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Greenspace in urban neighbourhoods and residents' health: adding quality to quantity

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ABSTRACT

Background: Previous research shows a positive link between the amount of green area in one's residential neighbourhood and self-reported health. However, little research has been done on the quality of the green area, as well as on quantity and quality of smaller natural elements in the streetscape. This study investigates the link between the objectively assessed quantity and quality of (1) green areas and (2) streetscape greenery on the one hand and three self-reported health indicators on the other.

Methods: 80 Dutch urban neighbourhoods were selected, varying in the amount of nearby green area per dwelling, as determined by Geographic Information System analysis. The quality of green areas, as well as the quantity and quality of streetscape greenery, was assessed by observers using an audit tool. Residents of each neighbourhood were asked to complete a questionnaire on their own health (N=1641). In multilevel regression analyses, we examined the relationship between greenspace indicators and three health indicators, controlling for socio-demographic and socioeconomic characteristics.

Results: Both indicators for the quantity of greenspace were positively related to all three health indicators. Quantity and quality indicators were substantially correlated in the case of streetscape greenery. Nevertheless, the quality indicators tended to have added predictive value for the health indicators, given that the quantity information was already included in the model.

Conclusions: The quantity and also the quality of greenspace in one's neighbourhood seem relevant with regard to health. Furthermore, streetscape greenery is at least as strongly related to self-reported health as green areas.

INTRODUCTION

There is growing awareness that the neighbourhood environment is important for people's health. Physical features of the neighbourhood may influence the health of residents.1 Several studies have shown a positive relationship between the objectively determined availability of greenspace in the living environment,2–5 as well as residents' perceptions of this availability, and their health and well-being.6–9Although perceptions are an important topic of study in their own right,10 11 we will focus on the physical features themselves: these constitute the main link with spatial policy and city planning.

Mitchell and Popham4 suggested that future research on greenspace and health should include its quality. According to them, poor quality greenspace might even be detrimental to health. What then is good quality

greenspace and why is this quality relevant? The concept of quality may be elaborated by looking at the mechanisms that are hypothesised to cause the health benefits of greenspace. The first mechanism proposes that greenspace offers restorative experiences, leading to stress reduction and/or recovering from attentional fatigue.12 A low aesthetical value is unlikely to contribute to the restorativeness of the experience.

The second mechanism proposes that greenspace stimulates physical activity, either by way of promoting more active modes of transport (walking, cycling) or by way of seducing people to be more active during leisure, in the form of outdoor recreational activity.13 In the case of active transport, greenspace can help to make routes more attractive. In the case of outdoor recreational activities, it is about making the environment or setting attractive to look at and also about offering suitable areas to perform the activities themselves.

A third proposed mechanism focuses on stimulating social contact between neighbourhood members and social cohesion in the neighbourhood.14 As in the case of stimulating physical activity, it is about seducing people to get out of their house. However, the focus is now on meeting spaces. A related issue is (social) safety.15 Green areas should be (perceived as) safe to visit. Fear of crime or otherwise unsafe conditions are likely to deter people from visiting otherwise attractive green areas or experiencing this visit positively. So it seems fair to say that greenspace should not just be there, but it should be pleasurable to experience and/or suitable for (recreational) use.16 17

The health studies in which the quantity of greenspace was objectively determined2–5 all made use of Geographic Information System data on land use. These databases usually do not contain information on small natural elements, such as street trees and front gardens, because these do not meet minimum size requirements for inclusion. However, to make the environment more pleasant and/or restorative, even a single street tree may help. So, also smaller natural elements may have beneficial health effects.5 10 18

As is the case with small natural elements, Geographic Information System databases usually do not contain detailed information on the quality of greenspace in urban neighbourhoods. Objective data on quality aspects and on small natural elements might be collected by audits. Tools for (quantity and) quality audits have been developed by Pikora *et al*16 and Hillsdon *et al*.19 Objective assessments of the quality of nearby greenspace have not been related to health before, with the exception of the study by Björk *et al*20 They determined the presence of five recreational values in the nearby natural environment. The number of values present was not related to self-reported health. Their study did not simultaneously take the *amount* of nearby greenspace into account.

To summarise, we hypothesise that the self-reported health of residents is related to the amount of nearby green area. Our second hypothesis is that the quality of the green areas has added predictive value with regard to health. Our third and fourth hypotheses are that the same holds for the quantity respectively quality of the greenery visible in the streetscape.

METHODS

Study area and population

Four large Dutch cities were selected, having comparable levels of urbanity and at least 125 000 inhabitants. Within each city 20 neighbourhoods were selected. Neighbourhoods were defined here as administrative units, having 2200 residents on average. Green areas were defined as parks, forests, nature and recreation areas based on the land use database of Statistics Netherlands. The average quantity of green area (ie, square metres available per residence within a distance of 500 m) was used to select more and less green neighbourhoods within each city to ensure sufficient variation.

During this selection, we tried to exclude neighbourhoods with very peculiar or extreme socioeconomic profiles to keep the sample as homogeneous as possible in this respect. Profiles were assessed based on neighbourhood-level data available at Statistics Netherlands (see table 1). To assess the quality of green areas, within each neighbourhood, three green areas with a minimum size of 1 ha were selected. In case no three such areas were present within the neighbourhood, areas from adjacent neighbourhoods were included. These areas were considered to be still nearby. To assess the greenery visible in the streetscape, four streets per neighbourhood were selected by placing four adjacent circles with a radius of 500 m on the map of the neighbourhood and selecting the street in the centre of the circle.

[TABLE 1]

Data on the environment

For the objective quantity of green areas, we used the aforementioned indicator. Based on the minimum amount of 75 m^2 of green area per residence within 500 m recommended by the Dutch Advisory Council for Rural Areas, five categories were distinguished: (1) <37.5, (2) 37.5–75, (3) 75–112.5, (4) 112.5–150 and (5) >150 m^2 per residence.

To measure the quality of green areas and the quantity and quality of streetscape greenery, audit tools were developed: one for green areas and one for streetscapes. Items were largely adapted from existing audit tools for neighbourhoods, physical activity or greenspace.16 21–29 Manuals for both tools were handed out to the four observers. Furthermore, a short training was provided by the first author, followed by a shared observation of one neighbourhood. In April 2007, the 80 neighbourhoods were visited by one of the observers, meaning 560 site observations: three areas and four streets per neighbourhood. Sixteen neighbourhoods were also visited by another observer to enable the assessment of inter-rater reliability.

The quality of green areas was assessed with 10 items, each on a 5-point scale (translated from Dutch): accessibility (very bad–very good), maintenance (very bad–very good), variation (very monotonous–very varied), naturalness (very unnatural–very natural), colourfulness (very uncolourful–very colourful), clear arrangement (very unsurveyable–very surveyable), shelter (very enclosed–very open), absence of litter (very little trash–very much trash), safety (very unsafe–very safe) and general impression (very negative–very positive) (Cronbach's α=0.65). Mean neighbourhood scores were computed on the basis of the scores of the three green areas on these 10 items. The quality of streetscape greenery was assessed with five items (same scales as before): maintenance, variation, clear arrangement, absence of litter and general impression (Cronbach's α=0.75). Mean neighbourhood scores were computed on the basis of the scores of the four selected streets. For the total quality scores, the average of the means per item was calculated for green areas and streetscape greenery separately.

Quantity of streetscape greenery was assessed with one item about the amount of greenery visible in the street, also on a 5-point scale (not very green impression–very green impression). Inter-rater consensus was calculated by dividing the number of agreements by the maximum possible number of agreements. Scores were defined to agree when they differed by no more than one scale point. Agreement per item ranged from 76% to 98%.

QUESTIONNAIRE

A random sample of 100 households in each neighbourhood was drawn to obtain information about perceived health data. In the summer of 2007, 8000 residents received a personal letter and a mail questionnaire with a map of their neighbourhood, indicating the three green areas. The questionnaire could also be filled out on the internet. After 2 weeks, all residents received a reminder card. It took about 30 min to fill out the questionnaire. Participants were eligible to win a ticket in a national lottery.

In total, 1553 respondents returned the mail questionnaire, while 208 respondents used the internet. However, 94 questionnaires were returned empty and another 26 contained many missing values, leaving 1641 questionnaires with (almost) complete data available for analysis. The overall net response rate was 22% and varied between 7% and 46% per neighbourhood. Characteristics of the neighbourhoods and sample are shown in tables 1 and 2.

[TABLE 2]

The stratified sample was not representative of the population of the 80 neighbourhoods. Non-Western ethnic minorities were heavily under-represented. Response rates were clearly lower in neighbourhoods with a high proportion of such ethnic minorities (r=−0.63). Income and education were not available at the neighbourhood level. However, the proportion of people on unemployment benefit (WW) was negatively related to the response rate as well (r=−0.33), making it likely that people with lower incomes were also under-represented. Since the latter correlation was smaller than the first one, it is likely that cultural/language issues were more important with regard to participation than socioeconomic status per se. Older age groups were clearly over-represented in the sample. Perhaps, people in this age category are more inclined to participate in surveys.

Health indicators

First, respondents were asked to rate their general health on a 5-point scale, running from 'bad' to 'excellent'. This indicator originates from the Short-Form 36.30 Second, it was asked whether one suffered from any out of a list of 37 acute health-related complaints in the last 14 days, such as headache, nausea, dizziness, listlessness, etc.31 Third, as an indicator for general mental health status, the Mental Health Inventory (MHI-5), also originating from the Short-Form 36, was used.32 It consists of five items to be score on a 6-point scale, with scores being transformed into a scale from 0 to 100. A score of 100 indicates perfect mental health (α=0.81).30

Socio-demographic characteristics

Demographic variables included were gender and age. Socioeconomic status was measured by education level (highest level of completed education, eight categories) and household income (three categories: below average, average, above average).

ANALYSIS

The relationship between greenspace and health was assessed by multilevel regression analyses, controlling for socio-demographic characteristics. Two levels were included: individual and neighbourhood. For perceived general health and mental health, linear regression analyses were performed. For acute health-related complaints, because of the distribution of scores, an (extra)Poisson model was used. The basic model (1) always included all socio-demographic characteristics. In the next step, each greenspace indicator was added separately (models 2.a–2.d). In subsequent analyses, we started with a model with one quantity indicator for greenspace and added the corresponding quality indicator (models 3.a and 3.c). To check for linearity, analyses with dichotomous versions of all four greenspace indicators (median split) were performed. Based on these dichotomous versions, an interaction term was constructed for green areas and streetscape greenery separately to check for additivity: low quantity and quality plus high quantity and quality versus the other two combinations (low/high, high/low).

Because of correlations between quantity and quality indicators, as well as with socioeconomic characteristics, we tested whether the model as a whole improved after adding a greenspace indicator. This was not possible for acute health-related complaints because of the use of an extra Poisson model: there is no deviance statistic available to compare such multilevel models as a whole. Analyses were performed with SPSS V.15 and MLwiN V.2.33

RESULTS

Inter-relationships of greenspace indicators

Table 3 shows the bivariate correlations between greenspace indicators. Correlations between quantity and quality of the same category of greenspace ranged between 0.36 and 0.76.

[TABLE 3]

Associations between greenspace and health

Table 4 shows that perceived general health was significantly and positively related to all four greenspace indicators. The model as whole always also improved, with the significance levels for parameter and model being equal. The relationship was stronger for quality of streetscape greenery and quantity of green area (both $p<0.001$, for both parameter and model).

[TABLE 4]

All greenspace indicators were also negatively related to the number of acute health-related complaints. Residents in neighbourhoods with a greater quantity of greenspace or with higher quality greenspace experienced less acute health-related complaints in the last 14 days. Finally, mental health status was positively related to three greenspace indicators. In all cases, residents in neighbourhoods with more or higher quality greenspace had a better mental health. The strongest relationship was observed for quality of streetscape greenery. Quality of green areas, on the other hand, was not related to mental health status. Model improvements were in line with results for parameters.

Given that both indicators dealing with the quantitative aspect showed significant predictive contributions for all three health indicators, our hypotheses regarding the quantity of green area (per dwelling) and streetscape greenery are clearly confirmed.

Adding quality to quantity (and interactions)

Models with a quantity indicator for greenspace were expanded with the corresponding quality indicator (table 5). Despite that correlations between quantity and quality indicators were not extremely high, in the sense of causing multicollinearity problems, most greenspace indicators now contribute less or even were not significant at all anymore. Nevertheless, when tested at the level of the model as a whole, adding quality information improved the model significantly in three of the four testable cases: 2 of 2 for streetscape greenery and 1 of 2 for green areas. In other words, the hypothesis on the added predictive value of the quality of the local greenspace is partially supported for green areas and completely supported for streetscape greenery.

[TABLE 5]

To check for linearity, the above analyses were repeated with dichotomous versions of all four greenspace indicators. Results (not in table) showed that the model fit tended to be lower, indicating that with the dichotomisation information had gone lost. The original models, assuming linearity, with quantity and quality already included (3.a and 3.c), were extended with the interaction term (low quantity and quality plus high quantity and quantity). Only in the case of perceived general health and green areas, this led to a significant interaction (and model improvement: $p<0.05$), with the following parameters: quantity=0.27 (0.013), quality=0.126 (0.066), interaction term=0.084 (0.040). The positive sign of the interaction term indicates that quantity is more important when quality is high and/or vice versa: quality is more important when quantity is high.

DISCUSSION

As hypothesised, indicators for quantity of greenspace were related to all three self-reported health indicators, for both green areas and greenery visible in the streetscape. Other studies found similar relationships,2–9 although using objective information on streetscape greenery is new in relation to health. Quality information on greenspace was also related to health indicators in five of the six cases. Moreover, in three of the four testable cases adding this information increased the (predictive) performance of the model, despite the overlap between quantity and quality indicators. In one case, an interaction between the quantity and quality of green areas was significant (perceived general health).

The quality of the streetscape greenery was related to all three health indicators, whereas the quality of green areas was not related to mental health. Usually green areas are located further away than greenery in the street and are only visited for specific (leisure) purposes. This may limit the exposure to such areas, especially compared with exposure to the own streetscape. The quality of the greenery visible in the streetscape might also be more influential because it reflects the quality of the streetscape in general. So it might not be the quality of specifically the greenery that is important but the attractiveness of streetscape as a whole. It seems worthwhile to investigate the relationship between quality of streetscape greenery, attractiveness of the neighbourhood (or residential satisfaction) and health in more detail. Agyemang *et al*34 pointed out that neighbourhood psychosocial stressors tend to be inter-related.

Quantity and quality were related to a substantial degree. Although it is not inevitably the case, both may be an expression of the concern of local authorities for the residential environment. This concern may be reflected in quantity as well as in quality aspects, such as level of maintenance. At a more basic level, realising a high level of variation, another quality aspect, may simply require a certain amount of greenspace to be able do so. The observed interaction for green areas suggests that, rather than quality and quality being able to compensate for each other, the one becomes more critical if the other is high.

A limitation of our study is the representativeness of the sample for the population within each of the 80 neighbourhoods. Response rates were not high and especially contained very few people from ethnic minorities. Therefore, it is clear that the outcomes of this study do not pertain to them. Other than that, the low response rate is likely to have mainly affected the statistical power of the study. Whereas a lack of representativeness can easily bias estimates of population means and percentages in order to affect the investigated relationships, the processes relating greenspace to health must be assumed to differ between

under- and over-represented segments of the population. Moreover, the representativeness of the sample is less of an issue with regard to the personal characteristics that were corrected for in the analyses.

Another limitation of the study is that it was cross sectional. Therefore, an important question is to what extent the observed relationships between quantity and quality of local greenspace and (self-reported) health are causal in nature. More insight in the process behind the relationship and mediators could help. For example, some studies found that green neighbourhoods were associated with a lower likelihood of being overweight8 29 35 and/or lower levels of (chronic) stress.7 8 Prospective studies can provide more definite answers regarding causality.

WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

Several studies have shown positive relationships between the objectively determined quantity of (larger) green areas in the neighbourhood and people's self-rated health.

WHAT DOES THIS STUDY ADDS

- The objectively determined quality of nearby green areas had added predictive value with regard to self-rated health, despite its inter-relationship with quantity.
- Objective information on the quantity and, in addition to this, the quality of streetscape greenery also had predictive value with regard to self-rated health.
- The ongoing densification of cities may have hitherto insufficiently recognised negative health consequences because of fewer contacts with natural elements.

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FOOTNOTES

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TABLES

Table 1 Characteristics of the selected neighbourhoods (n=80), by greenness (mean plus SD or percentage)

	Non-green (n=40)	Green (n=40)	Total (n=80)
Greenspace characteristics			
Quantity of green areas (1–5)	1.03 (0.16)	3.47 (1.22)	2.25 (0.87)
Quality of green areas (1–5)	3.23 (0.30)	3.44 (0.30)	3.34 (0.30)
Quantity of streetscape greenery (1–5)	2.61 (0.77)	3.41 (0.72)	3.01 (0.74)
Quality of streetscape greenery (1–5)	3.13 (0.38)	3.57 (0.40)	3.35 (0.39)
Socio-demographic characteristics (neighbourhood population)			
Age 15–44 years (%)	53	41	47
Age 45–64 years (%)	20	26	23
Age 65+ years (%)	11	16	13
Non-Western ethnic minority (%)	25	11	18
Unemployment benefit (permillage)	36	29	32

Greenness based on median split at 45 m^2 of green area per dwelling within 500 m.
Socio-demographic characteristics: Statistics Netherlands 2004.

Table 2 Socio-demographic characteristics and health indicators of the study sample by greenness (mean plus SD or percentage)

	Non-green (n=746)	Green (n=895)	Total (n=1641)
Socio-demographic characteristics (sample)			
Men (%)	45	51	48
Age 16–44 years (%)	51	31	40
Age 45–65 years (%)	33	41	37
Age 65+ years (%)	16	29	23
Higher vocational or university education (%)	54	52	5
High income (% clearly above standard)	44	55	50
Non-Western ethnic minority (%)	4	3	3
Health indicators			
Perceived general health (1–5)	3.04 (0.83)	3.13 (0.79)	3.09 (0.81)
Acute health-related complaints (0–37)	4.98 (4.01)	4.31 (3.60)	4.61 (3.79)
Mental health status (0–100)	75.2 (14.6)	78.0(13.9)	76.8 (14.3)

Greenness based on median split at 45 m^2 of green area per dwelling within 500 m.

Table 3 Pearson correlations between greenspace indicators at neighbourhood level (n=80)

	Green areas		Streetscape greenery	
	Quantity	Quality	Quantity	Quality
	1	2	3	4
Quantity of green areas	1.00			
Quality of green areas	0.36	1.00		
Quantity of streetscape greenery	0.53	0.42	1.00	
Quality of streetscape greenery	0.48	0.39	0.76	1.00

Table 4 Multilevel regression analysis for the relationship between greenspace indicators, introduced separately and health indicators: parameters and SEs (N=1641)

	Perceived general health (1–5; higher is healthier)	Acute health-related complaints† (0–37; fewer is healthier)	Mental health status (0–100; higher is healthier)
Basic model at step 1			
Intercept	2.730 (0.119)***	2.232 (0.119)***	63.256 (2.180)***
Gender (women=1)	−0.062 (0.040)	0.201 (0.040)***	−2.580 (0.708)***
Age	−0.006 (0.001)***	−0.003 (0.001)**	0.087 (0.023)***
Education level	0.058 (0.013)***	−0.045 (0.012)***	0.358 (0.228)
Income	0.151 (0.032)***	−0.181 (0.031)***	3.497 (0.569)***
Parameter value for greenspace indicator in models a to d at step 2			
Green areas			
Model 2.a: quantity	0.041 (0.012)*** §	−0.041 (0.014)**	0.683 (0.243)** ‡
Model 2.b: quality	0.189 (0.062)** ‡	−0.192 (0.067)**	2.278 (1.267)
Streetscape greenery			
Model 2.c: quantity	0.073 (0.023)** ‡	−0.069 (0.026)**	1.304 (0.455)** ‡
Model 2.d: quality	0.165 (0.044)*** §	−0.156 (0.049)**	3.071 (0.860)*** §

**p≤0.01; ***p≤0.001.
†Poisson model: parameter values for ln(pi); no −2 × LL deviance statistic available.
‡Model improvement from step 1 to step 2 at p<0.01.
§Model improvement from step 1 to step 2 at p<0.001.

Table 5 Multilevel regression analysis for the relationship between greenspace indicators and health indicators, with quality introduced after quantity: parameters and SEs (N=1641)

	Perceived general health	Acute health-related complaints†	Mental health status
Green areas (model 3.a)			
Quantity	0.032 (0.013)*	−0.032 (0.014)*	0.598 (0.259)*
Quality	0.132 (0.066)* ‡	−0.141 (0.070)*	1.214 (1.297)
Streetscape greenery (model 3.c)			
Quantity	0.017 (0.036)	−0.017 (0.039)	0.183 (0.699)
Quality	0.140 (0.070)* ‡	−0.132 (0.075)	2.801 (1.341)* ‡

Variables included in step 1 are gender, age, education level and income.
*p≤0.05.
†Poisson model: parameter values for ln(pi); no −2 × LL deviance statistic available.
‡Model improvement from step 2 to step 3 at p<0.05.