-economic and demographic characteristics into account, but - given the correlational nature of the data - the effects of selection cannot be ruled out completely. The subgroup analysis by SES groups, however, makes selection mechanisms related to socio-economic status rather unlikely. The relationship observed between green space and health was stronger for the less educated group and this is exactly the subgroup that is less likely to have much choice in their neighbourhood of residence. Our results may be influenced by selective migration based on people's health: .healthy people might choose to live in greener environments. However it is impossible to control for direct selection on the dependent variable in a crossectional study design. Most of the results found in this study correspond with the results of our earlier study, but there are a few differences. In our earlier study we did not find an effect for green space in the more urban areas. Furthermore, no significant relation was found in the young age group (De Vries et al., 2003).

Possible mechanisms and implications for policymakers

This research has shown that the presence of green space in people's living environment is positively related to perceived general health. The causes of this relation remain unknown, however. As stated above, previous research has mainly focused on demonstrating the relationship between exposure to green environments and well-being (Hartig et al., 2003; Hartig, 2004). The dominant theories in the field all consider stress reduction and attention restoration as a central causal mechanism (Hartig, 2004; Kaplan and Kaplan, 1989).

Very little is known about whether the relation between green space and health is caused by increased and prolonged physical activity (Humpel et al., 2002; King et al., 2002; Sallis et al., 1998), and improved social cohesion (Leyden, 2003; Kawachi and Berkman, 2000). Future research is needed to give more insight into the mechanisms behind the relationship between green space and health.

This research has shown that green space is more than just a luxury, and the development of green space should therefore be allocated a more central

position in spatial planning policy. Healthy planning should include a place for green space and policy makers should take the amount of green space in the living environment into account when endeavouring to improve the health situation of the elderly, the youth and lower socio-economic status groups, especially in urban environments.

3

Morbidity is related to a green living environment

This article was submitted as:
Maas J, Verheij RA, De Vries S, Spreeuwenberg P, Schellevis FG, Groenewegen PP. Morbidity is related to a green living environment.

Abstract

Due to increasing urbanisation people face the prospect of living in environments with few green spaces. There is increasing evidence for a positive relation between green space in people's living environment and self-reported indicators of physical and mental health. This study investigates whether morbidity is related to the amount of green space in people's living environment.

Morbidity data were derived from electronic medical records of 195 general practitioners from 96 Dutch practices, serving a population of 345,143 people. Morbidity was classified by the general practitioners according to the International Classification of Primary Care (ICPC). The percentage of green space within a one kilometer and three kilometer radius around the postal code coordinates was derived from an existing database and was calculated for each household. Multilevel logistic regression analyses were performed controlling for demographic and socio-economic characteristics.

The annual prevalence rate of 18 of the 24 disease clusters was lower in living environments with more green space. The relation was strongest for anxiety disorder and depression. The relation was stronger for children and people with a lower socio-economic status. Furthermore, the relation was strongest in slightly urban areas and not apparent in very strongly urban areas.

This study indicates that the previously established relation between green space and a number of self-reported general indicators of physical and mental health can also be found for clusters of specific physician assessed diseases. The study stresses the importance of green space close to home for children and lower socio-economic groups.

Introduction

Due to increasing urbanisation, combined with a planning policy of spatial densification, more people face the prospect of living in residential environments with little green space. At the same time, increasing evidence shows that green space has beneficial effects on people's health. Evidence has been found for a positive relation between green space and self perceived health (De Vries et al., 2003; Maas et al., 2006; Mitchell and Popham, 2007; Sugiyama et al., 2008), longevity (Takano et al., 2002), number of symptoms and the risk of psychiatric morbidity (De Vries et al., 2003). Access to a garden and shorter distances to green areas from the dwelling were associated with less stress and a lower likelihood of obesity (Nielsen and Hansen, 2007). Experimental studies showed that there is a positive relation between green space and restoration from stress and mental fatigue. More specific, exposure to nature has been found to have a positive effect on mood, concentration, self-discipline, and physiological stress (Health Council of the Netherlands and RMNO, 2004; Van den Berg et al., 2007; Hartig et al., 1991; Kaplan and Kaplan, 1989). These studies indicate that there is a relation between green space and self reported general indicators of physical and mental health.
In this article we will go one step further and investigate whether physician assessed disease clusters are also related to the amount of green space in people's living environment.

Morbidity data were derived from routine primary care electronical medical records. In the Netherlands morbidity presented in general practice is a good indicator of morbidity in the population. Basically all non-institutionalized people are registered with a GP. Furthermore, GPs have a gate keeping role for secondary care and are usually the first point of contact with the health care system.

To gain more insight into the relation between green space and physician assessed morbidity we analysed this relation separately for different age groups and different socio-economic groups. We hypothesise that the relation is stronger for elderly people and children (as compared to adults) because, as a result of their lower mobility, they spend more time in the vicinity of their home, resulting in higher exposure to green space in their living environment. The same applies to people with a lower socio-economic

status, whose activities and social contacts are situated close to their homes (Schwanen et al., 2002; Harms, 2006). Therefore we also hypothesise that people with a lower socio-economic status are more exposed to the green space in their living environment. Finally, the relation was analysed for different levels of urbanity to investigate whether the relation varies between urban and rural areas.

Methods

For this study data from two different datasets were combined. Morbidity data were collected within the framework of the second Dutch National Survey in General Practice (DNSGP-2), which included a nationwide, representative sample of 104 general practices with 195 GPs and a practice population of approximately 400,000 enlisted people, who were representative for the Dutch population in terms of age, gender and type of health insurance (Westert et al., 2005). For this study data from 96 practices that recorded morbidity for a full period of 12 months or more were used. This selection had no significant effect on the representativeness of the data (Westert et al., 2005). Only people who had been registered with their current GP for longer than 12 months prior to the study (n=345,143) were included, because we assumed that people will have to live for at least 12 months in the same living environment before any effect of it would be noticeable.
Environmental data were derived from the National Land Cover Classification database (LGN4) in 2001, which contains the dominant type of land use of each 25 by 25 metre grid cell of the Netherlands (Thunnissen and De Wit, 2000). The two datasets were matched on the basis of the x and y coordinates of the respondent's six character postal code (on average about 15 to 20 households have the same six character postal code).

Morbidity data
During a of 12 months period, data on all GP consultations with patients were extracted from the electronic medical records. These data included contact diagnoses and indications (diagnoses) for medication and referral to secondary care. Prevalence rates are based on contacts that were classified by the GP according to the International Classification of Primary Care

(ICPC) and subsequently clustered into episodes of disease (Lamberts and Wood, 1987).

The most prevalent episodes were combined into 24 disease clusters. These disease clusters have been used in several other studies (Van Lindert et al., 2004; Nielen et al., 2007) and include the most prevalent diseases in general practice (prevalence >10 per 1,000) (see table 3.1). The 24 disease clusters have been distributed over 7 disease categories, namely cardiovascular diseases, musculoskeletal diseases, mental diseases, respiratory diseases, neurological diseases, digestive diseases and miscellaneous.

Not all disease clusters were relevant for all age groups, therefore the epidemiological denominator varied (table 3.1). A prevalence rate for each cluster was calculated by dividing the number of patients with at least one disease episode in 2001 belonging to the cluster by the population at risk.

Table 3.1 Annual prevalence rates of clusters of diseases presented in general practices (cases per 1000) (n=345 143; unless stated otherwise)

Cluster	ICPC codes	N (abs)	/1000
Cardiovascular:			
High blood pressure (n=273,925)	K85 K86 K87	24,778	90.5
Cardiac disease	K71 K73 K74 K77 K78 K79 K80 K81 K82 K83 K84	9,044	26.2
Coronary heart disease (n=240,825)	K74 K75 K76	5,804	24.1
Stroke, brain hemorrage (n=240,825)	K89 K90	2,549	10.6
Musculoskeletal:			
Neck- and back complaints	L01 L02 L03 L84 L86	32,346	93.7
Severe back complaints	L02 L03 L85 L86	25,230	73.1
Severe neck and shoulder complaints	L01 L08 L83 L92	21,236	61.5
Severe elbow, wrist and hand complaints	L10 L11 L12 L72 L74	7,698	22.3
Osteoarthritis (n=240,825)	L89 L90 L91	4,521	18.8
Arthritis (n=240,825)	L88 T92	3,170	13.2
Mental:			
Depression	P03 P76	8,859	25.7
Anxiety disorder	P01 P74	8,033	23.3
Respiratory:			
Upper respiratory tract infection	A77 R72 R74 R75 R76 R80	31,457	91.1
Bronchi(oli)tis/pneumonia	R78 R81	10,806	31.3

- table 3.1 continues -

- table 3.1 continued -

Cluster	ICPC codes	N (abs)	/1000
Asthma, COPD	R91 R95 R96	12,813	37.1
Neurological:			
Migraine/severe headache	N01 N02 N03 N89 N90 N92	10,629	30.8
Vertigo	N17	4,023	11.7
Digestive:			
Severe intestinal complaints	D81 D85 D86 D92 D93 D94	5,264	15.3
Infectious disease from the intestinal canal	D70 D73	3,816	11.1
Miscellaneous:			
Medically Unexplained Physical Symptoms (MUPS)	A01 A04 D01 D08 D09 D12 D18 D21 D93 K01 K02 K04 L01 L02 L03 L08 L09 L14 L20 N01 N02 N17 P06 P20 R02 R21 T03 T07 T08	75,774	219.5
Chronical eczema	S86 S87 S88	22,303	64.6
Acute urinary tract infection	U70 U71 U72	13,303	38.5
Diabetes (n=290 479)	T88 T90	9,260	31.9
Cancer	A79 B72 B73 B74 D74 D75 D76 D77 F74 H75 K72 L71 N74 R84 R85 S77 S80 T71 T73 U75 U76 U77 U79 W72 X75 X76 X77 X81 Y77 Y78	6,086	17.6

Characteristics of the respondents' living environment

The LGN4 database discriminates 39 land use classes including crop types, forest types, water, various urban classes and semi-natural classes and has been proven to be valid, accurate and reliable (Thunnissen and De Wit, 2000; De Wit and Clevers, 2004). The total percentage of green space in the respondents' living environment was measured within a 1km radius and within a 3km radius around the centre point of the postal code of a respondent's home, to see whether there is a stronger relation for green space close by than green space further away. Only green spaces that dominate the land use in the 25 by 25 metre grid cell have been classified as green space in the dataset. Small-scale green spaces, such as street trees and roadside vegetation were only included as green space if they were dominant in the grid cell.

Level of urbanity

Another environmental characteristic is level of urbanity. This variable consists of five categories ranging from very strongly urban (1) to non-urban (5); it was measured at municipal level and was derived from Statistics Netherlands. The indicator is based on the number of households per square km and is commonly used in the Netherlands (Den Dulk et al., 1992).

Demographic and socioeconomic characteristics

Part of the relation between green space and health may be the result of direct or indirect selection. Direct selection would take place when people's health is related to their chances of living in a green environment. Indirect selection takes place when people with certain characteristics related to wellbeing (such as income) tend to live in a green environment (Verheij, 1996). As migration flows are related to such socio-demographic characteristics as age, income and education (Heins, 2002), we decided to rule out indirect selection effects by controlling statistically for demographic and socio-economic characteristics.

The demographic characteristics taken into account were gender (female=1) and age (which was taken into account as polynomial till the third order because there was no linear relation between the diagnose clusters and age) and were derived from the patient lists of the participating practices. To find out whether the relation between green space and morbidity differed between age groups, age was divided into six categories (viz. children [aged <12 year], adolescent [aged 13-17 year], youth [aged 18-25 year], young adults [aged 26-45 year], older adults [aged 46-65 year] and elderly [aged 65+]).

Socio-economic characteristics were collected by a registration form that was sent by mail to all people listed in the participating practices in the DNSGP-2 (n=380,000, response 76.5%) (Westert et al., 2005) and included education, work status, and health care insurance type.

Education was measured as the highest level of completed education (unknown/no education completed/primary education/secondary education/higher education). Work situation was categorised as: work situation unknown, paid job, attending school/studying, housewife/houseman, retired, disability pension, unemployed. Socio-economic status was additionally implicitly measured by type of health care insurance (unknown, public or private). The type of health care insurance can be regarded as an indicator of socio-economic status in the Dutch context in 2001, as people

with a higher income had a private health insurance, whereas people with a lower income had a obligatory public health insurance.
When testing the effect of green space for different SES groups, SES was operationalised as the level of education divided into three categories, viz. higher education (university or higher vocational education), secondary education and primary or no education. Characteristics of the study population are displayed in table 3.2.

Table 3.2 Characteristics of the study population

	Characteristics of the respondents (n= 345,143)
Demographic characteristics:	
Gender	
Male	49.5%
Age:	
≤12 year	14.4%
13–17 year	6.2%
18-25 year	9.6%
26-45 year	32.3%
46-65 year	24.7%
>65 year	12.8%
Socio-economic characteristics:	
Highest level of education	
Unknown	25.2%
No education completed	11.7%
Primary education	14.2%
Secondary education	36.8%
Higher education	12.1%
Health insurance:	
Unknown	23.9%
Public	50.9%
Private	25.3%
Work situation:	
Work situation unknown	27.9%
Paid job	31.5%
Attending school/studying	16.4%
Housewife/houseman	11.1%

- table 3.2 continues -

- table 3.2 continued -

	Characteristics of the respondents (n= 345,143)
Retired	9.0%
Disability pension	3.0%
Unemployed	1.1%
Level of urbanity:	
Very strongly urban	13.9%
Strongly urban	22.2%
Moderately urban	22.6%
Slightly urban	31.7%
Non urban	9.7%

Statistical analysis

The relation between percentage of green space in people's living environment and morbidity was assessed using multilevel logistic regression analyses, controlling for demographic and socio-economic characteristics and level of urbanity. We included two levels: individuals and practices, because of the hierarchical structure of the data within DNSGP-2. The multilevel logistic regression analyses were performed with MLwiN. The independent variables, including the percentage of green space, were centred around their average. The results thus represent morbidity of the average population living in an area with an average amount of green space. We used interaction effects between respective age groups, SES groups and level of urbanity and the green space indicator to investigate the relation for different age groups, SES groups and in different levels of urbanity.

Results

On average there is 42.4% of green space in a 1km radius and 60.8% of green space in a 3km radius around people's home. Table 3.3 presents the odds ratios for the annual prevalence rate of the 24 disease clusters for people who have 10% more green space than average. In general, a significant relation between the percentage of green space and the annual prevalence rate was only present for green space in a 1km radius. Only for anxiety disorders and infectious diseases of the digestive system the annual

prevalence rate was lower in environments with more green space in a 3km radius.

For 18 of the 24 disease clusters the annual prevalence rate was lower in living environments with a higher percentage of green space in a 1km radius. This relation is apparent for diseases in all seven disease categories. It is strongest for anxiety disorders and depression. For none of the disease clusters the relationship is negative.

Strength of the relation

An indication of the strength of the relation is given in table 3.4 which shows the annual prevalence per 1,000 for people with average characteristics on the control variables with respectively 10% and 90% green space in a 1km radius around their home. For anxiety disorders, the annual prevalence for people with average characteristics with 10% green space in a 1km radius was 26 per 1,000 people and for those with 90% green space in a 1km radius 18 per 1,000 people. For depression these figures are respectively 32 and 24 per 1,000.

Relation in different age groups

Further analysis showed that the relation was strongest for children younger than 12 and people between 46 and 65 (not in table). For children the relation was not only apparent for the percentage of green space in a 1km radius, but also for the percentage of green space in a 3km radius. For a few disease clusters the relation for children was especially strong, for example for vertigo (1km: OR = 0.81 (95% C. I = 0.74 - 0.90) / 3km: OR 0.85 [95% C. I = 0.77 -0.94]) and severe intestinal complaints (1km: 0.85 [95% C. I = 0.80 - 0.90] / 3km: 0.89 [95% C. I = 0.84 - 0.94]). The strongest relation for children was found for depression (1km: OR = 0.79 [95% C. I = 0.72 - 0.88] / 3km: OR = 0.84 [95% C. I = 0.78 - 0.91]).

The relations for the other age groups were similar to the overall relations shown in table 3.3.

Table 3.3 The effect of having 10% more green space in one's living environment on the prevalence of disease clusters (n=345,143; unless stated otherwise)

Cluster	Percentage of green space in 1km radius		Percentage of green space in 3km radius	
	OR	95% C. I.	OR	95% C. I.
Cardiovascular:				
High blood pressure (n=290 535)	**0.99**	**0.98 – 1.00**	1.00	0.98 – 1.02
Cardiac disease	**0.98**	**0.97 – 0.99**	1.00	0.96 - 1.04
Coronary heart disease (n=255 346)	**0.97**	**0.95 - 0.99**	0.97	0.93 – 1.01
Stroke, brain hemorrage	0.98	0.95 – 1	0.98	0.92 – 1.04
Musculoskeletal:				
Neck- and back complaints	**0.98**	**0.97 - 0.99**	0.99	0.97 – 1.00
Severe back complaints	**0.98**	**0.97 - 0.99**	1.00	0.98 - 1.01
Severe neck and shoulder complaints	**0.98**	**0.97 - 0.99**	1.00	0.98 - 1.01
Severe elbow, wrist and hand complaints	**0.97**	**0.96 - 0.98**	1.01	0.99 - 1.03
Osteoarthritis (n=255 346)	0.97	0.93 - 1.01	0.97	0.92 – 1.03
Arthritis (n=255 346)	0.99	0.97 - 1.01	1.00	0.96 – 1.04
Mental:				
Depression	**0.96**	**0.95 - 0.98**	0.98	0.96 – 1.00
Anxiety disorder	**0.95**	**0.94 - 0.97**	**0.96**	**0.93 - 0.99**
Respiratory:				
Upper respiratory tract infection	**0.97**	**0.96 - 0.98**	0.99	0.97 - 1.01
Bronchi(oli)tis/pneumonia	**0.99**	**0.97 – 1.00**	1.02	0.99 – 1.04
Asthma, COPD	**0.97**	**0.96 - 0.98**	1.01	0.99 – 1.03
Neurological:				
Migraine/severe headache	**0.98**	**0.97 - 0.99**	0.98	0.96 – 1.00
Vertigo	**0.97**	**0.95 - 0.99**	0.98	0.94 - 1.02
Digestive:				
Severe intestinal complaints	0.98	0.96 – 1.00	0.99	0.95 – 1.03
Infectious disease from the intestinal canal	**0.97**	**0.95 - 0.99**	**0.95**	**0.91 - 0.99**
Miscellaneous:				
Medically Unexplained Physical Symptoms (MUPS)	**0.97**	**0.96 - 0.98**	**0.98**	**0.97 - 0.99**
Chronic eczema	0.99	0.97 – 1.00	0.99	0.95 – 1.03
Acute urinary tract infection	**0.97**	**0.96 - 0.98**	0.98	0.95 – 1.01
Diabetes mellitus (n=343 103)	**0.98**	**0.97 - 0.99**	0.98	0.97 – 1.00
Cancer	1.00	0.98 – 1.02	0.99	0.95 - 1.03

note: odds ratio's derived from multilevel logistic regression analysis, controlling for demographic and socioeconomic characteristic and level of urbanity

Table 3.4 Prevalence rates per 1000 in living environments with 10% and 90% green space for different disease clusters

Cluster	Prevalence per 1000	
	10% green space	90% green space
Cardiovascular:		
High blood pressure	23.8	22.4
Cardiac disease	4.7	4.0
Coronary heart disease	1.9	1.5
Stroke, brain hemorrage	0.92	0.76
Musculoskeletal:		
Neck- and back complaints	125	106
Severe back complaints	99.2	65.8
Severe neck and shoulder complaints	75.6	63.3
Severe elbow, wrist and hand complaints	23	19.3
Osteoarthritis	21.8	21.3
Arthritis	6.7	6.2
Mental:		
Depression	32	24
Anxiety disorder	26	18
Respiratory:		
Upper respiratory tract infection	84	68
Bronchi(oli)tis/ pneumonia	16	14.7
Asthma, COPD	26	20
Neurological:		
Migraine/severe headache	40	34
Vertigo	8.3	6.6
Digestive:		
Severe intestinal complaints	14.9	12.3
Infectious disease from the intestinal canal	6.5	5.1
Miscellaneous:		
Medically Unexplained Physical Symptoms (MUPS)	237	197
Chronic eczema	5.5	4.9
Acute urinary tract infection	23.2	19.4
Diabetes Mellitus	10	8
Cancer	4.9	4.4

note: this table is based on results from multilevel logistic regression analysis controlling for demographic and socioeconomic characteristic and level of urbanity which were centred around the average

Relation for different socio-economic groups
Especially the lower educated groups had a lower annual prevalence rate when they had more green space in a 1km radius around their home. The strength of the relations for the different socio-economic groups are similar to the odds ratios shown in table 3.3 (not in table).

Relation for different levels of level of urbanity
Concerning the level of urbanity our analyses show that level of urbanity influences the relation between green space and the annual prevalence of disease clusters (not in table). There is often no relation between green space and the annual prevalence of disease clusters in the very strongly urban areas. At all other levels of urbanity people with more green space in a 1km radius around their home had a lower annual prevalence rate. The relations between green space and annual prevalence rates were strongest in slightly urban areas.

Discussion

Principal findings
This study shows that the previously established relation between green space and a number of self-reported general indicators of physical and mental health can also be found for specific, doctor-assessed disease categories. The annual prevalence rates for 18 of the 24 investigated disease clusters is lower in living environments with more green space. Green space close to home appeared to be more important than green space further away. This is in contrast with our previous studies (De Vries et al., 2003; Maas et al., 2006) which found the relation between self-reported health and the amount of green space in a 1km and a 3km radius around people's home to be equally strong. It appears that for the prevalence of these more specific diseases green space close to home is more important.
In line with our hypothesis the relation was strongest for people who were expected to spend more time in the vicinity of their homes, namely children and people with a lower socio-economic status. However, contrary to our expectations the relation appeared to be stronger for people aged between 46 and 65 than for elderly. Concerning level of urbanity, the relation appeared to be strongest in slightly urban areas. In very strongly urban areas there was no relation with the annual prevalence of disease clusters. This may be

related to the fact that green spaces in highly urban areas are more often found to evoke feelings of insecurity (Jorgensen et al., 2002), and thereby inhibiting their use.

Underlying mechanisms

The results of this study give some indications for the possible mechanism behind the relation between green space and health. Several mechanisms could be responsible for the relation between green space and health, of which the following are most commonly mentioned: recovery from stress and attention fatigue, encouragement of physical activity, facilitation of social contact and better air quality (Health Council of the Netherlands and RMNO, 2004; Groenewegen et al., 2006). What do the results tell us about the mechanism at work?

The strong relation we particularly found for anxiety disorder and depression suggests that recovery from stress and attention fatigue might be the most likely mechanism behind the relation between green space and health, though facilitation of social contacts might also contribute. However, there is no reason to discard any of the other possible mechanisms. In living environments with more green space, the prevalence of all respiratory illnesses was lower, indicating that air quality could also be a possible mechanism behind the relation between green space and health. For diseases related to physical activity (diabetes, high blood pressure, musculoskeletal diseases) somewhat less strong relations were found. But as the associations were present, physical activity could also be a possible mechanism. Further research will have to shed more light on the mechanisms behind the relation between green space and health.

This study shows that the role of green space in the living environment for health should not be underestimated. Most of the diseases which were found to be related to the percentage of green space in the living environment are highly prevalent in society and in many countries they are subject of large scale prevention programs. Furthermore, in many countries, diseases of the circulatory system, mental disorders and diseases of digestive system are among the most expensive diseases with respect to health care costs (Heijink et al., 2006). Our study contributes to the evidence that green space can help fight some major public health threats in western societies and should be allocated a more central position in spatial planning. Healthy planning should include a place for green space and policy makers should

take the amount of green space in the living environment into account when endeavouring to improve the health situation of children and lower socio-economic groups.

Strength and limitations

This is the first large epidemiological study investigating the relation between the amount of green space in the living environment of people and the prevalence of physician assessed diseases. Morbidity data were derived from a different database than the data on green space; consequently, there is no single source or method bias. On the other hand, we don't have information an exposure time.

The morbidity data are accurate because they were extracted from routine electronic medical records of general practices, and the inter-observer reliability of grouping contacts into episodes was high (Van der Linden et al., 2004). The registration covered a 12-month period for each practice in order to eliminate seasonal influences. Considering the representativeness of the participating GPs and their patients – and the high validity of the data – the results of the present study can be assumed to validly represent morbidity in Dutch general practice.

Furthermore, because general practice in the Netherlands is usually the first point of contact with the health care system, and because the GP has a gatekeeping role for specialist care, and because there are no large geographic (Kostalova, 2008) or social differences in access to general practice, morbidity presented in general practice can be regarded as a very close approximation of morbidity present in the open population.

The data used for this study also have some shortcomings. First, our data on green space, although assessed on a small scale, does not take small green spaces in the living environment into account. A 25 by 25 metre grid cell was only regarded as green space when green space dominates in the grid cell. Gardens and small-scale green spaces, such as street trees and green verges which could also influence people's health, are not regarded as green space in our study.

Second, because of the cross-sectional design of the study, it is not possible to make strong inferences about the causality of the relations that were found. The observed effects of green space on health may partly be caused by selection. We tried to rule out this possibility by taking socio-economic

and demographic characteristics into account, but the effects of selection cannot be ruled out completely. The results from the subgroup analyses by SES groups, however, make it rather unlikely that selection is the responsible mechanism. The relationship observed between green space and morbidity was stronger for the less well-educated group and this is exactly the subgroup that has fewer options in their choice of neighbourhood of residence. Our results may be influenced by selective migration based on people's health (direct selection). However, longitudinal studies on health related migration show that direct selection can not be held responsible for geographical differences that remain if socioeconomic and demographic factors are taken into account (Verheij et al., 1998; Van Lenthe et al., 2007).

Part II

Underlying mechanisms

4

Green space as a buffer between negative life events and health

This article was submitted as:
Maas J, Van den Berg A, Verheij RA, Groenewegen PP. Green space as a buffer between negative life events and health.

Abstract

This chapter investigates to what extent the presence of green space in the living environment can buffer the adverse impacts of stressful life events on perceived mental and physical health.

We related data on stressful life events and mental and physical health in 4,529 residents of the Netherlands to the percentage of green space within a one kilometre radius and a three kilometre radius around the postal code coordinates for each individual's address.

After adjustment for socio-economic and demographic characteristics, we found indications that the presence of green space in the wider living environment buffers the adverse impacts of stressful life events on self-reported physical health.

Introduction

Many people seek solace in nature in times of crisis. For example, after the attacks on the World Trade Centre in 2001, managers of national parks noticed a strong increase in visits. In an interview published on the Environment News Service, one manager remarked, "People were going out that day, going for walks, reflecting on what was going on" (Lazaroff, 2002). The usefulness of nature-based coping strategies is confirmed by an increasing number of studies showing that contact with nature can have beneficial effects on people's health (De Vries et al., 2003; Maas et al., 2006; Mitchell and Popham, 2007; Takano et al., 2002). Controlled, experimental research has found especially strong evidence for a positive relation between exposure to nature and restoration from stress and attention fatigue (e.g. Hartig et al., 2003; Ulrich et al., 1991).

Unfortunately, due to increasing urbanisation, combined with a spatial planning policy of densification, more people face the prospect of living in residential environments with limited access to green resources. According to dynamic stress-vulnerability (DSV) models (Heady and Wearing, 1989; Ormel and Neeleman, 2000) this may increase their vulnerability to the impact of stressful life events on mental and physical health. In general, individuals living in areas that lack green space are more vulnerable to the negative impacts of stressful life events because they have less opportunities for nature-based coping strategies than individuals living in areas with abundant green space (Kaplan and Kaplan, 1989). Thus, the availability of green space in the living environment may be an important environmental factor that moderates the impact of stressful life events on health and well-being.

The aim of this study is to investigate to what extent the presence of green space close to and farther away from the home can buffer the adverse impacts of stressful life events on perceived mental and physical health.

Neighborhoods, green space, and stress

There is a long tradition of research exploring the relationship between neighbourhood characteristics and individual well-being (Macintyre and Ellaway, 2000). Traditionally, this research has focused mostly on sociological and psychosocial factors such as social cohesion, social capital

and sense of community (Gee and Payne-Sturges, 2004). However, there is growing recognition for the importance of physical neighbourhood circumstances as both sources of stress and as resources that can help residents to cope with stress (Diez-Roux, 1998). One physical characteristic that has recently received much attention from researchers and policy makers as a potentially powerful physical neighbourhood resource is green space. Findings from recent EU research programs on urban green spaces confirm their role in improving people's life quality (Priestley et al., 2004; De Ridder, 2003). Like other public areas, parks and other green spaces can support physical activity and facilitate social cohesion (Kuo et al., 1998a; Takano et al., 2002). However, green spaces appear to have a special quality that is lacking in other, more barren public areas: contact with green space can provide restoration from stress and mental fatigue. This so-called 'restorative quality' of nature is corroborated by results of national surveys in several countries, which have consistently shown that people consider contact with nature one of the most powerful ways to obtain relief from stress (Frerichs, 2004; Grahn and Stigsdotter, 2003).

Origins of restorative effects of green space

Restorative effects of green space have generally been explained from an evolutionary perspective. Most of these explanations have in common the argument that, as a remnant of two or three million years of evolution in natural environments, modern humans have developed a partly genetic readiness to respond positively to habitable settings that were favourable to well-being and survival for premodern people (Appleton, 1975; Kaplan and Kaplan, 1989; Orians, 1986; Ulrich, 1993). Notably, this readiness to respond positively to habitable settings is assumed to be triggered only by natural environments, humans do not possess such a disposition for most built environments and materials (Ulrich, 1993).

An important implication of people's readiness to respond positively to nature is that their attention is easily and almost effortlessly held by natural scenes. This attention-drawing quality of natural settings is referred to as 'soft fascination' (Kaplan and Kaplan, 1989). Soft fascination is assumed to play an important role in the restorative quality of nature. When nature captures people's attention, executive systems that regulate directed attention get to rest, pessimistic thoughts are blocked, and negative emotions are replaced by positive ones (Hartig et al., 1996; Parsons, 1991).

Prolonged exposure to high-quality natural settings may even stimulate reflections on life's larger questions such as one's priorities, goals, and one's place in the larger scheme of things (Herzog et al., 1997). This may help a person to find new sense and direction in life.

Direct evidence for restorative effects of green space

A small but growing body of well-controlled empirical research speaks directly to the restorative effects of green space (Health Council of the Netherlands and RMNO, 2004; Van den Berg et al., 2007). In general, this research has shown more positive affective, cognitive, and physiological responses to natural settings as compared to built settings. These positive responses have been observed in diverse settings including remote wilderness areas (Hartig et al., 1991; Hartig et al., 2003) as well as nearby green space such as gardens (Ottosson and Grahn, 2005; Rodiek, 2002). Notably, people need not go outdoors to profit from nature's restorative functions. Merely viewing green space through a window can already have positive effects. Several studies have shown that residents of apartments with views of green space, in particular women and children who presumably spend much time at home, tend to report less stress and perform better on tests for cognitive functioning than their counterparts in apartments with barren views (Faber Taylor et al., 2002; Kaplan, 2001; Kuo and Sullivan, 2001; Tennessen and Cimprich, 1995; Wells, 2000).

The findings of field studies are backed up by laboratory experiments in which stressed participants are randomly assigned to conditions of viewing visual simulations of natural and urban environments (e.g. Berto, 2005; Hartig et al., 1996; Ulrich et al., 1991; Van den Berg et al., 2003). These experiments have consistently shown that viewing slides or videos of natural environments leads to a faster and more complete affective, cognitive and psycho- physiological stress recovery than viewing built environments. In sum, there is convergent evidence from different lines of research that contact with real or simulated natural environments can provide restoration from stress and mental fatigue.

Buffering effects of green space

Green space may not only impact stress and mental fatigue directly, but also have indirect effects by serving as a buffer against the health impacts of stressful life events. A buffer is a moderating variable that decreases the

association between an independent variable and an outcome variable, explaining how or under what circumstances the independent variable affects the outcome variable (Baron and Kenny, 1986; Evans and Lepore, 1997). A few studies have directly examined buffering effects of green space on various outcome variables. For example, research in rural communities in New York showed that nature in the residential environment may serve as a buffer of the impact of stressful life events on the psychological well-being of rural children (Wells and Evans, 2003). The impact of stressful life events on psychological distress and self-worth was weaker among children with a high amount of nature in or around their house than among children with a low amount of nearby nature. A study among employees of a wine-producing company in Southern Europe found that a view of natural elements (i.e. trees, vegetation, plants, and foliage) buffered the negative impact of job stress on intention to quit and general well-being (Leather et al., 1998). A recent Swedish study found evidence that the influence of a 'personal crisis' (i.e. a difficult event or severe loss with a strong emotional impact) on self-reported mental health and attention was weaker among individuals who spend much time contemplating nature and wildlife (Ottosson and Grahn, 2008).

Other studies have investigated protective effects of contact with nature in individuals who are undergoing stressful life conditions. For example, an intervention study among women diagnosed with breast cancer showed that women who carried out two hours of nature-based activities (e.g., visiting a scenic spot, tending plants or gardens, sitting by a window with natural views) per week for a period of about five weeks showed greater improvement in performance on attention tasks from the start to the end of the treatment period than a nonintervention group (Cimprich and Ronis, 2003). A Swedish study among residents of high-noise neighbourhoods found that residents with 'better' availability of green areas exhibited less stress-related psychosocial symptoms than residents with 'poorer' availability to green areas (Gidlöf-Gunnarsson and Öhrström, 2007). Because these studies have not included unstressed control groups, they do not provide direct evidence for buffer effects of green space. Nevertheless, the results show that contact with nature can help individuals to better cope with stressful life conditions.

Green space close by or farther away?

So far, research on the buffering effects of green space has mostly focused on readily available green space in the close vicinity of the home or workplace, e.g. plants in the living room or grass in the yard (Wells and Evans, 2003), a view of nature from the window (Leather et al., 1998), or green areas "close to your dwelling" (Gidlöf-Gunnarsson and Öhrström, 2007). The results confirm that green space 'at one's doorstep' can serve as a buffer against stress. Indeed, as Rachel Kaplan has put it, "accumulating from many short episodes, the view from the window can provide long-term contact with the natural environment. Perhaps such an enduring connection is particularly useful for sustaining restoration" (Kaplan, 2001).

In times of crisis, however, possibilities for contact with more large scale areas of nature farther away from one's home may be equally, or perhaps even more important to stay healthy in times of crisis. When people are confronted with major life events, such as death or divorce, they need time to reflect on their life, their actions, and priorities, to cope with the events. Such reflection involves a deep level of restoration that requires prolonged and intense engagement with nature (Kaplan and Kaplan, 1989). To be sure, deep restoration is possible in nearby green space (think of a person contemplating fish in a garden pond). However, it is presumably more easily obtained in more extensive natural areas farther away from one's home, where one can more readily obtain a sense of being away and connection with nature. A survey about the choice of restorative settings among elementary school teachers in Chicago provides some support for the validity of these notions (Gulwadi, 2006). Teachers who frequently suffered from vocational stress preferred to actually go out into nature and stay away for a longer period of time (such as taking a walk in the woods), whereas teachers with low levels of vocational stress found sufficient merit in brief sensory enjoyment of nearby nature (such as listening to birds' chirping). These findings suggests that the availability of more large-scale natural settings at a somewhat farther distance from home becomes more important in times of severe stress or crisis. As yet, however, health buffering effects of green space have not yet been related to the distance of the green space from home.

In this study we used quantitative data to investigate to what extent the presence of green space in the living environment can buffer the adverse

impacts of stressful life events on perceived mental and physical health. To gain more insight into the importance of the distance to green space, we made a distinction between green space within a 1km radius around the home, and green space within a 3km radius. Our main hypothesis was that the adverse impacts of experiencing stressful life events on physical and mental health is less severe in living environments with more green space, because green space can reduce vulnerability and thus promote resilience against stress. We also hypothesized that buffering effects would be stronger for green space in a 3km radius than for green space in a 1km radius, because having larger areas of green space farther away from one's home provides more opportunities for deep restoration.

Methods

Data

The data for this study were derived from two different datasets that were combined. The health data and data on stressful life events were collected within the framework of the second Dutch National survey of General Practice (DNSGP-2), conducted in the Netherlands in 2000-2002. The DNSGP-2 included a nationwide representative sample of 104 general practitioners practices with nearly 400,000 people on their list, who were a good representation of the Dutch population in terms of age, gender and type of health insurance (Westert et al., 2005).

As part of the DNSGP-2 a random sample of 12,699 people participated in a health interview survey (response rate 64.5%). Questionnaires were administered by trained interviewers during a face-to-face interview. To avoid seasonal patterns in morbidity, all interviews were carried out within 1 year (2001) and were distributed equally across all four seasons. Privacy of the participating persons was guaranteed and in accordance with Dutch legislation, and the study was approved by the Dutch Data Protection Authority. Patients were informed about the study prior to data collection (Westert et al., 2005). The socio-demographic characteristics of the respondents were highly comparable to those of the total Dutch population, although men, younger age groups and migrants were slightly underrepresented (Westert et al., 2005).

Environmental data were derived from the National Land Cover Classification database (LGN4) in 2001, which contains the dominant type of land use of each 25 by 25 metre grid cell in the Netherlands (Thunnissen and De Wit, 2000). The two datasets were matched on the basis of the x and y coordinates of the respondent's six character postal code (on average about 15 to 20 households have the same six character postal code).

Measures

Self-reported health indicators

We used three global health indicators:

1 *Number of health complaints* (maximum 43). Experienced in the last 14 days (e.g. headache, coughing, nausea, lower back pain) (Foets and Van der Velden, 1990).
2 *Perceived mental health.* Measured with the Dutch 12-item version of the General Health Questionnaire (GHQ-12; [Goldberg, 1972; Koeter and Ormel, 1991]). This variable was dichotomised: scores of 2 and higher were classified as an increased risk of psychopathology.
3 *Perceived general health.* Measured on a five-point scale, running from 'excellent' (1) to 'bad' (5). For our purposes the scores were dichotomised with scores from good to excellent classified as healthy (1). This kind of operationalizations has shown to be valid and predictive of health outcomes in numerous studies (Rütten et al., 2001; Simons, 2002).

Stressful life events

Stressful life events were assessed using the List of Threatening Experiences (LTE-Q), a self-report questionnaire that examines the incidence of 12 categories of stressful life events during someone's life course (Brugha et al., 1985). The LTE-Q assesses stressful life stressors involving moderate or long-term threat covering illnesses, accidents, losses, interpersonal problems, unemployment, financial crises and legal problems. The questionnaire shows acceptable levels of reliability and validity (Brugha and Cragg, 1990) and a high score has shown to be associated with increased risk of depression (Brugha and Conroy, 1985). Besides asking about the incidence of stressful life events during the life course it was also asked for each life event whether this event occurred within the last three months. With this information we constructed a new measure that assessed whether or not people experienced one or more stressful life events in the past three months. Only half of the people who responded to the health interview were

asked the question on stressful life events. Furthermore, people aged 18 years or younger were excluded, leaving 4,529 respondents.

Percentage of green space

Information on environmental characteristics was derived from the LGN4 database. The LGN 4 database distinguishes 39 land use classes including crop types, forest types, water, various urban classes and semi-natural classes and has been proven to be valid, accurate and reliable (De Wit and Clevers, 2004; Thunnissen and De Wit, 2000). The percentage of green space in the respondents' living environment was measured within a 1km radius (3.14 km^2) and within a 3km radius (28.27 km^2) around a respondent's home, to investigate whether green space close by and farther away have different impacts. To provide more insight into the relation we divided the percentage green space in a 1km and in a 3km radius into quartiles ranging from very little amount of green space to very much green space (see table 4.1). The total percentage of green space includes all urban green, agricultural green, forests and nature conservation areas. Only green spaces that have a dominant position in the 25 by 25 metre grid cell were regarded as green space in the dataset. Small-scale green spaces, like for instances street trees and green roadsides are not regarded as green space in our study because they did not have a dominant position in the grid cell. In the LGN4 database houses as well as the land within a zone of 10 metre from the house are classified as urban built environment. Thus, greenery in the immediate vicinity of the houses, such as gardens or trees, was not included in the measure of green space. Only gardens which exceed the 10 metre zone were taken into consideration.

Table 4.1 Percentage of green space in the different quartiles

	% green in 1km radius	**% green in 3km radius**
Very little green space	0 thru 23.29	0 thru 45.14
Little green space	23.30 thru 39.77	45.15 thru 62.82
Much green space	39.78 thru 58.16	62.83 thru 78.70
Very much green space	58.17 thru 100	78.71 thru 100

Demographic and socio-economic characteristics

Because health differs according to people's background characteristics we took the following individual characteristics into account:

1 *Demographic characteristics*. The demographic characteristics taken into account were gender (female = 1) and age (in years).
2 *Socio-economic status*. Measured by the level of education (divided into 4 dummy variables categories: unknown, low, middle, high) and household income (divided into 4 dummy variables: income unknown, high income (net monthly income >2,450 euro), middle income (net monthly income between 1,350 and 2,450 euro) and low income (net monthly income <1,350 euro)). Level of education and income were categorised because of the non-linear relation with some of the dependent variables. We included the categories 'unknown' for level of education and income to increase the sample size.
3 *Level of urbanity*. Another environmental characteristic is level of urbanity. This variable consists of five categories ranging from very strongly urban (1) to non-urban (5), and was measured at municipal level. The indicator is based on the number of households per square km and is widely used in the Netherlands (Den Dulk et al., 1992).

Table 4.2 shows the characteristics of the study population. Correlation tests did not show problems of multicollinearity.

Table 4.2 Characteristics of the study population (n=4,529)

	Characteristics of the study population
Demographic characteristics:	
Gender	
Female	55.7%
Male	44.3%
Age in years	49.3 (s.d. 16.6) (range 19-97)
Socio-economic characteristics:	
Level of education	
Level of education unknown	12.0%
Low	15.4%
Middle	53.1%
High	19.5%
Income	
Unknown	4.8%
Low	30.1%
Middle	40.5%
High	24.6%

- table 4.2 continues -

- table 4.2 continued -

	Characteristics of the study population
Level of urbanity:	
Very strongly urban	15.6%
Strongly urban	23.9%
Moderately urban	20.0%
Slightly urban	30.2%
Non urban	10.3%
Percentage of green space:	
Average % of green space in 1km radius	42.45% (s.d. 24.2) (range .4 - 99.3)
Average % of green space in 3km radius	60.7% (s.d. 21.7) (range 6.16 – 60.7)
Dependent variables:	
Health	
%of people with a good general health	80.8%
Average number of complaints	4.3 (s.d. 3.9)
% of people with increased risk for a bad mental health	22.5%
Stressful life events	
% of people who experienced a stressful life events in the past 3 months	20,1%

Statistical analyses

The relations between the amount of green space, the occurrence of stressful life events in the past three months and health indicators were assessed with multilevel regression analyses, controlling for socio-economic and demographic characteristics and level of urbanity. The multilevel analyses were performed with MLwiN. We included two levels, viz. practice and individual level, because the data of individuals were collected through general practices and therefore individuals clustered in practices. The postal code level was not included because there were hardly any people from the same six character postal code in the dataset. Multilevel logistic regression analysis was used in case the dependent variable was a dichotomy. The independent variables were centred around the average. The results thus represent the relation between stressful life events and health of the average population living in an area with an average amount of green space. We used a Wald test to test whether there is a linear buffer effect of green space in the living environment on the adverse impacts of stressful life events on self-reported mental and physical health.

Results

Stressful life events, green space and the number of health complaints in the past 14 days

Table 4.3 (model 1) shows that individuals who have experienced one or more stressful life events in the past three months reported more health complaints in the past 14 days than individuals who have not experienced a stressful life event in the past three months, β=.11, p<0.001. The relation between experiencing stressful life events and the number of health complaints does not vary significantly with the amount of green space in a 1km radius, p>0.61. However, there is a significant linear trend for the amount of green space in a 3km radius around the home, Chi^2=4.5, p<0.05. To illustrate this trend, we calculated the number of health complaints for individuals in areas with very little and very much green space. In areas with very little green space in a 3km radius individuals who had experienced a stressful life event in the past three months reported 5.5 health complaints in the past 14 days, whereas individuals who had not experienced such an event reported 5 health complaints. In areas with very much green space in a 1km radius individuals who had experienced a stressful life event in the past three months reported 5.5 health complaints in the past 14 days, against 5.3 health complaints reported by individuals who had not experienced a stressful life event. Thus, the impact of experiencing a stressful life event on health complaints was weaker for people living in areas with a large amount of green space.

Table 4.3 Multilevel regression analysis for a buffering effect of green space on the relationship between experience of a stressful life event in the past three months and the number of health complaints in the past 14 days (n=4,529; scale 0–43): unstandardized parameter and standard error

	Number of health complaints		
	Model 1	**Model 2**	**Model 3**
Intercept	4.356 (0.084)	4.355 (0.084)	4.364 (0.084)
Stressful life event in last 3 months	1.043 (0.138)***		
Green space in 1km radius:			
Stressful life event * Very little green space		1.161 (0.245)***	
Stressful life event * Little green space		0.966 (0.262)***	
Stressful life event * Much green space		1.733 (0.250)***	
Stressful life event * Very much green space		0.921 (0.277)**	
Wald test		$Chi^2 = 0.26$	
Green space in 3km radius:			
Stressful life event * Very little green space			1.177 (0.251)***
Stressful life event * Little green space			1.662 (0.264)***
Stressful life event * Much green space			0.633 (0.262)**
Stressful life event * Very much green space			0.689 (0.270)*
Wald test			$Chi^2 = 4.5$*

* p≤0.05; ** p≤0.01; *** p≤0.001

note: all analyses are controlled for age, gender, level of education, income and level of urbanity

Stressful life events, green space and perceived mental health

Table 4.4 (model 1) shows that individuals who have experienced one or more stressful life events in the past three months, have a significantly lower perceived mental health than those who have not experienced a stressful life event in the past three months, β=.83, p<0.001.

Model 2 and 3 show that the relation between stressful life events in the past three months and perceived mental health does not linearly decrease with the amount of green space, *p-values* >0.55. However, for both the 1km and the 3km radius the relation between stressful life events and perceived mental health is stronger in living environments with very little green space than in living environments with very much green space. However, Wald tests show that these contrasts were not significant, *p-values* >0.21.

Table 4.4 Multilevel logistic regression analysis for a buffering effect of green space on the relationship between experience of a stressful life event in the past three months and perceived mental health (n=4,529; scale 0-1): unstandardized parameter and standard error

	Perceived mental health		
	Model 1	**Model 2**	**Model 3**
Intercept	-1.303 (0.045)	-1.305 (0.045)	-1.296 (0.045)
Stressful life event in last 3 months	0.850 (0.083)***		
Green space in 1km radius:			
Stressful life event * Very little green space		1.025 (0.140)***	
Stressful life event * Little green space		0.543 (0.159)***	
Stressful life event * Much green space		0.994 (0.144)***	
Stressful life event * Very much green space		0.755 (0.169)***	
Wald test		$Chi^2 = 0.28$	
Green space in 3km radius:			
Stressful life event * Very little green space			0.859 (0.111)***
Stressful life event * Little green space			0.900 (0.120)***
Stressful life event * Much green space			0.903 (0.118)***
Stressful life event * Very much green space			0.720 (0.133)***
Wald test			$Chi^2 = 0.36$

* p≤0.05; ** p≤0.01; *** p≤0.001

note: - all analyses are controlled for age, gender, level of education, income and level of urbanity
- a higher score on perceived mental health reflects a worse perceived mental health

Stressful life events, green space and perceived general health

Table 4.5 (model 1) shows that individuals who have experienced one or more stressful life events in the past three months, have a significantly worse perceived health than those who have not experienced a stressful life event in the past three months, β=0.42, p<0.001. In the second and third model we investigated whether the relation between experiencing stressful life events and perceived general health differs for individuals who have more green space in respectively a 1km or a 3km radius around their house. The results show that the relation between experiencing stressful life events and perceived general health does not differ between the greener and less green living environments, as the Wald tests did not yield significant results, *p-values* >0.68.

Table 4.5 Multilevel logistic regression analysis for a buffering effect of green space on the relationship between experience of a stressful life event in the past three months and perceived general health (n=4,529; scale 0-1): unstandardized parameter and standard error

	Perceived general health ('good/ very good' = 1)		
	Model 1	**Model 2**	**Model 3**
Intercept	1.575 (0.042)	1.575 (0.042)	1.573 (0.042)
Stressful life event in last 3 months	-0.405 (0.093)***		
Green space in 1km radius:			
Stressful life event*Very little green space		-0.482 (0.158)**	
Stressful life event*Little green space		-0.304 (0.174)	
Stressful life event*Much green space		-0.412 (0.168)*	
Stressful life event*Very much green space		-0.406 (0.186)*	
Wald test		$Chi^2 = 0.025$	
Green space in 3km radius:			
Stressful life event*Very little green space			-0.318 (0.162)*
Stressful life event*Little green space			-0.700 (0.166)***
Stressful life event*Much green space			-0.214 (0.185)
Stressful life event*Very much green space			-0.376 (0.177)*
Wald test			$Chi^2 = 0.165$

* p≤0.05; ** p≤0.01; *** p≤0.001

note: all analyses are controlled for age, gender, level of education, income and level of urbanity

Conclusion and discussion

In this study we investigated to what extent the presence of green space in people's living environment can buffer the adverse impacts of stressful life events on self-reported general, mental and physical health. The results indicate a significant buffer effect of green space within the wider living environment on the adverse impact of stressful life events on self-reported physical health. Adult individuals who had recently experienced one or more stressful life events reported significantly fewer health complaints when they had a larger amount of green space available in their living environment. This buffer effect was found only for the 3km zone, not for the 1km zone For perceived general and mental health there were no differences

in the impact of stressful life events as a function of the amount of green space.

Buffer effects of green space were observed only for self-reported health complaints and not for perceived general and mental health. This can be explained by the fact that self ratings of general and mental health are more directly related to stressful life events than assessments of one's physical health status. By Western socio-cultural norms, it is considered inappropriate to say that your are feeling perfectly well when you have just experienced major life event such as death or divorce (e.g. Weisaeth, 2002). Consequently, questions about a person's general health are also implicitly questions about the occurrence of stressful life events. In a similar vein, some of the items in the mental health questionnaire (GHQ-12; [Goldberg, 1972; Koeter and Ormel, 1991]), such as "Have you recently lost much sleep over worry?" tap almost directly into the incidence of stressful life events. Thus, self ratings of general and mental health are partly reflections of stressful life events. Consequently, there is less room for buffering effects of green space, because the presence of green space in the living environment does not protect people against stressful life events.

The finding that a buffer effect of green space on the impact of stressful life events on self-reported health complaints was found only for the wider 3km zone and not for the 1km zone is consistent with our expectations. Because urban green spaces, such as parks, greenways or gardens, seldom cover more than 5 km^2, high percentages of green space within a 3km radius usually reflect the presence of more large-scale nature areas, such as forests, dunes or agricultural fields. Theoretically, a greater availability of such areas in one's living environment may therefore provide opportunities for reflection and restoration at a deeper level that cannot, or to a lesser extent, be achieved in a 1km zone. Nevertheless, because our data do not provide any information on the actual use of green space by the respondents, alternative explanations cannot be ruled out. For example, the buffering effect of green space in the wider living environment may have been caused by better air quality, or by the stimulating effect of green space on physical exercise (e.g. walking, cycling) (De Vries et al., 2003). However, previous research has shown that there are generally few differences in air quality between green and barren areas (Health Council of the Netherlands and RMNO, 2004). Moreover, we have not been able to demonstrate stimulating

effects of green space on physical exercise in previous research (Maas et al., 2008). For these reasons, we do not assume that these alternative interpretations are very plausible.

Although the general pattern of findings is consistent with our expectation, the finding that green space in the 1km zone did not have any buffering effects on the impact of stressful life events on health complaints is unexpected, and seems at odds with prominent role assigned to nearby nature in the restorative environments literature (Kaplan, 2001). However, it should be pointed out that the current study, green space in a close circle of 10 metre around the home was excluded from the analyses. This implies that opportunities for 'micro-restorative' experiences (Kaplan, 2001) with nature in or around the house, e.g. a glimpse of nature from the window, or listening to birds, were not included in our measure of green space close to the home. In this respect, the current study provides a conservative and rather limited test of the buffering effects of green space close to the home.

In general, the buffer effects of green space found in the current study are relatively weak in comparison to buffer effects of green space reported in previous studies (Gidlöf-Gunnarsson and Öhrström, 2007; Leather et al., 1998; Ottosson and Grahns, 2008). Because previous studies differed from the current research in many respects, including the study populations, definitions of green space, outcome variables and the type of stressor studied, it is difficult to identify the exact causes of the weaker buffer effects of green space in the current study. However, there is one major difference that may be particularly important: In the current study, we employed a representative sample of the Dutch adult population who were in relatively good health conditions (e.g., about 80% of the study population feel healthy). By contrast, previous studies have mostly focused on specific groups such as stressed employees, children, or residents of neighbourhoods with high noise levels, who presumably are more susceptible to the restorative powers of nature (e.g., because they are more in need of restoration, or because they are more bound to their living environment). Children, for example, are generally more affected by characteristics of their living environment than adults because they have less opportunities for independent mobility and therefore spend more time in the vicinity of their homes (cf. Faber Taylor et al., 2002). Unfortunately we could not examine the buffer effects of green space for children because we had no data on

stressful life events of children. In general, the low disease levels in open samples such as ours make it more difficult to detect buffer effects of green space (cf. Tijhuis et al., 1995).

Limitations and future perspectives

This study is one of the first to investigate the buffer effects of objectively measured green space on the health impacts of stressful life events in a healthy, representative adult population. However, the study is not without limitations. For example, as pointed out above, our data do not provide information on the actual use of green space by the respondents. Therefore, our interpretation that respondents in areas with a large percentage of green space farther away from their home more often visit nature to reflect on their lives must necessarily remain speculative. Future research may shed more light on the mechanisms underlying buffering effects of green space by comparing the coping behaviours of residents of green and barren neighbourhoods after they have experienced a stressful life event. For example, respondents could be asked to keep a time-activity diary for a certain period, or they could be asked to wear global positioning system (GPS) data recorders to track their behavioural patterns in a more objective manner (e.g. Phillips et al., 2001)

Another limitation of the study is that the cross-sectional design does not make it possible to draw strong inferences about the direction of causality. It is well-established that migration flows are influenced by socio-demographic characteristics such as age, income and education (Heins, 2002). Because these characteristics are also related to health, part of the buffering effect of green space on impacts of life events on health complaints may be the result of selective migration of people with certain characteristics that are indicative of good health to green environments (Verheij et al., 1998). We tried to rule out such indirect selection effects as much as possible by controlling statistically for these characteristics. However, it cannot be ruled out that we did not fully control for all potentially confounding influences of these characteristics. Longitudinal research is needed to firmly establish the direction of causality for the buffer effect of green space found in the present study. For example, residents of neighborhoods that are facing substantial changes in the amount and structure of green space could be followed over a longer period of time.

Finally, we want to point out that within our environmental measure only greenery with a dominant position in the 25 by 25 metre grid cell is regarded as green space. Small-scale natural elements and areas, like for instance trees along streets, green roadsides, and small gardens are not regarded as green space in the dataset. This could mean that the actual exposure to green space was in some neighbourhoods different from what we measured. Another limitation of our environmental measure is that green space within a distance of 10 metres of buildings is not included. Consequently, as pointed out before, buffer effects of green space that is directly accessible or visible from the home could not be studied. Future research may overcome these limitations by conducting in-situ inventories of local green space with observational checklists (e.g. URGE, 2004; Broomhall et al., 2004). A recent validation study in Dutch neighbourhoods has shown that these checklists can provide accurate and ecologically valid measures of local green space (Van Dillen and De Vries, 2008)

Concluding remarks

In their influential book "The experience of nature: a psychological perspective" Rachel and Stephen Kaplan (1989) have distinguished four progressive levels of restoration that require increasing time and intensity of the experience: clearing the head, recharging directed attention capacity, reducing internal noise, and finally "reflections on one's life, on one's priorities and possibilities, on one's actions and one's goals" (Kaplan and Kaplan, 1989). Thus far, empirical research has focused mostly on the first level of restoration and the short-term benefits of micro-restorative experiences with nearby nature, such as a viewing nature from the window. However, the importance of green space farther away from the doorstep should not be overlooked, because it may provide important opportunities for deeper reflection and restoration. Results of the current study are consistent with the notion that in times of crisis, the availability of green space farther away from the home is particularly important to stay physically healthy. However, because the exact mechanisms underlying the relationships found are unknown, more research on the actual coping strategies and use of green space by individuals undergoing a crisis is needed to substantiate our interpretations.

5

Physical activity as a possible mechanism behind the relationship between green space and health

A multilevel analysis

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Abstract

The aim of this study was to investigate whether physical activity (in general, and more specifically, walking and cycling during leisure time and for commuting purposes, sports and gardening) is an underlying mechanism in the relationship between the amount of green space in people's direct living environment and self-reported health. To study this, we first investigated whether the amount of green space in the living environment is related to the level of physical activity. When an association between green space and physical activity was found, we analysed whether this could explain the relationship between green space and health.

The study includes 4,899 Dutch people who were interviewed about physical activity, self-reported health and demographic and socioeconomic background. The amount of green space within a one-kilometer and a three-kilometer radius around the postal code coordinates was calculated for each individual. Multivariate multilevel analyses and multilevel logistic regression analyses were performed at two levels and with controls for socio-demographic characteristics and level of urbanity.

No relationship was found between the amount of green space in the living environment and whether or not people meet the Dutch public health recommendations for physical activity, sports and walking for commuting purposes. People with more green space in their living environment walked and cycled less often and fewer minutes during leisure time; people with more green space garden more often and spend more time on gardening. Furthermore, if people cycle for commuting purposes they spend more time on this if they live in a greener living environment. Whether or not people garden, the time spent on gardening and time spent on cycling for commuting purposes did not explain the relationship between green space and health.

Our study indicates that the amount of green space in the living environment is scarcely related to the level of physical activity. Furthermore, the amount of physical activity undertaken in greener living environments does not explain the relationship between green space and health.

Background

There is increasing attention and evidence for a positive relation between the amount of green space in the living environment and people's health and well-being. Several studies have shown that a more natural living environment positively influences people's self-reported health and leads to lower mortality risks (e.g. De Vries et al., 2003; Maas et al., 2006; Takano et al., 2002). However, little is known about the way in which green space exerts a beneficial effect on health. Several mechanisms may be underlying, of which the following are most commonly mentioned: recovery from stress and attention fatigue, encouragement of physical activity and facilitation of social contact (Groenewegen et al., 2006; Health Council of the Netherlands and RMNO, 2004). A large number of mainly experimental studies have produced strong evidence of the positive effect of nature on recovery from stress and attention fatigue (Health Council of the Netherlands and RMNO, 2004; Kaplan and Kaplan, 1989). Less is known about other possible underlying mechanisms, such as physical activity. In this study we aim to investigate whether physical activity is a possible mechanism behind the relationship between green space and health.

It has long been known that being physically active has positive health effects (US Department of HHS, 1996). If a green living environment provides an incentive to be physically active, this could positively influence people's health. Literature shows that people are inclined to undertake physical activity in aesthetically appealing environments (Giles-Cort and Donovan, 2002; Pikora et al., 2003; Sallis et al., 1998; Kamphuis et al., 2007). Natural environments are perceived to be more aesthetically appealing than built-up environments (Van den Berg et al., 2003; Frerichs, 2004). Therefore, natural environments may stimulate people to undertake healthy physical activities, such as walking or cycling, or to choose these activities as a mode of transport, and to spend more time on them (Taylor et al., 1998; Edwards and Tsouros, 2006).
Because of increasing urbanisation, combined with a spatial planning policy of densification, more people face the prospect of living in residential environments with fewer green resources. If the amount of green space in the living environment stimulates people to be physically active, the reduction of green space could have consequences for the amount of physical activity of the population.

Most of the literature concerning the relation between green in the living environment and the amount of physical activity focuses on specific types of physical activity, namely walking and cycling. Walking and cycling have been placed firmly on the public health agenda as a result of the awareness that health benefits could be derived by engaging in 30 minutes of moderate exercise every day (NIH, 1996). With regard to the influence of green space, a review of environmental influences on walking behaviour concludes that the aesthetic nature of the environment and accessibility of destinations, like parks and beaches, encourage walking (Owen et al., 2004). Pikora et al. (2003) concluded on the basis of available literature that attractiveness of the streetscape was one of the most important features related to walking and cycling. An attractive streetscape included, among other things, trees, wide grassy verges, parks, private gardens, diverse and interesting natural sights. These reviews mainly focused on research performed in Australia, the United States and the United Kingdom. Only a few studies have been performed on the relationship between the general level of physical activity and green space. A study by Ellaway et al. (2005) which used data collected in eight European countries showed that "for respondents whose residential environment contains high levels of greenery, the likelihood of being more physically active is more than three times as high, and the likelihood of being overweight and obese is about 40% less". However, on the other hand, a study by Hillsdon et al. (2006), conducted in the United Kingdom, found no association between hours per week of recreational physical activity and access to and quality of any urban green spaces in a cohort of middle-aged adults.
Hoehner et al. (2005) and McGinn et al. (2007) both investigated the correlation between the presence of trees along the neighbourhood streets and physical activity. McGinn et al. (2007) found that those who perceived that lack of trees for shade was not a problem, or a barrier to physical activity were more likely to be active during leisure time physical activity. Hoehner et al. (2005), however, found no association between trees along the neighbourhood streets and transportation or recreational activity.

In the Netherlands, little support is found for a positive relationship between the amount of local green space and walking and cycling (De Vries et al., 2004; De Vries, 2002). Studies performed in the Netherlands show that the availability of local green space has little or no influence on how often people walk or cycle. In the case of poor availability of green space, people

seem to walk and cycle more often in a built-up environment. For cycling, trips in the green environment tend to be longer than trips in the built-up environment (De Vries et al., 2004; De Vries, 2002; Wendel-Vos et al. 2004). A study by Wendel-Vos et al. (2004) showed that the amount of green and recreational space, specifically sports grounds and parks, within a radius of 300 and 500 metres of the participants' homes was positively associated with time spent on bicycling in a Dutch city. According to Wendel-Vos et al. (2004), it is however likely that this reflects the fact that people living in the outskirts of towns spend more time bicycling to the city. A study by Den Hertog et al. (2006), performed in four different districts in Amsterdam, showed that a park of good quality in the district stimulates active behaviour, especially for children. However, people in the more urban neighbourhoods – neighbourhoods with less green space – appeared to be more physically active and were less often overweight. This was attributed to the design of the more urban districts, which had more facilities at walking or cycling distance and had no private parking space.

Besides the fact that a green environment can invite people to be physically active, it might also encourage people to exercise for longer periods of time. Research by Pennebaker and Lightner (1980) showed that joggers who jogged in a green stimulating environment were distracted from signals of fatigue and physical symptoms. Furthermore, research by Pretty et al. (2007) showed that people who participated in outdoor exercise programmes more often complete the programme than people who participated in indoor exercise programmes. These two studies imply that people engage in physical activity for longer periods in a green environment than in an indoor environment.

Overall, the available studies indicate that the evidence for a relationship between the amount of green space and the level of physical activity is limited. There are only indications for a positive relationship between an attractive streetscape and the amount of walking and cycling in Australia, the United States of America and the United Kingdom. For other forms of physical activity and in other countries the available research is lacking or inconclusive. Furthermore, none of the described studies also link the possibly higher level of physical activity with people's health condition to see if the level of physical activity may be a mechanism underlying the relationship between green space and health.

It is interesting to investigate whether there is an association between green space and the level of physical activity particularly in the Netherlands, because of its strong walking and cycling culture in combination with its high degree of urbanisation.

The aim of this study was to investigate whether the relationship between green space and physical activity can be an underlying mechanism in the relationship between green space and self-reported health in the Netherlands.

More specifically, the following research questions will be addressed:

1 *'Do people with a greener living environment more often meet the Dutch public health recommendations for physical activity?'*

2 *'Are people with a greener living environment more often physically active and do they spend more time on physical activity?'*

3 *'Can the amount of physical activity undertaken in greener living environments explain (part of) the relationship between green space and health?'*

Different types of physical activity which can take place in green areas will be considered. First of all, we will investigate whether people with more green space in their living environment more often meet the Dutch public health recommendations for physical activity, which states that people should engage in at least 30 minutes of moderate-intensity physical activity on at least 5 days per week (Ministerie van VWS, 2001). Furthermore, the following types of physical activity will be considered which can be conducted directly from the home and can be influenced by the amount of green space: walking and cycling (both during leisure time as well as for commuting purposes), sports (for instance running, inline-skating) and gardening.
The relationship will be analysed for different types of green space to discover which type of natural surroundings particularly promote the level of physical activity. Furthermore, the relationship is analysed for different levels of urbanity. Urban areas are often characterised by limited green

space and a high availability of facilities (e.g. shops, services) at walking and cycling distance. On the other hand, in rural areas there is lots of green space, but people often have to use the car to visit facilities. Finally, the relationship will be analysed for different age groups and different socio-economic groups, because it is hypothesized that the correlation is likely to be stronger for groups that spend more time in the vicinity of their homes: youth and the elderly and people with a lower socio-economic status (Edwards and Tsouros, 2006).

Methods

Population

The data were derived from two different datasets that were combined for this study. The data concerning health and physical activity originate from the Second Dutch National Survey of General Practice (DNSGP-2). Data for the DNSGP-2 were gathered in 2001 via 104 general practices. A random sample of the practice population (n=5,265) were interviewed about topics including their self-reported health status, their level of physical activity and their demographic and socio-economic background characteristics. The important epidemiological criterion of covering the whole population at risk is met, since almost all non-institutionalised Dutch citizens are registered with a general practice. Privacy of the participating persons is guaranteed, which is in accordance with Dutch legislation, and the study was approved by the Dutch Data Protection Authority. Patients were informed about the study prior to data collection and had the opportunity to opt out (Westert et al., 2005).

Environmental data were derived from the National Land Cover Classification database (LGN4), which contains the dominant type of land use of each 25 by 25 metre grid cell in the whole of the Netherlands in 2001 (De Wit and Clevers, 2004). The two datasets were matched on the basis of x and y coordinates of the respondent's six character postal code (the same six character postal code is shared by no more than about 15 to 20 households). The percentage of green space within a 1km radius as well as within a 3km radius was calculated around these coordinates.

Only respondents who had valid responses on all relevant variables were included, leaving 4,899 respondents for inclusion.

Perceived general health

Perceived general health was self rated by respondents by replying to the following statement: "In general, would you say that your health is…". They could respond by one of the following categories: excellent/very good/good/moderate/bad. The scores were dichotomised with the scores 'excellent', 'very good' or 'good' classified as healthy. This kind of operationalizations has been shown to be valid and predictive of health indicators in numerous studies (Rütten et al., 2001; Simons, 2002).

Physical activity

Level of physical activity was assessed using the short questionnaire to assess health enhancing physical activity (in short: SQUASH). The SQUASH is "a fairly reliable and reasonably valid questionnaire" which "may be used to order subjects according to their level of physical activity in an adult population" (Wendel-Vos et al., 2003). The questionnaire was completed by people aged above 12 and the interviews were spread over a whole year (to avoid seasonal differences). The questionnaire includes questions on four domains of physical activity, viz. commuting activities (walking and bicycling), occupational physical activity, household activity, and leisure-time physical activity (walking, bicycling, gardening and sports). Three main queries were asked: days per week, average time per day and intensity.

For this study, only commuting activities and leisure-time physical activity were taken into account, because it is expected that occupational and household activity are not influenced by the amount of green space in the living environment.

From the SQUASH the total number of minutes of walking, cycling (both during leisure time and commuting purposes), sport activities and gardening per week were calculated by multiplying the number of days per week spent on the activities with the number of minutes per day spent on the activity. Furthermore, dummy variables were created which stated whether or not people spent time on the different physical activities and whether or not people were physically active for 30 minutes on at least five days per week.

In our analysis of walking and cycling for commuting purposes, we only included those who had a job or went to school (2,816 respondents). In the analysis for gardening, we only included those who had a garden (3,951 respondents).

Characteristics of respondents' living environment

Information on the environmental characteristics was derived from the LGN4 database. The LGN database distinguishes 39 land use classes including crop types, forest types, water, various urban classes and semi-natural classes (De Wit and Clevers, 2004; Thunnissen and De Wit, 2000). The total percentage of green space in the respondents' living environment was measured within a 1km radius and within a 3km radius around a respondent's home, to see whether green space close by has a stronger or weaker effect than green space further away. A 1km (equals 12 minutes walking) and a 3km (equals 12 minutes cycling) radius were chosen because these distances could be easily undertaken from people's home. Only green spaces that have a dominant position in the 25 by 25 metre grid cell will be regarded as green space in the dataset. Gardens and small-scale green spaces, such as roadside trees and grassy verges are not regarded as green space in our study if they had no dominant position in the grid cell.

The total percentage of green space includes all urban green space, agricultural green space, forests and nature conservation areas. To discover which types of natural surroundings particularly promote the level of physical activity, we calculated the percentages of the following categories inside both a 1km and a 3km radius, the percentage of agricultural green space, the percentage of natural green space (forests, peat grassland, etc.), and the percentage of urban green space (woods and grassy areas in built-up environments).

Level of urbanity

Another environmental characteristic is level of urbanity. This variable consists of five categories ranging from very strongly urban (1) to non-urban (5), and was measured at municipal level. The indicator is based on the number of households per square km and is widely used in the Netherlands (Den Dulk et al., 1992).

Demographic and socio-economic characteristics

Individual characteristics such as age, gender and socio-economic status, also play an important role in determining the level of physical activity (King et al., 2002; Giles-Corti and Donovan, 2003; Sallis et al., 1992). Furthermore, it is important to realise that part of the relationship between green space and physical activity may be the result of direct or indirect selection. Direct selection takes place when people who like to be physically

active in green spaces have a higher chance of living in a green environment, and people who feel healthy more often engage in physical activity. Indirect selection takes place when people with certain characteristics related to higher levels of physical activity (such as socio-economic status) can afford to live in a favourable environment. Migration flows are related to such socio-demographic characteristics as age, income and education (Heins, 2002).

To rule out selection effects as much as possible in a cross-sectional survey we took several demographic and socio-economic characteristics into account.

The demographic characteristics taken into account were gender (female=1) and age (in years). For the analyses concerning the relationship between the percentage of green space in the living environment and the level of physical activity, age was divided into five categories (viz. children (aged 12-17 years); youth (aged 18-25 years); young adults (aged 26-40 years); older adults (aged 41-65 years), elderly (aged 65+)), because there was a non-linear relationship between age and the different forms of physical activity.

Socio-economic status was measured by the level of education (low, middle, high) and household income (high income (net monthly income >2,450 euro's), middle income (net monthly income between 1,350 and 2,450 euro's) and low income (net monthly income <1,350 euro's), which were also categorised because there was a non-linear relationship. In the analysis of the relationship between the general level of physical activity and the amount of green space, we also included a dummy variable indicating whether or not people had a garden.

Statistical analyses

To study the relationship between the amount of green space and different types of physical activity we used a multivariate multilevel model, controlling for demographic and socio-economic characteristics and level of urbanity. In a multivariate multilevel model two dependent variables can be included in one model, and the outcomes can be studied simultaneously. A multilevel logistic regression analysis was used to find out whether people with more green in their living environment have a higher chance of being physically active. A Poisson model was used to analyse the relationship between the amount of green space in the living environment and the number of minutes spent on (specific forms of) physical activity, because the responses were not normally distributed. We included two levels, viz.

individuals and practices, because of the two-stage sampling design within DNSGP-2. Multilevel logistic regression analyses were performed to investigate the relationship between the amount of green space in the living environment and whether or not people meet the public health recommendations for physical activity.
Because we wanted to compare the relationship between different levels of level of urbanity and different age and socio-economic subgroups we used interaction effects between the level of urbanity or subgroup variable and the green indicator. Because of small numbers in the subgroups when looking at the duration of activity, we did not analyse differences in duration for age groups.
When we found a significant positive relationship between the amount of green space and physical activity we conducted a multilevel logistic regression analysis to analyse whether the found relationship could explain the relationship between green space and health. In all analyses we controlled for demographic characteristics, socioeconomic background characteristics and level of urbanity. The multilevel analyses were performed with MLwiN.

Results

Before analysing the relationship between the amount of green space in people's living environment and their level of physical activity, we looked at the bivariate correlation between the percentage of green space and level of urbanity. Level of urbanity (high-low) was strongly positively related to the total percentage of green space (r=0.60). Concerning the different types of green space, it was strongly positively related to the percentage of agricultural green space (r=0.64) and was negatively related to the percentage of urban green space (r=-0.42). The correlation with the amount of natural green space was much smaller (r=0.25). This indicates that agricultural green areas dominate the total amount of green space (table 5.1).

Besides the characteristics of the study population, table 5.2 shows that 51.7% of the study population meet the public health recommendations for healthy physical activity. Walking and cycling during leisure time are the activities that are undertaken by the largest part of the population. Relatively few people walk for commuting purposes.

Table 5.1 Mean (standard deviation) of the percentage of green space in a 1km and a 3km radius around people's home in different levels of level of urbanity

	Very highly urban areas (n=842)	**Highly urban areas (n=915)**	**Moderately urban areas (n=963)**	**Slightly urban areas (n=1,286)**	**Non urban areas (n=893)**
1km:					
% total green	25.8 (17.3)	27.5 (16.5)	36.6 (19.3)	49.3 (21.3)	68.2 (17.6)
% agricultural green	6.8 (13.0)	8.3 (13.1)	20.7 (18.6)	32.4 (25.0)	56.6 (19.7)
% natural green	0.4 (1.8)	3.2 (6.7)	1.5 (3.7)	5.2 (7.4)	5.0 (7.6)
% urban green	18.6 (11.7)	16.0 (7.7)	14.4 (8.5)	11.7 (7.2)	6.6 (4.8)
3km:					
% total green	36.2 (16.4)	45.6 (13.2)	58.8 (15.2)	71.7 (13.2)	82.7 (12.2)
% agricultural green	17.0 (16.5)	23.5 (14.3)	43.0 (16.4)	55.7 (17.7)	68.4 (12.8)
% natural green	1.4 (2.2)	6.6 (8.8)	5.3 (5.0)	8.0 (6.0)	11.0 (8.9)
% urban green	17.8 (6.5)	15.5 (5.0)	10.5 (5.9)	8.0 (5.4)	3.3 (2.2)

Table 5.2 Percentual distribution of characteristics of the study population (n=4,899)

	Characteristics of the respondents
Demographic characteristics:	
Gender	
female	54.4%
male	45.6%
Age	
child/adolescent (12-17 year)	7.8%
youth (18-25 year)	6.9%
young adults (26-40 year)	33.7%
older adults (41-65 year)	33.6%
elderly (>65 year)	18.1%
Socio-economic characteristics:	
Level of education	
low	20.6%
middle	59.8%
high	19.7%

- table 5.2 continues -

- table 5.2 continued -

	Characteristics of the respondents
Income	
low	32%
middle	44.1%
high	23.8%
Other characteristics:	
% of people with a garden	80.6%
Level of urbanity:	
very highly urban	17.2%
highly urban	18.7%
moderately urban	19.7%
slightly urban	26.3%
non urban	18.2%
Physical activity:	
% meets the Dutch public health recommendations for physical activity	51.7%
% of people actively engaged in sports activities	44.6%
average (sd) number of minutes spent on sports activities per week	209 (236)
% of people who walk during leisure time	60.4%
average (sd) number of minutes spent on walking during leisure time per week	214 (229)
% of people who cycle during leisure time	54.5%
average (sd) number of minutes spent on cycling during leisure time per week	186 (199)
% of people who walk for commuting purposes	8.2%
average (sd) number of minutes spent on walking for commuting purposes per week	146 (177)
% of people who cycle for commuting purposes	27.7%
average (sd) number of minutes spent on cycling for commuting purposes per week	136 (123)
% of people who garden	39.7%
average (sd) number of minutes spent on gardening per week	224 (279)
Health:	
percentage with perceived general health 'good', 'very good' or 'excellent'	82.2%

Meeting public health recommendations for physical activity

Table 5.3 shows the result for the logistic multilevel analyses on the relationship between the percentage of green space in the living environment and whether or not people meet the Dutch public health recommendations for healthy physical activity. The results show that there is no significant relationship between the percentage of green space and meeting the public health recommendations for physical activity, when controlling for demographic and socio-economic characteristics of the individual and level of urbanity. People with more green space in their living environment do not more often meet the public health recommendations for physical activity.

Table 5.3 Multilevel logistic regression analysis of the influence of green space on whether or not people meet the public health recommendations for physical activity: parameter and standard error [p-value] (n=4,899)

	Meeting public health recommendations for physical activity (yes=1)	
	1km	**3km**
Percentage of green (1km)	-0.0004 (0.002)	
Percentage of green (3km)		-0.0001 (0.002)

* p≤0.05; ** p≤0.01; *** p≤0.001

Sports

Table 5.4 shows that there is no relationship between the percentage of green space in the living environment and whether or not people participate in sports activities and the number of minutes people spend on sports activities. People with more green space in their living environment do not participate more often in sports activities and do not spend more minutes on sports activities.

Walking during leisure time

With regard to walking during leisure time, the results show that people walk less often during leisure time when there is more green space in their direct living environment. This relationship is as large in a 1km radius as in a 3km radius around one's home (table 5.4). Our analysis also shows that people spend less leisure time on walking when there is more green space in a 3km radius around their home. People with 20% green space in a 3km radius around their home walked approximately 250 minutes per week for

leisure, whereas people with 80% green space in a 3km radius around their home walked approximately 190 minutes per week during leisure time.

Cycling during leisure time

There is also a negative relationship between the percentage of green space in the living environment and whether or not people cycle during leisure time (table 5.4). This negative relationship is only significant for the percentage of green space in a 1km radius around one's home. There is no significant relationship between the percentage of green space in the living environment and the time people spend on cycling during leisure time.

Table 5.4 Multivariate regression analysis for the influence of the percentage of green space on sports and walking and cycling during leisure time: parameter and standard error [p-value] [1]

	Sports (n=4,899)		Walking during leisure time (n=4,899)		Cycling during leisure time (n=4,899)	
	1km	**3km**	**1km**	**3km**	**1km**	**3km**
Physically active (yes/no):						
% of green (1km)	0.002		-0.007		-0.006	
	(0.002)		(0.002)***		(0.002)***	
%of green (3km)		0.003		-0.006		-0.0004
		(0.002)		(0.002)**		(0.003)
Minutes of activity per week (calculated for those who are physically active):						
% of green (1km)	0.14		-0.24		-0.3	
	(0.3)		(0.24)		(0.2)	
% of green (3km)		-0.05		-0.98		-0.3
		(0.4)		(0.32)**		(0.3)

* p≤0.05; ** p≤0.01; *** p≤0.001

[1] all analyses are controlled for age, gender, level of education, income and level of urbanity

Walking for commuting purposes

There is no significant relationship between the percentage of green space and walking for commuting purposes (table 5.5). People with more green space in their living environment do not walk more often for commuting purposes and do not walk for commuting purposes for a longer period.

Cycling for commuting purposes

With regard to cycling for commuting purposes, our results show that there is a negative relationship between the percentage of green space in a 1km radius and whether or not people cycled for commuting purposes (table 5.5). However, if people cycled for commuting purposes they were likely to spend more time on it if they had a higher percentage of green space in a 1km and 3km radius around their homes. People with 20% green space in a 1km radius around their home cycle approximately 120 minutes per week for commuting purposes, whereas people with 80% green space in a 1km radius around their home cycle approximately 170 minutes per week for commuting purposes.

Gardening

Table 5.5 shows the results for the analysis of the relationship between the percentage of green space and gardening. People with a higher percentage of green space in a 1km radius around their home garden more often. The figures in table 5.5 show that only about 40% of people with 20% green space in a 1km radius around their home are active in gardening, whereas this is true for a mere of about 50% of those who have 80% green space in a 1km radius around their home. Furthermore, people who garden spend more time on gardening when they have more green space in a 1km or 3km radius around their home. People with 20% green space in a 1km radius around the home garden approximately 180 minutes per week, whereas people with 80% green space in a 1km radius around their home garden 265 minutes per week.

For the types of physical activity for which a relation with green space was found (walking during leisure time, cycling during leisure time, cycling for commuting purposes and gardening) we analysed whether the relationship between green space and the type of physical activity differed for the type of green space, level of urbanity, age group and socio-economic group (operationalised as education or income subgroups). In the next sections the general results of these analyses are given.

Table 5.5 Multivariate regression analysis for the influence of the percentage of green space on walking and cycling for commuting purposes and gardening: parameter and standard error [p-value] [1]

	Walking for commuting purposes (n=2,816)		Cycling for commuting purposes (n=2,816)		Gardening (n=3,951)	
	1km	**3km**	**1km**	**3km**	**1km**	**3km**
Physically active (yes/no):						
percentage of green (1km)	0.002 (0.004)		-0.005 (0.002)*		0.008 (0.002)***	
percentage of green (3km)		-0.001 (0.005)		-0.007 (0.004)		0.005 (0.003)
Minutes of activity per week (calculated for those who are physically active):						
percentage of green (1km)	0.9 (0.5)		0.83 (0.2)***		1.4 (0.3)***	
percentage of green (3km)		0.4 (0.7)		0.62 (0.25)*		1.45 (0.45)***

* p≤0.05; ** p≤0.01; *** p≤0.001

[1] all analyses are controlled for age, gender, level of education, income and level of urbanity

Type of green space

To investigate which type of green space especially promotes physical activity we analysed the relation for different types of green space, namely agricultural, natural and urban green space. Overall, the analyses show that the relationship between agricultural green space and the different types of physical activity was strongest.

Level of urbanity

To investigate whether the relationship between green space and the level of physical activity differs by level of urbanity we analysed the relation in the different levels of urbanity. The analyses show that in the more rural areas the relationship between green space and physical activity is stronger than in the more urban areas. The relationship between green space and physical activity is strongest in slightly urban areas.

Age groups

To test our hypothesis that the relationship between green space and physical activity is stronger for youth and elderly we performed subgroup analyses for different age groups (the analyses were controlled for age, gender, level of education, income and level of urbanity). These analyses show that the relationship between green space and physical activity for different age groups differs per type of activity. The negative relationship between the percentage of green space and whether or not people walk during leisure time was strongest for people aged between 12 and 25 years, followed by elderly and the negative relation was least strong for adults aged between 26 and 65. Concerning whether or not people cycle during leisure time, the negative relationship was strongest for children. With regard to cycling for commuting purposes the analyses show that the older people are, the stronger the relation. For gardening, the relation was strongest for elderly and people aged between 17 and 25.

Socio-economic groups

We hypothesized that the relationship between green space and physical activity is stronger for people with a lower socio-economic status. Our results indicate (not shown in table) that the relationship between the percentage of green space in the living environment and the types of physical activity was stronger for people with a lower level of education and people with a lower income.

Physical activity as an explanation for the relationship between green space and health

Only for the number of minutes spent on cycling for commuting purposes and for the frequency and duration of gardening a significant positive relationship is found with the percentage of green space in the living environment. Therefore we only investigated whether these kinds of physical activity can explain (part of) the relationship between green space and health.

Table 5.6 (model 1a and 1b) shows that adding the number of minutes people spend on cycling for commuting purposes does not have any effect on the significant influence of green space on self-reported health. The relation between green space and health does not diminish when minutes spent on cycling is added to the model. There was no relation between health and the percentage of green space in a 3km radius around people's

home for people who cycled to their work (model 2). Apparently, green space in a 3km radius around people's home does not influence health for this subgroup of people.

Table 5.7 shows that there is a significant relation between whether or not people garden and the self-reported health of people. People who garden feel healthier. However, whether or not people garden cannot explain the relation between green space and health, because adding this variable to the model (model 1b) does not have any effect on the relationship between green space and health.

Table 5.8 shows that there is no significant relation between health and the percentage of green space for the subgroup of people who garden. Furthermore, this table shows that the number of minutes spent on gardening is not related to perceived general health.

Table 5.6 Multilevel logistic regression analysis for perceived general health for people who cycle for commuting purposes (n=1,153): parameter and standard error [p-value][1]

	Perceived general health ('excellent/very good/good'=1)		
	Model 1a	**Model 1b**	**Model 2**
% of green (1km)	0.010 (0.003)**	0.011 (0.003)***	
% of green (3km)			0.006 (0.005)
Time spent on cycling for commuting purposes (minutes)		-0.001 (0.001)	

* p≤0.05; ** p≤0.01; *** p≤0.001

[1] all analyses are controlled for age, gender, level of education, income and level of urbanity

Table 5.7 Multilevel logistic regression analysis of gardening activity (yes/no) (n=3,942) for perceived general health: parameter and standard error [p-value][1]

	Perceived general health ('excellent/very good/good'=1)			
	Model 1a	**Model 1b**	**Model 2a**	**Model 2b**
% of green (1km)	0.006 (0.002)**	0.005 (0.002)**		
% of green (3km)			0.006 (0.003)**	0.006 (0.003)**
Gardening activity (yes=1)		0.195 (0.073) **		0.203 (0.073) **

* p≤0.05; ** p≤0.01; *** p≤0.001

[1] all analyses are controlled for age, gender, level of education, income and level of urbanity

Table 5.8 Multilevel logistic regression analysis of people who spend time on gardening (n=1,877) for perceived general health: parameter and standard error [p-value][1]

	Perceived general health ('excellent/very good/good'=1)			
	Model 1a	**Model 1b**	**Model 2a**	**Model 2b**
% of green (1km)	0.005 (0.003) [p=0.062]	0.005 (0.003) [p=0.062]		
% of green (3km)			0.006 (0.004) [p=0.106]	0.006 (0.004) [p=0.103]
Time spent on gardening (minutes)		0.000 (0.000) [p=0.992]		0.000 (0.000) [p=0.949]

[1] all analyses are controlled for age, gender, level of education, income and level of urbanity

Discussion

Green space and physical activity

Results from this study suggest that the amount of green space in people's living environment has little influence on people's level of physical activity. No significant relations were found between the percentage of green space in the living environment and whether or not people meet the Dutch public health recommendations for physical activity, sports and walking for commuting purposes.

We found a negative relation between the amount of green space and walking and cycling during leisure time. People in greener living environments undertake these activities less often. These results are in accordance with the Dutch study by Den Hertog et al. (2006) in which different neighbourhoods in the city of Amsterdam were compared and in which a negative relation between green space and walking and cycling was found as well.

The finding that people with more green space in their living environment less often walk or cycle is probably due to the fact that in greener living environments, facilities such as shops are further away and people more often use a car to reach facilities. Furthermore, greener living environments in more urban areas are often set out more spaciously, reducing the facility density and increasing the possibility of parking a car near one's home. The study by Den Hertog et al. (2006) performed in the Netherlands showed that - within an urban environment - both the density of facilities and parking

possibilities were important determinants for the amount of physical activity undertaken, especially walking and cycling. In neighbourhoods with a high density of facilities and without private parking spaces, people more often choose to walk or cycle.

Our results concerning walking and cycling during leisure time contrast with studies which find rather strong indications for a relationship between attractive streetscapes and the amount of walking and cycling in Australia, the United States of America and the United Kingdom (e.g. Pikora et al., 2003). A reason for the differences found could be that our data on green space did not provide specific information on the attractiveness of the streetscape. We were not able to investigate the influence of small green areas, like for instance trees along the roads. Furthermore, the differences found could be due to the walking and cycling culture in the Netherlands, which gives citizens of the Netherlands lots of opportunities to walk and cycle safely elsewhere, even when there is no green space in the direct vicinity of their homes.

We did find a positive relation between green space and gardening and cycling for commuting purposes. Especially the amount of agricultural green space influenced these types of physical activity positively. People with more agricultural green space in their living environment garden more often and for a longer duration, and if they cycle for commuting purposes, they spend more time on it. The fact that people with more agricultural green space in their living environment garden more often and spend more time on it, is most probably due to the fact that people in areas with more agricultural green space own larger size gardens.

An explanation for the fact that people who cycle for commuting purposes spend more time on this – a result which was also found in the study of Wendel-Vos et al. (2004) – is that living environments with more agricultural green space are often located further away from cities, which is where most jobs are available. Therefore, people in the areas with more agricultural green space have to cycle more minutes to reach their work or school. Or as Wendel-Vos et al. (2004) explains, "the result reflects the fact that people in outskirts of town spend more time on bicycling to the city".

Regarding the relationship between green space and physical activity in different levels of level of urbanity, the relation appeared to be stronger in the more rural areas than in the urban areas. The strongest relation was found in slightly urban areas.

Concerning the subgroup analysis, the link between physical activity and green space was strongest for people aged under 25 and for elderly, lower educated people and people with a low income. This is in line with our hypothesis that children, elderly and lower socio-economic groups, spend more time in the vicinity of their homes and are therefore likely to be more affected by the design of their direct living environment.

Physical activity as an explanation for the relationship between green space and health

The fact that people spend more time on cycling for commuting purposes and on gardening could not explain the relation between green space and health. Therefore, we can conclude that physical activity is not a likely mechanism behind the relation between green space in people's direct living environment and health that was found in previous studies.

In analyses in which only people were included who garden or people who spend time on cycling for commuting purposes, no relationship was found between green space and self-reported health. This can be explained by the fact that in these small subgroups the variation in green space is smaller. Additionally, people who spend time on gardening already spend time in green space and the extra benefit of green space outside their homes might not be discernable. Furthermore, people who garden and people who cycle for commuting purposes are probably healthier.

However, it is important to note that although people with greener living environments do not more often meet the Dutch public health recommendations for physical activity, it is possible that they more often undertake physical activity in a green environment. Different studies have shown that people with more green space in their living environment more often use green space (e.g. Nielsen and Hansen, 2007). Because we did not have any data on *where* people were physically active, we were not able to find out whether people with greener living environments more often exercise *in green spaces*. A study by De Vries et al. (2004) showed that the local green space supply does not determine *how often* people engage in recreation, but it does determine *where* people engage in recreation. The findings of this study also suggest that if there is no green space available people seek alternatives in other environments. Undertaking more physical activity in a green environment as opposed to an urban environment could

have health benefits in the form of reduced stress symptoms (e.g. Pretty et al., 2005; Hartig et al., 1991).
Furthermore, it is possible that the lack of an relation between the level of physical activity and the amount of green space is due to the high density of sports facilities and safe cycle tracks and footpaths almost anywhere in the Netherlands. Under these circumstances, the availability of green space is not a necessary condition to be physically active.

Strengths and limitations
This is one of the first studies to investigate whether the amount of physical activity undertaken can contribute to the explanation for the relation between green space and health found in previous studies. Where most studies only investigate the relationship between physical activity and green space or the relationship between green space and health, we investigated both the relationship between physical activity and green space as well as the relationship between green space, physical activity and health. Furthermore, unlike other studies performed in the Netherlands or in other countries, this study specifically investigates the relation between different types of green space and different types of physical activity for different subgroups and levels of urbanity.
The data on health (and physical activity) and land use were derived from various databases; consequently, there is no single source bias.
In our study we used objective environmental measures. Objective environmental measures reduce the risks of respondent bias. However, subjective environmental measures can also provide important information. People's perception of green spaces may, in fact, motivate their behaviour more than the actual amount of available green space. Green spaces or green spaces that are considered unsafe or of poor quality tend to be avoided. Thus, supplementing objective measures with measures of an individual's perception will improve our understanding of how the green environment affects physical activity level. We used a self-report measure for physical activity which is the most commonly used measure for assessing physical activity (US Department of HHS, 1996; Wendel-Vos et al., 2003). Using a self-report measure for physical activity has the advantage that it is easy to administer and generally acceptable to participants, and can measure a wide range of values (Wendel-Vos et al., 2003). Self-report measures have the disadvantage of incomplete recall and exaggeration of the amount of activity (US Department of HHS, 1996). For this study there are no direct

consequences in this respect, because we are interested in the relationship between green space and physical activity and it is not likely that people living in greener living environments will exaggerate more or less than people in less green living environments.
The measure used for physical activity, the SQUASH questionnaire, was not validated for each of the specific physical activities which are distinguished in this paper.

A limitation of our study is its cross-sectional design. The study does not inform us about the direction of causation. A second limitation is that we did not know where people were physically active. Other studies have found a significant correlation between the availability of green space and the use of green space (e.g. Nielsen and Hansen, 2007). Our study shows that the absence of green space does not necessarily lead to less physical activity in general, but that people probably compensate for the lack of green space by being physically active elsewhere. Future research should include questions on *where* people are physically active.
Furthermore, some potentially important control variables could not be taken into account. It would, for instance, have been interesting to see whether the density of (sports) facilities in different living environments has an effect on the level of physical activity. In addition, ownership of a dog, which has been proved to influence the level of physical activity, could not be taken into account (e.g. Cutt et al., 2007). Research has shown that there are rather strong indications for a relation between attractive streetscapes and the amount of walking and cycling in Australia, United States of America and United Kingdom (Pikora et al., 2003). Unfortunately, we were not able to investigate whether this relationship can also be found in the Netherlands, because we did not have detailed information on the greenness of the streetscape.

Conclusions

This study indicates that the amount of green space in the living environment is related to the overall level of physical activity only to a very limited extent. Furthermore, our study indicates that the amount of physical activity among people who live in greener environments cannot explain the relation between green space and health that was found in previous studies.

6

Social contacts as a possible mechanism behind the relation between green space and health

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Abstract

This study explored whether social contacts are an underlying mechanism behind the relationship between green space and health.

We measured social contacts and health in 10,089 residents of the Netherlands and calculated the percentage of green within a one kilometre and a three kilometre radius around the postal code coordinates for each individual's address.

After adjustment for socio-economic and demographic characteristics, less green space in people's living environment coincided with feelings of loneliness and with perceived shortage of social support.

Loneliness and perceived shortage of social support partly mediated the relation between green space and health.

Introduction

There is increasing attention and evidence for a positive relation between the amount of green space in the living environment and people's health and well-being. Several studies showed that more green space in the living environment of people is positively related to people's self-reported health and leads to lower mortality risks (e.g. De Vries et al., 2003; Maas et al., 2006; Mitchell and Popham, 2007; Takano et al., 2002). However, little is known from these studies about the way in which green space exerts a beneficial effect on health. Several mechanisms could be underlying of which the following are most commonly mentioned: recovery from stress and attention fatigue, encouragement of physical activity and facilitation of social contact (De Vries et al., 2003; Groenewegen et al., 2006; Health Council of the Netherlands and RMNO, 2004; Maas et al., 2006). A large number of mainly experimental studies have produced strong evidence of the positive effect of nature on recovery from stress and attention fatigue (e.g. Hartig et al., 2003; Hartig et al., 1991; Health Council of the Netherlands and RMNO, 2004; Kaplan and Kaplan, 1989). About other possible underlying mechanisms, such as social contacts, less is known. One review suggests green space might 'have beneficial effects on health in so far as green space promotes social contact, for example through green meeting places in neighbourhoods, group-based nature activities (e.g. walking or willow pollarding) and gardening (shared gardens for the elderly and allotment gardens)' (Health Council of the Netherlands and RMNO, 2004). In this study, we aim to investigate whether social contacts are a possible mechanism behind the relation between green space and health.

Several terms have been used in studies of the health-enhancing components of social relationships, such as social support, social network and social integration (Berkman et al., 2000). In this paper, we prefer to use the container term social contacts for all these terms. Social contacts can take many forms, including having a conversation, undertaking joint activities and paying visits. It is widely recognised that social relationships can influence a variety of health outcomes (e.g. Berkman et al., 2000; Hawe and Shiell, 2000). Persons actively involved in communities or socially engaged with others tend to live longer (Kawachi et al., 1997) and are healthier both physically as well as mentally (e.g. Kawachi and Berkman, 2000; Leyden, 2003).

Meeting opportunities are important for the development of local communities and social ties with neighbours because people have to be able to meet to establish relationships (Flap and Völker, 2005; Völker et al., 2007). Most contact between neighbours will occur in places like local, recreation facilities, schools, churches and parks (Kuo et al., 1998a; Völker et al., 2007). The presence of trees and grass in common spaces, as opposed to barren common spaces, may attract residents to outdoor spaces, thereby leading to more frequent contacts among neighbours (Coley et al., 1997). Natural settings in common space are attractive because they can for example provide shadow, privacy and sound buffering from surrounding environments and they could have restorative effects (Coley et al., 1997; Hartig et al., 2003; Kaplan and Kaplan, 1989). Three closely related studies, performed by the same research group in an underprivileged area of Chicago, provide indication of a positive relation between the presence of green public facilities and social ties (Coley et al., 1997; Kuo et al., 1998a; Kweon et al., 1998).

Coley et. al. (1997) investigated the link between the use of outdoor public spaces and the presence, number and location of trees. They found that the presence of trees "consistently predicted greater use of outdoor spaces by all people, young and older, as well as groupings of people consisting of both youth and adults together"(Coley et al., 1997). Furthermore, they found that "the amount of time residents spent in common space was strongly predicted by the presence, location and number of trees" (Coley et al., 1997).

Kuo et. al. (1998) took this line of research to the next level and studied whether greener neighbourhoods give rise to stronger neighbourhood social ties. They found that levels of vegetation predict both use of common spaces and the strength of neighbourhood social ties. Moreover, they found that use of common spaces mediated the relation between vegetation and neighbourhood social ties (Kuo et al., 1998a).

Kweon et. al. (1998) subsequently investigated the relationship between older adults' exposure to nearby green common spaces and their level of social integration and attachment to local community. They found modest relationships between the use of green outdoor common space and the strength of neighbourhood social ties and sense of community for older adult residents of inner-city neighbourhoods.

Overall, these studies broadened our understanding of the importance of green space for neighbourhood social ties. However, it is unknown whether these results also apply to other settings. The studies were conducted in

highly deprived urban areas where green elements were very scarce. The question is whether these relationships will also be found in other, richer and greener neighbourhoods.

Besides offering meeting opportunities green spaces can also promote a general sense of community. According to Kim and Kaplan (Kim and Kaplan, 2004), sense of community of residents is strengthened when they feel at home (community attachment), have bonds with others, feel a sense of connection with the place (community identity) and have access for local exploration (pedestrianism). An empirical investigation showed that natural features and open spaces were the most important physical features which contribute to these four domains of sense of community. Natural features can promote a sense of community by increasing feelings of emotional attachment to a neighbourhood and people's identity with a place, which in turn could decrease feelings of loneliness and increases social support (Pretty et al., 1994; Prezza et al., 2001). Therefore, it is interesting not only to investigate the direct relation between green space and contact with neighbours but also with feelings of loneliness and social support.

A few studies have addressed the relation between green space and social contacts and sense of community. Flap and Völker (2005) showed that Dutch neighbourhoods with more open green space and recreational facilities, promote a sense of community. A study by Ewert and Heywood conducted in the United States of America (1991) showed that undertaking activities in natural environments appeared to have stimulating effects on social contacts and social cohesion. The results of a study by Leyden (2003) show that people in Ireland in walkable neighbourhoods, which are among other things characterised by the availability of local parks, are "more likely to know their neighbours, to participate politically, to trust others, and to be involved socially". On the other hand, in Western Australia, Wood et al. (2007) did not find a relation between distance to park from the respondents home and social capital.

Overall, there are several indications of a positive relation between green space and social contacts. The aim of this study is to investigate whether social contacts are a possible factor mediating the relation between green space and health.

More specifically, the following questions will be answered:

1 *'Is the amount of green space in people's living environment related to people's health?'*

2 *'Do people with more social contacts feel healthier?'*

3 *'Is the amount of green space in people's living environment related to social contacts?'*

4 *'Can the relation between green space and social contacts explain the relation between green space and health?'*

To gain more insight in the relation between social contacts and green space, we will analyse it for different subgroups. First of all, the relation will be analysed for different age groups to find out whether the relation is stronger for children and elderly, who have fewer resources to develop and maintain social ties that are further away from their homes. As a consequence of the more limited mobility of children and elderly, they rely more on nearby neighbours and their neighbourhood to support their needs (e.g. Kweon, 1998). Furthermore, the relation will be analysed for different social economic status groups to find out whether groups with a lower social economic status benefit more from green space in their living environment. Finally, we will investigate whether the relation is the same for urban and rural areas. Neighbourhoods in urban areas are more likely to be deteriorated, more often have to deal with vandalism, have a less strong local community and lower levels of social control (Flap and Völker, 2005; Steenbekkers et al., 2006). People living in rural areas more often socialize with their neighbours, less often experience nuisance from their neighbours (Steenbekkers et al., 2006) and have more social contacts in general (De Jong Gierveld, 1998). Overall, however, levels of deterioration are relatively low in the Netherlands.

Methods

Data

The data for this study were derived from two different datasets that were combined for this study. The health data and data on social contacts were collected within the framework of the second Dutch National Survey of General Practice (DNSGP-2), conducted in the Netherlands in 2001. The DNSGP-2 included a nationwide representative sample of 104 general practices with approximately 400.000 people on their list, who were a good representation of the Dutch population in terms of age, gender and type of health insurance (Westert et al., 2005).

As part of the DNSGP-2 a random sample of 12,699 people participated in a health interview survey (response rate 64.5%). Questionnaires were administered by trained interviewers during a face-to-face interview. To avoid seasonal patterns in morbidity, all interviews were carried out within 12 months in 2001 and distributed equally across all four seasons. People aged between 12 and 17 were interviewed, with one parent present. Privacy of the participating persons is guaranteed and in accordance with Dutch legislation, and the study was approved by the Dutch Data Protection Authority. Patients were informed about the study prior to data collection (Westert et al., 2005). The socio-demographic characteristics of the respondents were highly comparable to those of the total Dutch population, although men, younger age groups and migrants were slightly underrepresented (Westert et al., 2005).

Environmental data were derived from the National Land Cover Classification database (LGN4), which contains the dominant type of land use of each 25 by 25 metre grid cell in the whole of the Netherlands in 2001 (Thunnissen and De Wit, 2000). The two datasets were matched on the basis of the x and y coordinates of the respondent's six character postal code (on average about 15 to 20 households have the same six character postal code). Only respondents who had valid responses on the relevant variables were included, leaving 10,089 respondents.

Measures

Self-reported health indicators

We used three global health indicators that have shown to be positively related with the amount of green space in the living environment in a study by De Vries et al. (2003) are as follows:

- *Perceived general health.* Measured on a five-point scale, running from 'excellent' (1) to 'bad' (5). For our purposes the scores were dichotomised with scores from good to excellent classified as healthy (1). This kind of operationalizations has shown to be valid and predictive of health indicators in numerous studies.(Rütten et al., 2001; Simons, 2002)
- *Number of health complaints* (maximum 43) experienced in the last 14 days (e.g. headache, coughing, nausea and lower back pain) (Foets and Van der Velden, 1990).
- *Self-rated propensity to psychiatric morbidity*. Measured with the Dutch 12-item version of the General Health Questionnaire (GHQ-12) (Goldberg, 1972; Koeter and Ormel, 1991). This variable was dichotomised: scores of 2 and higher were classified as an increased risk of psychopathology.

Social contacts

We used the following measures of social contacts:

- *Loneliness.* Measured using six items that were based on the UCLA loneliness scale, e.g. "I feel part of a group friends", "I feel isolated from others", "There are people who really understand me" (Russell 1996). A summary score counted the degree of loneliness (possible score range 6-18), with a higher score representing a higher degree of loneliness. The scale had an internal reliability (Cronbach's alpha) of 0.64.
- *Social support.* Measured with the social support list (SSL), which has shown good construct validity and high reliability (Bridges et al., 2002; Van Sonderen, 1993a). The SSL measures among other things the interactions (SSL-I) and discrepancies (SSL-D) that people experience in receiving social support from their direct environment. Each list originally consists of 34 items which form six subscales. Only questions related to three subscales (in total 19 items) were included in the health interview to shorten the length of the survey, namely emotional support with problems (8 items), instrumental interactions (7 items) and informative support (4 items) (Van Sonderen, 1993b). For this study, we investigated both the number of supportive interactions people receive (using SSL-I) and the shortage of social support (using the SSL-D)

  The number of supportive interactions. The SSL-I measures the number of supportive interactions people receive from their social support network. The response categories are as follows: seldom/never (1); now and then (2); regularly (3) and often (4). A total score on the SSL-I was

measured by summing up the scores on the 19 items, the higher the score the more social support (Cronbach's alpha=0.85).

Shortage of social support. The SSL-D represents the subjective experience of mismatches between the received and desired frequency of receiving social support. The response categories are:

1 I miss it, I would like it to happen more often;
2 I don't really miss it, but it would be nice if it happened a bit more often;
3 just right, I would not want it to happen more or less often;
4 it happens too often, it would be nice if it happened less often.

The focus of this study was on the perceived lack of social support, that is "I miss it". Following the instructions for using this scale, the first category was recoded into value 3 and the second category kept the value 2. The latter two response categories (categories 3 and 4) both received the value 1. A higher score on the scale thus equals a larger shortage of social support. A total score on the SSL-D was measured by summing up the scores on the 19 items (Cronbach's alpha=0.86).

Only a random sample of about half the study population (n=4,944) has been asked questions concerning social support to shorten the length of the questionnaire. Furthermore, only the respondents who filled in all questions were included (excluded 102 respondents).

- *Contact with neighbours and friends in the neighbourhood.* Respondents were asked how often they had contact with their neighbours or friends in the neighbourhood. Because the answers were not normally distributed, we decided to make a dummy variable on whether people often contacted neighbours and friends in the neighbourhood (more than 3 time per week or 1 to 3 times per week = 1) or not often (1 to 3 times per month, 4 to 11 times per year, maximally 3 times a year = 0). Only a random sample of about half the study population (n=4,635) has been asked this question in order to shorten the length of the questionnaire. Some of the respondents (n=228) stated that this question was not applicable for them. We left these respondents out of the analysis leaving 4407 respondents for this analysis.

Characteristics of respondents' living environment

The following two indicators were used to measure characteristics of the respondents' living environment:

- *Percentage of green space*. Information on the environmental characteristics was derived from the LGN4 database. The LGN4 database discriminates 39 land-use classes including crop types, forest types, water, various urban classes and semi-natural classes and has been proven to be valid, accurate and reliable (De Wit and Clevers, 2004; Thunnissen and De Wit, 2000). The total percentage of green space in the respondents' living environment was measured within a 1km radius and within a 3km radius around a respondent's home, to see whether green space close by has a stronger or weaker effect than green space further away. The total percentage of green space includes all urban green, agricultural green, forests and nature conservation areas. Grid cells of 25 by 25 metre are regarded as green space in the dataset if green space has a dominant position. Gardens and small-scale green spaces, like for instances street trees and green roadsides are not regarded as green space in our study because they had no dominant position in the grid cell.
- *Level of urbanity*. Another environmental characteristic is level of urbanity. This variable consists of five categories ranging from very strongly urban (1) to non-urban (5), and was measured at municipal level. The indicator is based on the number of households per square km and is widely used in the Netherlands (Den Dulk et al., 1992).

Demographic and socio-economic characteristics

Network research reveals that social networks or social interaction of people with different background characteristics differ considerably. Women tend to have larger and more intimate social networks (Kendler et al., 2005). The number of friends and the frequency of social contacts decline with age (Van Tilburg, 1998). Furthermore, people with higher education and higher income levels have larger networks than people with lower education and income levels (Tijhuis, 1994). Because social networks and health differ according to people's background characteristics, we took several of these characteristics into account:

- *Demographic characteristics*. The demographic characteristics taken into account were gender (female=1) and age (in years). To find out whether the relation between social contacts and green space differed for different age groups, age was divided into five categories (viz. children [aged 12-17 years], youths [aged 18-25 years], young adults [aged 26-40 years], older adults [aged 41-65 years], elderly [aged 65+]).

- *Socio-economic status (SES)* was measured by level of education (divided into four dummy variables categories: unknown, low, middle and high) and household income (divided into four dummy variables: income unknown, high income (net monthly income >2,450 euro), middle income (net monthly income between 1,350 and 2,450 euro) and low income (net monthly income <1,350 euro)). Level of education and income were categorised because of the non-linear relation with some of the dependent variables. We included the categories 'unknown' for level of education and income in order to avoid excessive drop-out of respondents.
- *Size of the respondent's household*. Because the size of the respondent's household also influences the level of social contacts of the respondent (e.g. Tijhuis, 1994) we included a variable measuring the size of the respondent's household in the analysis concerning the relation between green space and the different forms of social contacts.

Table 6.1 shows the characteristics of the study population. Correlation tests did not reveal any problems of multicollinearity.

Table 6.1 Descriptive statistics for the variables included in the analyses (n=10,089)

	% (n)	**M (SD) (Range)**
Demographic characteristics		
Gender:		
female	54.9 (5,538)	
male	45.1 (4,551)	
Age:		
children (12– 17 year)	8.8 (883)	
youth (18-25 year)	7.7 (776)	
young adults (26-45 year)	32.8 (3,309)	
older adults (46-65 year)	33.1 (3,341)	
elderly (>65 year)	17.6 (1,780)	
Number of people in household		2.9 (1.4) (range 1 – 14)
Socio-economic characteristics		
Level of education:		
level of education unknown	12.0 (1,206)	
low	20.9 (2,107)	
middle	49.9 (5,036)	
high	17.2 (1,740)	

- table 6.1 continues -

- table 6.1 continued -

	% (n)	M (SD) (Range)
Income:		
unknown	5.6 (56)	
low	29.6 (2,983)	
middle	41.2 (4,152)	
high	23.7 (2,391)	
Level of urbanity		
very strongly urban	15.9 (1,609)	
strongly urban	24.2 (2,445)	
moderately urban	20 (2,013)	
slightly urban	29.9 (3,014)	
non urban	10.0 (1,008)	
Percentage of green space		
average percentage in a 1km radius		42.5%(s.d. 24.2) (range .3 - 99.3)
average percentage in a 3km radius		60.7% (s.d. 21.6) (range 6.16 – 60.7)
Dependent variables		
Health:		
percentage of healthy people		82.4% (8,310)
average number of complaints		4.3 (s.d. 3.8)
people with aself-rated propensity for psychiatric morbidity		22.6% (2,097)
Social contacts		
often contact with neighbours (n=4,407)		66.8%
loneliness (n=10,089)		7.5 (s.d. 2) (range 6-18)
number of supportive interactions (n=4,842)		33.8 (s.d. 6.8) (range 19-65)
shortage of social support (n=4,842)		21.3 (s.d. 3.9) (range 19-57)

Statistical analyses

The relation between the amount of green space, social contacts and health was assessed by multilevel regression analyses, controlling for socio-economic and demographic characteristics and level of urbanity. The multilevel analyses were performed with MLwiN. We included two levels, viz. practice and individual level, because the data of individuals were gathered through general practices and therefore individuals clustered within practices. The postal code level was not included because there were hardly any people from the same six character postal code in the dataset. The independent variables, including the percentage of green space, were

centred around the average which reduces chances of multicollinearity (Draper and Smith, 1998). The results reflect the individual level. Multilevel logistic regression analysis was used in case the dependent variable was a dichotomy. Because we wanted to compare the relation for different levels of urbanity and different subgroups, we used several models in which we included interaction effects between the level of urbanity or subgroup variable and the green indicator.
As we want to investigate whether social contacts mediate the relation between green space and health, we used Baron and Kenny's (1986) procedure for establishing whether mediation has occurred. To show mediation, the independent variable must significantly influence the potential mediator, the mediator must have a significant relationship with the dependent variable, and the relationship between the independent variable and dependent variable should be eliminated (full mediation) or weakened (partial mediation) when the mediator is controlled for. We used a series of multilevel (logistic) regression equations and the Sobel test (Preacher and Hayes, 2004) to test for mediation.

Results

Relation between green space and health

We investigated the relationship between green space and health both with our total sample and with the subsample that provided data on social support and contact with neighbours.
We first investigated the relation for the percentage of green space in a 1km radius around people's home. Subsequently, we investigated the relation for the percentage of green space in a 3km radius around people's home. Overall, people with more green space in their living environment feel healthier, have experienced a lower number of health complaints in the last 14 days and have lower self-rated propensity for psychiatric morbidity (table 6.2, models 1 and 2). The relation between green space and the different health indicators was stronger and more consistent for the percentage of green space in a 1km radius around people's home. In the dataset with a smaller sample size, there was no relation between the percentage of green space in a 3km radius around people's home and the three health indicators (table 6.2, models 3 and 4).

Relation between social contacts and health

Whether or not people often have contact with neighbours or friends in the neighbourhood are not related to any of the health indicators (table 6.2, model 5). Concerning the relation between loneliness and health, table 6.2 shows that people who feel less lonely have a better self-reported health, experienced fewer health complaints and have a lower self-rated propensity for psychiatric morbidity (table 6.2, model 6). People who report a larger number of supportive interactions feel less healthy, report a higher number of health complaints and have a higher self-rated propensity for psychiatric morbidity (table 6.2, model 7). People who experience a larger shortage of social support feel less healthy, report a higher number of health complaints and have a higher self-rated propensity for psychiatric morbidity (table 6.2, model 8).

Table 6.2 Regression analysis for the relation between green space and the three health indicators and for the relation between social contacts and the three health indicators: unstandardized regression coefficient and standard error

	Perceived general health ('good/ very good' =1)	**Number of health complaints**	**Propensity for psychiatric morbidity (=1)**
Percentage of green space:			
n=10,089			
Model 1: % of green (1km)	0.0044 (0.0016)**	-0.011 (0.002)***	-0.005 (0.002)**
Model 2: % of green (3km)	0.005 (0.002)*	-0.010 (0.004)*	-0.004 (0.002)*
n=4,842			
Model 3: % of green (1km)	0.003 (0.002)	-0.010 (0.003)**	-0.0047 (0.0021)*
Model 4: % of green (3km)	0.002 (0.003)	-0.001 (0.005)	-0.002 (0.003)
Social contacts:			
Model 5: often contact with neighbours	0.120 (0.085)	-0.109 (0.120)	-0.127 (0.078)
Model 6: loneliness	-0.159 (0.012)***	0.355 (0.019)***	0.195 (0.012)***
Model 7: number of supportive interactions	-0.051 (0.006)***	0.112 (0.054)*	0.070 (0.006)***
Model 8: shortage of social support	-0.072 (0.009)***	0.236 (0.013) ***	0.128 (0.009)***

* p≤0.05; ** p≤0.01; *** p≤0.001

note: - a high score indicates feelings of loneliness, a high number of social interactions, a high shortage of social support and often contact with neighbours of friends in the neighbourhood

- all regression coefficients are derived from separate analyses controlling for age, gender, household size, level of education, income and level of urbanity

Relation between green space and social contacts

Loneliness

For all measures of social contact, we investigated in separate models whether they were related to the percentage of green space in a 1 or 3km radius. Table 6.3a shows that there is a significant relation between both the percentage of green in a 1km and in a 3km radius around people's home and their feelings of loneliness. People with more green space in their living environment feel less lonely.

The different models in table 6.4 show the results for the relation between green space and loneliness for different subgroups. The subgroup analyses show that there is a relation between green space and loneliness in strongly urban municipalities, for children (1km and 3km), young adults (1km and 3km), adults (3km), elderly (3km), lower educated people and for people with a low income (1km and 3km) (see table 6.4).

Social support

No significant relations are found between the percentage of green space in the living environment and the number of supportive interactions respondents receive from their social support network (see table 6.3a). However, people with more green space in a 1km radius around their home experience less shortage of social support (see table 6.3b). Our subgroup analyses show that this relation is apparent in strongly urban municipalities, for children, youth, elderly and for people with a low income (see table 6.4). There was no significant relation between the amount of green space in a 3km radius around people's home and shortage of social support (see table 6.3b).

Contact with neighbours or friends in the neighbourhood

Although there is no relation between whether or not people often contact neighbours and friends in the neighbourhood and the health indicators, we did want to investigate whether there is a relation between green space and this indicator for social contacts. There appeared to be no significant relation between the percentage of green space and whether or not people often contacted neighbours or friends in the neighbourhood (see table 6.3b).

Table 6.3a Regression analysis for the relation between green space, loneliness, the number of supportive interactions: unstandardized regression coefficient and standard error

	Loneliness (n=10,089)		**Number of supportive interactions (SSL-I) (n=4,842)**	
	Model 1 (1km radius)	**Model 2 (3km radius)**	**Model 1 (1km radius)**	**Model 1 (1km radius)**
Intercept	7.5 (0.033)***	7.5 (0.033)***	33.8 (0.161)	33.8 (0.161)
Demographic characteristics:				
Gender (woman)	-0.316 (0.039)***	-0.316 (0.039)***	1.5 (0.184)***	1.5 (0.184)
Age	0.022 (0.001)***	0.022 (0.001)***	-0.117 (0.006)***	-0.118 (0.006)***
Socio-economic characteristics:				
Level of education				
Education level unknown	0.411 (0.075)***	0.412 (0.075)***	-0.484 (0.350)	-0.488 (0.350)
Lower educated	0.497 (0.067)***	0.499 (0.067)***	0.133 (0.321)	0.121 (0.321)
Middle educated	0.153 (0.056)**	0.155 (0.056)**	-0.792 (0.261)**	-0.807 (0.261)**
Higher educated	Reference category			
Income				
Income unknown	0.466 (0.093)***	0.463 (0.093)***	-0.428 (0.446)	-0.434 (0.446)
Low income	0.653 (0.059)***	0.653 (0.059)***	-0.004 (0.277)	0.011 (0.277)
Average income	0.301 (0.051)***	0.301 (0.051)***	-0.028 (0.239)	0.046 (0.238)
High income	Reference category			
Other characteristics:				
Household size	0.032 (0.016) *	0.031 (0.016) *	-0.036 (0.079)	-0.048 (0.079)
Level of urbanity:				
Very strongly urban	0.346 (128)**	0.227 (144)	1.5 (0.6)*	2.4 (0.7)***
Strongly urban	0.195 (0.117)	0.134 (0.122)	0.8 (0.6)	1.4 (0.6)**
Moderately urban	0.042 (0.114)	0.028 (0.112)	0.6 (0.5)	1.0 (0.537)
Slightly urban	0.059 (0.106)	0.071 (0.106)	-0.3 (0.5)	-0.183 (0.498)
Non urban	Reference category			
% of green (1km)	-0.002 (0.001)*		-0.004 (0.006)	
% of green (3km)		-0.005 (0.002)**		0.015 (0.010)

* p≤0.05; ** p≤0.01; *** p≤0.001

note: a high score indicates feelings of loneliness, a high number of social interactions, a high shortage of social support and often contact with neighbours of friends in the neighbourhood

Table 6.3b Regression analysis for the relation between green space, shortage of social support and contact with neighbours: unstandardized regression coefficient and standard error

	Shortage of social support (SSL-D) (n=4,842)		**Contact with neighbours (1=often) (n=4,407)**	
	Model 1 (1km radius)	**Model 2 (3km radius)**	**Model 1 (1km radius)**	**Model 1 (1km radius)**
Intercept	21.3 (0.085)	21.3 (0.084)	0.713 (0.044)	0.714 (0.044)
Demographic chacteristics:				
Gender (woman)	0.041 (0.114)	0.043 (0.114)	-0.112 (0.066)	-0.114 (0.066)
Age	-0.017 (0.004)***	-0.017 (0.004)***	-0.001 (0.002)	-0.001 (0.002)
Socio-economic characteristics:				
Level of education				
Education level unknown	-0.389 (0.216)	-0.389 (0.216)	0.144 (0.124)	0.145 (0.124)
Lower educated	-0.101 (0.197)***	-0.102 (0.197)***	0.041 (0.123)	0.043 (0.123)
Middle educated	-0.485 (0.160)**	-0.470 (0.161)**	0.062 (0.089)	0.063 (0.089)
Higher educated				
Income				
Income unknown	0.031 (0.275)	0.028 (0.275)	0.454 (0.170)**	0.454 (0.170)**
Low income	0.792 (0.170)***	0.810 (0.170)***	0.299 (0.098)**	0.294 (0.098)**
Average income	0.166 (0.147)	0.184 (0.147)	0.153 (0.083)	-0.262 (0.188)
High income	Reference category			
Other characteristics:				
Household size	-0.059 (0.048)	-0.068 (0.048)	0.085 (0.029)**	0.085 (0.029)**
Level of urbanity:				
Very strongly urban	1.159 (0.347)***	1.607 (0.393)***	-0.325 (0.212)	-0.262 (0.188)
Strongly urban	0.749 (0.319)*	1.129 (0.331)***	-0.046 (0.180)	-0.028 (0.174)
Moderately urban	0.297 (0.308)	0.584 (0.302)	-0.265 (0.163)	-0.281 (0.167)
Slightly urban	0.207 (0.282)	0.340 (0.275)	-0.127 (0.147)	-0.166 (0.151)
Non urban	Reference category			
% of green (1km)	-0.007 (0.003)*		-0.004 (0.003)	
% of green (3km)		0.002 (0.005)		-0.003 (0.002)

* p≤0.05; ** p≤0.01; *** p≤0.001

note: a high score indicates feelings of loneliness, a high number of social interactions, a high shortage of social support and often contact with neighbours of friends in the neighbourhood

Table 6.4 Relation between green space and different social relationship indicators controlled for demographic and socioeconomic characteristics and level of urbanity: unstandardized regression coefficient and standard error

	Loneliness (n=10,089)	**Shortage of social support (n=4,842)**
Model 1:		
% of green (1km)* very strongly urban	0.004 (0.003)	-0.007 (0.010)
% of green (1km)* strong	-0.007 (0.002)***	-0.019 (0.007) *
% of green (1km)* moderately	-0.003 (0.003)	0.001 (0.007)
% of green (1km)* slightly	-0.000 (0.002)	-0.006 (0.006)
% of green (1km)* non urban	-0.004 (0.004)	-0.005 (0.012)
Model 2:		
% of green (3km)* very strong	0.000 (0.004)	
% of green (3km)* strong	-0.009 (0.004)*	
% of green (3km)* moderately	-0.004 (0.004)	
% of green (3km)* slightly	-0.004 (0.004)	
% of green (3km)* non urban	-0.009 (0.006)	
Model 3:		
% of green (1km)* children	-0.004 (0.002)*	-0.021 (0.007)**
% of green (1km)* youth	-0.001 (0.002)	-0.014 (0.006)*
% of green (1km)* young adults	-0.002 (0.001) *	-0.003 (0.004)
% of green (1km)* older adults	-0.0021 (0.001)	-0.003 (0.004)
% of green (1km)* elderly	-0.003 (0.002)	-0.019 (0.005)***
Model 4:		
% of green (3km)* children	-0.006 (0.002)*	
% of green (3km)* youth	-0.004 (0.002)	
% of green (3km)* young adults	-0.004 (0.002)*	
% of green (3km)* older adults	-0.005 (0.002)*	
% of green (3km)* elderly	-0.005 (0.002)*	
Model 5:		
% of green (1km)* lower educated	-0.008 (0.002)***	-0.009 (0.006)
% of green (1km)* middle educated	-0.002 (0.001)	-0.004 (0.004)
% of green (1km)* high educated	0.003 (0.002)	-0.009 (0.006)
Model 6:		
% of green (3km)* lower educated	-0.012 (0.003)***	
% of green (3km)* middle educated	-0.006 (0.002)*	
% of green (3km)* high educated	0.002 (0.003)	

- table 6.4 continues -

- table 6.4 continued -

	Loneliness (n=10,089)	Shortage of social support (n=4,842)
Model 7:		
% of green (1km)* low income	-0.006 (0.002)**	-0.019 (0.005)***
% of green (1km)* middle income	-0.001 (0.002)	-0.003 (0.005)
% of green (1km)* high income	0.001 (0.002)	0.001 (0.005)
Model 8:		
% of green (3km)* low income	-0.008 (0.002)**	
% of green (3km)* middle income	-0.003 (0.002)	
% of green (3km)* high income	-0.002 (0.003)	

* p≤0.05; ** p≤0.01; *** p≤0.001

note: a high score indicates feelings of loneliness and a high shortage of social support. All models were controlled for age, gender, household size, level of education, income and level of urbanity

Loneliness and shortage of social support as a possible mechanism behind the relation between green space and health

Only for loneliness (1km and 3km) and shortage of social support (1km) all requirements for testing mediation are met, since for the other mediators no relation was found with the percentage of green space in the living environment. Therefore, we only tested whether loneliness or shortage of social support mediate the relation between green space and the different health indicators

Green space, loneliness and health

Table 6.5 shows the results for loneliness. The results show that adding loneliness to the model slightly influences the relation between the percentage of green space and perceived general health, the number of health complaints in the last 14 days and people's self-rated propensity to psychiatric morbidity. This indicates partial mediation. To test whether loneliness mediates the relation between green space and the different health indicators we conducted a Sobel test. Loneliness appears to partially mediate the relation between green space and self-perceived health (1km: z=6.26, p<0.001 / 3km: z=7.43, p<0.001), number of health complaints (1km: z=-6.22, p<0.001 / 3km: z=7.36, p<0.001) and self-reported propensity to psychiatric morbidity (1km: z=-5.57, p<0.001 / 3km: z=6.89, p<0.001).

Table 6.5 Regression analysis for the relation between green space, loneliness and perceived general health, number of health complaints and propensity for psychiatric morbidity: controlled for demographic and socioeconomic characteristics and level of urbanity: unstandardized regression coefficient and standard error (n=10,089)

	Model 1 (1km radius)	**Model 2 (1km radius)**	**Model 3 (3km radius)**	**Model 4 (3km radius)**
Perceived general health ('good/very good' =1):				
% of green (1km)	0.0044 (0.0016)**	0.0040 (0.0016)*		
% of green (3km)			0.005 (0.002)*	0.0042 (0.0022)*
loneliness		-0.157 (0.012)***		-0.157 (0.012)***
Number of health complaints:				
% of green (1km)	-0.011 (0.002)***	-0.010 (0.002)***		
% of green (3km)			-0.010 (0.004)*	-0.008 (0.004)*
loneliness		0.353 (0.019)***		0.354 (0.019)***
Propensity for psychiatric morbidity (=1):				
% of green (1km)	-0.005 (0.002)**	-0.005 (0.002)**		
% of green (3km)			-0.004 (0.002)*	-0.003 (0.002)
loneliness		0.194 (0.012)***		0.194 (0.012)***

* p≤0.05; ** p≤0.01; *** p≤0.001

note: - a high score indicates feelings of loneliness

- the results for the different health indicators were derived from separate analyses. The first model includes all control variables (age, gender, household size, level of education, income and level of urbanity) and the percentage of green space in a 1km radius. In the second model loneliness is added. The third model includes all control variables (age, gender, household size, level of education, income and level of urbanity) and the percentage of green space in a 3km radius. In the fourth model loneliness is added

Green space, shortage of social support and health

Table 6.6 shows the results for the triad between shortage of social support, the amount of green space in a 1km radius and the number of health complaints and the self-rated propensity for psychiatric morbidity. The triad for green space, shortage of social support and self-reported health was not investigated, because the analyses on the relation between green space and self-reported health (see table 6.2) showed that there was no significant

relation between the percentage of green space and self-reported general health for the smaller sample.

Concerning the number of health complaints our analyses show that adding shortage of social support to the model slightly diminishes the relation between the amount of green space in a 1km radius and the number of reported health complaints in the last 14 days. Shortage of social support appears to partially mediate between the amount of green space in a 1km radius and number of health complaints (1km: *Sobel*=-0.0039, z=-6.35, p<0.001/ 3km *Sobel*=-0.0036, z=5.25, p<0.001).

The analyses concerning people's self-rated propensity for psychiatric morbidity show that adding shortage of social support to the model renders the percentage of green space in a 1km radius insignificant. Shortage of social support mediated the relation between the percentage of green space in a 1km radius and self-rated propensity for psychiatric morbidity (1km: *Sobel*=-0.0004, z=-6.19, p<0.001 / 3km *Sobel*=-0.0004, z=5.30, p<0.001).

Table 6.6 Regression analysis for the relation between green space, shortage of social support and number of health complaints and propensity for psychiatric morbidity: controlled for demographic and socioeconomic characteristics and level of urbanity: unstandardized regression coefficient and standard error (n=4,842)

	Model 1	**Model 2**
Number of health complaints:		
% of green (1km)	-0.010 (0.003) **	-0.008 (0.003) **
shortage of social support		0.235 (0.013) ***
Propensity for psychiatric morbidity (=1):		
% of green (1km)	-0.0047 (0.0021)*	-0.0038 (0.0021)
shortage of social support		0.128 (0.009) ***

* p≤0.05; ** p≤0.01; *** p≤0.001

note: - a high score indicates a high shortage of social support
- the results for the different health indicators were derived from separate analyses. The first model includes all control variables (age, gender, household size, level of education, income and level of urbanity) and the percentage of green space in a 1km radius. In the second model shortage of social support is added

Discussion

This study examined whether social contacts mediate the relation between green space and health. We started by investigating the relation between green space and different health indicators. Our study shows that people with more green space in 1km radius around their home have better self-perceived health, have experienced fewer health complaints in the last 14 days and have a lower self-rated propensity for psychiatric morbidity. This is consistent with the studies by De Vries et al (2003) and Maas et. al. (2006), who used other datasets to investigate the relation between green space and health, and strengthens the evidence for a positive relation between the amount of green space in a 1km radius around people's home and health. However, although significant relations between the amount of green space in a 3km radius around people's home and health have been found in the studies by De Vries et al. (2003) and Maas et al. (2006), this study did not find a consistent significant relation, indicating that green space closer to home might be more important for people's health.
Concerning the relation between social contacts and health our results showed that both loneliness and experienced shortage of social support are negatively related to people's self-reported health, the number of health complaints and the self-rated propensity for psychiatric morbidity. This is consistent with other studies which also find a positive relation between social isolation, social support and health (e.g. House et al., 1988; Kawachi et al., 1997; Kendler et al., 2005; Van Oostrom et al., 1995). There was no relation between whether or not people had frequent contacts with neighbours and any of the three health indicators. We found a negative relation between the number of supportive interactions and the health indicators; people with more health problems received more social support. This negative relationship between the number of supportive interaction and health has also been found in other studies (Tijhuis, 1994; Van Sonderen and Ormel, 1997) and may be due to the higher need for social support of unhealthy people.

Green space and social contacts

Concerning the relation between green space and social contacts, our results show that people with more green space in their living environment feel less lonely and experience less shortage of social support, but they did not have more contact with neighbours or friends in the neighbourhood and they did

not receive more social support. This suggests that the relation between green space and social contacts has more to do with the fact that green spaces can strengthen sense of community via place attachment and place identity of its residents, than with actual contacts with neighbours. Further research is needed to investigate whether the relation between green space and social contacts is mediated by the four domains of sense of community.

A direct comparison between the results of this study and the studies conducted in Chicago is not possible. First of all, because of the different settings in which the studies are performed. Unlike the Chicago studies, which were performed in underprivileged areas, this study was performed on a representative sample of the Netherlands and includes all kinds of neighbourhoods and people with different backgrounds. Furthermore, the Chicago studies focus on specific small-scale green space close to people's home, while in this study small-scale green space like for instance gardens, street trees, playgrounds with trees and green roadsides are not seen as green spaces, as a results of restrictions of the database we used.

Only green space close to home appeared to be related to social support. The subgroup analyses show that the relation between green space and loneliness and the relation between green space and shortage of social support was strongest in the strongly urban areas. Furthermore, as we hypothesised, both relations appeared to be strongest for children and elderly who, as a consequence of limited mobility rely more on their neighbourhood to support their needs (Kweon et al., 1998). Finally, the relation was strongest for people with a low income or a low level of education, indicating that they benefit most of green space in their living environment for their social contacts. Apparently, the amount of green space in the living environment is less important for social contacts of people with a high SES.
The studies conducted in Chicago also found a relation between social ties and the presence of green public space for people with a low socio-economic status (SES) (Coley et al., 1997; Kuo et al., 1998a; Kweon et al., 1998). However, as has been mentioned before, because these studies were conducted in an underprivileged area in Chicago, no comparison could be made between the relation for lower and higher SES-groups.

Social contacts as an explanation for the relation between green space and health

Because only loneliness and shortage of social support were related to the amount of green space in the living environment, we only investigated whether loneliness and a smaller shortage of social support could explain the relation between green space and health.

We used three different health indicators to investigate this. Both loneliness and shortage of social support partially mediated the relation between green space and the different health indicators. Shortage of social support even completely mediated the relation between green space and self-rated propensity for psychiatric morbidity.

Strengths and limitations

Only few studies have investigated the relation between social contacts and green space (e.g. Ewert and Heywood, 1991; Kuo et al., 1998a) and, as far as we know, there are no other studies which also investigated the triad between green space, social contacts and different health indicators.

The data on health and social contacts were derived from a different database then the data on green space; consequently, there is no single source bias.

For our study, we used objective environmental measures. Objective environmental measures reduce the risks of respondent bias. However, subjective environmental measures can also provide important information. People's perception of green spaces may, in fact, motivate their behaviour more than the actual amount of available green space. Unsafe green spaces or green spaces with a low quality will be avoided by people. Thus, combining objective measures and measures of individual's perception will improve our understanding of how the green environment affects social contacts (Coley et al., 1997; Kuo et al., 1998a; Kweon et al., 1998).

Although the data used for this study have important advantages, they also have a few shortcomings. First of all, our data on green space, although assessed on a small scale, does not take small green spaces in the living environment into account. Only green space that has a dominant position in the 25 by 25 metre grid cell will be regarded as green space in the dataset. Small-scale green spaces, which have been shown to influence the strength of neighbourhood social ties and informal social contacts among neighbours in underprivileged areas in Chicago (Coley et al., 2007; Kuo et al., 1998a; Kweon et al., 1998).

Secondly, because of the cross-sectional design of the study, it is not possible to make a statement about the direction of causation. It is possible that people who like to have more social contacts chose to live in greener environments because these environments offer meeting opportunities.
A third limitation of the study is that we did not know if the social contacts of people took place in green environments. Future research should focus on whether green space is actually used as a place to meet others.
Some possibly important control variables could not be taken into account. Besides meeting opportunities, several other conditions are important for the development of local communities and social ties, namely 'individual motivation to invest in others in the group, alternatives to realize individual goals and interdependencies' (Flap and Völker, 2005; Völker et al., 2007), community attachment, community identity, social interaction, pedestrianism (Kim and Kaplan, 2004). In this study, we only focussed on meeting opportunities in the form of a green environment. It remains unknown how the other conditions influence the relation between green space and social contacts.

Conclusion

It is widely recognised that social relationships can influence several health outcomes. Furthermore, there is increasing evidence for a positive relation between green space and health and there are indications of a positive relation between the amount of green space in the living environment and social relationships. However, it was unknown whether social contacts are a possible factor mediating the relation between green space and health.
This study indicates that the amount of green space in the living environment is not only related to people's health condition but is also positively related to people's feelings of loneliness and shortage of social support, especially for children, elderly, and people with a lower economic status. Furthermore, both feelings of loneliness and shortage of social support partially mediated between the relation between green space and health.

Part III

Green space and social safety

7

Is green space in the living environment associated with people's feelings of social safety?

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Abstract

This study investigates whether the percentage of green space in people's living environment positively or negatively affects their feelings of social safety. More specifically, we investigated the extent to which this relationship varies between urban and rural areas and between groups in the community that can be identified as more or less vulnerable, and the extent to which different types of green space exert different influences.

The study includes 83,736 Dutch citizens who were interviewed about their feelings of social safety. The percentage of green space in the living environment of each respondent was calculated and data were analysed using a three-level latent variable model, controlled for individual and environmental background characteristics.

Our analyses show that more green space in people's living environment is associated with enhanced feelings of social safety, except in very strongly urban areas, where enclosed green spaces are associated with reduced feelings of social safety.

Contrary to the common image of green space as a dangerous hiding place for criminal activity that causes feelings of insecurity, our study suggests that green space generally enhances feelings of social safety. The results also suggest, however, that green space in the most urban areas is a matter of concern where social safety is concerned.

Introduction

There is increasing attention towards and evidence for a positive relationship between the amount of green space in people's living environment and people's health. Several studies have shown that a more natural living environment is positively related to people's self-reported health and leads to lower mortality risks (De Vries et al., 2003; Maas et al., 2006; Mitchell and Popham, 2007; Nielsen and Hansen, 2007; Takano et al., 2002), but there might be another side to this coin, as natural spaces are also often regarded as unsafe places. In this paper, therefore, we investigate the relationship between the availability of green space and people's feelings of safety.

Feelings of social safety

Feeling safe is a prerequisite for well-being, quality of life and good health (Chivite-Matthews and Maggs, 2002; Green et al., 2002). Safety can be judged both objectively (safety measured by facts and figures) and subjectively (perceived safety experienced by the individual) (Van Winsum-Westra and De Boer, 2004). This paper is concerned with subjective social safety. Social safety refers to safety resulting from human behaviour and interactions between people in public space (Van Winsum-Westra and De Boer, 2004). Objective social safety may differ from subjective social safety but, in terms of behavioural constraints, it is subjective safety that influences behaviour and that causes people to avoid places that they associate with insecurity.

Both individual as well as neighbourhood characteristics affect feelings of social safety. Some environments feel safer than others (Hale et al., 1994). The role of green space appears ambiguous, however. On the one hand, green space can be perceived as dangerous, because it may facilitate crime by providing a hiding place for perpetrators and criminal activity (Herzog and Flynn-Smith, 2001; Van Winsum-Westra and De Boer, 2004). On the other hand, studies from the US suggest that exposure to some types of natural environments may actually enhance feelings of social safety in a neighbourhood, because green space can reduce feelings of anger, frustration and aggression, as well as increase surveillance (Kuo and Sullivan, 2001a; Kuo and Sullivan, 2001b). The aim of this present study is to investigate whether green space positively or negatively affects feelings of social safety. In addition to investigating the general relationship, we will

also study whether this relation varies between urban and rural areas and between different population categories (men/women, old/young). These issues are explained more specifically and hypotheses are formulated in the following section.

Level of urbanity

Urban and rural areas constitute different kinds of environments in which to examine feelings of social safety. Rural areas are more sparsely populated, have a different population (fewer young adults, one-person households and ethnic minorities, for example), and are often seen as harmonious, peaceful, tranquil, closely-knit communities with lots of green space (Little et al., 2005; Steenbekkers et al., 2006; Valentine, 1997). As a consequence, rural areas are usually regarded as being safer areas than urban areas (Francis, 1999; Little et al., 2005; Oppelaar and Wittebrood, 2006). Urban green spaces are often regarded as unsafe, due to the allegedly poorer standard of maintenance (Jorgensen et al., 2002), and because they can provide potential hiding places for criminals (Herzog and Chernick, 2000; Nasar and Fisher, 1993; Nasar et al., 1993).

In conclusion, the reduced feelings of safety and the higher crime rates in urban settings, combined with our expectation that the nature of rurality will positively influence the way people living in these areas experience their feelings of safety, led to the following hypothesis.

Hypothesis 1: *People living in urban areas with more green space will feel less safe than people living in rural areas with more green space.*

Vulnerable population groups

Little is known about whether the relationship between green space and feelings of social safety varies between population groups. Nor is it known whether the more vulnerable population groups in society feel less safe with more green space nearby. Literature on feelings of social safety in green environments has shown that particularly women, elderly and ethnic minorities feel unsafe in green environments (Van Winsum-Westra and De Boer, 2004). Women mainly fear sexual assault; the safety concerns of the elderly are heightened by their perceived frailty, reduced mobility and sense of vulnerability; and the safety concerns of ethnic minorities are mainly related to fear of racial aggression (Burgess, 1988; Jorgensen et al., 2002; Jorgensen and Anthopoulou, 2007; Koskela, 1997; Koskela and Pain, 2000;

Madge, 1997). Safety concerns are often a major factor that limits the use of green urban spaces and woodlands (Burgess, 1988; Madge, 1997).
This leads to the following hypothesis.

Hypothesis 2: *Women, elderly people and members of ethnic minorities feel less safe in green environments than other population groups.*

Type of green space

Another relevant issue is the type of green space. Several studies have shown that open green space (green spaces that preserve visibility) increases feelings of social safety, as opposed to closed green space (green spaces that do not preserve visibility), due to the higher visibility of potential dangers (Hanyu, 2000; Herzog and Chernick, 2000; Herzog and Flynn-Smith, 2001; Herzog and Kutzli, 2002; Jorgensen et al., 2002; Kuo et al., 1998b; Kuo and Sullivan, 2001b; Müderrisoglu and Demir 2004). This leads to the following hypothesis.

Hypothesis 3: *Open green spaces are positively related to feelings of social safety, whereas closed green spaces are negatively related to feelings of social safety.*

Most research on the relationship between green space and feelings of social safety uses qualitative methods and tends to focus on specific green spaces, such as local parks or forests in local settings (Hanyu, 2000; Herzog and Chernick, 2000; Herzog and Kutzli, 2002; Jorgensen et al., 2002). Based on a systematic search in Web of Science we can conclude that this is the first quantitative study that focuses on the relationship between the amount of green space in the living environment and feelings of social safety. Quantitative studies can improve our understanding of general patterns and differences between subgroups of the population. They can improve the basis for informed policy making, can identify people and places for in-depth studies and they can also place locally specific qualitative research in a more general context.

Methods

Data

We used four different datasets for the purposes of this study. The data on feelings of social safety were taken from the Police Population Monitor 2001 (n=88,607; non-response 28%).

This is a nationwide representative telephone survey commissioned by the Netherlands Ministry of the Interior and Kingdom Relations, and the Ministry of Justice. It is held every two years among a randomly selected sample of approximately 90,000 people and focuses on differences in crime rates, feelings of social safety and opinions on the police (PMB 2001). Environmental data were derived from the National Land Cover Classification database (LGN4), which contains the dominant type of land use for each 25 by 25 metre grid cell in the Netherlands for the year 2001 (De Wit and Clevers, 2004). A 25 by 25 metre grid cell is only regarded as green space when the cell is dominated by green space. As a consequence, smaller green areas, like trees along a road or small bushes situated near built-up areas are not regarded as green space.

The availability of green space is our main variable of interest. However, there may be other environmental factors that also affect social safety. Data on these other environmental factors were derived from Statistics Netherlands and from the Living Environment Database of the Netherlands Ministry of Housing, Spatial Planning and the Environment, and related to the years 2001 and 1998 (in some cases). All were measured at 4-digit postal code level.

The four different datasets were geographically linked on the basis of 4-digit postal codes. The Netherlands is divided into 4,000 4-digit postal codes. A 4-digit postal code in the Netherlands represents an average of 1,772 households. The 4-digit postal codes often correspond with neighbourhoods in urban areas, whereas they sometimes represent a whole village in rural areas. Only respondents with no missing data were included in the analysis (83,736).

Measures

Data at individual level

Feelings of social safety

The dependent variable in our analyses is a measure of feelings of social safety experienced in the general population. People were asked to answer

the following questions about their feelings of social safety.

- How often do you feel unsafe?
- How often do you avoid places, because you think they are unsafe?
- How often do you not open the door at night, because you think it is unsafe?
- How often do you leave valuable things at home, because you are afraid they will get stolen outside?
- How often do you make a detour to avoid unsafe places?

The first item is a general question about people's feelings of social safety, whereas the other four items are concerned with people's actual behaviour on account of their feelings of insecurity. The answers that could be given were: often (1); sometimes (2); or never (3). A higher score meant that people felt safer. The items were used to construct a scale for feelings of social safety in a multilevel model. The internal consistency of the scale at the individual level depends on the degree of intercorrelation among the items and the number of items on the scale (Raudenbush, 1991) and ranges from 0 to 1, as does Cronbach's Alpha. The internal consistency of the scale at individual level is 0.92, which indicates that it is a good scale. All items contribute differently to the scale of social safety and were therefore taken into account as control variables in the model.

Demographic and socio-economic characteristics of respondents

The following demographic and socio-economic characteristics of the respondents were taken into account, because they could potentially affect feelings of social safety: gender (male=0; female=1), age (divided into four categories, viz. 15-25, 26-45, 46-65, 65+), ethnicity (0=native Dutch; 1=ethnic minorities), highest level of completed education (as an ordinal variable), work situation (0=paid job; 1=no job), living in an owner-occupied or rented home (owner occupied home=0; rented home=1) (see table 7.1). The last three variables were included to control for the socio-economic status of the individual. People with a lower socio-economic status often feel less safe because they feel economically unprotected against the consequences of becoming a victim (Luymes and Tamminga, 1995; Oc and Tiesdell, 1997).

Table 7.1 Percentual distribution or mean (standard deviation) of characteristics of the study population (n=83,736)

	M (SD)
Demographic characteristics:	
Gender	
female	53.0%
male	47.0%
Age	
26-45	8.3%
46-65	37.3%
65+	33.8%
15-25	20.6%
Socio-economic characteristics:	
level of education	4 (1.8)
ethnic minority	3.4%
native Dutch	97.0%
unemployed	56.5%
employed	43.5%
rented home	35.8%
owner-occupied home	64.2%
Level of urbanity:	
very strongly urban	15.4%
strongly urban	26.5%
moderately urban	19.2%
rural areas	34.2%

Data at postal code level

Green space

Information on the percentages of green space was derived from the LGN 4 database. The LGN 4 database distinguishes 39 categories of land use, including crop types, forest types, water, grass areas, various built-up areas, railways and main roads, and is a database which has proven to be valid, accurate and reliable (De Wit and Clevers, 2004; Thunnissen and De Wit, 2000).

The total percentage of green space was calculated for each 4-digit postal code sector and included all urban green, agricultural green, forests and nature conservation areas.
The National Landcover Classification Database distinguishes between open green spaces and closed green spaces. Open green spaces include grass areas, grass areas in built-up environments, open sand in costal areas, open dune vegetation, riparian areas, dune heath, heath, etc. Closed green spaces include forests of all kinds (coniferous forests, deciduous forests) in built-up and non built-up environments, and closed dune vegetation. Parts of a park that are characterised by grass areas are regarded as open green for example, whereas parts of a park that are characterised by forest types are regarded as closed green. Table 7.2 gives an overview of the average and standard deviation of the percentage of green space at different levels of urbanity. The level of urbanity (high-low) was strongly positively related to the total percentage of green space (r=.73), but there is no excessive colinearity.

Table 7.2 Mean (standard deviation), minimum and maximum of the percentage of green space per level of urbanity

	Level of urbanity							
	Very strongly urban		**Strongly urban**		**Moderately urban**		**Non urban**	
	mean (sd)	min./ max.	mean (sd)	min./ max.	mean (sd)	min./ max.	mean (sd)	min./ max.
% of green space	17.6% (17.3%)	0%/ 96.1%	33.6% (26.3%)	0%/ 99.7%	55.2% (24.3%)	1.45%/ 98.6%	78.4% (16.3%)	2.96%/ 98.6%
% of open green space	10.1% (13.3%)	0%/ 96.1%	25.2% (23.2%)	0%/ 97.8%	42.2% (23.4%)	0.4%/ 96.4%	68.4% (19.6%)	1.1%/ 97.5%
% of closed green space	7.4% (8.4%)	0%/ 42.8%	8.4% (11.6%)	0%/ 90.1%	13.0% (16.5%)	0%/ 83.2%	9.9% (11.5%)	0%/ 84.9%

Measure of urbanity

The levels of urbanity we used were based on the number of households per square kilometer within the municipality and are widely used in the Netherlands (Den Dulk et al., 1999). The original classification consists of five categories: (1) very strongly urban (over 2,500 addresses per km²); (2) strongly urban (1,500-2,500 addresses per km²); (3) moderately urban (1,000-1,500 addresses per km²); (4) slightly urban (500-1,000 addresses per km²); and (5) non-urban (less than 500 addresses per km²), but we grouped

slightly urban and non-urban municipalities into one category for the purposes of this study. These two levels are often combined in the Netherlands to describe rural areas (LNV, 2004; Steenbekkers et al., 2006).

Aspects of the living environment that can cause feelings of social insecurity

When investigating the relationship between feelings of social safety and the amount of green space in a person's living environment, it is important to rule out other environmental factors that could influence feelings of social safety in the living environment. People tend to feel less safe in environments with elevated crime rates. Crime rates are related to the relative size of the male population and percentages of adolescents, young adults and ethnic minorities, i.e. groups that are at higher risk of becoming offenders and victims of crime (South and Messner, 2000; Wilcox et al., 2003; Wittebrood and Oppelaar, 2005), which led us to include the percentage of females, the percentage of people aged 15-24 and the percentage of ethnic minorities in the postal code area. Another part of the variation in crime levels is related to socio-economic neighbourhood characteristics, such as concentrated poverty and residential instability (measured by levels of home ownership and residential mobility) (Sampson and Raudenbush, 1999). Both characteristics of the postal code area were taken into account. Concentrated poverty was operationalised as the average gross monthly income of the households (in euros). Residential stability was measured by the percentage of rented homes as well as the number of households that moved within, or to or from the municipality per year, expressed as a percentage of the total number of households.

Research also indicates that there are some places which are empirically associated with high levels of crime, such as restaurants, bars or pubs, hotels and areas with shopping centres (Eck and Weisburd, 1995) therefore we included these environmental factors as well. The number of cafés, the number of hotels and the number of restaurants were all measured per 100 households, while the percentage of shops was measured as a percentage of the number of units of real estate.

Design/statistical analyses

We explored seven variations of a three-level latent variable model in order to study the relationship between the amount of green space in people's living environment and feelings of social safety. This model was used for several reasons. A multilevel model was used in order to account for

clustering within the different levels in the data. A three-level hierarchical model was used that distinguished between individuals nested within environments and responses to different scale items within individuals. The latter level was included as an alternative to the more common solution of combining the item scores at individual level into one indicator for social safety. This was considered a more appropriate way of measuring people's feelings of social safety, while using different items, because it generates an average score for feelings of social safety, controlling for individual and environmental characteristics, which increases reliability (Raudenbush, 2003).

In short, the first level of the model (item level) serves as a measurement model; it describes the linkage between the items of feelings of social safety and the latent true scores for each person. The regression coefficients of the items indicate to what extent the average score on the items deviates from the general average on the feelings of social safety scale. The coefficients cannot be interpreted the same way as the variables which haven been taken into account at individual and postal code level.

The two highest levels of the model may be viewed as a two-level model predicting the latent true scores. At the second level (individual level), the true scores are the outcomes estimated at the individual level based on the scores on the individual items. It shows the variation between individuals within postal code areas. The third level shows the variance between postal code areas (Raudenbush and Sampson, 1999).

Likelihood ratio test were used to compare the explanatory power of the more complicated model with the previous ones; the lower the value, the better the explanatory power. The estimates of the variables in the model are related to the average on the five items of the scale. The analyses were performed with MLwiN 2.0.

Results

Green space and feelings of social safety

The first model includes all background and control variables at individual and postal code levels. The percentage of green space was added in the second model. The results show that the percentage of green space positively influences feelings of social safety. People with more green space in their living environment feel safer.

Adding the percentage of green space to the model reduces the variance at postal code level, while the variance at individual level remains the same, which indicates that the relationship between the percentage of green space and feelings of social safety is the same for everybody living in the same postal code area. The relation between green space and feelings of social safety is more a relation on environmental level than a relation on individual level, which means that people will feel equally unsafe in an postal code area with the same amount of green space, regardless of their gender or age. A comparison of the variance between model 1 and model 2 shows that green space explains 8.3% of the variance at postal code level that remained after controlling for all control variables at individual and postal code level (see table 7.3).

Strength of the relationship

The relationship between green space and feelings of social safety is relatively strong (table 7.3, model 2). It is comparable with the relationship with the number of rented houses or the percentage of people in the postal code area aged 15-25, both of which indicators are considered to be important factors influencing feelings of social safety (South and Messner, 2000). The effect of 10% more green space is approximately equal to that of 10% fewer rented houses and 5% fewer people aged 15-25. Figure 7.1 visualises the results from the regression models on the strength of the relationship between green space and people's feelings of social safety.

Relationship between social safety and green space at different levels of urbanity

We used the third model (table 7.3) to examine the relationship between the percentage of green space and feelings of social safety at each level of urbanity (hypothesis 1).

Adding the relationship between the percentage of green space and feelings of social safety at each level of urbanization significantly increased the explanatory power of the model. The difference between -2*log likelihood chi square values of model 2 and 3 is 40 ($df=3$, $p<0.001$), so that the relationship between green space and feelings of social safety should apparently be considered in its urban or rural context.

Figure 7.1 Feelings of social safety by percentage of green space, percentage of rented houses and percentage of people aged between 15-25 based on the three-level latent variable model of table 3, model 2 (controlled for demographic and socioeconomic characteristics at individual and area levels)

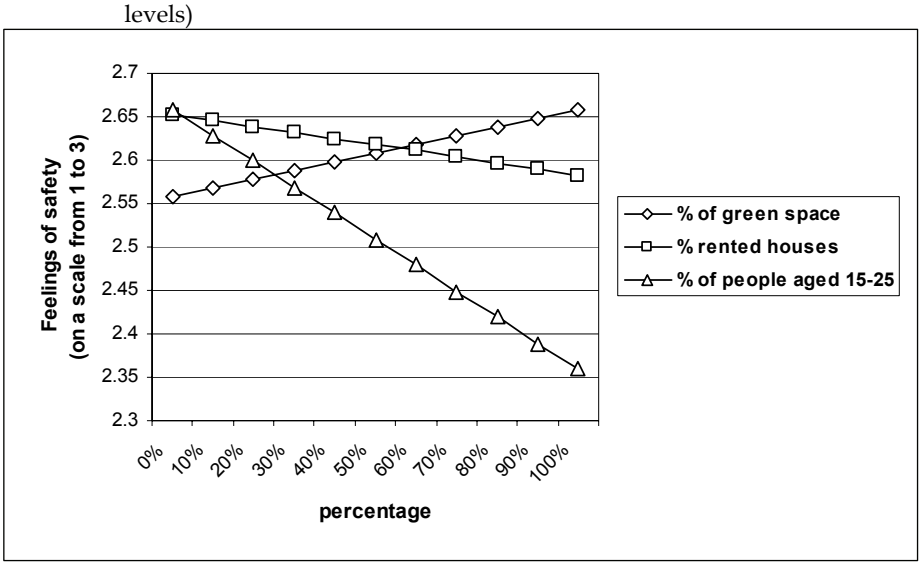


Table 7.3 Relation between green space and feelings of safety by level of urbanity, controlled for demographic and socioeconomic characteristics at individual and area levels: parameters and standard errors

	Feelings of social safety		
	Model 1: feelings of social safety	**Model 2: total % of green space**	**Model 3: total % of green space per level of urbanity**
Average feeling of social safety	2,622 (0.002) ***	2,624 (0.002) ***	2,614 (0.003) ***
Item level:			
item 1: Feeling unsafe in general	Reference category		
item 2: Avoiding places	-0.1017 (0.002) ***	-0.1017 (0.002) ***	-0.1017 (0.002) ***
item 3: Not opening the door at night	-0.1706 (0.003) ***	-0.1706 (0.003) ***	-0.1706 (0.003) ***
item 4: Leaving valuable things at home	-0.1812 (0.003) ***	-0.1812 (0.003) ***	-0.1812 (0.003) ***
item 5: Making a detour to avoid unsafe places	-0.0680 (0.003) ***	-0.0680 (0.003) ***	-0.0680 (0.003) ***

- table 7.3 continues -

- table 7.3 continued -

	Feelings of social safety		
	Model 1: feelings of social safety	**Model 2: total % of green space**	**Model 3: total % of green space per level of urbanity**
Individual level:			
female	-0.237 (0.003)***	-0.237 (0.003)***	-0.237 (0.003)***
male	Reference category		
age 26-45	0.023 (0.006) ***	0.023 (0.006) ***	0.023 (0.006) ***
age 46-65	-0.009 (0.006)	-0.009 (0.006)	-0.009 (0.006)
age 65+	0.008 (0.007)	0.008 (0.007)	0.001(0.007)
age 15-25	Reference category		
level of education	-0.011 (0.001) ***	-0.011 (0.001) *	-0.011 (0.001) *
ethnic minority	-0.006 (0.008)	-0.006 (0.008)	-0.006 (0.008)
native Dutch	Reference category		
unemployed	-0.040 (0.004) ***	-0.040 (0.004) ***	-0.040 (0.004) ***
employed	Reference category		
rented home	-0.024 (0.003) ***	-0.024 (0.003) ***	-0.024 (0.003) ***
owner-occupied home	Reference category		
Postal code level:			
% people aged 15-24	-0.004 (0.0008) ***	-0.003 (0.0008) ***	-0.003 (0.0008) ***
% women	-0.008 (0.001)***	-0.006 (0.001) ***	-0.005 (0.001) ***
% ethnic minority	-0.004 (0.0002)***	-0.004 (0.0002) ***	-0.004 (0.0002) ***
% rented houses	-0.0008 (0.0002)***	-0.0007 (0.0002) ***	-0.0007 (0.0002) ***
% of households that moved within, to or from the municipality	-0.0002 (0.0001)	-0.0001 (0.0001)	-0.0001 (0.0001)
% shops of the total number of real estate units	-0.563 (0.110) ***	-0.313 (0.110) ***	-0.382 (0.120) ***
number of cafés per 100 households	-0.243 (0.046) ***	-0.243 (0.046) ***	-0.230 (0.046) ***
number of hotels per 100 households	0.630 (0.097) ***	0.579 (0.097) ***	0.543 (0.095) ***
number of restaurants per 100 households	0.065 (0.038)	0.069 (0.038)	0.076 (0.037) **
average gross monthly income	-0.00001 (0.000)**	-0.00001 (0.000)**	-0.00001 (0.000)**
very strongly urban	-0.128 (0.010) ***	-0.090 (0.010) ***	-0.135 (0.018) ***
strongly urban	-0.139 (0.007) ***	-0.109 (0.008) ***	-0.102 (0.008) ***
moderately urban	-0.085 (0.007) ***	-0.067 (0.007) ***	-0.062 (0.007) ***
rural areas	Reference category		

- table 7.3 continues -

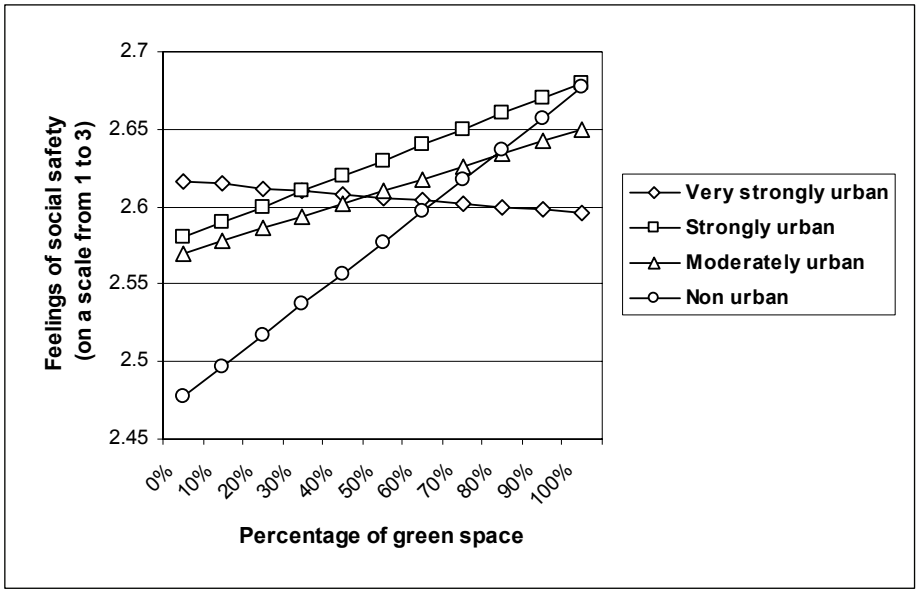
- table 7.3 continued -

	Feelings of social safety		
	Model 1: feelings of social safety	**Model 2: total % of green space**	**Model 3: total % of green space per level of urbanity**
% green space		0.001 (0.0001) ***	
% green space in very strongly urban areas			-0.0002 (0.0003)
% green space in strongly urban areas			0.001 (0.0002) ***
% green space in moderately urban areas			0.0008 (0.0002) ***
% green space in rural areas			0.002 (0.0002) ***
Variance item level:			
item 1: Feeling unsafe in general	0.2159 (0.0013)	0.2159 (0.0013)	0.216 (0.0013)
item 2: Avoiding places	0.2522 (0.0015)	0.2522 (0.0015)	0.2522 (0.0013)
item 3: Not opening the door at night	0.4705 (0.0025)	0.4705 (0.0025)	0.4704 (0.0013)
item 4: Leaving valuable things at home	0.4734 (0.0025)	0.4734 (0.0025)	0.4732 (0.0013)
item 5: Making a detour to avoid unsafe places	0.2224 (0.0013)	0.2224 (0.0013)	0.2224 (0.0013)
Variance individual level	0.121 (0.0009)	0.121 (0.0009)	0.121 (0.0013)
Variance postal code level	0.0036 (0.0003)	0.0033 (0.0003)	0.0032 (0.0013)
-2*log likelihood	784,090	784,017***	783,977***

* p≤0.05; ** p≤0.01; *** p≤0.001

Model 3 (table 7.3) shows that there is a significant positive relationship between green space and feelings of social safety at all levels of urbanity, except in the very strongly urban areas. In all areas, with the exception of very strongly urban areas, people tend to feel safer when they have more green space in their living environment. In very strongly urban areas, the amount of green space in people's living environment is negatively related to their feelings of social safety, although the relation is not a significant one. Figure 7.2 visualises the results from the regression models on the relationship between green space and people's feelings of social safety at the different levels of urbanity.

Figure 7.2 Feelings of social safety by percentage of green space per level of urbanity based on the three level latent variable model of table 7.3, model 3 (controlled for demographic and socioeconomic characteristics at individual and area levels)



Vulnerable population groups and feelings of social safety

It was hypothesized (hypothesis 2) that vulnerable population groups would feel less safe in green environments. We used models 4 and 5 (table 7.4) to examine the relationship between green space and feelings of social safety for men and women respectively, and for different age groups. Contrary to our expectations, women with more green space in their living environment feel safer (table 7.4, model 4). In the very strongly urban areas, however, this relation is not significant. Feelings of social safety among men were generally unaffected by the amount of green space in the living environment.

Again contrary to our expectations (table 7.4; model 5), elderly people feel safer when there is more green space in their living environment, except in the very strongly urban areas, where there is no such relation. Furthermore, people aged 15-25 feel less safe in very strongly urban areas when there is more green space in their living environment.

Table 7.4 Relation between green space and feelings of social safety by gender and age per level of urbanity, controlled for demographic and socioeconomic characteristics at individual and area levels: parameters and standard errors

	Feelings of social safety			
	Very strongly urban areas	**Strongly urban areas**	**Moderately urban areas**	**Rural areas**
Model 4:				
% of green space * female	0.00008	0.0015	0.0013	0.0026
	(0.0003)	(0.0002)***	(0.0002)***	(0.0003)***
% of green space * male	-0.0005	0.0004	0.0002	0.0004
	(0.0003)	(0.0002)	(0.0002)	(0.0002)
Model 5:				
% green space * people aged 15-25	-0.001	0.0002	0.0007	0.0001
	(0.0004)***	(0.0003)	(0.0005)	(0.0005)
% green space * people aged 26-45	-0.0005	0.0009	0.0006	0.001
	(0.0003)	(0.0002)*	(0.0002)**	(0.0003)***
% green space * people aged 46-65	0.0006	0.001	0.001	0.002
	(0.0003)	(0.0002)***	(0.0003)***	(0.0003)***
% green space * people aged 65+	-0.00003	0.0008	0.0007	0.002
	(0.0003)	(0.0002)**	(0.0003)*	(0.0004)***

* p≤0.05; ** p≤0.01; *** p≤0.001

Type of green space

It was hypothesised (hypothesis 3) that open green spaces are positively related to feelings of social safety, while closed green spaces are negatively related to feelings of social safety, and so the relation was analysed for different types of green spaces, taking the urban-rural setting of each type of green space into account. In models 6 and 7 (table 7.5), we examined the relationship between open and closed green space respectively and feelings of social safety.

The results of this analysis confirm our hypothesis and show a positive relationship between open green space in the living environment and feelings of social safety, except in the very strongly urban areas, where this relationship is absent (table 7.5, model 6).

Closed green space seems to be positively related to feelings of social safety, but not in the most urban areas, where closed green space is negatively related to feelings of social safety (table 7.5, model 7). Figures 7.3 and 7.4 visualise the results from the regression model for the relationship between open and closed green space respectively and people's feelings of social safety at different levels of urbanity.

Figure 7.3 Feelings of social safety by percentage of open green space per level of urbanity based on the three level latent variable model of table 5, model 6 (controlled for demographic and socioeconomic characteristics at individual and area levels)

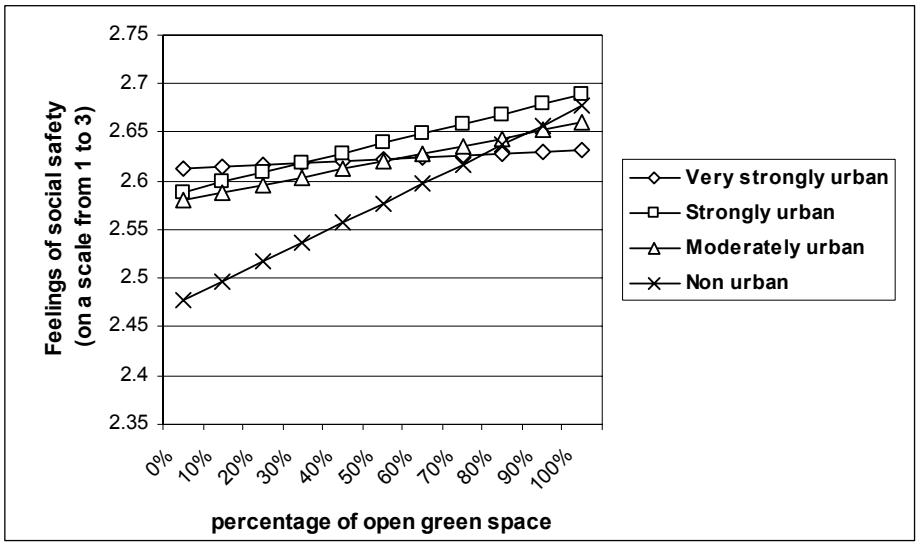


Figure 7.4 Feelings of social safety by percentage of closed green space per level of urbanity based on the three level latent variable model of table 5, model 7 (controlled for demographic and socioeconomic characteristics at individual and area levels)

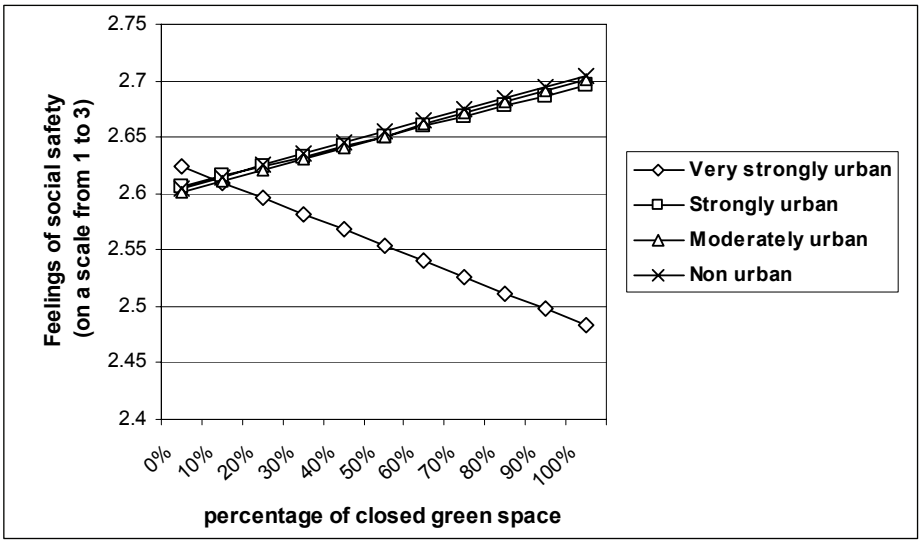


Table 7.5 The relation between the percentage of open or closed green space on feelings of social safety per level of urbanity, controlled for demographic and socioeconomic characteristics at individual and area levels: parameters and standard errors

	Feelings of social safety	
	Model 6: % of open green space per level of urbanity	**Model 7: % of closed green space per level of urbanity**
% open green space in very strongly urban areas	0.0002 (0.0004)	
% open green space in strongly urban areas	0.001 (0.0002)***	
% open green space in moderately urban areas	0.0008 (0.0002)***	
% open green space in rural areas	0.002 (0.0002)***	
% closed green space in very strongly urban areas		-0.0014 (0.0007)*
% closed green space in strongly urban areas		0.0009 (0.0004)*
% closed green space in moderately urban areas		0.0010 (0.0004)**
% closed green space in rural areas		0.0010 (0.0003)***

* p≤0.05; ** p≤0.01; *** p≤0.001

Conclusion and discussion

This study examined the relationship between the percentage of green space in the living environment and feelings of social safety and has led us to conclude that green space in people's living environment is generally associated with enhanced feelings of social safety. This relationship is concurrent with the positive relationship between green space and people's health that was found in the literature. Closed green space was only found to increase feelings of insecurity in very strongly urban areas, a conclusion which has implications for spatial planning. Investing in green space not only makes people healthier, but also helps to make them feel safer.

In contrast to the findings of Kuo and Sullivan (2001b), we found that the positive relationship with social safety is not restricted to open green spaces in strongly urban areas, moderately urban areas and rural areas. This may be due to differences in measurement and the interpretation of measurements in the Dutch setting. Treed spaces were classified as closed green spaces in our study, while treed spaces that preserve visibility are classified as open green space in the Kuo and Sullivan study (2001b).

Although this study has implications for spatial planning, further research is needed to translate some of the findings into clear cut guidelines for decision-making in urban planning. It is unknown, first of all, why closed green spaces in very strongly urban areas are associated with increased feelings of insecurity, while they are associated with enhanced feelings of social safety at all other levels of urbanity. This might be due to the size of buildings in very strongly urban areas with lots of green space. Buildings in these areas are likely to be larger, higher and more compact, which are building characteristics which are known to affect fear of crime (Newman and Franck, 1982). Furthermore, it might be associated with poorer levels of maintenance of green areas in very strongly urban areas. The maintenance of green spaces is important for people's feelings of social safety and disorder in the form of graffiti, garbage and vandalism diminishes feelings of social safety. These are forms of disorder that are more common in more urban areas (Burgess, 1988; Madge, 1996; Van Winsum-Westra and De Boer, 2004). Further research is required to investigate whether, building size and deprivation in neighbourhoods in very strongly urban areas influences the relationship between green space and feelings of social safety.

A second finding that requires further research is the finding that women and elderly people feel safer in living environments with more green space. Our findings cannot be explained by selective non-response, since the different age groups and both men and women are well represented and reasons for refusing to participate were not related to the subject of the questionnaire.

Previous research has given clear indications that women and elderly people actually feel unsafe in green environments (Burgess, 1988; Jorgensen et al., 2002; Jorgensen and Anthopoulou, 2007; Koskela, 1997; Koskela and Pain, 2000; Madge, 1997), but the present study indicates that green space in the living environment is associated with overall enhanced feelings of safety. Further research is required, therefore, to discover why women and the elderly feel safer in living environments with more green space.

Strengths and limitations of the study

This is the first study based on a large dataset to explore the relationship between the amount of green space in the living environment and feelings of social safety. The data on feelings of social safety and the land use data were derived from different datasets and there is no single source bias as a consequence. The data used for this study were not originally collected to

measure the relationship between the amount of green space in people's living environment and feelings of social safety. As a consequence we had to work with 4-digit postal code sectors to calculate the percentage of green space which might be regarded as a rather crude measurement. Data at neighbourhood or 6-digit postal code sector level would perhaps have been better, but the necessary data were not available. Reijneveld et al. (2000), however, found that the choice between neighbourhoods and postal code sectors hardly affected the outcomes in a study on small area differences in health in the city of Amsterdam.

Although the data used for this study have several advantages, they also have a few shortcomings. First of all, our data on green space - although assessed on a small scale - does not take small green spaces in the living environment into account. Only green space with a dominant position in the 25 by 25 metre grid cell was regarded as green space in the dataset. Small bushes around a block of houses may be relevant to feelings of social safety, but could not be taken into account in this study. Secondly, our measure of feelings of social safety is rather general and not necessarily related to people's direct living environment. Furthermore, the questionnaire did not provide insight into where, at what time, and why people felt unsafe. Further research should use more specific questions, including questions on time and place, and qualitative approaches that contextualize and measure feelings of social safety in neighbourhoods with varying amounts of green space.

We were only able to look at a limited set of possibly confounding environmental characteristics in this study. Furthermore, no information was available on the quality of the green areas. Specific factors like maintenance of green areas, social cohesion and sense of anonymity may shed more light on the negative relation for closed green spaces in very strongly urban areas and should be taken into account in future research. Likewise, we could only investigate the relationship for some vulnerable groups (women and elderly) in the population. Future studies should differentiate between ethnic groups, people with mental illnesses, disabled people, and lower socio-economic groups for example. Moreover, this study could not specify how much square metre green space is needed to enhance feelings of social safety, since it only provides insight into the general relationship between the percentage of green space in the living

environment and feelings of social safety. Future research should study in more detail how much green space is needed and the specific type of green space necessary.

Part IV

Use of green space in the health care sector

8

Are health benefits of psychical activity in natural environments used in primary care by general practitioners in the Netherlands?

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Abstract

There is a growing body of literature showing that physical activity and nature positively influences people's health and well-being. Additionally literature indicates that there may even be a synergic benefit from being physically active whilst simultaneously being exposed to nature. This insight is used in recovery programmes for work related stress and mental health care settings. However, as primary care is usually people's first point of contact with the health care system, the greatest benefits for people's health can probably be obtained in primary health care settings. The aim of the present study is therefore to investigate to what extent general practitioners advise patients on physical activity and whether they refer to the additional health benefits of physical activity in a natural environment.

A secondary analysis was performed on a random sample of 2,784 video-taped patient consultations of 100 general practitioners in The Netherlands. Many characteristics of these consultations were known on the basis of earlier analyses: diagnosis, age and sex of patient and whether or not the issue of physical activity had been brought up by either patient or doctor. First, we investigated to what extent and with which health problems advice was given concerning physical activity. Second, from these consultations, a stratified sample of 100 consultations was observed in order to investigate whether an advice was given by the general practitioner concerning the additional benefits of nature.

In 26% of all consultations advice on physical activity was given by the general practitioner. Physical activity was mentioned more often in cases of vague complaints than in cases with a clear cut diagnosis. As could have been expected, physical activity was mentioned relatively frequently in cases of musculoskeletal complaints and complaints of the nervous system. The additional benefits of physical activity in natural environments was not mentioned during any of the consultations.

In conclusion, general practitioners regularly give advice on physical activity. However, they fail to mention that physical activity in nature areas might have additional health benefits. Given the fact that medical treatment is increasingly evidence based, we think the evidence for the health benefits of physical activity in nature needs to be stronger. Results from such research could eventually find their way into the guidelines of the general practitioners.

Introduction

Given the growing public health concern about obesity, diabetes and heart diseases, there is increasing attention for the benefits of physical activity for people's health and well-being (NIH Consensus Development Panel on Physical Activity and Cardiovascular Health, 1996; Oguma et al., 2002). In addition, there is also growing evidence of a positive relation between health and the amount of green space in people's environment (Maas et al., 2006). Combining these two positive relations of both physical activity and a natural environment with health, it seems only logical, that physical exercise in a natural environment should have additional benefits compared with physical exercise in an unnatural environment. Support for this last hypothesis was found by Hartig et al. (1991) and Pretty et al. (2005).
The aim of this study is to investigate to what extent advice on physical activity is given in primary care, and to what extent the additional benefits of physical activity in nature areas are used in primary care consultations.

Physical activity and health

There is a large body of evidence pointing towards the health benefits of regular physical activity (Oguma et al., 2002). All studies indicate that being physically active is good for people's health and/or well-being (Pate et al., 1995; US Department of HHS, 1996; NIH, 1996; Scully et al., 1998; Rütten, 2001). More specifically, the literature shows that physical activity can provide long-term protection against a range of illnesses. The most important and most frequently cited illnesses are coronary heart disease, hypertension, a number of cancers, type II diabetes, osteoporosis, anxiety and depression and all-cause mortality (Pate et al., 1995; Scully et al., 1998). Physical activity has an important role in health promotion and the prevention of disease (Scully et al., 1998; Booth et al., 2000).

Nature and health

There is also a growing body of literature on the relationship between the physical environment and people's health. The negative health effects of air pollution, bad housing and noise have been known for many years. On top of this, there seems to be a renewed consciousness about the positive health effects of a natural environment. A natural environment can include for example parks, forests, trees, public gardens, but also agricultural green space. In 2004, the Health Council of the Netherlands and the RMNO

concluded on the basis of an international literature review, that there are consistent cues for assuming a positive link between nature and health, though more research was needed. Most evidence comes from experimental psychological studies on the effect of nature on recovery from stress and attention fatigue. These studies suggest that nature has a positive effect on mood, concentration, self-discipline and physiological stress. Even after brief exposure to a natural environment, beneficial effects occur (Kaplan and Kaplan, 1989; Hull, 1992; Health Council of the Netherlands and RMNO, 2004). Ulrich, for example, showed in 1984 that patients with a view of trees recovered more quickly from a gall bladder operation than people who viewed a brick wall during their recovery (Ulrich, 1984). Research concerning American prisoners indicated that prisoners who had view over grass and forests less often reported ill, compared with prisoners whose cells faced a brick yard (Moore and Arch, 1982). Moreover, two large scale epidemiological studies show a positive relation between the amount of green space in people's living environment and self-reported health (De Vries et al., 2003; Maas et al., 2006).

Besides having positive effects on stress and attention restoration, nature might also influence the amount of physical activity. Natural environments are perceived as more attractive than built environments (Van den Berg et al., 2003). Therefore, green areas may act as an incentive for residents to undertake healthy physical activities such as walking or cycling or to choose these activities as a mode of transport, and to spend more time on them (Taylor et al., 1998).

Similar suggestions were made by Ellaway et al. (2005), who showed that people living in a green environment, have a three times higher probability of being physically active, and a 40% smaller probability of being overweight or obese. Furthermore, research in the Netherlands showed that children with more green in their living environment, fewer high rise buildings and more outdoor sports facilities were more physically active (De Vries et al., 2007).

Physical activity in a natural environment and health

The previous section shows that both physical activity and nature are positively related to people's health condition. Additionally, there are indications that being physically active in a natural environment has synergic effects on people's health as opposed to being physically active elsewhere. Hartig et al. (1991) found that walking in a natural environment

had significant better restorative effects than walking in urban surroundings. People who walked in a natural environment experienced a sense of being away, coherence, and compatibility to a higher degree than did people who went for a walk in a urban environment. The people who walked in a natural environment had higher ratings on overall happiness and lower ratings on anger and aggression scores. A study from Bodin and Hartig (2003) found that regular runners preferred the park to urban environments. The restorative effects were only slightly but not significantly higher in a park.
Pretty et al. (2005) showed that watching a rural pleasant environment while exercising indoor had the greatest effects in reducing blood pressure and in improving the mood as opposed to watching rural unpleasant and urban environments.

Use of health benefits of nature in health care settings
Summing up, there is reason to believe that the relation between physical activity and nature on the one hand and health on the other hand, can be used in health care settings. To some degree this is already happening in hospitals and nursing homes (Van den Berg, 2005). One example of the way in which nature is used in these health care sectors is through healing gardens. These healing gardens are, among other things, designed to make people feel safe, less stressed and more comfortable. Furthermore, agricultural farms are used as a basis for promoting human mental and physical health and social well-being. On these farms, animals, plants, the garden, the forest and the landscape are used in recreational or work related activities for different kinds of patients. The number of these farms is increasing rapidly in many countries (Hassink and Van Dijk, 2006).

Use of health benefits of physical activity in nature in primary care
The health benefits of physical activity in natural environments are also used in primary care in some countries. In the United Kingdom, initiatives for promoting physical activity in a natural environment started when an Oxfordshire general practitioner began prescribing outdoor exercise instead of valium for depressive illness in 1995. He started to see impressive results from his prescriptions. This resulted, among other things, in over 50 Green Gyms in the UK to date. Participants of Green Gyms exercise in the countryside or open spaces. Participants can also take part in conservation activities such as tree planting, hedge laying, fostering rare plants and

animals, restoring ancient downland. This offers an alternative for people who do not like the idea of joining a sports centre or gym (see Green Gym, 2007). A New Zealand study (Elley et al., 2003) showed that people who get written physical activity (PA) advice from their general practitioner are more physically active and have a better quality of life.
The above examples suggest that there are possibilities to use physical activity in nature areas for health promotion purposes in primary care settings. Primary care can play an important role in the prevention of obesity, stress related illnesses, diabetes, and heart disease. This is particularly true for countries where primary care doctors are providing continuous care for the whole population and where it is usually people's first point of contact with the health care system. However, the extent to which primary care patients are given advise on physical activity in natural environments is not known. In this paper we try to fill this gap by addressing the following sequence of questions:

1 *'To what extent do general practitioners offer advice on physical activities? Which health problems induce this type of advice?'*

2 *'To what extent does the likelihood of this type of advice depend on socio-demographic characteristics of the patient?'*

3 *'To what extent does the likelihood of this type of advice depend on characteristics of the general practitioner?'*

4 *'To what extent does this type of advice include any reference to nature or green space?'*

As primary care in the Netherlands is mainly a matter of general practices, it was decided to focus on patient consultations in general practice.

Methods

The data that were used for this study were derived from the Second Dutch National Survey of General Practice (DNSGP-2). Aim of DNSGP-2 was to monitor public health and health inequalities. The dataset includes data from a representative sample of 104 general practices, with 195 general

practitioners and about 350,000 patients (Westert et al., 2005). Within the framework of DNSGP-2, 2,784 consultations of general practitioners were videotaped with the aim to get more insight into the communication between general practitioners and their patients. Data collection took place in 2001.

Physical activity

In an earlier study, all video tapes were observed and scored on a number of aspects on the basis of validated observation protocols (Van den Brink-Muinen et al., 2004). One of the aspects on which the video tapes were judged, was whether or not a lifestyle recommendation concerning 'physical activity' was discussed during the consultation. In the remainder of this paper, this will be referred to as the presence of a PA advice.

Nature

The original observation protocols did not render information about whether or not nature areas or similar terms came up during the consultations. The videotapes needed to be viewed and judged again. There were 564 videotapes that contained PA advice. Of these, a random sample of 100 tapes were viewed again to see whether or not any reference was made to nature, green space, forests, or similar terms. A total of 10 of these tapes were also viewed by a second observer.

Diagnoses

For each consultation, symptoms/diagnoses were recorded by the general practitioner using the International Classification of Primary Care (ICPC) (Lamberts and Wood, 1987). This is a classification with 17 chapters on the basis of 17 functions of the body. In each chapter a distinction is made between symptoms and diagnosis codes. Symptom codes are used if a general practitioner is unable to diagnose a patient. A stomach ache that a general practitioner can not diagnose, will be recorded simply as a stomach ache (symptom). In a later consultation he or she might diagnose it as appendicitis (diagnosis).

Patient characteristics

The following patient characteristics have been taken into account to examine to what extent the likelihood of PA advice depends on characteristics of the patient: gender, age (0–15, 16–25, 26–40, 41–55, 56–65,

465), level of education (no education, elementary school, high school, higher education/university) or type of health insurance (public or private). The type of health insurance has been taken into account, because it can be regarded as an indicator of socio-economic status in The Netherlands, with public insurance for about 60% of the population (lower incomes) and private insurance for the rest (higher incomes) (WHO, 1997). These characteristics are taken into account because they are all closely related to people's health condition and to their level of physical activity.

General practitioners characteristics

The following general practitioner characteristics have been taken into account to examine to what extent the likelihood of PA advice depends on characteristics of the general practitioner: gender, age (30–39, 40–49, 50–59, 60–69 years), type of practice (single handed, duo or group) and number of working hours (expressed in fulltime equivalents [fte]). Furthermore, we investigated whether the likelihood of PA advice depends on the level of urbanity of the practice location. The level of urbanity is divided into five levels ranging from very highly urban (1) to non-urban (5). The indicator is based on the number of households per square kilometre and is commonly used in the Netherlands (Den Dulk et al., 1999).

Analyses

The analyses concerning patient and general practitioner characteristics were limited to those complaints that are theoretically related to people's level of physical activity. In this manner we were able to account for differences in prevalence between different patient categories and differences in the case mix of general practitioners. The following complaints were selected: fatigue, high blood pressure, overweight, diabetes, complaints concerning the musculoskeletal apparatus and mental complaints. After making this selection 829 consultations remained.

The data were analysed using the SPSS software package. Tests for significance were performed using Chi-square tests and ANOVA.

Results

Physical activity

In 26% of all consultations, the general practitioner gave an advice concerning physical activity (564 consultations). This type of advice occurred most frequently in patients with musculoskeletal problems (figure 8.1).

As could have been expected, the top 15 complaints in which PA advice is given mainly involve musculoskeletal complaints and illnesses. However, PA advice was also given in cases of high blood pressure, cough, stomach ache and dizziness (table 8.1).

PA advice was more often given in cases where the general practitioner was unable to give a clear cut diagnosis (table 8.2).

Figure 8.1 Percentage of consultations in which physical activity was mentioned per ICPC chapter (n=2,074)

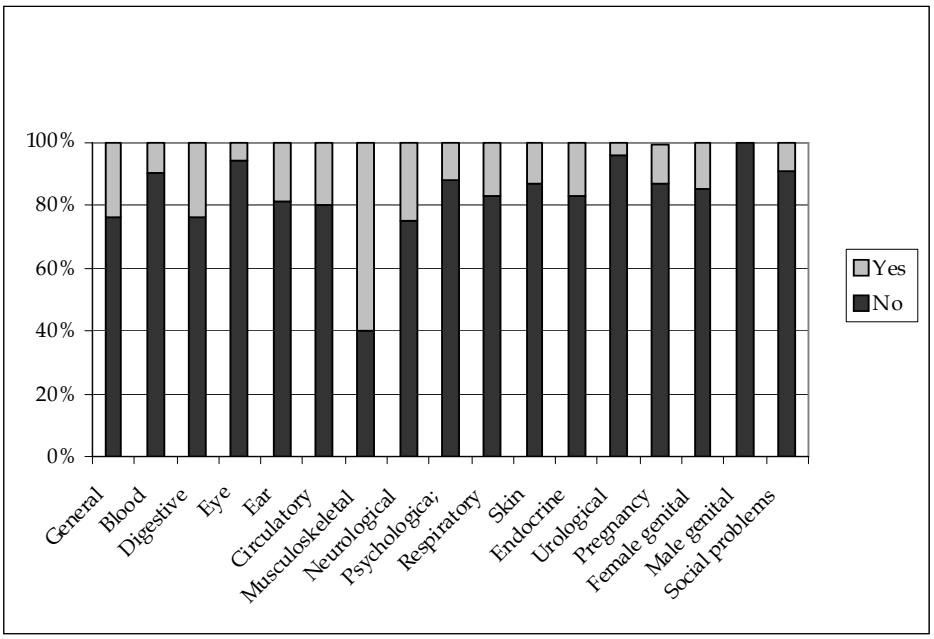

Table 8.1 Top-15 complaints/diagnoses in which a PA advice was given

Complaint	Percentage of consultations
Back complaints	63
Knee complaints	40
Shoulder complaints	23
High blood pressure	22
Ankle complaints	22
Neck complaints	17
Arm complaints	15
Leg complaints	15
Feet/toe complaints	15
Chest complaints	13
Hand/finger complaints	10
Cough	10
Complaint unknown	10
Generalised stomach ache	9
Dizziness	9

Table 8.2 Percentage of consultations in which PA advice was given according to diagnosis/symptom recording (n=2,074)

	Physical activity was mentioned (%)
Consultation in which a diagnosis was recorded	19.5
Consultations in which a symptom was recorded	31.3

$p<0.001(Chi^2)$

Patient and general practitioner characteristics

Tables 8.3 and 8.4 give an overview of the differences in likelihood of a PA advice between patients and between general practitioners. For these analyses only consultations were selected which involved diagnoses or complaints in which theoretically a PA advice could have occurred. Given this selection, PA advice was given significantly more often in consultations with male patients and patients aged between 16 and 40. There are no significant differences in the likelihood of a PA advice according to level of education and type of health insurance.

General practitioners who work less than half time and general practitioners with practices in more urban areas, more often give a PA advice. Characteristics of the general practitioner like gender, age and type of practice were not related to the probability of giving a PA advice.

Only consultations in which the following complaints were mentioned were included in the analysis: fatigue, high blood pressure, overweight, diabetes, complaints concerning musculoskeletal apparatus and mental complaints.

Table 8.3 Percentage of consultations in which PA advice was given, by patient's gender, age, level of education and type of health insurance

	Physical activity mentioned	Significance
Gender (n=829):		***
male	50.0%	
female	38.5%	
Age (n=829):		**
0-15	42.6%	
16-25	54.2%	
26-40	51.6%	
41-55	43.3%	
56-65	40.9%	
>65	33.0%	
Level of education (n=631):		ns
no education	45.0%	
elementary school	41.7%	
secondary school	40.1%	
higher education	53.1%	
Type of health insurance (n=785):		ns
public insurance	43.0%	
private insurance	44.0%	

* $p<0.05$; ** $p<0.01$;*** $p<0.001$; ns: not significant (Chi^2)

note: only consultations in which the following complaints were mentioned were included in the analysis: fatigue, high blood pressure, overweight, diabetes, complaints concerning musculoskeletal apparatus and mental complaints

Table 8.4 Percentage of consultations in which PA advice was given, by general practitioners gender, age, type of practice, number of FTEs and urbanity level (n=140)

	Physical activity mentioned	Significance
Gender:		ns
male	44.4%	
female	43.9%	
Age:		ns
30-39	48.7%	
40-49	48.7%	
50-59	38.2%	
60-69	40.0%	
Type of practice:		ns
solo practice	46.0%	
dual practice	43.2%	
group practice	43.6%	
Number of whole time equivalents (fte):		**
t/m 0.5 fte	67.1%	
0.6-0.7 fte	38.5%	
0.8-0.9 fte	43.2%	
1.0 fte	42.9%	
Urbanity:		*
very highly urban	44.0%	
highly urban	45.0%	
moderately urban	42.6%	
slightly urban	38.0%	
non urban	40.8%	

* p<0.05; ** p<0.01;*** p<0.001; ns: not significant (ANOVA)

note: only consultations in which the following complaints were mentioned were included in the analysis: fatigue, high blood pressure, overweight, diabetes, complaints concerning the musculoskeletal apparatus and mental complaints

Nature

A random sample of 100 videotaped consultations with a PA advice was drawn in order to investigate whether nature, green space or equivalent was mentioned. Nature was mentioned in only two of these. In one consultation a patient suffering from chest pain and dizziness said he walked for half an

hour daily, preferably in a urban environment, because "if something happens, there is always someone near to help me". In the other consultation a patient was advised not to "remain sitting behind the geraniums". To sit behind the geraniums is a Dutch expression for inactivity. In sum, nature was not mentioned during any of the videotaped consultations.

Discussion

Literature suggests that people's health benefits from both physical activity and the presence of nature. Additionally, there are indications that the combination of the two, physical activity in a natural environment, has synergic health effects as opposed to physical activity in other settings. More specifically, literature shows that being physically active, nature and being physically active in nature can prevent for example overweight, diabetes and stress.

To a limited extent these insights are used in health care. For example, there is an increasing number of agricultural farms that are used as a basis for promoting mental and physical health and well-being (Hassink and Van Dijk, 2006). Also hospitals and nursing homes are increasingly aware of the benefits of green space and nature areas (healing gardens) (van den Berg, 2005). And finally, in primary care the health benefits of physical activity, nature and physical activity in nature are used in a some countries. In New Zealand people get a written physical activity advice from their general practitioner (Elley et al., 2003). In the UK there are initiatives for promoting physical activity in natural environments Green Gym (2007).
However, it was unknown whether the health benefits of physical activity in a natural environment are used in patient consultations by Dutch general practitioners in primary care. This study shows that Dutch general practitioners regularly advice patients to be physically active, especially in patients who suffer from musculoskeletal problems, and problems concerning the nervous system. However, they do not mention the possible additional benefits of physical activity in nature areas.
There may be several reasons for the fact that only general practitioners in the UK advice patients to be physically active in a natural environment. First, general practitioners might not believe in the extra benefit of being

physically active in a natural environment. General practitioners mainly prescribe treatment which is evidence based, which is legitimate in the field of research and which pays back in terms of economic structure. Knowledge on the relation between nature and health is low ranked in the medical fields.

Second, they do not have time to discuss this with patients. Another reason for the differences found between the UK and The Netherlands probably lies in the design of the study. Watching a random selection of consultation of general practitioners may yield similar results in the UK, as initiatives for promoting physical activity in a natural environment are a rather new phenomena, even in the UK.

For The Netherlands as well as for other countries, we believe that in the short run the use of the positive relation between nature and health can perhaps be improved by providing and distributing information in general practice about the health benefits of physical activity in natural areas, and about the possibilities that local facilities can offer in this respect. However, given the fact that medical treatment is increasingly evidence based, we think that the scientific evidence for the health benefits of physical activity in nature needs to be stronger. More knowledge is needed about the precise type of nature patients need to get the highest health benefits. Will a walk down a tree lined street suffice? Or does nature need to be more like a park or forested area? Results from such research could eventually find their way into the guidelines for general practitioners that are issued by professional general practitioners organizations in many countries. Only then there is a possibility that nature will start to play a role in primary care.

9

Summary of conclusions and discussion

Abstract

In this chapter we will discuss the main conclusions, as well as policy implications and implications for future research. First of all, however, a short overview of the background, research questions, data and methods will be presented.

Background and research questions, data and methods (chapter 1)

The shortest summary of this thesis is in its title "Vitamin G", where the G stands for the green space around us and Vitamin stands for the possible positive relationship between green space and people's health. The aim of this thesis is to investigate whether green space in people's living environment is positively related to their health.

In our society, in which a large number of people live in urban areas, green space is no longer an obvious component of the direct living environment. Increasing urbanisation, combined with a spatial planning policy of densification has put urban green space under pressure. If the availability of green space positively influences health, living in less green environments could have health consequences. Notions about beneficial effects of green space have persisted throughout history (Van den Berg and Van den Berg, 2001). However, evidence for a direct relation between the amount of green space in the living environment and health is scarce. Only two epidemiological studies had investigated the direct relation when the Vitamin G programme started (Takano et al., 2002; De Vries et al., 2003). These studies suggest a positive link between the amount of green space in the living environment and health. A number of questions remained unanswered, however. First of all, little was known about the strength of the relation between green space and health was. Secondly, it was unknown whether the relationship between green space and health differs for specific health outcomes, such as cardiovascular disease or depression. Thirdly, more knowledge was needed on whether the relation between green space and health differs between sub-groups in the Dutch population. Fourthly, it was unclear if the relation between green space and health differs for various types of green space (Health Council of the Netherlands and RMNO, 2004) and fifthly, it was unknown whether the relation depends on the proximity of green space. In other words, the relation between green space and health needed to be investigated more thoroughly. These areas of research were investigated in the first part of this thesis.

The second part of this thesis is concerned with the mechanisms behind the relationship between green space and health. Two mechanisms were investigated; exposure and behaviour. Most empirical evidence on the

beneficial effects of green space was found in controlled, experimental research and focused on demonstrating the relation between exposure to green environments and recovery from stress and mental fatigue. Very little is known about the role of a behavioural mechanism that is based on the general idea that green space could increase and prolong physical activity (Pikora et al., 2003; Giles-Corti and Donovan, 2002) and improve social contacts (Kawachi and Berkman, 2000; Kuo et al., 1998a). This led us also to examine in this thesis whether the amount of green space in the living environment encourages these two forms of behaviour.
Apart from these causal mechanisms, the relationship may partly be the result of direct or indirect selection. We controlled statistically for the possibility of indirect selection by taking socio-demographic and socio-economic characteristics of people into account when analysing the relation between green space and health and the causal mechanisms behind this relation. It is impossible to control for direct selection in a cross sectional study design and so we were unable to rule out the influence of direct selection.

There may be another side to the possible positive relationship between green space and health, however, as green spaces are sometimes regarded as unsafe places. In part III we investigated whether the amount of green space in people's living environment positively or negatively affected feelings of social safety.

In the last part of this thesis we investigated whether the health benefits of green space are used in health care. More specifically, we investigated whether health benefits conferred by nature were used in patient consultations by Dutch general practitioners.

In short, this thesis addressed the following research questions:

1 *'How strong is the relationship between the amount of green space in people's living environment and their health?'*
   a *To what extent is this relationship dependent on the type of health-related outcome measure involved (self-reported health, depression, cardiovascular diseases)?*

b *To what extent is this relationship dependent on the categories of the population involved (e.g. the elderly, children, low socio-economic status)?*
c *To what extent is this relationship dependent on the type of green space involved (e.g. urban green, agricultural green)?*
d *To what extent is this relationship dependent on the proximity of green spaces?*

2 *'Can the relationship between the amount of green space in people's living environment and their health be explained by mechanisms of exposure and behaviour?'*

3 *'Does the amount of green space in people's living environment positively or negatively affect feelings of social safety?'*

4 *'To what extent are the health benefits of natural environments used in the health care sector in the Netherlands?'*

Data and methods

The health data used for this thesis originate from the Second Dutch National Survey of General Practice (DNSGP-2), which encompasses data from a representative nationwide sample of 104 general practices in the Netherlands, comprising 195 GPs and including approximately 400,000 patients. Data on feelings of social safety originate from the Police Population Monitor 2001, a representative nationwide survey among a randomly selected sample of approximately 90,000 people, which focuses on developments in crime rates, feelings of social safety and opinions on the police (PMB, 2001).
Data on the distribution of green space in the Netherlands were derived from the National Land Cover Classification database (LGN4), which contains the dominant type of land use of each 25 by 25 metre grid cell in the whole of the Netherlands.

Most research questions were assessed using multivariate multilevel model analysis, controlling for demographic and socio-economic characteristics and level of urbanity.

Main findings, discussion and scientific implications

Part I: The relationship between green space and health

In the first part of this thesis we examined the relationship between the amount of green space in the living environment and self-reported general health (chapter 2) and morbidity (chapter 3). We controlled statistically for indirect selection in these studies.

Perceived general health (chapter 2)
The findings of chapter 2 showed that the amount of green space in people's living environment is positively associated with perceived general health. This relationship is apparent in both urban as well as rural areas The relationship between green space and health is considerable; the chance that residents will describe their health as less than good is 1.5 times as large in living environments with little green space than it is in living environments with very much green space. The relationships within a 1km or 3km radius were equally strong; it is only in the very strongly urban areas that green space further away is more important. Where the type of green space is concerned, both the amount of agricultural and the amount of natural green space in the living environment were positively related to perceived general health. The relationship between green space and health is somewhat stronger for people with a lower socio-economic status as opposed to people with a high socio-economic status, and is stronger for young people and the elderly compared to adults aged between 25 and 64 years.

Moreover, the results of this study suggest that the availability of green space might be an important factor in explaining urban/rural health differences. Previous research has shown that the association between level of urbanity and people's self-reported health cannot be explained by demographic, socio-economic and behavioural factors, or by selective migration (Verhei et al., 2008). The results of the study presented in chapter 2 indicate that the availability of green space is more strongly associated with people's perceived general health than level of urbanity, controlling for age, gender, socio-economic status, job status and ethnicity.

Further analysis of the relationship between green space and perceived general health showed a linear relationship (not shown in chapter 2).

Perceived general health does not appear to have a threshold above which more green space does not lead to a better health status; every piece of green space counts.

This study replicated the analyses of De Vries et al. (2003), using larger, more recent and more comprehensive datasets that are better attuned to each other. The findings of our study correspond with the findings of De Vries et al. (2003), who also found a positive relationship between green space and perceived general health that was stronger for people with a low socio-economic status and for housewives and elderly people, who were hypothesised to spend more time in the vicinity of their homes. De Vries et al. also found in their study that people with a greener living environment reported fewer symptoms and had better mental health.

Several indications of a positive relationship between green space and health have been found in other countries as well in the past few years. In England Mitchell and Popham (2007) replicated our study and found that a higher proportion of green space in an area is generally associated with better self-reported health, although the association depended on the degree of urbanity and level of income deprivation. There was no significant association between green space and health in higher income suburban and rural areas, which the authors believed might be explained by the quality of green space, a factor that had not been taken into account in the study. In Sweden, Björk et al. (2008) found no relationship between self-perceived health and the amount of green space within a 100-metre and a 300-metre radius around the house. Also in Sweden, Nielsen et al. (2007) found that people who had access to a garden or had green areas a short distance away from their houses were less stressed and had a lower likelihood of obesity. Ellaway et al. (2005) also investigated the relationship between green space and obesity. They used a European cross-sectional survey and found that respondents whose residential environment contains high levels of greenery had about a 40% lower likelihood of being overweight and obese.

The results of a study by Sugiyama et al. in Australia (2007) showed that people who perceived their neighbourhood as very green had respectively 1.37 and 1.60 times higher odds of better physical and mental health. Perceived neighbourhood greenness appeared to be more strongly associated with mental health than it was with physical health. People living in neighbourhoods that were perceived as medium green did not have higher odds of better physical or mental health, which indicates that very

green neighbourhoods have a particularly beneficial effect on health. Finally, a longitudinal study performed among senior citizens in Tokyo in Japan showed that living in areas with walkable green streets and green spaces near the residence was positively associated with the longevity of urban senior citizens (Takano et al., 2002).

In conclusion, a positive association between neighbourhood green space and several general health indicators was found in a number of countries that differ in population density and the availability of green space.

Morbidity (chapter 3)

Several studies have thus provided evidence for a positive association between green space in the living environment and self-reported general indicators of physical and mental health. In chapter 3 we went one step further and investigated whether several physician-assessed disease clusters were also related to the amount of green space in people's living environment.

This chapter used large-scale representative medical record data on morbidity to show that the annual prevalence rates for 18 of the 24 disease clusters investigated were lower in living environments with more green space within a 1km radius around people's homes, controlling for demographic and socio-economic characteristics, and level of urbanity. No significant relationships were found for the amount of green space within a 3km radius around people's homes. Green space close to home appears to be more important where the prevalence of disease is concerned. Where the disease clusters were concerned, the relationship was strongest for anxiety disorder and depression; the chance of depression was 1.33 times higher in living environments with little green space than in living environments with very much green space.

The relationship appeared to be especially strong in children and people with a low socio-economic status.

Scientific implications of the relationship between green space and health

The studies presented in chapter 2 and 3 were among the first studies to provide evidence for a direct positive relationship between green space and health in the Netherlands. Our studies and studies performed in other countries showed that the relationship existed with different types of health measures as the relationship was apparent for perceived health, specific

diseases, stress, number of complaints and mental health, for example (De Vries et al., 2003; Mitchell and Popham, 2007; Takano et al., 2002; Nielsen and Hansen, 2007; Sugiyama et al., 2007).
With regard to the strength of the relationship, self-reported health seems to be more strongly related to the amount of green space in the living environment than the prevalence of specific diseases is. The chance of feeling unhealthy is 1.5 times larger in living environments with little green space, than it is in living environments with very much green areas. This relationship is weaker for the prevalence of specific diseases. In the case of depression, which is one of the disease clusters strongly related to the amount of green space in the living environment, the chance of this disorder is 1.33 times greater in areas with little green space.

Relationship for different subgroups
We also investigated the extent to which the relationship between green space and health differed for subgroups in the Dutch population. Although the relationship is clear for all subgroups in the population, it appears to be stronger in younger people, the elderly and people with a low socio-economic status, which might be explained by the fact that these population groups spend more time in the vicinity of their homes as a result of lower mobility (Schwanen et al., 2002; Harms, 2006b). Another explanatory factor could be that the health situation of people with lower socio-economic status is worse on average, which leaves more room for health improvement. As a result they might be more susceptible to the amount of green space in their living environment.

Type of green space
Where the type of green space was concerned, we found a slightly stronger relationship for natural and agricultural green space as compared to urban green space.

Proximity of green space
We can conclude with regard to the proximity of green space, that the relationship between self-reported health and green space in the near vicinity of the home and that with green space at a further distance were equally strong, although green space further away is more important in very strongly urban areas. The relationship with the prevalence of specific diseases was only apparent for green space in the near vicinity (1km).

Overall, these findings suggest that green space close to people's home is somewhat more important for health than green space further away which could be explained by the fact that the use of and exposure to green space decreases with increasing distance from green space (Nielsen and Hansen, 2007; Neuvonen et al., 2008).

Part II: Mechanisms behind the relationship between green space and health

In the second part of this thesis, we investigated how the relationship between green space and health could be explained. In chapters 4 to 6 we studied two possible mechanisms behind the relationship between green space and health.
We first investigated whether the relationship between green space and health might be explained by exposure to green space (chapter 4). We secondly explored whether behaviour could explain the relationship between green space and health (chapters 5 and 6). In all studies we controlled statistically for indirect selection.

Exposure

Green space, stressful life events and health (chapter 4)

According to the dynamic stress-vulnerability (DSV) model (Heady and Wearing, 1989; Ormel and Neeleman, 2000) the prospect of living with limited access to green resources may increase people's vulnerability to the impact of stressful life events on mental and physical health. There is convergent evidence from different lines of research that contact with real or simulated natural environments, including nearby green space, can provide restoration from stress and mental fatigue. Residents of neighbourhoods with abundant green space generally have more opportunities to visit and contemplate nature and profit from its restorative effects than residents in neighbourhoods that lack green space (Kaplan and Kaplan, 1989), which means that the availability of green space in the living environment may be an environmental factor that moderates the impact of stressful life events on health and well-being.
In chapter 4, we examined the extent to which the presence of green space close to and further away from the home can buffer the adverse impact of stressful life events on self-reported general, mental and physical health.

The results indicate that green space within the wider living environment acts as a buffer against the adverse impact of stressful life events on self-reported physical health. Adult individuals who had recently experienced one or more stressful life events reported significantly fewer health complaints when they had a larger amount of green space in their living environment, although this buffer effect was found only for the 3km zone, not for the 1km zone. Where perceived general and mental health were concerned, no differences were found in the impact of stressful life events as a function of the amount of green space.
A possible explanation for the finding that green space was found to have a buffer effect for the wider 3km zone and not for the 1km zone, is that high percentages of green space within a 3km radius might reflect the presence of more large-scale nature areas. A greater availability of large-scale nature areas in the living environment may provide opportunities for reflection and restoration at a deeper level, which cannot, or to a lesser extent be achieved in small-scale nature areas (within a 1km zone). We found a relatively weak buffer effect in comparison with other studies, which may be caused by the fact that we used a representative sample of the Dutch population who were in relatively good health, while previous studies focused on specific groups.

Behavioural mechanisms

Physical activity (chapter 5)

In chapter 5, we investigated whether physical activity is an underlying mechanism behind the relationship between the amount of green space in people's direct living environment and self-reported health. In order to study this, we first examined whether the amount of green space in the living environment is related to different kinds of physical activity. Secondly, where we found an association between green space and a certain kind of physical activity, we analysed whether this could be an explanation for the relationship between green space and health.
No relationship was found between the amount of green space in the living environment and whether or not people met Dutch public health recommendations for physical activity. Nor was a relationship found between green space and sports and walking for commuting purposes. We found a negative relationship between green space and walking and cycling in leisure time. People with more green space in their living environment walked and cycled less often and for fewer minutes during leisure time, which may be related to the fact that greener neighbourhoods are often set

up more spaciously with fewer shops and more parking facilities near people's homes.

We did find a positive relationship between green space and cycling for commuting purposes and gardening. The amount of agricultural green space in the living environment was particularly positively related to these types of physical activity. The fact that people spent more time on cycling for commuting purposes and on gardening could not explain the relationship between green space and health.
The relationships found between green space and physical activity were strongest for people with a low socio-economic status, and for children and the elderly.

On the basis of these results, we concluded that physical activity is not a likely mechanism behind the relationship between the amount of green space in people's direct living environment and health. It is important to note, however, that although people with greener living environments do not more often meet the Dutch public health recommendations for physical activity, it is possible that they more often undertake physical activity in a green environment. A number of studies have shown that people with more green space in their living environment more often use green space (e.g. Nielsen and Hansen 2007). But we had no data on where people were physically active and were therefore unable to find out whether people with greener living environments exercise in green spaces more often. A study by De Vries et al. (2004) showed that the local supply of green space does not determine how often people engage in recreation, but it does determine where people engage in recreation.
Furthermore, it is possible that the absence of a relationship between the level of physical activity and the amount of green space is due to the high density of sports facilities and safe cycle tracks and footpaths in the Netherlands. Under these circumstances, the availability of green space is not a necessary condition for being physically active.
Finally, it is important to note that we investigated the relationship between the availability of green space and physical activity. We had no information on whether the green spaces included in the investigation were suitable for physical activity.

In addition to the results presented in this chapter, we also investigated the relationship between green space and physical activity in adolescents. The results showed that adolescents aged between 12 and 17 more often met the Dutch public health recommendations for physical activity when they had more green space in their living environment, which indicates a relationship between green space and physical activity in adolescents. This finding is supported by other research that also demonstrated positive relationships between green space and physical activity for children and adolescents (Timperio et al., 2004; Cohen et al., 2006).

Social contacts (chapter 6)

Neighbourhood green space can provide an attractive meeting opportunity for neighbours (Coley et al., 1997) and can promote a sense of community (Kim and Kaplan, 2004). Furthermore, it is widely recognised that social relationships can influence a variety of health outcomes. As a consequence, chapter 6 examined whether the relationship between green space and health is mediated by social contacts.

The results show that people with more green space in their living environment felt less lonely and less often experienced a shortage of social support. No relationship was found between green space and the frequency of contact with neighbours, or with the number of supportive interactions. Loneliness and shortage of social support both partially mediated the relationship between green space and self-reported health, the number of health complaints experienced in the past 14 days, and mental health. Shortage of social support even completely mediated the relationship between green space and mental health.

We only found a relationship between the amount of green space in the living environment and loneliness and shortage of social support in people with a low SES, which indicates that people with low SES benefit more from green space as compared to people with a higher socio-economic status. The amount of green space in the living environment seems to be less important for the social contacts of people with a high SES. The relationship was also stronger for adolescents and the elderly as compared to adults.

We investigated the relationship for objective green spaces and had no information, therefore, on whether the green spaces were unsafe or of good quality. Places that are unsafe or of low quality will be avoided by people. The fact that we did not find a relationship between green space and contact

with neighbours could be explained by the non-inclusion of small-scale green spaces in the study. These small-scale green spaces were particularly associated with the use of outdoor public spaces and social ties (Coley et al., 2007; Kuo et al., 1998a; Kweon et al., 1998).

Scientific implications concerning the mechanisms

Chapters 4 to 6 investigated whether the relationship between green space and health could be explained by mechanisms of exposure and behaviour. Based on our studies, we conclude that social contacts form the most important mechanism behind the relationship between green space and health, because we did not find strong relationships for the other mechanisms. Conclusions regarding the mechanisms behind the relationship between green space and health should not, however, be based solely on the studies performed in this thesis. Other scientific evidence concerning the mechanisms has to be taken into account as well. Although we found only weak indications that green space in the wider living environment acted as a buffer against the adverse impact of stressful life events on health, it can be concluded when other scientific evidence is taken into account, that restoration from stress and mental fatigue might be the most likely mechanism behind the relationship between green space and health. This is the only mechanism for which there is convergent evidence from different lines of research which shows that contact with real or simulated natural environments, including nearby green space, can provide restoration from stress and mental fatigue. Furthermore, the results regarding the relationship between green space and prevalence of specific diseases also indicate that stress reduction might be the most likely mechanism, because the relationship we found was strongest for stress-related illnesses.

Scientific evidence on the influence of the other mechanisms is scarce. Our studies were among the first to investigate the triad of a mechanism, green space and health. Sugiyama et al. (2007) also examined whether mechanisms of physical activity and social contacts might explain the relationship between green space and health; more specifically, they examined whether walking, social coherence and local social interaction mediated the relationship between greenness and physical and mental health. Their results showed that recreational walking mediated the relationship between greenness and physical health, whereas the relationship between greenness and mental health was partly accounted for by recreational walking and social coherence. Their study provides evidence that both physical activity

and social contacts might be an underlying mechanism behind the relationship.
This thesis also provides evidence that social contacts might be a possible mechanism behind the relationship between green space and health.
Where physical activity is concerned, our results indicate that physical activity might be an underlying mechanism for adolescents, but we found no indications that physical activity in adults was a possible mechanism behind the relationship between green space and health.
The scientific evidence available is also ambiguous on the relationship between green space and physical activity. As was shown in the introduction to chapter 6, several studies have found that aesthetics of the environment and the availability and accessibility of parks stimulate certain types of physical activity (Pikora et al., 2003; McGinn et al., 2007). On the other hand, there are also studies that did not find a relationship between green space and physical activity (Hillsdon and Thorogood, 1996; Kaczynski and Henderson, 2007).
The contrasting results found in the various studies may be explained by the different types of physical activity and the different types of green space investigated, which makes comparison between the studies difficult.

Relationship for subgroups
With regard to physical activity and social contacts, we also investigated whether the relationship varied in different subgroups in the Dutch population. Our results showed that for physical activity as well as for social contacts, the relationship appeared to be stronger for people with a lower socio-economic status and for adolescents and the elderly.

Type of green space
We found with reference to the type of green space, that the amount of agricultural green space was more strongly related to physical activity. We did not investigate the role of the type of green space in stress and social contacts.

Proximity of green space
As regards the relationship between proximity of green space and physical activity and loneliness, there appeared to be no strong difference between green space close by and green space at a greater distance. For shortage of social support only green space in the near vicinity was important.

Furthermore, we found that green space only acted as a buffer in the relationship between experiencing stressful life events and health for green space at a further distance. This suggests that, in times of crisis, people need an environment that facilitates restorative experiences at a deeper level.

Selection

Part of the found relationship between green space and health might be due to direct or indirect selection. We tried to rule out indirect selection effects by controlling statistically for individual demographic and socio-economic characteristics. The results from the analyses for various socio-economic status groups, make it rather unlikely that indirect selection is the mechanism responsible. The relationship observed between green space and health was stronger for people with the lowest level of education, which is precisely the subgroup that has fewer options in the choice of neighbourhood of residence.

Our results may also be influenced by selective migration based on people's health; healthy people might choose to live in greener environments (direct selection). Unfortunately, it is impossible to control for direct selection on the dependent variable in a cross-sectional study design. Longitudinal studies on health-related migration show, however, that direct selection cannot be held responsible for the geographical differences that remain if socioeconomic and demographic factors are taken into account (Verheij et al., 1998; Van Lenthe et al., 2007).

Alternative mechanisms

Several other mechanisms may also be involved. An important mechanism that is not discussed separately in this thesis, but which might be important in explaining the relationship between green space and health, is air pollution.

Air pollution can cause several respiratory diseases (Brunekreef and Holgate, 2002; ATS, 1996; WHO, 2004). Green spaces have the ability to remove air pollutants and consequently improve human health (Nowak et al., 2006; Van Hove, 2008; Beckett et al., 2000). The results in chapter 3 indicate that air pollution could also be a possible mechanism behind the relationship between green space and health, because the annual prevalence of almost all morbidity clusters related to respiratory complaints was lower in living environments with more green space. Future research should also

take air quality into account when investigating the explanation for the relationship between green space and health .

Part III: Green space and feelings of social safety

In part three, we investigated the relationship between the amount of green space in the living environment and feelings of social safety.

Green space and feelings of social safety (chapter 7)
The amount of green space in the living environment might increase feelings of insecurity, because green spaces are sometimes regarded as unsafe places where assailants can hide. Therefore we investigated the relationship between the amount of green space in the living environment and feelings of social safety. The results from chapter 7 suggest that the amount of green space in people's living environment is generally associated with enhanced feelings of social safety. Only in very strongly urban areas the amount green space in the living environment was found to increase feelings of insecurity. Contrary to our expectations, vulnerable population groups (women and the elderly) did not feel less safe in greener living environments. Our results for the type of green space show that both the amount of open green space and the amount of closed green space in the living environment increase feelings of social safety. In very strongly urban areas, however, the amount of closed green space was negatively related to feelings of social safety. It seems that investing in green space not only contributes to people's health, but also helps to make them feel safer.
We unfortunately had no information on the quality of the green areas. Specific characteristics of green spaces, like maintenance of green areas, social cohesion and sense of anonymity may shed more light on the negative relationship for closed green spaces in very strongly urban areas, and should be taken into account in future research.

Part IV: Use of green space in health care settings

Use of green space in health care settings (chapter 8)
In the last part of this thesis we investigated whether the health benefits of green space are used in health care settings. People have traditionally

ascribed healing powers to nature and used nature in health care facilities. Rapid technological advances in the health care sector meant, however, that healthcare settings no longer took the healing effects of the environment into consideration (van den Berg 2005). Literature suggests that people's health benefits from both physical activity and the presence of nature. Additionally literature shows that there may even be a synergic benefit from being physically active whilst simultaneously being directly exposed to nature (Pretty et al., 2005; Hartig et al., 1991). These insights are used in health care to a limited extent. An increasing number of farms are used as a basis for promoting mental and physical health (Hassink and Van Dijk, 2006) and there is increasing awareness in nursing homes and hospitals of the benefits of green spaces and natural areas (Van den Berg, 2005).

Furthermore, these insights are used in primary care in New Zealand and the UK (Humphreys, 2003; Elley et al., 2003) It was, however, unknown whether the health benefits of nature were used by Dutch general practitioners in patient consultations. As general practice is usually people's first point of contact with the health care system in the Netherlands, the greatest benefits for people's health can probably be obtained in primary health care settings. We first investigated the extent to which general practitioners advise patients on physical activity. Secondly, we investigated whether they refer to the additional health benefits of physical activity in a natural environment. For this purpose, we observed a randomly stratified sample of 100 of the 564 videotaped patient consultations during which a recommendation on physical activity was given.

Although advice on physical activity was given by general practitioners during 26% of all consultations, the additional benefits of physical activity in natural environments were not mentioned by GPs during any of the consultations.

This part of the thesis shows that there is scope for increasing the amount of attention given to the potential benefits of green space in health care settings.

Policy implications

Although notions of the beneficial effects of green space have existed throughout history (Van den Berg and Van den Berg, 2001) and people generally believe that green space is good for their health (Frerichs, 2004),

there was hardly any scientific evidence of a direct relationship between green space and health until recently.
This thesis provides evidence of a direct relationship between green space and health in the Netherlands. First of all, the results show that the amount of green space in people's living environment is positively related to several self-reported health measures (general health, number of health complaints and mental health). Secondly, the findings of the study on the relationship between green space and morbidity show that the relationship between the amount of green space in the living environment and health should not be underestimated. Most of the diseases that were found to be related to the amount of green space in the living environment are highly prevalent in society and are subject of large-scale prevention programmes in many countries. Furthermore, diseases of the circulatory system, mental disorders and diseases of the digestive system, for which we found a relation with the amount of green space, are among the most expensive diseases in terms of health care costs in many countries (Heijink et al., 2006). Thirdly, the results indicate that people who live in a greener living environment generally feel safer.

In short, evidence is provided for the proposition that green space is more than just a luxury, since the availability of green space is positively related to perceived and objective health and to feelings of social safety.
The findings of this thesis indicate that the development of green space should be allocated a more central position in policy related to health, nature and spatial planning and provide arguments that are needed to place the topic of green space and health on the political agenda and to legitimise policy in this field.

National policy on health, nature and spatial planning
The relationship between green space and health touches upon several policy fields, namely health, nature conservation and spatial planning. It is vital that the various parties involved cooperate to make sure that green space does not disappear from the streetscape.

Current policy of the Netherlands Ministries of Health, Welfare and Sports, Housing, Spatial Planning and the Environment, and Agriculture, Nature and Food Quality is partly concerned for the next few years with vulnerable population groups, such as the elderly, children and adolescents, and people

with a low socio-economic status. In this thesis, we found a stronger relationship between green space and health for these population groups. This suggests that policy makers should take the amount of green space in the living environment into account when endeavouring to improve the health situation of the elderly, young people and groups with lower socio-economic status, especially in urban environments where there is little green space.

The interest in using green space to create a healthy living environment has increased during the years in which the Vitamin G programme has been running. Although the relationship between green space and health was never mentioned in previous policy documents on prevention, the 2007 policy paper on health and prevention from the Ministry of Health, Welfare and Sport includes a central role for green space to encourage physical activity and to contribute to a healthy living environment (Ministerie van VWS, 2007). Furthermore, the Ministry of Housing, Spatial Planning and the Environment included a role for green space in its National Action Plan on Environment and Health (Ministerie van VROM, 2008). This National Action Plan covers the activities that need to be implemented in the area of environment and health for the period 2008-2012. One of its key areas of this plan encompasses healthy design and layout of the living environment, in which green space plays a considerable role. These are some of the documents which show that there is increasing interest in green space for creating a healthy living environment. Most official governmental documents on creating a healthy living environment or improving the quality of the living environment, however, mainly focus on improving air quality and decreasing noise nuisance. The results of this thesis indicate that policy makers should also be aware of the role of green space when endeavouring to create healthy, safe and good quality living environments.

Policy at municipal level

Although there is increasing attention for green space at national level, this attention has not (yet) been reflected in policy documents at municipal level. Most municipalities in the Netherlands have policy documents on improving the health of their citizens and on housing and residence, but the current policy documents have little or no room for green space (Van Loon, 2008; Van den Broek and Kwekkeboom, 2007; Groenforum Nederland, 2008). Only the policy documents on improving health from some of the

largest cities in the Netherlands have included green space and presented the ambition to use green space for creating a healthier living environment (Van Loon, 2008).

Urban planning

The findings of this thesis could be used as arguments for preserving, or – if possible – enlarging the amount of green space in urban living environments for health reasons, especially in the urban environment where space is under pressure. The greatest opportunities for including green space in neighbourhoods can be found in those areas where radical changes are planned. Urban planners should take green space into account when redesigning existing neighbourhoods or when new neighbourhoods are being developed.

This thesis does not provide information on how green space should be designed for optimal health benefits. The studies on the mechanisms behind the relationship between green space and health could provide information on the kind and amount of necessary green space, because the ideal design of green spaces differs per mechanism. Walking and cycle paths would be convenient for physical activity, benches for social contacts, and quietness is important for recovery from stress. In view of the degree of uncertainty about the exact mechanism behind the relationship, it seems wise to design green spaces that provide a combination of quietness and opportunities for physical activity and social contacts.

Cost and benefit analyses

Urban planning is often supported by analyses of the cost and benefit of building plans. It would be useful to examine the way in which possible reductions in health care costs related to the amount of green space in the living environment can be added to the cost and benefit analyses.

Policy of densification

Due to increasing urbanisation combined with a spatial planning policy of densification, more people face the prospect of living in less green residential environments. This thesis sheds an interesting light on the policy of densification and its relationship with health. The policy of densification was introduced to discourage car dependency and to preserve nature areas outside cities, yet it is unknown whether the policy of densification did not

have negative consequences for people's health. Green space comes under pressure because buildings are constructed on open areas as a result of the policy of densification.. This thesis shows that the disappearance of green space from people's living environment is likely to have negative effects on their health. On the other hand, our study on the relationship between green space and physical activity indicated that people living in more dense neighbourhoods (neighbourhoods with less green space) walk and cycle more often for leisure. This suggests that more dense neighbourhoods do indeed discourage car dependency.
We did not find a relationship between the amount of green space in the living environment and whether or not people met the Dutch public health recommendations on healthy physical activity. The fact that we found no difference in healthy physical activity suggests that adults compensate for the increase in walking and cycling for leisure by participating in fewer other types of physical activity. The policy of densification seems to have no consequences, therefore, for the total amount of physical activity engaged in by adults.
Children, on the other hand, more often met the Dutch public health recommendations for physical activity when they had more green space in their living environment, so it appears that the policy of densification does have negative consequences for their level of physical activity.
Overall, the results suggest that the policy of densification could have health consequences, due to the decrease of green space in the neighbourhood and a reduction in the level of physical activity engaged in by children.

Health care sector
Because of increasing indications that green space is beneficial to people's health, different parties in the health care sector should be made aware of the possible positive impact of green spaces. The Dutch Ministry of Agriculture, Nature and Food Quality has set out an tender to investigate how the health care sector can be made aware of the potential of green space and how the sector can be mobilised to use green space. The initial results of this tender show that there are several possibilities for health care providers to use the potential of green space.

One of the main goals of current policy of the Ministry of Health, Welfare and Sports is to increase the level of physical activity engaged in by Dutch citizens. A number of programmes have recently been initiated to stimulate

people to be physically active. Based on the research on the additional health effects of physical activity in green environments, it could be useful to add a green variant to these initiatives by offering physical activity options in green areas. If a green variant were to be added to the existing programme, it would be useful to investigate the effectiveness of the green variant as opposed to the effectiveness of the non-green variant.

Recommendations for future research

Although the studies performed for this thesis have provided lots of interesting new results, they also raise questions that should be answered in future research.

Causality of the relationship between green space and health
This thesis provides strong indications of a positive relationship between the amount of green space in the living environment and several subjective and objective health indicators in a representative sample of people in the Netherlands. Part of the found relationship might be due to direct or indirect selection. We tried to rule out indirect selection as much as possible by controlling statistically for demographic and socio-economic characteristics of the individual. Apart from individual characteristics, neighbourhood characteristics like neighbourhood socio-economic status might also be responsible for the relationship found between green space and health. Future research should also take neighbourhood characteristics into account in order to rule out the effects of indirect selection.
We were unfortunately unable to control for direct selection on the dependent variable, because we used a cross-sectional study design. Future research should use a longitudinal study design to find out whether the relationship found is due to direct selection.

Research aimed at specific population-groups
This thesis provides more knowledge on whether the relationship between green space and health differs between subgroups of the Dutch population. The fact that we were able to use existing large-scale datasets enabled us to investigate the relationship in a large population and for different subgroups. Our results show stronger relationships for children, the elderly and people with a lower socio-economic status, but, as was also mentioned

in a knowledge agenda on nature and health (RMNO et al., 2007), more knowledge is needed to find out what kinds of green space beneficially influence the health of these population groups. Do neighbourhoods with lots of children need the same green space as neighbourhoods with mainly elderly people?
Furthermore, the relationship between green space and subgroup-related illnesses should be investigated more thoroughly. In the case of children, for example, it would be interesting to investigate whether there is a relationship between the amount of green space in the living environment and Attention Deficit Hyperactivity Disorder (ADHD).

Type and amount of green space
With regard to the type of green space, we found indications of a stronger relationship between agricultural and natural green space and health, but more knowledge is needed about the type of green space with which the greatest health gains will be achieved. Will tree-lined streets suffice? Or does nature need to be more like a park or wooded area? And is the same type of green space equally useful for health benefits for different population groups?
In order to be able to translate the findings of this thesis into more concrete policy implications, more research is needed on how much green space is necessary to improve people's health. No concrete recommendations can be made on the basis of the results of this thesis regarding how much green space is needed in people's living environment to improve their health. Is the norm of 75 square metres per dwelling imposed by the Ministry of Housing, Spatial Planning and the Environment (Ministerie van VROM, 2004) sufficient, or should there be more green space? Future research should focus on answering this question.

Proximity of green space
One of the research questions was concerned with whether the relationship depends on the proximity of green space. The overall findings of this thesis provide some indications for using green spaces at different levels of proximity with the objective of improving various health outcomes. In this thesis we only investigated the relationship for green space within a 1km and a 3km radius around people's homes. Future research should investigate the relationship between health and green space at other distances from the home.

Mechanisms behind the relationship

No clear conclusions could be drawn concerning the influence of the behavioural mechanisms. Future research should, therefore, focus on investigating the relationship between green space and physical activity and social contacts more thoroughly. Apart from the mechanisms investigated in this thesis, other mechanisms should also be taken into account in future research. The results of the study on the relationship between green space and morbidity indicate that air pollution might also be a possible mechanism, because the prevalence of almost all clusters related to respiratory complaints was lower when people had more green space in their direct living environment. Future research should therefore also investigate the relationship between green space and air pollution.

Use of green space in health care settings

This thesis showed that the health benefits of green space are used to a limited extent in health care settings. This could be due to the lack of scientific evidence conclusively showing that people's health benefits from green space in health care settings. Several initiatives of using green space in health care settings taken by health care providers could possibly be improved, if they were accompanied by good research. Initiatives for using green space in the health care sector should be evaluated in order to increase insight into their effectiveness. Future research should focus on evaluating examples of good practices that aim to increase the amount of green space in health care settings, or refer to green spaces to improve people's health.

Measures of green space used

We used the LGN4 database for the purposes of this thesis to assess the amount of green space in people's living environment. The use of the LGN4 dataset enabled us to make a detailed assessment of the amount of green space in people's living environment. There are only few countries in which nationwide data on green space are available. Yet the dataset did not provide all the information necessary to obtain in-depth insight into the relationship between green space and health. The following sections contain suggestions for measuring instruments for green space that could be used in future research.

Small-scale green space

The use of the LGN4 dataset enabled us to make a detailed assessment of the amount of green space in people's living environment. The data on green space used in this thesis did not take small green spaces in the living environment into account, despite having been assessed in detail. Only green spaces that have a dominant position in the 25 by 25 metre grid cell are regarded as green space in the dataset. Small-scale green spaces like street trees and green roadsides, which usually do not have a dominant position in the grid cell, are not regarded as green space as a result, even though these small green spaces could influence health and feelings of social safety. Shrubs around a block of houses, for example, may be important to feelings of social safety. Furthermore, small-scale green space such as green streetscapes have been shown to be related to social contacts (Coley et al., 1997; Kuo et al., 1998a) and physical activity (Owen et al., 2004; Pikora et al., 2003). Future research should benefit from taking small–scale green spaces into account.

Gardens

In the LGN4 database only large gardens are regarded as green space because houses are buffered with a 10-metre buffer which was regarded as urban built environment. Gardens often have green elements which increase the exposure to green space, but only gardens that exceed the 10-metre buffer are regarded as green space. We recommend that future research on the relationship between green space and health does take gardens and possibly even the design of the gardens into account while a garden does not have to contain green space.

Quality and accessibility of green space

Moreover, future research should investigate whether the quality and accessibility of green space also play a role in the relationship between green space and health. This thesis investigated the relationship between the quantity and availability of green space and health, but both the quality and the accessibility of green space may also play an important role in people's health. Low quality green areas may increase feelings of insecurity and decrease the use of the areas.

Use of and exposure to green space

Using existing data has the disadvantage that the data were not originally designed to answer our research questions. Additional information would sometimes have been useful in answering our research questions. The datasets used do not provide information on the amount of time people are exposed to the green space in their living environment or to green space somewhere else. As far as behaviour was concerned, we also had no information on *where* people were physically active or where their social contacts took place. As regards feelings of social safety, the data did not provide insight into where, at what time, and why people felt unsafe. Future research should focus on gathering this information. Qualitative approaches could be useful for answering questions about why people use or do not use green spaces for physical activity and social contacts.

Subjective measures of green space

In this thesis, we used objective measures of green space, which reduced the risks of respondent bias. Subjective measures of green space, however, can also provide important information. People's perception of green spaces may, in fact, affect their behaviour more than the actual amount of green space available. Green spaces that are considered unsafe or of poor quality tend to be avoided, which means that supplementing objective measures of green space with measures of people's perception of green space will improve our understanding of how the green environment affects health, behaviour and feelings of social safety (Coley et al., 1997; Kuo et al., 1998a; Kweon et al., 1998).

Samenvatting (Summary in Dutch)

De kortste samenvatting van dit proefschrift is te vinden in de titel: "Vitamine G", waarbij de G staat voor het groen om ons heen en Vitamine staat voor de mogelijk positieve relatie tussen groen en gezondheid. In dit proefschrift wordt onderzocht of de hoeveelheid groen in de woonomgeving van mensen samenhangt met de gezondheid van mensen.

Achtergrond en onderzoeksvragen

In onze huidige samenleving waar een groot aantal mensen in een stedelijke omgeving woont, is groen geen vanzelfsprekend onderdeel meer van de directe leefomgeving. Als gevolg van de toenemende urbanisatie en het compacte stad beleid is het groen in stedelijke gebieden onder druk komen te staan. Als de aanwezigheid van groen in de woonomgeving de gezondheid van mensen positief kan beïnvloeden, dan kan leven in een minder groene woonomgeving negatieve consequenties hebben voor de gezondheid van mensen. Mensen kennen van oudsher een heilzame werking toe aan de natuur (Van den Berg and Van den Berg, 2001). Maar wetenschappelijk bewijs voor een directe relatie tussen de hoeveelheid groen in de woonomgeving en gezondheid is schaars. Slechts twee epidemiologische onderzoeken hadden het directe verband onderzocht toen er met het Vitamine G programma werd gestart (Takano et al., 2002; De Vries et al., 2003). Deze studies verschafte eerste aanwijzingen voor een positieve relatie tussen de hoeveelheid groen in de woonomgeving en gezondheid. Maar een aantal vragen bleven onbeantwoord. Ten eerste was er weinig bekend over de sterkte van de relatie tussen groen en gezondheid. Ten tweede is het onbekend of de relatie verschilt voor specifieke gezondheidsuitkomsten, zoals bijvoorbeeld de ontwikkeling van cardiovasculaire ziektes of depressie. Ten derde is er meer kennis nodig over in of de relatie verschilt voor verschillende bevolkingsgroepen. Ten vierde was het onduidelijk of de relatie tussen groen en gezondheid verschilt voor typen groen. (Gezondheidsraad en RMNO, 2004). Ten vijfde is het onbekend of de relatie afhankelijk is van de nabijheid van het groen. Met andere woorden, er is diepgaander onderzoek nodig naar de relatie tussen groen en gezondheid.
Deze onderzoeksgebieden zijn behandeld in het eerste van dit proefschrift.

In het tweede deel van dit proefschrift is onderzocht of mechanismen die verband houden met blootstelling en gedrag de relatie tussen groen en gezondheid kunnen verklaren. Het meeste empirische bewijs voor de voordelige relatie met groen is gevonden in gecontroleerd, experimenteel onderzoek dat zich richt op het aantonen van de relatie tussen blootstelling aan groene omgevingen en herstel van stress en aandachtsvermoeidheid (Gezondheidsraad en RMNO, 2004). Over de rol van een gedrags-mechanisme is veel minder bekend. Het idee achter het gedragsmechanisme is dat groen mogelijk bewegen kan stimuleren en sociale contacten kan vergemakkelijken (Pikora et al., 2003; Kawachi en Berkman, 2000 Kuo et al., 1998). Daarom onderzoeken we in dit proefschrift tevens of deze twee vormen van gedrag de relatie tussen groen en gezondheid kunnen verklaren.
Naast deze causale mechanismen, kan een deel van de relatie het resultaat zijn van directe of indirecte selectie. We hebben statistisch gecontroleerd voor de mogelijkheid van indirecte selectie door in de analyses rekening te houden met demografische en sociaal-economische kenmerken van mensen. Omdat het onmogelijk is om te controleren voor directe selectie in een cross-sectionele studie was het niet mogelijk om de invloed van directe selectie uit te sluiten.

Er kan ook een andere kant zitten aan de mogelijk positieve relatie tussen groen en gezondheid, omdat groen soms ook geassocieerd met gevoelens van onveiligheid. Daarom onderzoeken we in het derde deel van dit proefschrift of de hoeveelheid groen in de woonomgeving van mensen positief of negatief gerelateerd is aan gevoelens van sociale veiligheid.

In het laatste deel van dit proefschrift onderzoeken we of de kennis over de relatie tussen groen en gezondheid gebruikt wordt in de gezondheidszorg. Meer specifiek hebben we onderzocht of de gezondheidsvoordelen van groen gebruikt worden gebruikt in leefstijladviezen gegeven door huisartsen.

Samenvattend zullen in dit proefschrift de volgende onderzoeksvragen beantwoord worden:

1 *'Hoe sterk is de relatie tussen de hoeveelheid groen in de woonomgeving en gezondheid?'*
   a *In welke mate verschilt de relatie voor verschillende bevolkingsgroepen (bijvoorbeeld ouderen, kinderen en mensen met een lage sociaal-economische status)?*
   b *In welke mate is de relatie afhankelijk van het type groene ruimte (bijvoorbeeld stedelijk groen, agrarisch groen)?*
   c *In welke mate is de relatie afhankelijk van de gebruikte gezondheidsuitkomst (ervaren gezondheid, depressie, hart- en vaatziekten)?*
   d *In welke mate is de relatie afhankelijk van de nabijheid van groen?*

2 *'Kan de relatie tussen de hoeveelheid groen in de woonomgeving van mensen en gezondheid verklaard worden door de mechanismen blootstelling en gedrag?'*

3 *'Is de hoeveelheid groen in de woonomgeving van mensen positief of negatief gerelateerd aan gevoelens van veiligheid?'*

4 *'In welke mate worden de gezondheidsvoordelen van natuurlijke omgevingen gebruikt in de gezondheidszorg?'*

Data en methoden

De gezondheidsgegevens die voor dit proefschrift zijn gebruikt zijn afkomstig van de Tweede Nationale Studie naar Ziekten en Verrichtingen in de Huisartspraktijk (NS2). Dit is een landelijke representatieve gegevensverzameling onder 104 huisartspraktijken in Nederland waarbij 195 huisartsen en ongeveer 400.000 mensen betrokken zijn.
De gegevens over gevoelens van veiligheid zijn afkomstig uit de Politiemonitor Bevolking 2001. Dit is een landelijke representatieve opinieonderzoek onder een aselecte steekproef van ongeveer 90.000 mensen dat zich richt op verschillen in misdaadcijfers, gevoelens van sociale veiligheid en meningen over de politie (PMB, 2001).
Data over de verdeling van groente ruimte in Nederland zijn afkomstig uit het Landelijke Grondbestand Nederland 4 (LGN4). In dit bestand is

Nederland verdeeld in grid cellen van 25 bij 25 meter. Van elk van deze cellen is bekend wat het dominante type grondgebruik is. Met behulp van deze gegevens is vervolgens het percentage groen in de woonomgeving van mensen berekend.
De meeste onderzoeksvragen zijn beantwoord met behulp van multivariate multilevel modellen waarin gecontroleerd wordt voor demografische en sociaal-economische achtergrondkenmerken en mate van verstedelijking.

Belangrijkste bevindingen, discussie en wetenschappelijke implicaties

Deel 1: de relatie tussen groene ruimte en gezondheid

In het eerste van dit proefschrift zijn de relaties tussen de hoeveelheid groen in de woonomgeving en de ervaren gezondheid (hoofdstuk 2) en morbiditeit onderzocht (hoofdstuk 3). In deze studies is statistisch gecontroleerd voor indirecte selectie.

Ervaren gezondheid (hoofdstuk 2*)*
De bevindingen van hoofdstuk 2 laten zien dat de hoeveelheid groen in de woonomgeving van mensen positief geassocieerd is met de ervaren gezondheid van bewoners. De positieve relatie tussen groen en ervaren gezondheid is zowel in stedelijke gebieden als in plattelandsgebieden gevonden. De sterkte van de relatie bleek aanzienlijk; de kans dat bewoners hun gezondheid als minder dan goed beoordelen is in weinig groene woonomgevingen 1,5 keer zo groot als in heel groene woonomgevingen. De relatie tussen groen en ervaren gezondheid is even sterk voor de hoeveelheid groen in een 1km straal als voor de hoeveelheid groen in een 3km straal om het huis, alleen in de heel sterk stedelijke gebieden wordt groen verder weg belangrijker voor de gezondheid van mensen. Wat betreft het type groen blijkt dat zowel agrarisch groen als stedelijk groen positief gerelateerd zijn aan de ervaren gezondheid. De relatie tussen de hoeveelheid groen in de woonomgeving en gezondheid is iets sterker voor mensen met een lage sociaal-economische status vergeleken met mensen met een hoge sociaal-economische status en voor jongeren en ouderen in vergelijking met volwassenen in de leeftijd tussen 25 en 64 jaar.

De resultaten die gepresenteerd zijn in dit hoofdstuk wijzen er tevens op dat de hoeveelheid groen in de woonomgeving belangrijk kan zijn bij de verklaring van de gezondheidsverschillen tussen stad en platteland. Eerder onderzoek toont aan dat de relatie tussen mate van verstedelijking en de ervaren gezondheid van mensen vrij goed bestand is tegen pogingen om te controleren voor demografische, sociaal-economische en gedragsgerelateerde factoren alsook voor selectieve migratie (Verheij et al., 2008). De resultaten van het onderzoek dat gepresenteerd is in hoofdstuk 2 laten zien dat de hoeveelheid groen in de woonomgeving sterker gerelateerd is aan de ervaren gezondheid van mensen dan stedelijkheid wanneer wordt gecontroleerd voor leeftijd, geslacht, sociaal-economische status, werkstatus en etniciteit.

Verdere analyses betreffende de relatie tussen groen en ervaren gezondheid lieten een lineaire relatie zien (niet weergegeven in hoofdstuk 2). Voor ervaren gezondheid lijkt er geen drempel te zijn waarboven meer groen niet tot een betere gezondheid leidt: elk beetje groen telt.

In deze studie zijn de analyses van De Vries et al. (2003) gerepliceerd door gebruik te maken van grotere en recentere datasets die beter op elkaar zijn afgestemd. De bevinding van het in hoofdstuk twee gepresenteerde onderzoek komen overeen met de bevindingen van De Vries et al. (2003) waarin eveneens een positieve relatie werd gevonden tussen groen en ervaren gezondheid. De relatie bleek eveneens sterker te zijn voor mensen met een lage sociaal-economische status en voor ouderen. In de studie van De Vries et al. is eveneens gevonden dat mensen met meer groen in hun woonomgeving minder gezondheidsklachten en een betere geestelijke gezondheid ervaren.
In andere landen zijn in de laatste paar jaar ook verschillende aanwijzingen gevonden voor een positieve relatie tussen groen en gezondheid. In Engeland repliceerden Mitchell en Popham (2007) onze studie. Zij vonden dat een grotere hoeveelheid groen in een gebied over het algemeen geassocieerd was met een betere ervaren gezondheid. De positieve associatie bleek echter wel afhankelijk te zijn van de mate van verstedelijking en inkomen. Er werd geen relatie gevonden tussen groen en gezondheid in suburbane en plattelandsgebieden met hogere inkomens. Dit zou volgens de onderzoekers te maken kunnen hebben met de kwaliteit van het groen die in dit onderzoek niet is meegenomen.

In Zweden vonden Björk et al. (2008) geen relatie tussen de hoeveelheid groen in een 100 meter en 300 meter straal om het huis en ervaren gezondheid. Nielsen et al. (2007) vonden dat mensen woonachtig in Zweden die toegang hadden tot een tuin of op korte afstand van groene gebieden woonde minder gestrest waren en minder kans hadden op obesitas. Ellaway et al. (2005) onderzochten tevens de relatie tussen groen en obesitas. Met behulp van een cross-sectioneel Europees onderzoek vonden ze dat respondenten met veel groen in hun woonomgeving een 40% lagere kans hadden op overgewicht en obesitas.
De resultaten van een studie uitgevoerd in Australië door Sugiyama et al. (2007) toonde aan dat mensen die hun buurt als heel groen ervaren een respectievelijk 1.37 en 1.60 maal hogere kans hadden op een betere fysieke en geestelijke gezondheid. De ervaren mate van groen in de buurt bleek sterker gerelateerd te zijn aan geestelijke gezondheid dan aan fysieke gezondheid. Mensen woonachtig in buurten die als gemiddeld groen werden ervaren hadden green grotere kans op een betere fysieke of geestelijke gezondheid, wat aangeeft dat met name hele groene buurten gezondheid stimuleren. Tenslotte, toonde een longitudinale studie uitgevoerd onder ouderen woonachtig in Tokio, Japan aan dat woonomgevingen met groene straten en groen dichtbij de woning positief geassocieerd waren met levensduur van oudere bewoners van steden (Takano et al., 2002).

Samenvattend kan er gesteld worden dat er een positieve associatie gevonden is tussen groen in de woonomgeving en verschillende gezondheidsuitkomsten in landen die verschillen in bevolkingsdichtheid en beschikbaarheid van groen.

Morbiditeit (hoofdstuk 3)
Verschillende studies hebben dus bewijs geleverd voor een positieve relatie tussen de hoeveelheid groen in de woonomgeving en zelfgerapporteerde algemene indicatoren voor fysieke en geestelijke gezondheid. In hoofdstuk 3 zijn we nog een stap verder gegaan dan deze onderzoeken en hebben we onderzocht of verschillende, door de arts vastgestelde ziekteclusters gerelateerd zijn aan de hoeveelheid groen in de woonomgeving van mensen. Met behulp van grootschalige representatieve morbiditeitdata laten de bevindingen uit dit hoofdstuk zien dat de jaarlijkse prevalentie van 18 van de 24 meegenomen ziekteclusters lager is in woonomgevingen met meer

groen in een 1km straal om het huis van mensen. Er werden geen significante relaties gevonden met de hoeveelheid groen in een 3km straal om het huis van mensen. Dit wijst erop dat groen dichter bij huis belangrijker is voor de prevalentie van ziekten dan groen op een grotere afstand.
Wat betreft de ziekteclusters was de relatie het sterkst voor angststoornissen en depressie. De kans op depressie is 1,33 keer zo hoog in woonomgevingen met weinig groen dan in woonomgevingen met heel veel groen.
De relatie bleek met name sterk te zijn voor kinderen en voor mensen met een lage sociaal-economische status.

Wetenschappelijke implicaties over de relatie tussen groen en gezondheid
De in hoofdstuk 2 en 3 gepresenteerde studies behoren tot één van de eerste studies bewijs leveren voor een directe positieve relatie tussen de hoeveelheid groen in de woonomgeving en gezondheid in Nederland.
De studies gepresenteerd in dit proefschrift en de studies uitgevoerd in andere landen tonen aan dat de relatie tussen groen en gezondheid niet afhankelijk is van de gebruikte gezondheidsindicator. De relatie was zichtbaar voor ervaren gezondheid, specifieke ziektes, stress, het aantal gezondheidsklachten, geestelijke gezondheid en obesitas (De Vries et al., 2003; Mitchell en Popham, 2007; Takano et al., 2002; Nielsen en Hansen, 2007; Sugiyama et al., 2007).
Wat betreft de sterkte van de relatie, wijzen de resultaten op een sterkere relatie tussen groen en ervaren gezondheid dan tussen groen en de prevalentie van specifieke ziektes. De kans dat iemand zich ongezond voelt is voor mensen woonachtig in weinig groene omgevingen 1,5 keer zo groot als voor mensen woonachtig in heel groene omgevingen. Voor de prevalentie van specifieke ziektes is deze relatie minder sterk. De kans op één van de ziekteclusters die sterk gerelateerd is aan de hoeveelheid groen in de woonomgeving, namelijk depressie, is 1,33 keer zo hoog als wanneer men in een woonomgeving woont met weinig groen.

Relatie voor verschillende bevolkingsgroepen
We hebben ook onderzocht in welke mate de relatie verschilt voor verschillende bevolkingsgroepen. Alhoewel de positieve relatie tussen groen en gezondheid voor alle onderzochte bevolkingsgroepen aanwezig is, blijkt de relatie sterker te zijn voor jonge mensen, ouderen en mensen met een lage sociaal-economische status. Een mogelijke verklaring hiervoor is dat deze

mensen meer tijd in de nabijheid van hun huis doorbrengen als gevolg van lagere mobiliteit (Schwanen et al., 2002; Harms, 2006b). Bij mensen met een lagere sociaal-economische status kan een mogelijke verklaring tevens zijn dat gemiddeld genomen hun gezondheidssituatie minder is waardoor er meer ruimte is voor verbetering. Hierdoor kunnen ze ook wat meer ontvankelijk zijn voor de hoeveelheid groen in de woonomgeving.

Type groen
Wat betreft het type groen vonden we een iets sterkere relatie voor natuurlijk en agrarisch groen vergeleken met stedelijk groen.

Nabijheid van groen
Tot slot kunnen we met behulp van de uitgevoerde studies nagaan of groen dichter bij huis sterker gerelateerd was aan de gezondheid van mensen dan groen verder weg. Voor de ervaren gezondheid bleek de relatie tussen de hoeveelheid groen in een 1km en in een 3km straal even sterk te zijn, alhoewel in de heel sterk stedelijke gebieden groen verder weg belangrijker was. Voor morbiditeit was er alleen een relatie met groen in de directe woonomgeving van mensen (1km). In het algemeen lijkt het erop dat groen dichtbij huis iets belangrijker is voor de gezondheid van mensen. Dit kan te maken hebben met het feit dat het gebruik en de blootstelling aan groen afneemt naarmate het groen verder weg is (Nielsen en Hansen, 2007; Neuvonen et al., 2008).

Deel II: Mechanismen achter de relatie tussen groen en gezondheid

In het tweede deel van dit proefschrift hebben we onderzocht hoe de relatie tussen groen en gezondheid kan worden verklaard. In hoofdstuk 4 tot en met 6 zijn twee achterliggende mechanismen aan de orde gekomen.
We hebben eerst onderzocht of de relatie tussen groen en gezondheid verklaard kan worden door psychologische processen die gekoppeld zijn aan blootstelling aan groen (hoofdstuk 4). Daarnaast hebben we onderzocht of gezond gedrag de relatie tussen groen en gezondheid kan verklaren (hoofdstuk 5, 6). In alle studies hebben we zoveel mogelijk gecontroleerd voor indirecte selectie.

Blootstelling

Groene ruimte, stressvolle levensgebeurtenissen en gezondheid (hoofdstuk 4)

Volgens het Dynamische Stress-Kwetsbaarheid model (Heady en Wearing, 1989; Ormel en Neeleman, 2000) kan het vooruitzicht te leven in een omgeving met beperkte toegang tot groene ruimte, de kwetsbaarheid vergroten doordat de invloed van het meemaken van een stressvolle gebeurtenis op geestelijke en fysieke gezondheid groter wordt. Er is wetenschappelijk bewijs uit diverse onderzoeksvelden dat aantoont dat contact met natuurlijke omgevingen, waaronder groen nabij de woonomgeving, kan bijdragen aan hestel van stress en mentale vermoeidheid. Mensen met meer groen in hun woonomgeving hebben meer mogelijkheden om het groen te bezoeken en aanschouwen en kunnen meer profiteren van de herstellende effecten dan bewoners van buurten met weinig groen (Kaplan en Kaplan, 1989).

In hoofdstuk 4 hebben we onderzocht in hoeverre de aanwezigheid van groen dichtbij of verder weg van huis de negatieve invloed van stressvolle levensgebeurtenissen op ervaren, geestelijke en fysieke gezondheid kan verminderen.

De resultaten van de studie duiden op een buffereffect van de hoeveelheid groen in de wijdere woonomgeving van mensen op de negatieve invloed van stressvolle levensgebeurtenissen op de ervaren fysieke gezondheid. Volwassenen die onlangs één of meer stressvolle levensgebeurtenissen hadden meegemaakt rapporteerde significant minder gezondheidsklachten als ze meer groen in hun woonomgeving hadden. Het buffereffect werd alleen gevonden voor de hoeveelheid groen in een 3km straal om de woning en niet voor de hoeveelheid groen in een 1km straal om de woning. Voor ervaren algemene en geestelijke gezondheid werden geen buffereffecten gevonden.

Een mogelijke verklaring voor het feit dat er alleen een buffer effect werd gevonden voor groen in een 3km straal om het huis is dat een hoger percentage groen in een 3km straal de aanwezigheid van meer grotere natuurgebieden weerspiegeld. De beschikbaarheid van grotere natuur-gebieden in de woonomgeving biedt wellicht mogelijkheden voor reflectie en restoratie op een dieper niveau, dat niet, of in mindere mate, kan worden bereikt in kleinere natuurgebieden (in een 1km straal). Vergeleken met andere studies vonden we een relatief zwak buffereffect. Dit kan te maken hebben met het feit dat we in onze studie gebruik hebben gemaakt van een representatieve steekproef van de Nederlandse bevolking waarin de

respondenten over het algemeen goed gezond waren, terwijl de eerdere studies zich hebben gericht op specifieke groepen.

Gezond gedrag

Bewegen (hoofdstuk 5)

In hoofdstuk 5 is onderzocht of bewegen een mogelijk mechanisme is achter de relatie tussen de hoeveelheid groen in de woonomgeving en ervaren gezondheid. Om dit te onderzoeken zijn we eerst nagegaan in hoeverre de hoeveelheid groen in de woonomgeving gerelateerd is aan de mate van bewegen. Wanneer er een verband tussen groen en een bepaald vorm bewegen werd gevonden, hebben we onderzocht of het gevonden verband de relatie tussen groen en ervaren gezondheid kon verklaren.

Wij vonden geen relatie tussen de hoeveelheid groen in de woonomgeving en het al dan niet voldoen aan de Nederlandse Norm voor Gezond Bewegen (NNGB). Daarnaast vonden we ook geen relatie tussen de hoeveelheid groen in de woonomgeving en sporten en wandelen voor woon-werkverkeer. We vonden een negatieve relatie tussen de hoeveelheid groen in de woonomgeving en wandelen en fietsen in de vrije tijd. Mensen met meer groen in hun woonomgeving bleken minder vaak te wandelen en fietsen in hun vrije tijd. Dit kan te maken hebben met het feit dat groene buurten vaak wat ruimer zijn opgezet met minder winkels in de directe omgeving en meer ruimte voor parkeerplekken.

We vonden wel een positieve relatie tussen de hoeveelheid groen in de woonomgeving en tuinieren en fietsen voor woon-werkverkeer. Met name de hoeveelheid agrarisch groen bleek positief samen te hangen met deze typen bewegen. Dat mensen vaker en langer tuinieren en fietsen voor woon-werkverkeer kon de relatie tussen groen en ervaren gezondheid niet verklaren.

De gevonden relaties tussen groen en bewegen waren het sterkst voor mensen met een lage sociaal-economische status, en voor kinderen en ouderen.

Op basis van de resultaten van dit onderzoek zouden we kunnen concluderen dat bewegen geen voor de hand liggend mechanisme is achter de relatie tussen de hoeveelheid groen in de woonomgeving van mensen en ervaren gezondheid. Echter, het is belangrijk om op te merken dat alhoewel mensen met een groenere woonomgeving niet afwijken van andere groepen in de mate waarin zij voldoen aan de NNGB, het nog steeds wel mogelijk is dat mensen met een groenere woonomgeving wel vaker in een groene

omgeving bewegen. Verschillende andere studies hebben aangetoond dat mensen met meer groen in hun woonomgeving vaker gebruik maken van het groen (onder andere Nielsen en Hansen, 2007). Omdat we geen gegevens hebben over waar mensen bewegen, konden we niet achterhalen of mensen woonachtig in een groenere omgeving vaker in groene gebieden bewegen. Een studie van De Vries et al. (2004) toonde aan dat het lokale groen aanbod niet bepaalt hoe vaak mensen recreëren, maar *waar* mensen recreëren. Bewegen in een groene omgeving in plaats van in een stedelijke omgeving kan gezondheidsvoordelen opleveren in de vorm van verminderde stress symptomen (onder andere Pretty et al., 2005; Hartig et al., 1991).
Bovendien is het mogelijk dat het feit dat we nauwelijks relaties hebben gevonden tussen de hoeveelheid groen in de woonomgeving en bewegen te maken heeft met de hoge dichtheid van sportfaciliteiten en de veilige wandel- en fietspaden in Nederland. In deze omstandigheden, is de beschikbaarheid van groen geen noodzakelijke conditie om mensen aan het bewegen te krijgen. Ten slotte is het belangrijk om te vermelden dat we uitdrukkelijk hebben gekeken naar de relatie tussen de aanwezigheid van groen en bewegen. Met de beschikbare gegevens konden we niet vaststellen of het aanwezige groen ook daadwerkelijk geschikt was voor recreatie en sporten.

Naast de resultaten die in hoofdstuk 6 zijn gepresenteerd, hebben we ook de relatie tussen groen en bewegen specifiek voor adolescenten onderzocht. Uit de resultaten bleek dat adolescenten met een leeftijd tussen 12 en 17 met meer groen in hun woonomgeving vaker voldoen aan de Nederlandse Norm Gezond Bewegen. Er lijkt dus wel een relatie tussen groen en bewegen te zijn voor adolescenten. Dit resultaten wordt ondersteund in andere onderzoeken waar ook een positieve relatie tussen groen en bewegen voor adolescenten gevonden wordt (Timperio et al., 2004; Cohen et al., 2006).

Sociale contacten (hoofdstuk 6)
Groene ruimte in buurten kunnen aantrekkelijke ontmoetingsmogelijkheden voor de buurtbewoners verschaffen en kunnen gemeenschapszin bevorderen. Verder is het breed erkent dat sociale contacten een verscheidenheid van gezondheidsuitkomsten kunnen beïnvloeden. In hoofdstuk 6 hebben we daarom onderzocht of het hebben van sociale

contacten een mogelijk mechanisme is achter de relatie tussen groen en gezondheid.
De resultaten laten allereerst zien dat mensen met meer groen in hun woonomgeving zich minder eenzaam voelen en minder vaak een tekort aan sociale steun ervaren. Er werd geen relatie gevonden tussen groen en de contactfrequentie met buren en met het aantal ondersteunende contacten.
Eenzaamheid en het tekort aan sociale steun bleken de relatie tussen groen en de verschillende ervaren gezondheidsmaten (ervaren gezondheid, het aantal gerapporteerde gezondheidsklachten in de afgelopen 14 dagen en geestelijke gezondheid) gedeeltelijk te medieëren. Het tekort aan sociale steun bleek de relatie tussen groen en geestelijke gezondheid zelfs geheel te verklaren.
We vonden alleen een relatie tussen groen en eenzaamheid en tekort aan sociale steun voor mensen met een lage sociaal-economische status. Dit suggereert dat mensen met een lage sociaal-economische status meer profijt hebben van het groen dan mensen met een hoge sociaal-economische status. Blijkbaar is de hoeveelheid groen in de woonomgeving minder belangrijk voor de sociale contacten van mensen met een hogere sociaal-economische status.

Voor deze studie hebben we gebruik gemaakt van objectieve gegevens over de hoeveelheid groen. We hadden geen informatie over de kwaliteit of veiligheid in deze groen gebieden, terwijl onveilige gebieden en gebieden van slechte kwaliteit sneller worden vermeden door mensen. Een verklaring voor het feit dat we geen relatie hebben gevonden tussen groen en contact met buurtgenoten kan zijn dat we in de analyses geen rekening hebben gehouden met kleinschalig groen. Dit terwijl het wetenschappelijk bewijs juist aanwijzingen laat zien voor een relatie tussen kleinschalig groen en sociale contacten (Coley et al., 2007; Kuo et al., 1998a; Kweon et al., 1998).

Wetenschappelijke implicaties met betrekking tot de mechanismen
In hoofdstuk 4 tot en met 6 is onderzocht hoe de relatie tussen groen en gezondheid verklaard kan worden. Uit de bevindingen van dit proefschrift kunnen we concluderen dat sociale contacten het belangrijkste mechanisme is achter de relatie tussen groen en gezondheid. Dit omdat we geen sterke relaties vonden voor de andere mechanismen.

Echter, conclusies aangaande de mechanismen achter de relatie tussen groen en gezondheid zouden niet alleen gebaseerd moeten worden op de in dit proefschrift gepresenteerde studies. Andere wetenschappelijke kennis betreffende de mechanismen moet ook meegenomen worden.
In dit proefschrift vonden we alleen zwakke aanwijzingen voor een buffer effect van de hoeveelheid groen in de woonomgeving op de negatieve invloed van stressvolle levensgebeurtenissen op gezondheid. Toch kan met behulp van overige wetenschappelijke kennis geconcludeerd worden dat herstel van stress en mentale vermoeidheid het meest waarschijnlijke mechanisme is achter de relatie tussen groen en gezondheid. Alleen voor dit mechanisme is overtuigend bewijs vanuit verschillende onderzoeksvelden dat contact met natuur herstel van stress en aandachtsvermoeidheid kan verschaffen. Hiernaast laten de resultaten van het onderzoek naar de relatie tussen groen en morbiditeit zien dat de gevonden relatie het sterkst is voor stressgerelateerde klachten.
Over de andere mechanismen is minder wetenschappelijke kennis beschikbaar. Onze studies behoren tot de eerste studies waarin de triade tussen een mechanisme, groen en gezondheid wordt onderzocht. Sugiyama et al. (2007) hebben ook onderzocht of bewegen en sociale contacten de relatie tussen groen en gezondheid kunnen verklaren. Meer specifiek hebben ze onderzocht of recreatief wandelen en sociale samenhang en locale sociale interacties de relatie tussen groen en gezondheid medieëren. Ze vonden dat recreatief wandelen de relatie tussen groen en fysieke gezondheid medieerde, terwijl de relatie tussen groen en geestelijke gezondheid alleen gedeeltelijk verklaard kon worden door recreatief wandelen en sociale samenhang. Samenvattend liet deze studie zien dat zowel bewegen als sociale contacten mogelijke mechanismen achter de relatie tussen groen en gezondheid kunnen zijn.
Dit proefschrift levert ook bewijs voor het hebben van sociale contacten als mogelijk mechanisme achter de relatie tussen groen en gezondheid.
Wat betreft bewegen wijzen onze resultaten erop dat voor adolescenten bewegen een mogelijk achterliggend mechanisme zou kunnen zijn. Maar voor volwassenen en ouderen vonden we geen aanwijzingen voor bewegen als mogelijk mechanisme achter de relatie tussen groen en gezondheid.
Ook de wetenschappelijke literatuur is niet eenduidig over de relatie tussen groen en bewegen. Zoals is aangegeven in de introductie van hoofdstuk 6 zijn er verschillende studies die hebben aangetoond dat esthetisch aantrekkelijke omgevingen en de aanwezigheid en toegankelijkheid van

parken bepaalde soorten bewegen kunnen stimuleren. Aan de andere kant zijn er ook andere studies waarin geen relatie tussen groen en gezondheid wordt gevonden (Hillsdon en Thorogood, 1996; Kazcynski en Henderson, 2007).
De tegenstrijdige resultaten van de verschillende studies kunnen verklaard worden door de verschillende vormen van bewegen en verschillende typen groen die zijn onderzocht.
Dat studies naar de relatie tussen bewegen en natuurlijke omgevingen zulke diverse resultaten laten zien kan voor een deel verklaard worden doordat er in de studies verschillende soorten bewegen onderzocht worden in verschillende natuurlijke settings. Dit maakt onderlinge vergelijking van het onderzoek moeilijk.

Relatie voor verschillende bevolkingsgroepen
Voor bewegen en sociale contacten hebben we ook onderzocht of de relatie verschilt voor bevolkingsgroepen. Voor beide bleek de relatie sterker te zijn voor mensen met een lage sociaal-economische status en voor adolescenten en ouderen.

Type groen
Wat betreft het type groen bleek de relatie tussen groen en bewegen sterker te zijn voor agrarisch groen. Voor sociale contacten en stress is de rol van het type groen niet onderzocht.

Nabijheid van groen
Met betrekking tot de nabijheid van groen bleek voor bewegen en eenzaamheid zowel groen dichtbij als groen verder weg belangrijk te zijn. Voor het tekort aan sociale steun bleek alleen groen dichtbij belangrijk te zijn. Verder vonden we alleen een buffer effect van groen voor de relatie tussen het meemaken van stressvolle levensgebeurtenissen en gezondheid voor de hoeveelheid groen in een 3km straal om het huis van mensen. Dit suggereert dat mensen in tijden van crisis behoefte hebben omgevingen die restoratie op een dieper niveau mogelijk maken.

Selectie
Een deel van de gevonden relatie tussen groen en gezondheid kan het gevolg zijn van directe of indirecte selectie. We hebben zoveel mogelijk gecontroleerd voor de invloed van indirecte selectie door in de analyses

rekening te houden met demografische en sociaal-economische kenmerken. Toch kan de rol van indirecte selectie niet geheel worden uitgesloten. De resultaten van de analyses voor mensen met een verschillende sociaal-economische achtergrond maken het echter niet aannemelijk dat indirecte selectie het verantwoordelijke mechanisme is. De geobserveerde relatie tussen groene ruimte en gezondheid was sterker voor de lager opgeleiden, terwijl mag worden aangenomen dat deze bevolkingsgroep minder mogelijkheden heeft in de keuze voor een buurt.
De gevonden resultaten zouden ook het gevolg kunnen zijn van selectieve migratie gebaseerd op de gezondheid van mensen: gezonde mensen zouden ervoor kunnen kiezen om in een groenere woonomgeving te gaan wonen (directe selectie). Het is onmogelijk om voor directe selectie te controleren in een cross-sectioneel onderzoek. Echter, longitudinale studies over op gezondheidsgerelateerde migratie laten zien dat directe selectie niet verantwoordelijk gehouden kan worden door geografische verschillen die blijven bestaan na controle voor sociaal-economische en demografische kenmerking (Verheij et al., 1998; Van Lenthe et al., 2007).

Ander mogelijke niet onderzocht mechanismen
Verschillende andere mechanismen zouden ook een rol kunnen spelen bij de verklaring van de relatie tussen groen en gezondheid. Een belangrijk mechanisme dat niet specifiek is besproken in dit proefschrift, maar dat wel belangrijk kan zijn bij het verklaren van de relatie tussen groen en gezondheid is luchtkwaliteit.
Luchtvervuiling kan verschillende ziekten aan de luchtwegen veroorzaken (Brunekreef en Holgate, 2002; ATS, 1996; WHO, 2004). Volgens verschillende studies kan groen luchtvervuiling verminderen en daarmee de gezondheid van mensen verbeteren (Nowak et al., 2006; Van Hove, 2008; Beckett et al., 2000). De resultaten van de studie die in hoofdstuk 3 is gepresenteerd wijzen erop dat luchtvervuiling een mogelijk mechanisme achter de relatie tussen groen en gezondheid zou kunnen zijn. Dit omdat in woonomgevingen met meer groen, de jaarlijkse prevalentie van bijna alle ziekteclusters gerelateerd aan klachten aan de luchtwegen lager was. Toekomstig onderzoek zou bij de verklaring van de relatie tussen groen en gezondheid dan ook rekening moeten houden met de rol van luchtkwaliteit.

Deel III: Groen en gevoelens van sociale veiligheid

In deel drie van dit proefschrift is de relatie tussen de hoeveelheid groen in de woonomgeving en gevoelens van sociale veiligheid onderzocht.

Groen en gevoelens van sociale veiligheid (hoofdstuk 7)
Dit proefschrift levert bewijs voor een positieve relatie tussen de hoeveelheid groen in de woonomgeving en de gezondheid van mensen. De hoeveelheid groen in de woonomgeving hoeft echter niet alleen positieve effecten te hebben. Groen kan ook gevoelens van onveiligheid oproepen omdat groen als schuilplaats voor criminelen wordt gezien. Daarom hebben we in hoofdstuk 7 de relatie tussen de hoeveelheid groen in de woonomgeving en gevoelens van sociale veiligheid onderzocht. De resultaten van de studie laten zien dat mensen met meer groen in hun woonomgeving zich over het algemeen veiliger voelen. Alleen in heel sterk stedelijke gebieden werd een negatieve relatie gevonden tussen de hoeveelheid gesloten groen en gevoelens van sociale veiligheid. De zogenaamde kwetsbare bevolkingsgroepen (vrouwen en ouderen) voelden zicht niet onveiliger in woonomgevingen met meer groen.
Wat betreft het type groen, vonden we dat zowel de hoeveelheid open, als de hoeveelheid gesloten groen in de woonomgeving positief samenhangt met de gevoelens van sociale veiligheid. Zoals hierboven vermeld, bleek gesloten groen alleen in heel sterk stedelijke gebieden de gevoelens van onveiligheid te vergroten. Het lijkt er op dat groen niet alleen bij kan dragen aan de gezondheid van mensen, maar ook kan bijdragen aan de gevoelens van veiligheid.
Helaas beschikten we niet over informatie over de kwaliteit van het groen. Specifieke kenmerken van het groen, zoals bijvoorbeeld over het onderhoud, sociale cohesie en de mate van anonimiteit kunnen wellicht meer licht werpen op de gevonden negatieve relatie van gesloten groen in heel stedelijke gebieden.

Deel IV: Gebruik van groen in de gezondheidszorgsector

Gebruik van groen in de gezondheidszorgsector (hoofdstuk 8)
In het laatste deel van dit proefschrift is onderzocht of de gezondheids-voordelen van groen gebruikt worden in de gezondheidszorgsector.

Traditioneel hebben mensen een geneeskrachtige werking toegeschreven aan de invloed van een natuurlijke omgeving en werd die veronderstelde invloed gebruikt in verschillende gezondheidszorginstellingen. Echter, door de snel groeiende technologische ontwikkelingen zijn de gezondheidszorginstellingen veel minder dan vroeger omringd door groen (Van den Berg en Van den Berg, 2001). De literatuur suggereert dat de gezondheid van mensen profijt heeft van zowel bewegen als van de aanwezigheid van natuur. Bovendien zijn er aanwijzingen dat bewegen in een groene omgeving beter is voor de gezondheid dan bewegen elders (Pretty et al., 2005; Hartig et al., 1991). Deze inzichten worden slechts in beperkte mate gebruikt in de gezondheidszorgsector. Een toenemend aantal boerderijen wordt gebruikt als basis om de geestelijke en fysieke gezondheid van mensen te bevorderen (Hassink en Van Dijk, 2006). Daarnaast is er een toenemend bewustzijn in verpleeg- en verzorgingshuizen en ziekenhuizen aangaande de gezondheidsvoordelen van groen en natuur (Van den Berg, 2005). In Nieuw-Zeeland en Groot-Brittannië worden de inzichten over de gezondheidsvoordelen van natuur gebruikt in de eerstelijnszorg (Humphreys, 2003; Elley et al., 2003).
Tot nu toe was het echter onbekend of de gezondheidsvoordelen van natuur ook gebruikt worden in de huisartsenzorg. Daarom hebben we dit onderzocht door een aselecte steekproef van 100 van de 2.784 opgenomen huisartsenconsulten te observeren. We hebben allereerst onderzocht in hoeverre huisartsen patiënten adviseren om te bewegen. Daarnaast zijn we nagegaan in hoeverre huisartsen advies geven om in de natuur te bewegen. Omdat de huisartsenzorg voor Nederlanders meestal het eerste contactpunt is met het gezondheidszorgsysteem kunnen de grootste gezondheidsvoordelen waarschijnlijk hier worden bereikt.
Uit de resultaten bleek dat alhoewel in 26% van de huisartsconsulten advies werd gegeven werd over bewegen, de toegevoegde waarde van bewegen in natuur niet ter sprake kwam tijdens huisartsconsulten in 2001.
Dit deel van dit proefschrift laat zien dat er ruimte is om de hoeveelheid groen in de gezondheidssector te vergroten.

Beleidsaanbevelingen

Alhoewel mensen van oudsher een heilzame werking aan de natuur toekennen en mensen over het algemeen ook geloven dat groen goed is voor

de gezondheid (Frerichs, 2004), was er tot voor kort amper wetenschappelijk bewijs voor een directe relatie tussen groen en gezondheid.
Dit proefschrift levert bewijs voor een directe positieve relatie tussen de hoeveelheid groen in de woonomgeving en gezondheid in Nederland. Allereerst laat de bevindingen zien dat de hoeveelheid groen in de woonomgeving van mensen positief samenhangt met diverse ervaren gezondheidsmaten (ervaren gezondheid, het aantal gezondheidsklachten en geestelijke gezondheid).
Ten tweede laten de bevindingen van de studie naar de relatie tussen groen en morbiditeit zien dat de rol van groen in de woonomgeving voor gezondheid niet onderschat moet worden. De meeste ziektes die gerelateerd bleken te zijn aan de hoeveelheid groen in de woonomgeving hebben een hoge prevalentie in de samenleving en zijn in veel landen onderwerp van grote preventie programma's. Hiernaast zijn ziektes van de luchtwegen, geestelijke ziekten en ziektes van het digestieve systeem, waarvoor we een relatie vonden met groen, aandoeningen die in aanmerkelijke mate bijdragen aan het totale niveau van kosten van de gezondheidszorg (Heijink et al., 2006). Ten derde laat dit proefschrift zien dat mensen met meer groen in hun woonomgeving zich over het algemeen veiliger voelen.

Samenvattend biedt dit proefschrift aanwijzingen voor de stelling dat groene ruimte meer is dan een luxe product. De aanwezigheid van groen is gerelateerd aan de ervaren en objectieve gezondheid van mensen en aan gevoelens van sociale veiligheid. De bevindingen suggereren dat de ontwikkeling van groene ruimte een meer centrale rol zou moeten krijgen toebedeeld in beleid gerelateerd aan gezondheid, natuur of ruimtelijke ordening. Bovendien verschaft het argumenten om het onderwerp groen en gezondheid op de politieke agenda te krijgen en om beleid op dit gebied te legitimeren.

Landelijk beleid aangaande gezondheid, natuur en ruimtelijke ordening
De relatie tussen groen en gezondheid raakt verschillende beleidsvelden, namelijk gezondheidszorg, natuurbeheer en ruimtelijke ordening.. Het is essentieel dat de verschillende hierbij betrokken partijen samen werken en ervoor zorgen dat het groen niet volledig uit het straatbeeld verdwijnt.

Het beleid van de Ministeries van VWS, LNV en VROM richt zich deels op de kwetsbare bevolkingsgroepen zoals ouderen, kinderen en jongeren en

mensen met een lage sociaal-economische status. In dit proefschrift vonden we met name een sterke relatie tussen groen en gezondheid voor deze bevolkingsgroepen. De bevindingen duiden er dan ook op dat beleidsmakers rekening moeten houden met de hoeveelheid groen in de woonomgeving wanneer ze de gezondheid van deze groepen wil verbeteren, met name in stedelijke gebieden waar weinig groen beschikbaar is.

In de jaren waarin het Vitamine G-programma is uitgevoerd, is er een toenemende interesse voor het gebruik van groen voor een gezonde leefomgeving. Was er in de beleidsdocumenten van de laatste jaren vrijwel geen aandacht voor groen, in de laatste visie op gezondheid en preventie van het Ministerie van VWS (2007) wordt groen gezien als een middel dat ingezet kan worden om bewegen te stimuleren en een gezonde leefomgeving te creëren. Ook het Ministerie van VROM (2008) ziet een rol weggelegd voor groen in de Nationale Aanpak Milieu en Gezondheid. Dit actieplan bevat de activiteiten op het gebied van omgeving en gezondheid die geïmplementeerd moeten worden in de jaren 2008-2012. Een van de belangrijkste punten van het actieplan is het gezond ontwerpen en inrichten van de leefomgeving. De rol van groenvoorzieningen neemt hierbij een prominente plaats in.
Dit zijn voorbeelden van enkele documenten die aantonen dat, althans op landelijk niveau, er een toenemende aandacht is voor groen bij het inrichten van de leefomgeving. Echter, de meeste officiële regeringsdocumenten over het gezond inrichten van de leefomgeving of het verbeteren van de kwaliteit van de leefomgeving richten zich met name op de rol van het verbeteren van luchtkwaliteit en het verminderen van geluidsoverlast. De resultaten van dit proefschrift laten zien dat beleidsmakers die pogen een gezonde, veilige en kwalitatief goede leefomgeving in te richten zich ook bewust moeten zijn van de rol die groen hierin kan spelen.

Gemeentelijk beleid
Alhoewel er op nationaal niveau meer aandacht is voor groen, is deze aandacht nog niet doorgedrongen tot beleidsdocumenten op gemeentelijk niveau. In de huidige gemeentelijke nota's voor gezondheidszorgbeleid en de gemeentelijke woonvisies (hierin worden richtlijnen gegeven over wonen en de kwaliteit van de woonomgeving) is nog weinig plaats voor groen (Van Loon, 2008; Van den Broek en Kwekkeboom, 2007; Groenforum Nederland, 2008). Alleen in de nota's voor gezondheidszorgbeleid van enkele grote

steden is een rol voor groen weggelegd. Groen wordt in deze nota's gezien als middel voor het creëren van een gezonde woonomgeving (Van Loon, 2008).

Stedelijke planning
Met name in stedelijke omgevingen, waar groen onder druk staat, kunnen de bevindingen van dit proefschrift gebruikt worden als argument om ten minste de hoeveelheid groen te behouden of – als het mogelijk is – de hoeveelheid groen te vergroten om gezondheidsredenen. Stedelijke ontwikkelaars zouden met name rekening kunnen houden met groen bij het herstructureren van bestaande buurten en bij de ontwikkeling van nieuwe buurten.

Op de vraag hoe het groen dan het best kan worden ingericht voor optimale gezondheidsvoordelen kan worden, kan met behulp van het in dit proefschrift uitgevoerde onderzoek helaas nog geen antwoord gegeven worden. Het onderzoek naar de mechanismen achter de relatie tussen groen en gezondheid zou informatie kunnen leveren over het soort en de hoeveelheid groen die nodig zijn. Alhoewel we concluderen dat herstel van stress waarschijnlijk het meest aannemelijke mechanisme is achter de relatie, concluderen we ook dat sociale contacten en bewegen mogelijke mechanismen kunnen zijn. De ideale inrichting van het groen is per mechanisme verschillend. Voor bewegen zijn wandel- en fietspaden handig, voor sociale contacten bankjes en voor herstel van stress is met name rust bijvoorbeeld belangrijk. Nu het achterliggende mechanisme nog onbekend is lijkt het meest verstandig om nieuwe groengebieden zo in te richten dat een combinatie van rust, mogelijkheden tot bewegen en mogelijkheden voor sociale contacten wordt geboden.

Kosten-baten analyses
Stedelijke planning wordt veelal ondersteund door een kosten-batenanalyses van de bouwplannen. Het zou nuttig zijn om te onderzoeken hoe in toekomstige kosten-batenanalyses de gezondheidseffecten van groen mee genomen kunnen worden.

Compacte stad beleid
Als gevolg van de toenemende urbanisatie en het compacte stad beleid is het groen in stedelijke gebieden onder druk komen te staan. Dit proefschrift

geeft een interessant beeld van het compacte stad beleid en haar relatie met gezondheid. Het compacte stad beleid was geïntroduceerd met het idee dat compact bouwen de afhankelijkheid van de auto zou kunnen verminderen en de natuur buiten de stad behouden zou kunnen blijven. Het is echter de vraag of het compacte stad beleid niet ook enkele negatieve gevolgen heeft voor de gezondheid van bewoners van steden. Omdat open ruimtes als gevolg van het compacte stad beleid zijn volgebouwd, is het groen in de stad onder druk komen te staan. Dit proefschrift toont aan dat de verdwijning van groen uit de woonomgeving negatieve gevolgen zou kunnen hebben voor de gezondheid van mensen.

Aan de andere kant laat onze studie naar de relatie tussen groen en bewegen zien dat mensen die wonen in compactere buurten (buurten met minder groen) vaker wandelen en fietsen in hun vrije tijd. Dit suggereert dat compact bouwen de auto mobiliteit inderdaad kan verminderen.

We vonden geen relatie tussen de hoeveelheid groen in de woonomgeving en of mensen voldoen aan de Nederlandse Norm Gezond Bewegen (NNGB). Het feit dat we geen verschillen vonden in gezond bewegen suggereert dat volwassenen de toename in wandelen en fietsen in hun vrije tijd compenseren door minder deel te nemen aan andere soorten bewegen.

Het compacte stad beleid lijkt dus geen consequenties te hebben voor de totale hoeveelheid bewegen van volwassenen.

Aan de andere kant bleken kinderen vaker aan de NNGB te voldoen als ze meer groen in hun woonomgeving hadden. Het lijkt erop dat het compacte stad beleid wel negatieve consequenties hebben voor hun totale hoeveelheid bewegen.

Samenvattend suggereren de resultaten dat het compacte stad beleid negatieve gevolgen kan hebben voor de gezondheid, door de vermindering van de hoeveelheid groen in de woonomgeving en de afname van de mate van bewegen van kinderen.

Gezondheidszorgsector

Vanwege de toenemende aanwijzingen voor een positieve relatie tussen groen en gezondheid, zouden verschillende partijen in de gezondheids-zorgsector op de hoogte gebracht moten worden van de positieve invloed van groen. Begin 2008 heeft het Ministerie van LNV heeft opdracht gegeven om onder andere na te gaan welke mogelijkheden er zijn binnen de bestaande structuur van de gezondheidszorg om aanbieders van zorg te motiveren het potentieel van natuur te mobiliseren in hun dagelijkse

activiteiten. De eerste resultaten van het onderzoek laten zien dat er verschillende mogelijkheden zijn voor gezondheidszorgaanbieders om het potentieel van groen te gebruiken.

Een van de kernpunten van het beleid van het Ministerie van VWS is het bevorderen van bewegen van de Nederlandse bevolking. Recent zijn er verschillende beweeginitiatieven of interventies gestart. Gebaseerd op de kennis over de toegevoegde waarde van bewegen in groen voor de gezondheid van mensen, is het aan te bevelen om ook groene variante op deze beweeginitiatieven of interventie te initiëren, bijvoorbeeld door beweegprogramma's aan te bieden in groengebieden. Vervolgens zou het erg zinvol zijn om de effectiviteit van de groene variant te vergelijken met die van het niet groene variant.

Aanbevelingen voor toekomstig onderzoek

Alhoewel de onderzoeken die voor dit proefschrift zijn uitgevoerd veel interessante nieuwe resultaten hebben opgeleverd, roepen ze ook verschillende vragen op die in vervolg onderzoek beantwoord kunnen worden.

Causaliteit van de relatie tussen groen en gezondheid
Dit proefschrift verschaft sterke aanwijzingen voor een positieve relatie tussen de hoeveelheid groen in de woonomgeving en verschillende subjectieve en objectieve gezondheidsindicatoren voor een representatieve steekproef van de Nederlandse bevolking. Een deel van de relatie tussen groen en gezondheid kan het gevolg zijn van directe of indirecte selectie. We hebben geprobeerd om zoveel mogelijk voor indirecte selectie te controleren door statistisch rekening te houden met demografische en sociaal-economische achtergrondkenmerken van individuen. Naast individuele kenmerken kunnen buurtkenmerken, zoals bijvoorbeeld de sociaal-economische status van de buurt, wellicht ook een verklaring bieden voor de gevonden relatie. Om nog beter te controleren voor indirecte selectie zou vervolg onderzoek ook rekening moeten houden met buurtkenmerken.

Helaas is het onmogelijk om te controleren voor directe selectie op de afhankelijke variabele, omdat we gebruik maken van cross-sectioneel

onderzoek. Toekomstig onderzoek zou een longitudinaal onderzoeksdesign moeten gebruiken om de relatie tussen groen en gezondheid nader te onderzoeken.

Onderzoek naar de relatie voor specifieke bevolkingsgroepen

Dit proefschrift verschaft kennis over of de relatie tussen groen en gezondheid verschilt voor verschillende Nederlandse bevolkingsgroepen. Omdat we gebruik konden maken van grootschalige bestaande gegevens konden we de relatie tussen groen en gezondheid onderzoeken in een grote populatie en voor verschillende subgroepen. Onze resultaten laten sterkere relaties zien voor kinderen, ouderen en mensen met een lager sociaal-economische status. Maar, zoals ook al genoemd wordt in de Kennisagenda Natuur en Gezondheid van het RMNO (2007), meer kennis is nodig om uit te zoeken welk soort groen met name de gezondheid van de verschillende bevolkingsgroepen bevordert. Hebben buurten met veel kinderen een ander soort groen nodig dan buurten met voornamelijk ouderen?

Daarnaast moet de relatie tussen groen en de aan de subgroep gerelateerde ziektes grondiger worden onderzocht. Voor kinderen zou het bijvoorbeeld interessant zijn om te kijken of er een relatie is tussen de hoeveelheid groen in de woonomgeving en ADHD.

Type en hoeveelheid groen

Wat betreft het type groen vonden we aanwijzingen voor een sterkere relatie tussen agrarisch en natuurlijk groen en gezondheid, maar verder onderzoek over dit onderwerp is nodig om na te gaan met welk type groen de grootste gezondheidsvoordelen kunnen worden bereikt. Is het voldoende om straten te hebben met een rijtje bomen? Of moet het groen eruit zien zoals een park of een bos? En is hetzelfde soort groen even bruikbaar voor de gezondheids-voordelen van verschillende bevolkingsgroepen?

Meer onderzoek naar de hoeveelheid groen die nodig is om de gezondheid te bevorderen is noodzakelijk om de bevindingen van dit proefschrift te vertalen naar concrete beleidsaanbevelingen. Gebaseerd op de resultaten van dit proefschrift kunnen namelijk geen concrete aanbevelingen gedaan worden over de hoeveelheid groen die nodig is om de gezondheid van mensen te bevorderen. Is de norm opgelegd door het Ministerie van VROM (2004), van 75 vierkante meter groen per huishouden genoeg of zou er meer groen moeten zijn? Toekomstig onderzoek zou zich op het beantwoorden van deze vraag moeten richten.

Nabijheid van groen

In dit proefschrift is onderzocht of de relatie tussen groen en gezondheid afhankelijk is van de afstand tot het groen. Over het algemeen geven de resultaten aanwijzingen voor de afstand waarop het groen moet worden ingezet voor het nastreven van verschillende gezondheidsuitkomsten. In dit proefschrift is alleen de relatie onderzocht voor de hoeveelheid groen in een 1km en een 3km straal om het huis van mensen. In toekomstig onderzoek zou de invloed van groen op een andere afstanden van het huis onderzocht moeten worden.

Mechanismen achter de relatie

Op basis van de resultaten konden geen duidelijke conclusies getrokken worden over de invloed van het gedragsmechanisme. Toekomstig onderzoek zou zich dan ook moeten focussen op het grondig onderzoeken van de relatie tussen groen en bewegen en sociale contacten. Daarnaast moeten ook de rol van andere niet in dit proefschrift behandelde mechanismen onderzocht worden. In de studie aangaande de relatie tussen groen en morbiditeit worden aanwijzingen gevonden voor luchtkwaliteit als mogelijk mechanisme, aangezien de prevalentie van bijna alle clusters die gerelateerd zijn aan ziektes van de luchtwegen lager is als mensen meer groen in hun woonomgeving hebben. Toekomstig onderzoek zou daarom ook de relatie tussen groen en luchtkwaliteit moeten onderzoeken.

Gebruik van groen in gezondheidszorginstellingen

Dit proefschrift laat zien dat de gezondheidsvoordelen van groen slechts in beperkte mate gebruikt worden in gezondheidszorginstellingen. Dit kan te maken hebben met het gebrek aan wetenschappelijk bewijs voor gezondheidsvoordelen van groen in zorginstellingen. Verschillende initiatieven voor het gebruik van groen in de gezondheidszorginstellingen zouden wellicht op een hoger niveau gezet kunnen worden als ze werden ondersteund door goed onderzoek.

Om de wetenschappelijke kennis te vergroten zouden de huidige initiatieven voor het gebruik van groen in de gezondheidszorg geëvalueerd moeten worden. Toekomstig onderzoek moet zich dan ook richten op het onderzoeken van 'best practices' gericht op groen in zorginstellingen.

De gebruikte groen maat

In dit proefschrift is gebruik gemaakt van het LGN4 gegevensbestand om de hoeveelheid groen in de woonomgeving van mensen vast te stellen.

Door gebruik te maken van het LGN4 databestand konden we op een gedetailleerde schaal de hoeveelheid groen in de woonomgeving vaststellen. Er zijn maar weinig landen waarin op zo'n gedetailleerd niveau landelijke data over groen beschikbaar zijn. Het gegevensbestand bevatte echter niet alle informatie die nodig is om een diepgaand inzicht te krijgen in de relatie tussen groen en gezondheid. In de volgende paragraven worden suggesties gegeven voor groengegevens die in toekomstig onderzoek gebruikt kunnen worden.

Kleinschalig groen

Alhoewel de data over het groen vastgesteld zijn op een gedetailleerd niveau, wordt in de gebruikte dataset kleinschalig groen in de woonomgeving van mensen niet mee genomen. Alleen groen dat een dominante positie heeft in de 25 bij 25 meter grid cel wordt in de dataset als groen beschouwd. Kleinschalig groen zoals bijvoorbeeld straatbomen, groenstroken langs wegen, die doorgaans geen dominante positie hebben in de grid cel, zullen daarom niet als groen worden beschouwd.

Dit kleinschalig groen zou wel de gezondheid of veiligheid van mensen kunnen beïnvloeden. Zo kunnen kleine bosjes rondom huizenblokken relevant zijn voor gevoelens van onveiligheid. Eerder onderzoek heeft verder ook aangetoond dat kleinschalig groen, zoals bijvoorbeeld een groen straatbeeld, gerelateerd is aan sociale contacten (Coley et al., 1997; Kuo et al., 1998a) en bewegen (Owen et al., 2004; Pikora et al., 2003).

Om een compleet beeld te krijgen van de hoeveelheid groen in de woonomgeving van mensen en de invloed daarvan op de gezondheid van mensen zou toekomstig onderzoek ook rekening moeten houden met kleinschalig groen.

Tuinen

In het LGN4 databestand worden alleen grote tuinen als groen beschouwd omdat om huizen, met een buffer van 10 meter om het huis, als bebouwd gebied worden beschouwd. Alleen tuinen die groter zijn dan de buffer van 10 meter zullen als groen beschouwd worden. Tuinen bevatten veelal groene elementen wat de feitelijke blootstelling aan groen kan vergroten. Daarom zou vervolg onderzoek naar de relatie tussen groen en gezondheid en de

relatie tussen stress en groen rekening moeten houden met het feit of mensen al dan niet een tuin hebben en misschien zelfs met het ontwerp van de tuin, omdat een tuin niet perse groen hoeft te bevatten.

Kwaliteit van het groen

Daarnaast zou toekomstig onderzoek zich moeten richten op de vraag of de kwaliteit en toegankelijkheid van het groen een rol spelen. Dit proefschrift heeft gekeken naar de kwantiteit en de beschikbaarheid van het groen. Echter, zowel de kwaliteit van het groen als de toegankelijkheid van het groen kunnen belangrijk zijn voor de gezondheid en de ervaren veiligheid. Groene gebieden van slecht kwaliteit zouden de gevoelens van onveiligheid kunnen vergroten en het gebruik kunnen verlagen.

Gebruik van en blootstelling aan groen

Het gebruik van bestaande data heeft het nadeel dat de data niet verzameld zijn om de onderzoeksvragen te beantwoorden. In sommige gevallen zouden andere gegevens geschikter zijn om de onderzoeksvragen van dit proefschrift te beantwoorden. De gebruikte gegevens konden bijvoorbeeld geen informatie verschaffen over de hoeveelheid tijd die mensen werden blootgesteld aan het groen in hun woonomgeving of elders. Daarnaast, betreffende het gezondheidsgedrag hebben we geen informatie over waar mensen bewegen of over waar de sociale contacten plaatsvonden. Met betrekking tot de gevoelens van veiligheid gaven de gegevens geen inzicht in waar, wanneer en waarom mensen zich onveilig voelde. Toekomstig onderzoek zou dit soort informatie gericht moeten verzamelen. Kwalitatieve methoden kunnen in vervolg onderzoek gebruikt worden voor het beantwoorden van vragen naar waarom mensen wel of niet gebruik maken van groen voor bewegen of sociale contacten.

Subjectieve metingen van groen

In dit proefschrift is gebruik gemaakt van objectieve metingen van groen. Objectieve metingen van groen reduceren het risico van vooringenomenheid van de respondent. Maar, subjectieve metingen van het groen kunnen ook belangrijke informatie leveren.

De perceptie van groen kan het gedrag van mensen meer beïnvloeden dan de daadwerkelijke hoeveelheid beschikbare groen. Groen dat als onveilig wordt beschouwd of als van slechte kwaliteit zal sneller vermeden worden door mensen. Het aanvullen van de objectieve metingen van groen met

subjectieve metingen van groen kan het inzicht in de relatie tussen een groene woonomgeving en gezondheid, gezond gedrag en sociale veiligheid vergroten.

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Curriculum Vitae

Jolanda Maas was born on April 8, 1980 in Voorburg, the Netherlands. She followed her secondary education at the Stedelijk College location Pallas in Zoetermeer, from which she graduated in 1998. Following this, she studied Sociology at the Utrecht University from 1998 to 2002. After graduating she worked at Arbeid en Opleidingen Consult in Tilburg where she investigated questions concerning the labour market and professional and adult education.

In 2003 she started working at NIVEL (Netherlands Institute for Health Services Research) where she started working on thesis in January 2005.

Currently she works at the VU Medical Centre in Amsterdam as a researcher. In this project, in cooperation with the National Institute for Public Health and the Environment, the relationship between characteristics of open space and physical activity is studied.

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