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Supplement Article

Exploring why residents of socioeconomically deprived neighbourhoods have less favourable perceptions of their neighbourhood environment than residents of wealthy neighbourhoods

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Summary

Residents of socioeconomically deprived areas perceive their neighbourhood as less conducive to healthy behaviours than residents of more affluent areas. Whether these unfavourable perceptions are based on objective neighbourhood features or other factors is poorly understood. We examined individual and contextual correlates of socioeconomic inequalities in neighbourhood perceptions across five urban regions in Europe.

Data were analysed from 5205 participants of the SPOTLIGHT survey. Participants reported perceptions of their neighbourhood environment with regard to aesthetics, safety, the presence of destinations and functionality of the neighbourhood, which were summed into an overall neighbourhood perceptions score. Multivariable multilevel regression analyses were conducted to investigate whether the following factors were associated with socioeconomic inequalities in neighbourhood perceptions: objectively observed neighbourhood features, neighbourhood social capital, exposure to the neighbourhood, self-rated health and lifestyle behaviours.

Objectively observed traffic safety, aesthetics and the presence of destinations in the neighbourhood explained around 15% of differences in neighbourhood perceptions between residents of high and low neighbourhoods; levels of neighbourhood social cohesion explained around 52%. Exposure to the neighbourhood, self-rated health and lifestyle behaviours were significant correlates of neighbourhood perceptions but did not contribute to socioeconomic differences.

This cross-European study provided evidence that socioeconomic differences in neighbourhood perceptions are not only associated with objective neighbourhood features but also with social cohesion. Levels of physical activity, sleep duration, self-rated health, happiness and neighbourhood preference were also associated with neighbourhood perceptions.

Keywords: multilevel, neighbourhood perceptions, socioeconomic status, SPOTLIGHT.

Abbreviations: BMI, body mass index; IPAQ, International Physical Activity Questionnaire; OR, odds ratio; SES, socioeconomic status; 95%CI, 95% confidence interval.

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Introduction

Individuals living in socioeconomically deprived neighbourhoods have increased propensity to be overweight, experience poorer health and have higher mortality rates (1–3). Socioeconomic inequalities may at least be partly related to perceptions of residents in deprived neighbourhoods that their neighbourhood is not conducive to healthy behaviours. Neighbourhood perceptions may be based on actual, objective opportunities in the neighbourhood, as studies have shown that residents of deprived (low socioeconomic) neighbourhoods have less access to local health-promoting resources such as grocery stores and recreational facilities (4–8). Yet other studies suggest that deprived neighbourhoods may actually have better opportunities for healthy behaviours (4,9–11) so objective opportunities may not fully account for the perceptions of the neighbourhood. This may be explained by the concordance between perceived and objective features of the neighbourhood environment that is typically moderate to low (12–17), especially among lower educated individuals (18). For example, a study conducted in the UK showed that respondents in more deprived neighbourhoods lived closer to green spaces but they reported poorer perceived accessibility, poorer safety and less frequent use (19).

While differences in objective neighbourhood features may explain some of the socioeconomic differences in neighbourhood perceptions (20), other factors may contribute as well. There are still few empirical studies exploring alternative reasons for the different neighbourhood perceptions of residents of wealthy and deprived neighbourhoods. Two studies conducted in the Netherlands and Sweden showed that social cohesion and social participation contributed to socioeconomic differences in neighbourhood perceptions of safety and aesthetics (20,21). People who have more social connections in the neighbourhood may make more use of neighbourhood facilities (such as community centres) or neighbourhood activities (such as neighbourhood walks) and may therefore be more aware of what is present in their neighbourhood. It is also likely that individuals who are more involved with or more conscious of their neighbourhood surroundings (for example, because they spend a significant amount of their leisure time in their neighbourhood) are likely to have more favourable neighbourhood perceptions than individuals who are less aware of their surroundings. Kamphuis *et al.* (20) therefore suggested that future studies should take into account factors such as time spent in the neighbourhood, or the main mode of transport that is used within the neighbourhood, as indicators of exposure to the neighbourhood environment. Demographic factors, such as gender, country of origin, educational level, housing tenure and employment status, have also been linked to socioeconomic differences in neighbourhood perceptions (3,21,22), as well as self-assessed health and depressive feelings (20,22,23). It may be that healthy, happy and physically active individuals may better recognize services and facilities for healthy behaviours in their neighbourhood. However, none of the studies investigated the role of physical activity or other lifestyle behaviours as correlates of neighbourhood perceptions.

In conclusion, there is evidence that the objective neighbourhood environment, social environmental factors, demographics, psychosocial factors and health status contribute to socioeconomic differences in neighbourhood perceptions. Exposure to the neighbourhood environment and lifestyle behaviours may play a role as well. However, the studies conducted to date have been limited to a single country or region, and each investigated only a limited number of correlates. International comparisons of the various factors contributing to differences in neighbourhood perceptions between residents of high and low socioeconomic status (SES) neighbourhoods are therefore needed.

More favourable perceptions of the local environment have been linked to a range of physical activities and a healthier weight status (9–11,24). Interventions to influence residents' perceptions to make them aware of the environmental opportunities for healthy behaviour, especially in more deprived areas, may be a feasible way to contribute to healthier behaviours and lower body weight. Within the framework of the European SPOTLIGHT project (25), the current study aimed to (1) establish whether neighbourhood perceptions differ between residents of high and low SES neighbourhoods; (2) if so, explore individual correlates (i.e. demographic, health-related and lifestyle-related factors and exposure to the neighbourhood environment) and contextual correlates (i.e. physical and social environmental factors) of this difference and (3) examine whether associations differ across urban regions in Europe. A complementary study within the same project examined the concordance between objectively observed obesogenic features of the neighbourhood environment and perceived obesogenic features of the neighbourhood environment (26).

Methods

Study design and sampling

This study was part of the SPOTLIGHT project (25), conducted in five urban European regions: Ghent and suburbs (Belgium), Paris and inner suburbs (France), Budapest and suburbs (Hungary), the Randstad (a conurbation including the cities Amsterdam, Rotterdam, the Hague and Utrecht in the Netherlands) and Greater London (UK). Sampling of neighbourhoods and recruitment of participants have been described in detail elsewhere (27). Neighbourhoods were defined as according to small-scale local administrative boundaries as used in each country except for Hungary.

Budapest is divided into districts and suburbs that are highly heterogeneous in terms of population and much larger than the equivalent administrative areas in the other study countries. In order to ensure comparability between study areas, we thus defined 1 km^2 areas to represent neighbourhoods in Budapest and suburbs. Across all five locations, the average area of a neighbourhood was 1.5 km^2, and the mean population density was 2,700 inhabitants per neighbourhood. Detailed characteristics of the neighbourhoods are described in a previously published open access paper (27).

Neighbourhood sampling was based on a combination of residential density and SES data at neighbourhood level. Eligible neighbourhoods had to contain at least 800 households. Neighbourhoods were then classified as high and low SES on the basis of recent data on neighbourhood median income retrieved from each country's national statistics office (27). In each country, low SES neighbourhoods comprised neighbourhoods within the lowest tertile of median income, and high SES neighbourhoods comprised neighbourhoods within the highest tertile of median income. Data on residential density were obtained from the Urban Atlas database (28), and neighbourhoods were categorized into high or low residential density (corresponding to >80% and <50% of areas covered by residential buildings). This resulted in four types of neighbourhoods: low SES/low residential density, low SES/high residential density, high SES/low residential density and high SES/high residential density. In each country, three neighbourhoods of each neighbourhood type were randomly sampled (i.e. 12 neighbourhoods per country, 60 neighbourhoods in total).

The aim was to recruit at least 100 participants per neighbourhood (6,000 in total), with an anticipated response rate of around 10%. As we expected lower response rates from participants in low SES neighbourhoods (29), we oversampled adults (≥18 years) from low SES neighbourhoods (1,200 adults per neighbourhood) relative to high SES neighbourhoods (800 adults per neighbourhood). Subsequently, a random sample of adult inhabitants was invited to participate in an online survey via postal invitation using the Dillman method (30). The web-based survey could be accessed through the internet, or participants could request a paper-based version if preferred.

The survey contained questions on demographics, neighbourhood perceptions, social environmental factors, health, motivations and barriers for healthy behaviour, obesity-related behaviours and weight and height. A total of 6,037 (10.8%, out of 55,893) individuals participated in the study between February and September 2014. Response rates varied by urban region, from 7.4% in greater Budapest and Greater London to 15.6% in the Ghent region. The study was approved by the corresponding local ethics committees of participating countries, and all participants in the survey provided informed consent.

Measures

Demographics

Information on age, gender, employment status and household composition (number of adults and children in the household) was collected through the survey. As education systems differed between countries, we divided self-reported education levels into 'higher education' (college or university level) and 'lower education' (from less than primary to higher secondary education).

Assessment of perceptions about the residential physical environment

Physical environmental neighbourhood characteristics potentially related to physical activity were based on the validated assessing levels of physical activity environmental questionnaire and assessed with 5-point Likert scale items (ranging from 1 [totally disagree] to 5 [totally agree]) (31). Some items were recoded so that a higher score indicated a more positive perception of the neighbourhood environment (27). Additionally, participants reported on the presence of destinations (supermarkets, local shops, fast food restaurants, café/bars, open recreation areas or leisure facilities) in the neighbourhood. These items were rated as 1 (not present) or 5 (present). Based on the framework by Pikora *et al.* (32), four domains of neighbourhood perceptions were created: 'perceived safety' (Cronbach's $\alpha = 0.44$), 'perceived aesthetics' (Cronbach's $\alpha = 0.68$), 'perceived functionality' (Cronbach's $\alpha = 0.73$) and 'perceived destinations' (Cronbach's $\alpha = 0.74$). Combining these four domains (averaging the items used in the four subscales) resulted in an 'overall neighbourhood perception' score for each individual, ranging from 1 to 5 (Cronbach's $\alpha = 0.76$). Higher scores indicate more positive perceptions of the neighbourhood physical environment. The items included in the four domains are described in Supporting Information Table S1.

Objective obesogenic environmental characteristics

Neighbourhood characteristics were objectively assessed using a previously validated virtual audit tool based on Google Street View, the SPOTLIGHT virtual audit tool (33). A total of 41 environmental characteristics in relation to walking, cycling, public transport, aesthetics, land-use mix, grocery stores, type of food outlets and physical activity facilities was assessed in 4,486 street segments in 59 neighbourhoods (one Hungarian neighbourhood was not covered by Google Street View at the time of the virtual audit). Four constructs of neighbourhood characteristics were created, following a similar categorization to the one followed for perceived environmental characteristics: 'traffic safety' (Cronbach's $\alpha = 0.68$), 'aesthetics' (Cronbach's $\alpha = 0.73$), 'functionality' (Cronbach's $\alpha = 0.63$) and 'destinations' (Cronbach's $\alpha = 0.82$). Combining these four domains

did not result in a reliable 'overall neighbourhood score', so we continued with the four separate domains. A description of items included in the four domains is listed in Supporting Information Table S2.

Social environment

Aspects of neighbourhood social capital were assessed using a 13-item scale (Cronbach's $\alpha = 0.86$), with 5-point ordinal scale answering categories ranging from 1 (totally disagree) to 5 (totally agree). Factor analysis identified two reliable constructs of social capital, namely, 'social network' (Cronbach's $\alpha = 0.83$) and 'social cohesion' (Cronbach's $\alpha = 0.79$) (34). Examples of items within these factors were 'I often visit my neighbours in their home' (social network) and 'most people in this neighbourhood can be trusted' (social cohesion).

Lifestyle behaviours

Transport-related and leisure time physical activity were estimated using two domains of the validated International Physical Activity Questionnaire (35) by asking the frequency (number of days in the last seven days) and duration (average time per day) per domain. As part of the online survey, the Marshall questionnaire (36) was used to collect data on total hours of sitting per day. Information on fruit consumption was derived from a common food frequency item asking participants 'How many times a week do you eat fruit?'. The item was scored on a 9-point frequency scale ranging from 'once a week or less' to 'more than twice a day'. Participants further reported on their smoking behaviour (current, former or never smoker), sleep duration (average hours per night) and alcohol consumption (on a 9-point frequency scale ranging from 'one glass a week or less' to 'more than two glasses a day').

General health, anthropometrics and happiness

We used a visual analogue scale to assess general health, ranging from 0 (very unhealthy) to 100 (very healthy). Participants were asked to indicate any longstanding illness, disability or infirmity that limited daily activities or work (yes/no). Further, participants reported their height and weight, and we calculated body mass index (kg/m^2). Finally, participants indicated their level of happiness on a 5-point Likert scale ranging from very unhappy to very happy, which was dichotomized into happy (4–5) or not happy (1–3).

Neighbourhood exposure

To assess the degree of exposure to their neighbourhood environment, participants were asked to report how long they had lived in the neighbourhood (years of residency; dichotomized by the median into <10 years and ≥ 10 years) and whether they preferred to keep living in the neighbourhood or would prefer to move elsewhere. Participants answered the question 'Do you spend most of your leisure time inside your neighbourhood?' with yes or no. Lastly, they reported on household car and bicycle ownership.

Analyses

We excluded individuals who could not be allocated to one of the 59 selected neighbourhoods ($n = 732$) as we could not ascertain their precise residential address. This resulted in an analytical sample of 5,205 participants. Missing values ranged from $<1\%$ (age) to 26% (self-rated health). Based on the assumption that data were missing at random (i.e. the probability that a variable value is missing depends on other data that are observed in the dataset but not on any of the missing values), multiple imputations were performed. Given the percentage of missing values, 30 imputed datasets were generated, as recommended by Rubin (37) and Bodner (38). Missing values were imputed using predictive mean matching in SPSS version 22.0 (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). All variables described in the methods section were entered in the imputation models.

As the individual's 'overall neighbourhood perceptions' score was normally distributed, we conducted multilevel linear regression analysis with random intercepts for neighbourhoods. In the null model, we only used 'overall neighbourhood perceptions' as the dependent variable. In model 1, we added neighbourhood SES as a covariate to assess differences in neighbourhood perceptions between residents of high and low SES neighbourhoods. We subsequently present seven models (model 2–8) that serve as an exploration of correlates of neighbourhood socioeconomic differences in neighbourhood perceptions. Variables that changed the coefficient of neighbourhood SES by $>10\%$ were retained in the model (39).

In model 2, we assessed whether the association between neighbourhood SES and neighbourhood perceptions was independent of individual level demographics (level of education, age, gender, household composition and employment status). As household composition and employment status did not change the coefficient of neighbourhood SES by $>10\%$, they were removed from the model. In all further models, we adjusted for age, gender and level of education.

In model 3, we added objective neighbourhood features, and in model 4, we included neighbourhood social capital aspects. In model 5, we added lifestyle behaviours, model 6 included health-related variables and model 7 included the neighbourhood exposure variables. In model 8, we included all aforementioned variables to assess the combined explanatory power of the variables.

We interpreted the difference in the coefficient of neighbourhood SES between model 1 and the subsequent models as the contribution of the models to differences in neighbourhood perceptions between residents of high and low SES neighbourhoods. Further, we report the intraclass

coefficient and the change therein as the proportion of variance accounted for by the neighbourhood level for each model (40).

Lastly, we stratified the analyses by urban region and present models 2 and 8 for each region.

As a sensitivity analysis, we (i) repeated the analyses on a non-imputed dataset and (ii) repeated the analyses with individual SES as variable of interest.

Analyses were conducted in SPSS version 22.0 (SPSS Inc.). Significance was interpreted as a two-sided p-value of <0.05.

Results

The characteristics of residents of high and low SES neighbourhoods are shown in Table 1. For example, participants in low SES neighbourhoods were more likely to have lower education, had a more unfavourable perception of their neighbourhood and had lower self-rated health. Some of these differences were comparable across urban regions, such as the socioeconomic differences in individual education levels, overall neighbourhood perceptions, neighbourhood preferences, social network and social cohesion. Some socioeconomic differences were only statistically significant in some urban regions. For example, we only found socioeconomic differences in physical activity in the Ghent region, only in sedentary behaviours in greater Paris and only in alcohol consumption in greater Budapest (data not shown).

Table 2 shows that individuals in high SES neighbourhoods had a 0.28 point more favourable overall neighbourhood perception (95%CI = 0.18; 0.38), which barely changed after adjustment for age, gender and individual level of education (model 2). This difference corresponds to half a standard deviation difference in neighbourhood perceptions.

Inclusion of objectively observed neighbourhood features (model 3) attenuated the coefficient for neighbourhood SES by 15% to $B = 0.23$ (95%CI = 0.14; 0.32). Fewer neighbourhood destinations, better aesthetics and better traffic safety were significantly associated with more favourable neighbourhood perceptions.

The inclusion of neighbourhood social capital (model 4) attenuated the coefficient of model 2 by 52% ($B = 0.27$ to $B = 0.13$). Higher levels of neighbourhood social cohesion were significantly associated with more favourable neighbourhood perceptions.

The inclusion of lifestyle behaviours (model 5) or health-and-happiness-related factors (model 6) barely affected socioeconomic differences in neighbourhood perceptions. Yet lower levels of physical activity, higher levels of sleep duration, better self-rated health and being happy were significantly associated with more favourable neighbourhood perceptions.

Table 1 Characteristics of residents in low and high SES neighbourhoods ($N = 5205$)

	Mean (standard deviation) or percentages		
	Residents of low SES neighbourhoods ($N = 2581$)	Residents of high SES neighbourhoods ($N = 2624$)	F or χ^2 statistic (p-value)
Age (years)	51.0 (16.3)	53.4 (16.3)	28.1 (<0.001)
Gender (% women)	55%	55%	0.0 (0.96)
Education (% college or university)	46%	62%	116.0 (<0.001)
Employed (% currently employed)	54%	55%	0.5 (0.49)
Household composition (% >2 household members)	35%	40%	12.1 (0.001)
Overall neighbourhood perception† (range: 1–5)	2.6 (0.5)	2.9 (0.5)	256.6 (<0.001)
Social network (range: 4–20)	9.9 (3.7)	10.9 (3.6)	816.1 (<0.001)
Social cohesion (range: 5–25)	16.5 (3.8)	18.2 (3.2)	274.0 (<0.001)
Physical activity (hours per week)	9.9 (9.1)	9.2 (8.5)	8.4 (0.004)
Fruit (times per week)	6.7 (4.8)	7.3 (4.9)	24.2 (<0.001)
Sitting (hours per d)	8.9 (3.8)	8.9 (3.6)	0.2 (0.88)
Smoking (% currently smoking)	18%	11%	42.4 (<0.001)
Alcohol (glasses per week)	4.1 (5.3)	4.4 (5.1)	2.1 (0.15)
Sleep (hours per night)	7.1 (1.1)	7.2 (1.1)	3.4 (0.05)
Self-rated health (range: 0–100)	68.3 (19.9)	71.0 (19.1)	18.2 (<0.001)
Self-reported body mass index (kg/m^2)	25.6 (4.8)	24.8 (4.1)	32.6 (<0.001)
Happiness (% yes)	80%	85%	22.0 (<0.001)
Illness, mobility issues or handicaps (% yes)	24%	18%	24.8 (<0.001)
Length of residency (% > 10 years)	62%	68%	15.5 (<0.001)
Neighbourhood preference (% want to stay)	59%	76%	149.1 (<0.001)
Spending most leisure time in the neighbourhood (% yes)	70%	75%	8.8 (0.003)
Car ownership (% yes)	68%	82%	126.1 (<0.001)
Bicycle ownership (% yes)	71%	75%	12.6 (<0.001)

†Higher scores indicate more positive perceptions of the neighbourhood physical environment.
SES, socioeconomic status.

Table 2 Multivariable multilevel regression coefficients (95%CIs) for factors contributing to differences in neighbourhood perceptions between low and high SES neighbourhoods ($N = 5205$)

	Empty model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Demographics		*B* (95%CI)	*B* (95%CI)	*B* (95%CI)	*B* (95%CI)	*B* (95%CI)	*B* (95%CI)	*B* (95%CI)	*B* (95%CI)
Neighbourhood SES (high)	–	**0.28**	**0.27**	**0.23**	**0.13**	**0.27**	**0.26**	**0.25**	**0.13**
		(0.18; 0.38)	**(0.17; 0.37)**	**(0.14; 0.32)**	**(0.03; 0.24)**	**(0.17; 0.37)**	**(0.17; 0.36)**	**(0.15; 0.34)**	**(0.03; 0.23)**
Age (years)			−0.00	−0.00	−0.00	−0.00	0.00	−0.00	0.00
			(−0.00; 0.00)	(−0.00; 0.00)	(−0.00; −0.00)	(−0.00; 0.00)	(−0.00; 0.00)	(−0.00; 0.00)	(−0.00; 0.00)
Gender (female)			**−0.04**	**−0.04**	**−0.04**	**−0.05**	**−0.04**	**−0.04**	**−0.05**
			(−0.07; −0.01)	**(−0.07; −0.01)**	**(−0.07; −0.01)**	**(−0.08; −0.01)**	**(−0.07; −0.01)**	**(−0.07; −0.01)**	**(−0.07; −0.02)**
Educational level (high)			**0.04**	**0.04**	**0.04**	0.03	0.02	0.03	0.02
			(0.01; 0.07)	**(0.01; 0.08)**	**(0.01; 0.07)**	(0.00; 0.07)	(−0.01; 0.05)	(0.00; 0.06)	(−0.01; 0.05)
Objective obesogenic environmental characteristics									
Traffic safety				**0.45**					**0.56**
				(0.07; 0.82)					**(0.14; 0.97)**
Aesthetics				**0.45**					0.22
				(0.07; 0.82)					(−0.16; 0.60)
Functionality				−0.01					0.00
				(−0.42; 0.40)					(−0.39; 0.39)
Destinations				**−3.37**					**−3.22**
				(−5.44; −1.29)					**(−5.34; −1.09)**
Social environment									
Nbh social cohesion					**0.07**				**0.07**
					(0.02; 0.12)				**(0.01; 0.12)**
Nbh social network					0.03				−0.03
					(−0.03; 0.08)				(−0.09; 0.05)
Lifestyle behaviours									
Hours total PA per week						**−0.00**			**−0.00**
						(−0.00; −0.00)			**(−0.00; −0.00)**
Fruit consumption per week						0.00 (0.00; 0.01)			0.00
									(−0.00; 0.00)
Hours total sitting per day						−0.00			0.00
						(−0.00; 0.00)			(−0.00; 0.00)
Smoking (yes)						0.01 (−0.04; 0.05)			0.02
									(−0.03; 0.06)
Total glasses of alcohol per week						0.00 (−0.00; 0.00)			0.00
									(−0.00; 0.00)
Hours of sleep per night						**0.03 (0.02; 0.04)**			**0.02**
									(0.01; 0.04)
General health, anthropometrics and happiness									
Self-rated health							**0.00**		**0.00**
							(0.00; 0.00)		**(0.00; 0.00)**
Body mass index									

(Continues)

Table 2. (Continued)

	Empty model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
							−0.00		−0.00
							(−0.00; 0.00)		(−0.00; 0.01)
Happy (yes)							**0.07**		**0.05**
							(0.03; 0.11)		**(0.01; 0.09)**
Illness, disability or handicap (yes)							0.01		0.00
							(−0.04; 0.05)		(−0.05; 0.05)
Neighbourhood exposure									
Length of residency (>10 years)								−0.03	−0.03
								(−0.06; 0.01)	(−0.06; 0.01)
Want to stay in nbh (yes)								**0.13**	**0.12**
								(0.10; 0.17)	**(0.09; 0.15)**
Spent most time in nbh (yes)								−0.01	−0.00
								(−0.04; 0.03)	(−0.03; 0.03)
Car ownership (yes)								**0.05**	0.02
								(0.01; 0.10)	(−0.02; 0.08)
Bicycle ownership (yes)								−0.02	−0.03
								(−0.05; 0.02)	(−0.07; 0.01)
Within neighbourhood variance	**0.23 (0.01)**	**0.23 (0.01)**	**0.23 (0.01)**	**0.23 (0.01)**	**0.23 (0.01)**	**0.23 (0.01)**	**0.23 (0.01)**	**0.23 (0.01)**	**0.22 (0.01)**
Between neighbourhood variance	**0.06 (0.01)**	**0.03 (0.01)**	**0.03 (0.01)**	**0.02 (0.00)**	**0.02 (0.01)**	**0.03 (0.01)**	**0.03 (0.01)**	**0.03 (0.01)**	**0.02 (0.00)**
Intraclass coefficient (change in proportional variance from model 2)	0.21 (−)	0.12 (−)	0.12 (0%)	0.08 (33%)	0.08 (33%)	0.12 (0%)	0.12 (0%)	0.12 (0%)	0.08 (33%)

Bold values represent significant associations ($p < 0.05$). Model 1: neighbourhood level SES. Model 2: neighbourhood level SES, individual level education, age and gender. Model 3: model 2 + objective neighbourhood features. Model 4: model 2 + neighbourhood social capital aspects. Model 5: model 2 + lifestyle behaviours. Model 6: model 2 + health. Model 7: model 2 + neighbourhood awareness. Model 8: all variables included in the previous models.
nbh = neighbourhood; SES, socioeconomic status.

In model 7, the association between neighbourhood SES and neighbourhood perceptions was attenuated by 7% after inclusion of variables related to neighbourhood exposure ($B = 0.25$, 95%CI = 0.15; 0.34). Wanting to stay in the neighbourhood and owning a car were significantly related to more favourable neighbourhood perceptions.

The results in model 8 show that the association between neighbourhood SES and neighbourhood perceptions could be partly (namely, 52%: $B = 0.27$ changed to $B = 0.13$) explained by the included variables. More specifically, age, gender, destinations present in the neighbourhood, traffic safety, levels of physical activity, sleep duration, self-rated health, happiness and preference to stay in the neighbourhood were associated with SES differences in neighbourhood perceptions. This was also reflected by the 33% change in proportional variance after inclusion of all variables.

Results of analyses stratified by country (urban regions) are presented in Supporting Information Table S3. We show models 2 and 8. Differences in neighbourhood perceptions between residents of high and low SES neighbourhoods were observed across the European regions, with the most pronounced differences in the Ghent region ($B = 0.33$, 95% CI = 0.16; 0.49), greater Paris ($B = 0.33$, 95%CI = 0.10; 0.56) and the Randstad region ($B = 0.32$, 95%CI = 0.03; 0.62). The variables included in model 8 explained most of the SES differences in neighbourhood perceptions in four urban regions, but not in Greater London. In greater Paris, the inclusion of all variables even reversed the direction of the association ($B = -0.30$, 95%CI = -0.55;-0.05).

The only factor significantly associated with socioeconomic differences in neighbourhood perceptions in all five regions was the preference to stay in the neighbourhood. The objective presence of destinations was most strongly related to socioeconomic differences in neighbourhood perceptions in the Ghent region, whereas objective neighbourhood aesthetics was a stronger correlate in the Randstad region (the Netherlands). Neighbourhood social cohesion mainly contributed to SES differences in neighbourhood perceptions in the Paris region and greater Budapest. Physical activity levels were a contributor in the Randstad region and greater Paris, while sleep duration was a contributor in the Ghent region. Self-rated health was only correlated with neighbourhood perceptions in the Randstad region, but preference to stay in the neighbourhood was correlated in all five countries. Lastly, car ownership was most important in greater Budapest.

Results for analyses with non-imputed data were comparable (Supporting Information Table S4). Results for analyses with individual SES as the variable of interest can be found in Table 2. While the variables included in model 8 also explained 50% of the socioeconomic inequalities in neighbourhood perceptions ($B = 0.04$, 95%CI = 0.01; 0.07 in model 2 to $B = 0.02$, 95%CI = -0.01; 0.05 in model 8), this was largely due to individual factors (models 5, 6 and 7), instead of the environmental factors (models 3 and 4) that explained the neighbourhood socioeconomic inequalities in the main analysis.

Discussion

Favourable perceptions of the local environment may be important for engaging in physical activity and for a healthier weight status (9–11,24). This may be especially true in more deprived neighbourhoods where people are less likely to meet recommendations for healthy diets (41), are more likely to be overweight (2) and tend to be less positive about the neighbourhoods they live in (3). This study is one of the first to investigate the factors underlying differences in neighbourhood perceptions.

Using a European survey conducted in socioeconomically contrasting neighbourhoods, we were able to identify differences in overall neighbourhood perceptions between residents of high and low SES neighbourhoods in large urban areas. We examined the individual, social and built environmental correlates of differences in neighbourhood perceptions between residents of high and low socioeconomic neighbourhoods in Europe. As hypothesized and in line with earlier research (20,42), residents from low SES neighbourhoods had less favourable neighbourhood perceptions than residents in high SES neighbourhoods.

Our results further indicate that this could partly be explained by objectively established less favourable neighbourhood features: objectively observed traffic safety, aesthetics and the presence of destinations in the neighbourhood explained around 15% of differences in neighbourhood perceptions between residents of high and low SES neighbourhoods. In the study of Kamphuis *et al.* (20), objectively observed aesthetics explained most of the neighbourhood variation in neighbourhood perceptions among residents of Dutch neighbourhoods. This is coherent with our findings for the Randstad region (the Netherlands), in which higher levels of objective aesthetics were significantly associated with more positive neighbourhood perceptions. The finding that objective environmental features only explained a small part of the variation in neighbourhood perceptions was consistent across regions. It may of course be that individuals are influenced by environmental cues without realizing it (and thus not consciously perceiving the environment as such). Indeed, environmental cues are known to influence eating and physical activity behaviours even if individuals are not aware of their effects: health behaviours are often not the result of deliberate, consciously planned decision-making (43).

Lower levels of social cohesion in low SES neighbourhoods explained around 52% of differences in neighbourhood perceptions between residents of high and low neighbourhoods. A Swedish study demonstrated that

neighbourhood social capital could explain 70% of the neighbourhood variance in perceived safety (44). This, along with the findings from our study, corresponds with the notion that neighbourhood perceptions on opportunities, local resources and neighbourhood image are interrelated with opportunities for participation, norms of cooperation and reciprocity and patterns of mutual aid and information exchange (45). As such, more attention should be given to the interplay of social and physical environmental factors in the factors influencing obesity-related behaviours and obesity.

Other factors associated with neighbourhood perceptions were self-rated health, happiness, physical activity levels, sleep duration and a preference to stay in the neighbourhood, but these factors contributed less to socioeconomic differences. Differences in relevant correlates were observed in the analyses stratified by urban region, such that only the preference to stay in the neighbourhood was a statistically significant correlate across all five regions. The findings for self-rated health and happiness were in concordance with previous studies conducted in the Netherlands and the UK (20,22,23); as in our stratified analysis, the contribution of self-rated health and happiness to neighbourhood perceptions was most pronounced in the Randstad and Greater London.

Obviously, it is not possible to infer causality on the basis of this cross-sectional study. However, even on the basis of longitudinal observational or experimental studies, disentangling causal and selective effects remains a challenge. Health behaviours and health are determined in a system in which individuals interact with each other and with their environment, and both individuals and environments may change and adapt over time – resulting in a web of conditions and feedback loops – i.e. a complex adaptive system (46) – that are difficult if not impossible to disentangle (47). For example, our finding that physical activity was correlated with socioeconomic differences in neighbourhood perceptions (mainly in the Randstad region and greater Paris) might be because residents of high SES neighbourhoods are healthier, more active or optimistic people who have the means and the opportunity to live in a supportive neighbourhood and maintain their health behaviours (20,22,23,44,48). Nevertheless, this does not mean that increased physical activity does not contribute to improved neighbourhood perceptions – these factors may reinforce each other. In fact, multiple studies have provided evidence for a bidirectional relationship between physical activity and mental well-being (49–52). Therefore, the results of the present study may provide a first indication that improvements in neighbourhood attraction, safety and design contribute to neighbourhood perceptions. This is concordant with the findings from a recent study conducted in the USA, showing that changing the built environment (placing a full-service supermarket in a 'food desert') changed perceived access to healthy food. However, it did not lead to changes in fruit and vegetable intake, whole grain consumption or body mass index (53). Future studies could examine whether improvements to the built environment may lead to decreasing socioeconomic inequalities in health behaviours through improvement of how residents perceived their neighbourhood environment. However, our results indicate that objectively improving built and safety environmental features of lower SES neighbourhoods may not be enough. Multilevel intervention studies may also need to include a focus on social cohesion in the neighbourhood, as this is likely to affect neighbourhood perceptions as well as health behaviours (54).

Strengths and limitations

Strengths of the present study include the large population-based sample from five European urban regions, the harmonized data collection across heterogeneous neighbourhoods, the representation of both high and low SES groups and the use of a validated tool to assess objective neighbourhood features (33). Main limitations are (1) the cross-sectional design that does not allow for causal inference; (2) the self-report of lifestyle behaviours, which may be prone to under-reporting and over-reporting and could lead to same-source bias and, (3) although common among large European surveys (55), the low response rate (10%). These three limitations give reason for caution in interpreting the outcomes as selection bias is likely to have occurred. Further, although we sampled individuals from high and low SES neighbourhoods, our measure of individual SES was quite crude, and it is likely that there was residual confounding by individual SES. Lastly, the study was conducted among residents of neighbourhoods in large urban areas, which may limit the generalizability of the present findings to less urbanized or rural areas.

Conclusions

This cross-European study provided evidence that differences in neighbourhood perceptions between residents of high and low SES areas are partly attributable to objective neighbourhood features, but also to the social cohesion in a neighbourhood and, to a lesser extent, by levels of physical activity, sleep duration, self-rated health, happiness and neighbourhood preference.

In this study, we had the opportunity to assess the potential effect of a wide range of explanatory variables. Traffic safety, aesthetics and variety of destinations, as assessed by an innovative tool using Google Street View, emerged as significant contributors to the neighbourhood SES differences in perceptions. Future studies should examine whether improvements in neighbourhood attraction, safety and design indeed contribute to decreasing socioeconomic inequalities

in health behaviours by improving how residents perceived their neighbourhood environment. However, our results indicate that objectively improving built and safety environmental features of lower SES neighbourhoods may not be enough. If our results are confirmed by future studies, intervention studies could focus on the possible effects of enhanced neighbourhood social cohesion.

Declaration of interests

The authors have no conflicts of interest to declare.

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