Morbidity is related to a green living environment

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EDITOR'S CHOICE

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ABSTRACT

Background: As a result of 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 physician-assessed morbidity is also related to green space in people's living environment.

Methods: Morbidity data were derived from electronic medical records of 195 general practitioners in 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. The percentage of green space within a 1 km and 3 km 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 socioeconomic characteristics.

Results: The annual prevalence rate of 15 of the 24 disease clusters was lower in living environments with more green space in a 1 km radius. The relation was strongest for anxiety disorder and depression. The relation was stronger for children and people with a lower socioeconomic status. Furthermore, the relation was strongest in slightly urban areas and not apparent in very strongly urban areas.

Conclusion: 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 morbidity. The study stresses the importance of green space close to home for children and lower socioeconomic groups.

INTRODUCTION

As a result of 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,[1–4] longevity,[5] number of symptoms and the risk of psychiatric morbidity.[1] Access to a garden and shorter distances to green areas from the dwelling were associated with less stress and a lower likelihood of obesity.[6] 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.[7–10]

These studies indicate that there is a relation between green space and self-reported general indicators of physical and mental health. Thus, people living in greener environments report better physical and mental health. The decrease in green space could therefore have health consequences. However, it remains unknown whether living in residential environments with little green space also has negative consequences for objective health. In this explorative study we will go one step further than other studies and investigate whether the prevalence of several physician-assessed morbidity clusters is also related to the amount of green space in people's living environment. This is the first study to investigate the relation between green space and prevalence of physician-assessed morbidity. This study has an explorative character and takes into account a broad number of diseases highly prevalent in society.

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 socioeconomic groups. We hypothesise that the relation is stronger for elderly people and children than 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 socioeconomic status (SES), whose activities and social contacts are situated close to their homes.[11 12] Therefore we also hypothesise that people with a lower SES are more exposed to the green space in their living environment. Finally, the relation was analysed for different levels of urbanicity 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.[13] 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, because after the selection the sample was still representative for the Dutch population.[13] 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 25×25 m grid cell in The Netherlands.[14] 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 15–20 households have the same six-character postal code). The dataset included 50 187 postal codes and on average 6.9 respondents resided in each postal code area.

Morbidity data

Morbidity data were derived from routine primary care electronic medical records. In The Netherlands morbidity presented in general practice is a good indicator of morbidity in the population.[15] Basically all non-institutionalised 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 healthcare system. The data have been validated for obtaining prevalence estimates.[16]

During a 12-month 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 and subsequently clustered into episodes of disease.[17]

The most prevalent episodes were combined into 24 disease clusters. These disease clusters have been used in several other studies[18 19] and cover the full range of the most prevalent diseases in general practice (prevalence >10 per 1000) (see table 1). The 24 disease clusters have been distributed over seven disease categories, namely cardiovascular diseases, musculoskeletal diseases, mental diseases, respiratory diseases, neurological diseases, digestive diseases and miscellaneous. The principal aim of this study was to explore possible associations between green space and specific diseases. Therefore, chosen disease clusters were not based on a presumed mechanism behind this association beforehand. Instead, we chose a common basis categorisation covering the full range of morbidity most frequently presented in general practice, according to the bodily system involved.

Not all disease clusters were relevant for all age groups; therefore, the epidemiological denominator varied (table 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. The population at risk was based on age groups in which the diseases occurred. Some disease clusters, like for instance high blood pressure, were only present in the older age groups. Therefore, for high blood pressure the prevalence rate was calculated by dividing the number of patients with at least one high blood pressure episode in 2001 by the older age groups and not for the population as a whole.

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 and accurate.[14 20] The total percentage of green space in the respondents' living environment was measured within a 1 km radius and within a 3 km radius around the postcode centroid 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 25×25 m grid cell (more than 50% of the grid cell is green) 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.

Urbanicity

Another environmental characteristic is urbanicity. This variable consists of five categories, ranging from very strongly urban (1) to non-urban (5); it was measured at the municipal level and was derived from Statistics Netherlands. The indicator is based on the number of households per square kilometre and is commonly used in The Netherlands.[21]

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 well-being (such as income) tend to live in a green environment.[22] As migration flows are related to such sociodemographic characteristics as age, income and education,[23] we decided to rule out indirect selection effects as far as possible by controlling statistically for demographic and socioeconomic characteristics.

The demographic characteristics taken into account were gender (female = 1) and age (which was taken into account as a polynomial until the third order because there was no linear relation between the disease 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: children (<12 years), adolescents (13–17 years), youths (18–25 years), young adults (26–45 years), older adults (46–65 years) and elderly people (65+ years).

Socioeconomic 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%)[13] and included education, work status and healthcare insurance type. For a number of people these socioeconomic characteristics were unknown. To reduce the number of missing entries we included a category unknown in the analyses. 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. Socioeconomic status was additionally implicitly measured by type of healthcare insurance (unknown, public or private). The type of healthcare insurance can be regarded as an indicator of SES in the Dutch context in 2001, as only people with a higher income had private health insurance, whereas people with a lower income had obligatory public health insurance.

When testing the relation between green space and the annual prevalence of disease clusters for different SES groups, SES was operationalised as the level of education divided into three categories: higher education (university or higher vocational education), secondary education and primary or no education. Characteristics of the study population are displayed in table 2.

Table 1 Annual prevalence rates of clusters of diseases presented in general practice (cases per 1000) (n = 345 143 unless stated otherwise)

Cluster	ICPC codes	N (abs)	Per 1000
Cardiovascular			
High blood pressure (n = 273 925)	K85 K86 K87	24778	90.5
Cardiac disease	K71 K73 K74 K77 K78 K79 K80 K81 K82 K83 K84	9044	26.2
Coronary heart disease (n = 240 825)	K74 K75 K76	5804	24.1
Stroke, brain haemorrhage (n = 240 825)	K89 K90	2549	10.6
Musculoskeletal			
Neck and back complaints	L01 L02 L03 L84 L86	32346	93.7
Severe back complaints	L02 L03 L85 L86	25230	73.1
Severe neck and shoulder complaints	L01 L08 L83 L92	21236	61.5
Severe elbow, wrist and hand complaints	L10 L11 L12 L72 L74	7698	22.3
Osteoarthritis (n = 240 825)	L89 L90 L91	4521	18.8
Arthritis (n = 240 825)	L88 T92	3170	13.2
Mental			
Depression	P03 P76	8859	25.7
Anxiety disorder	P01 P74	8033	23.3
Respiratory			
Upper respiratory tract infection	A77 R72 R74 R75 R76 R80	31457	91.1
Bronchi(oli)tis/pneumonia	R78 R81	10806	31.3
Asthma, COPD	R91 R95 R96	12813	37.1
Neurological			
Migraine/severe headache	N01 N02 N03 N89 N90 N92	10629	30.8
Vertigo	N17	4023	11.7
Digestive			
Severe intestinal complaints	D81 D85 D86 D92 D93 D94	5264	15.3
Infectious disease of the intestinal canal	D70 D73	3816	11.1
Miscellaneous			
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	75774	219.5
Chronic eczema	S86 S87 S88	22303	64.6
Acute urinary tract infection	U70 U71 U72	13303	38.5
Diabetes (n = 290 479)	T88 T90	9260	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	6086	17.6

COPD, chronic obstructive pulmonary disease; ICPC, International Classification of Primary Care; MUPS, medically unexplained physical symptoms.

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 socioeconomic characteristics and urbanicity. 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 urbanicity and the green space indicator to investigate the relation for different age groups, SES groups and in different levels of urbanicity. Because of the large dataset we adopted a strict type 1 error criterion of $\alpha = 0.01$.

RESULTS

On average there is 42.4% of green space in a 1 km radius and 60.8% of green space in a 3 km radius around people's homes. Table 3 presents the ORs 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 1 km radius. Only for anxiety disorders, infectious diseases of the digestive system and medically unexplained physical symptoms (MUPS) the annual prevalence rate was lower in environments with more green space in a 3 km radius.

For 15 of the 24 disease clusters the annual prevalence rate was lower in living environments with a higher percentage of green space in a 1 km radius. This relation is apparent for diseases in all seven disease categories. It is strongest for anxiety disorders and depression. The relationship is negative for none of the disease clusters.

Strength of the relation

An indication of the strength of the relation is given in table 4, which shows the annual prevalence per 1000 for people with average characteristics on the control variables with respectively 10% and 90% green space in a 1 km radius around their home. For anxiety disorders, the annual prevalence for people with average characteristics with 10% green space in a 1 km radius

Table 2 Characteristics of the study population

	Characteristics of the study population (%) (n = 345 143)
Demographic characteristics	
Gender	
Male	49.5
Age	
⩽12 years	14.4
13–17 years	6.2
18–25 years	9.6
26–45 years	32.3
46–65 years	24.7
>65 year	12.8
Socioeconomic 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
Retired	9
Disability pension	3
Unemployed	1.1
Urbanicity	
Very strongly urban	13.9
Strongly urban	22.2
Moderately urban	22.6
Slightly urban	31.7
Non urban	9.7

was 26 per 1000 people and for those with 90% green space in a 1 km radius 18 per 1000 people. For depression these figures are respectively 32 and 24 per 1000. In general, the found relation between green space and physician-assessed morbidity is comparable with the relation between age and morbidity. An increase in 1 percentage point of green space on physician-assessed morbidity equals the effect of 1-year lower age.

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 1 km radius, but also for the percentage of green space in a 3 km radius. For a few disease clusters the relation for children was especially strong, for example for vertigo (1 km OR 0.81, 95% CI 0.74 to 0.90; 3 km OR 0.85, 95% CI 0.77 to 0.94) and severe intestinal complaints (1 km OR 0.85, 95% CI 0.80 to 0.90; 3 km OR 0.89, 95% CI 0.84 to 0.94). The strongest relation for children was found for depression (1 km OR 0.79, 95% CI 0.72 to 0.88; 3 km OR 0.84, 95% CI 0.78 to 0.91).

The relations for the other age groups were similar to the overall relations shown in table 3.

Table 3 the relation between having 10% more green space than average in one's living environment and the prevalence of disease clusters (n = 345 143 unless stated otherwise)

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

ORs are derived from multilevel logistic regression analysis, controlling for demographic and socioeconomic characteristic and urbanicity.
COPD, chronic obstructive pulmonary disease; MUPS, medically unexplained physical symptoms.
Numbers in bold signify $p<0.01$.

Relation for different socioeconomic groups

Especially the lower educated groups had a lower annual prevalence rate when they had more green space in a 1 km radius around their home. For example, the odds for chronic obstructive pulmonary disease (COPD) were smaller for the lower educated (1 km OR 0.97; 95% CI to 0.95 to 0.99) than for higher educated (OR 0.98; 95% CI 0.96 to 1.00).

Relation for different levels of urbanicity

Concerning the level of urbanicity our analyses show that urbanicity 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 urbanicity people with more green space in a 1 km 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.

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Table 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 haemorrhage	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	23.0	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	16.0	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 of the intestinal canal	6.5	5.1
Miscellaneous		
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

This table is based on results from multilevel logistic regression analysis controlling for demographic and socioeconomic characteristic and urbanicity that were centred around the average.
COPD, chronic obstructive pulmonary disease; MUPS, medically unexplained physical symptoms.

DISCUSSION

Principal findings

This explorative 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 15 of the 24 investigated disease clusters is lower in living environments with more green space in a 1 km radius. Green space close to home appeared to be more important than green space further away. This is in contrast with our previous studies[1 2] which found the relation between self-perceived health and the amount of green space in a 1 km and a 3 km radius around people's homes to be equally strong. It appears that for the prevalence of these more specific diseases green space close to home is more important. This study differs from other studies, which mainly focused on the relation between green space and self-perceived measures of physical and mental health.[1–4 6] This is the first study to assess the relation between green space and specific diseases, derived from electronic medical records of GPs. This dataset helps better establish the relation between green space and health, because it used physician-assessed morbidity as outcome, because there was no single source bias in the data, and because we used a large dataset that was representative for The Netherlands.

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 lower SES. However, contrary to our expectations the relation appeared to be stronger for people aged between 46 and 65 than for elderly people. Concerning urbanicity, 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,[24] thereby inhibiting their use. This study only gives some indications for the relation between green space and morbidity for different subgroups. Further research should focus specifically on one of the subgroups to investigate the relation for subgroups more thoroughly.

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 programmes. Furthermore, in many countries, diseases of the circulatory system and mental disorders are among the most expensive diseases with respect to healthcare costs.[25] Our study contributes to the evidence that green space can help fight some major public health threats in Western societies. Healthy spatial planning should take the amount of green space in the living environment into account when endeavouring to improve the health situation, particularly of children and lower socioeconomic groups.

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.[4 7 25 26] What do the results tell us about the mechanism at work?

The strong relation we found, particularly for anxiety disorder and depression, suggests that mental health in particular might be affected by the amount of local green space. Recovery from stress and attention fatigue then seems a likely mechanism behind the relation between green space and health; also, facilitation of social contacts might contribute. However, there is no reason to discard any of the other possible mechanisms. For example, physical activity is also known to have mental health benefits.[27] Furthermore, in living environments with more green space the prevalence of most 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, coronary heart disease, musculoskeletal diseases) somewhat less strong relations were found. But as associations were present, physical activity could also be a possible mechanism.

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 morbidity.

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 on exposure time.

The morbidity data are accurate because they were extracted from routine electronic medical records of general practices, and the interobserver reliability of grouping contacts into episodes was high.[15] 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 healthcare system, and because the GP has a gate-keeping role for specialist care, and because there are no large geographic[28] 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 general 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 25×25 m 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. Consequently, the relation might be slightly underestimated.

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 relations between green space and health may partly be caused by selection. We tried to rule out this possibility by taking socioeconomic 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 mechanism responsible. 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 cannot be held responsible for geographical differences that remain if socioeconomic and demographic factors are taken into account.[29 30]

Third, we tried to control as much as possible for individual SES. However, we did not have any information on the income of the respondents, which is a relevant indicator for SES. Furthermore, we did not control for other confounders at the neighbourhood level, although different studies have shown that, for example, neighbourhood SES could also influence health.[31 32] Because this was an explorative study we chose to keep the design somewhat simple. Further research should try to find out whether a relation can also be found when neighbourhood SES is controlled for.

The aim of this study was to explore possible associations between specific diseases and green space. The disease clusters used in this study were therefore based on bodily systems, and covering the full range of morbidity most frequently presented in general practice. However, this does not mean that we consider all relationships equally plausible (in a causal sense). For some disease clusters it seems more difficult to understand why their prevalence would be positively related to the local amount of green space, for example infectious diseases of the intestinal canal. Furthermore, given the many significant relationships the absence of others relationships is also worthwhile noting. For example, high blood pressure could be hypothesised to be linked to chronically high stress levels as well as lack of physical activity, but was not related to the amount of green space. Further research will have to shed more light on the mechanisms behind the relation between green space and health, and to what extent green space indeed plays a causal role in the observed relationships.

What is already known on this subject

- There is increasing evidence for a positive relation between green space in the living environment and a number of self-reported indicators of physical and mental health.
- Small-scale psychological research showed that exposure to green space has a positive effect on stress reduction and attention restoration.
- Several epidemiological studies have shown that green space is positively correlated with self-perceived health, number of symptoms experienced and mortality.

What this study adds

- This study uses large-scale representative medical record data to investigate whether the prevalence of a number of disease clusters is related to the amount of green space in people's living environment.
- The annual prevalence rates for 15 of the 24 investigated disease clusters is lower in living environments with more green space in a 1 km radius around people's homes.
- The study stresses the importance of green space close to people's homes.
- The relationship is particularly strong for children and lower socioeconomic groups.

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Darwin anniversary

Darwinism

► Barker DJP. Glossary: Developmental origins of adult health and disease. *J Epidemiol Community Health* 2004;**58**:114–5.

This term is often used to describe the natural selection of genes that optimises the fitness of a species in a particular environment. Darwin was also aware, however, that the environment to which individuals are exposed during development produces variation within one generation. ''When a variation is of the slightest use to a being'', he wrote, ''we cannot tell how much of it to attribute to the accumulative action of natural selection, and how much to the conditions of life''.

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