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Greater perceived access to green spaces near homes: Safer and more satisfied residents

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ABSTRACT

Safe and green living environments are highly appreciated by people and, as stated by the United Nations, are a key priority for sustainable urban development. The current study explores whether perceived and objective indicators of access to green spaces in the living environment, as well as individual socio-demographic characteristics, affects perceived safety as well as municipal satisfaction. It also examined whether perceived safety moderates the relationship between perceived access to green spaces and municipal satisfaction. Five indicators of access to green spaces were used: Four were objectively derived using Geographical Information Systems (GIS), while one indicator was based on survey data on inhabitants' perceived access to green spaces. The same survey also revealed the variables of perceived safety and municipal satisfaction. Correlation, regression, and moderation analyses were applied. The results showed that objective and perceived indicators did not correlate. Furthermore, strong and positive associations were revealed between perceived access to green spaces and municipal satisfaction B=0.45 (95% CI = 0.41, 0.50) and perceived safety (B = 0.39; 95% CI = 0.32, 0.46). The more satisfied people were with their access to green spaces and safety outdoors in the evenings and nights, the more satisfied they were with their living environments. These associations were evident even after controlling for socio-demographic variables. These results provide evidence of the importance of green spaces and support planners' arguments for preserving current or developing new green spaces. The study also shows the importance of not only relying on objective indicators of access to green spaces and encourages planners and researchers to explore perceived indicators.

1. Introduction

Ensuring safe and attractive places for people to reside in are important priorities for planners, policymakers, and politicians. These concerns are also identified and underlined in the United Nations' (UN) sustainable development goal (SDG) 11, *Sustainable cities and communities* (United Nations, 2015). Sub goal 11.7 states that especially women, children, the elderly, and people with disabilities, should have access to safe, inclusive, and accessible green and public spaces. In this study, we are interested in whether access to green spaces in the living environment, as well as individual socio-demographic characteristics, affects municipal satisfaction and the perceptions of safety. Several studies have explored how the built environment and other neighbourhood characteristics impact residents' satisfaction with their neighbourhood (for an overview, Neal, 2020). A meta-analysis showed that both objective and perceived features of the physical environment affect neighbourhood satisfaction (Neal, 2020), however, the direct effect of these factors is found to be weak. The association between access to green space and inhabitants' satisfaction with their neighbourhood has also been investigated, but the significance of access to green space is diverging (see for example Björk et al., 2008; Kearney, 2006). The study by Björk et al. (2008) confirmed that people who live in neighbourhoods with access to natural areas that offer recreational qualities are more satisfied with their neighbourhoods, whereas the study by Kearney (2006) showed that proximity to nearby nature was not that important for neighbourhood satisfaction. Others stress the importance of green space quality rather than quantity for neighbourhood satisfaction (de Jong et al., 2012; Ta et al., 2021; Zhang et al., 2017). A limitation when reviewing the green space literature is the broad or unclear definition of green space. In this empirical study, we operationalize access to green space in a variety of ways, both objectively as well as perceived (section 2.2).

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Associations between access to green space and safety have also been examined, as well as safety as a factor associated with neighbourhood satisfaction. For example, studies have confirmed that individuals who live in areas with significant amount of vegetation feel safer than individuals living in less vegetated areas (Troy et al., 2012; Schusler et al., 2018; Wolfe & Mennis, 2012). However, there are studies highlighting issues around the fear of crime in urban green spaces (Mak & Jim, 2022; Maruthaveeran & van den Bosh, 2015) not least because vegetation can provide hiding places for criminal activities, such as robbery, assault, and drug trafficking (Sreetheran & van den Bosch, 2014). Conscious design and maintenance can however reduce the risk of such events (Evensen et al., 2021; Jansson et al., 2013; Sezavar et al., 2023) and ensure that people can take advantage of the health and well-being benefits of living near green spaces. Thus, increased knowledge of the relationships between access to green spaces and perceived safety (Eizenberg & Jabareen, 2017) and residents' satisfaction with their living environment is important for contributing to social sustainability.

1.1. Determinants of neighbourhood satisfaction

According to the pathway model of Neal and Brutzman (2023), neighbourhood satisfaction is assumed to be a result of three groups of determinants. The first group includes individual characteristics such as gender, age, education, country of birth, and income. The second group embraces perceived or subjective neighbourhood factors and consists of information about how individuals think their neighbourhood is characterized. The third group of determinants includes objectively measured factors such as noise, pollution, population density, population heterogeneity, and square meters of parkland. These three groups of determinants will be explored further in this paper by considering *socio-demographic* as well as *perceived* and *objective* indicators of access to green space.

The trade-off and relative significance between the objectively and perceived factors have been debated (Neal, 2020), and research indicates that the perceived determinants are more important than the objectively measured ones (Mantey, 2021). The relative significance of perceived and objectively assessed access to green space on municipality satisfaction, which is the topic in the present paper, has as far as we know, not been investigated.

The three groups of determinants are linked to neighbourhood satisfaction in different ways. Campell and his co-authors' (1976) suggest a pathway starting with the objective factors which determine people's perceptions of their neighbourhood and their assessments of it. In their model, individual characteristics such as age and gender confound the association between objective factors, perceived factors and assessed features. Other researchers have proposed a model where three independent groups of determinants (i.e. individual characteristics, perceived and objective neighbourhood factors) affect neighbourhood satisfaction directly (Guest & Lee, 1983; Neal, 2020), not being connected in one pathway such as in Campbell et al. (1976). Neal's (2020) model is later adjusted and personal characteristics such as personality traits is suggested to confound the association between perceived determinants and neighbourhood satisfaction (Neal & Brutzman, 2023).

1.2. Perceived safety in relation to neighbourhood satisfaction

The connection between perceived safety and neighbourhood satisfaction has been investigated, but how these two factors are connected differ. Mouratidis' (2020) approach was to investigate how safety and satisfaction were related to neighbourhood deprivation, but he did not include the two factors in the same model. Mantey (2021) based her model on Campbell et al. (1976) and included safety in the group of perceived factors linked to satisfaction. Based on explanatory factor analysis, she found that safety in addition to landscape, population density, traffic noise, walkability, possibility to relax, and spending time in nature were significantly associated with neighbourhood satisfaction (Mantey, 2021).

Lachowycz and Jones' (2013) have presented a framework on the relationship between green space and health (a topic related to satisfaction). They argue that safety can determine people's motivation to use green space. Safety therefore affects the mechanism between access to green space and health, hence should be treated as a moderator. We will test whether this mechanism is applicable for municipal satisfaction. This will provide new knowledge about how green space is associated with municipal satisfaction depending on whether the respondents perceive their neighbourhood as safe or not safe.

1.3. Aim of the study

In this study, we contribute to the body of research by exploring inhabitants' perceived access to green space as well as objective indicators of green space in a Swedish context. Adding to the theoretical discussion, we also examine if perceived safety affects the association between access to green space and municipal satisfaction. The following objectives were formulated.

- Explore correlations and associations between perceived and objectively assessed *access to green spaces*, *perceived safety*, and *municipal satisfaction* in a Swedish context.
- Examine associations between *socio-demographic characteristics* and *perceived safety*, and *municipal satisfaction.*
- Examine *perceived safety* as a potential moderator of the relationship between access to green spaces and municipal satisfaction.

2. Material and methods

This paper applied an epidemiological approach and a cross-sectional design. The objective green space indicators were linked to survey data on socio-demography, perceived access to green spaces, perceived safety, and municipal satisfaction to address the study objectives. The study was approved by the Swedish Ethical Review Authority.

2.1. Study area

Täby municipality in Sweden was chosen as the study area (Fig. 1) because it is one of six participating municipalities (along with Espoo, Stavanger, Aarhus, Ii, and Wilhelmina) in the Nordic research project *NORDGREEN - Smart Planning for Healthy and Green Nordic Cites*. Täby was an appropriate study area due to the availability of rather extensive survey data covering people's perceived access to green spaces, municipal satisfaction, and perceived safety (Statistics Sweden, 2022a), along with geographical information on each participants' residential location within neighbourhoods in the municipality.

Täby borders Stockholm, the capital of Sweden, and is about 30 min by car north of the capital. The municipality, which has about 73,000 inhabitants (Statistics Sweden, 2021), is predicting a 25% increase in the number of inhabitants by 2050 (Täby Municipality, 2022). To prepare for this population growth, Täby is planning for 650 new dwellings annually in the coming years. Täby has a relatively high proportion of park coverage, a high proportion of park area per inhabitant, and a short mean distance to parks from where people reside compared to the other Nordic municipalities in the same project (Aamodt et al., 2023). Moreover, prioritizing the protection of green spaces is explicitly mentioned in both the current (Täby Municipality, 2022) and previous (Täby Municipality, 2010) municipal comprehensive plans, including the ambitious goal of consisting of 50% green spaces by 2050. Additional key priorities in the current comprehensive plan are to make Täby an attractive and safe place to live, which aligns with the UN's SDG 11 and represents the core of this article.

Fig. 1. The location of Täby in the Nordic region.

2.2. objective indicators of access to green spaces

In this study, we explore different types of objectively measured green space indicators (see below) and one perceived indicator of access to green spaces (see section 2.4). Four objective green space indicators were computed and used as exposure variables: *vegetation cover*, *proportion of green areas*, *total proportion of green spaces*, and *mean distance to nearest green space.* All variables were continuous. The free software packages Quantum GIS (version 3.4.1) and Python were used to perform the analyses.

Vegetation cover was computed as follows: Satellite images were downloaded from the Copernicus webpage (www.copernicus.eu). The images comprised the results of a data-processing algorithm of red and near-infrared light (NIR). For each pixel in the study area (250 × 250 m), the satellites registered the magnitude of red and NIR light. Based on these values, the Normalized Difference Vegetation Index (NDVI) was computed as follows: NDVI = (NIR − Red)/(NIR + Red). Values close to 1 corresponded to high vegetation density, while values close to −1 corresponded to no vegetation density. We used images taken from the Sentinel-3 satellite each fortnight from April 2021 to July 2021 and selected the maximum value representing the greenest period. For each DeSO[1] area a mean score was computed.

The proportion of green areas was computed as follows: Following Barboza et al. (2021), we used the European Urban Atlas and downloaded data on a broad range of green and blue spaces, including both urban and rural spaces, such as green urban areas, sport and leisure facilities, pastures, meadows, and wetlands. The various green spaces were merged into a green area map. We used this map to compute the proportion of green areas within each spatial statistical unit (DeSO area).

The total proportion of green spaces and *the mean distance to nearest green space* were computed as follows*:* land cover and land use maps derived from the Swedish Map Authorities (https://www.lantmateriet.se) were downloaded. We selected the following categories: parks, cemeteries, and forests, and produced a union of these categories in GIS. Based on this map, we computed the *total proportion of green spaces* within the DeSO area. We also calculated the distance to the nearest green space for all residents in the municipality and calculated an average of the distance within each DeSO area, which gave us the variable *mean distance to nearest green space.* Hence, the variables *total proportion of green spaces* and *mean distance to nearest green space* comprise a restricted number of green space types, compared with the variable *proportion of green areas* mentioned above.

2.3. Statistics Sweden's citizen survey in Täby (medborgarundersökningen)

We used data from Statistics Sweden's Citizen Survey conducted in Täby in 2019 and 2020. Statistics Sweden conducts the Citizen Survey (commissioned by Swedish municipalities) annually to obtain residents' opinions about municipal *operations* and *services* and *what it is like to live in the municipality*. The three parts comprise a battery of 12 A4 pages of questions. Statistics Sweden invited a representative sample of inhabitants from Täby municipality to participate in the Citizen Survey (Statistics Sweden, 2022a). A total of 1700 residents were invited to participate in 2019, of which 735 responded (43.2%). In 2020, 1200 residents were invited to participate, and 533 responded (44.4%). The same questionnaire was used for both years; therefore, we merged the datasets and gathered survey data from 1268 inhabitants. We excluded respondents living outside Täby municipality (n = 21) or participants with a missing reference number (n = 6), as it was not possible to link GIS-derived green space indicators to these respondents. We also excluded participants with missing values for any of the variables of interest in this study (n = 52), resulting in an analytical sample of 1189 inhabitants.

The survey data provided information on *perceived access to green spaces*, *perceived safety*, *municipal satisfaction*, and *socio-demographic characteristics* of the participants, including age, education level, gender, region of birth, and civil status. The items *perceived access to green spaces*, *perceived safety*, and *municipal satisfaction* were scattered among other items in the questionnaire, under the heading *what it is like to live in the municipality*. The variables are described in further detail in Section 2.4. We also obtained information about which of the 38 DeSO areas in which each participant resided. These DeSO areas were used to compute objective indicators of access to green spaces (as described in section 2.2), and we subsequently linked these indicators to the Citizen Survey data obtained using the common DeSO code as the linkage key.

2.4. The variables obtained from the Täby Citizen Survey

The perceived green space indicator (*perceived access to green spaces*), the outcome variables (*municipal satisfaction* and *perceived safety*), and the socio-demographic covariates were derived from the Täby Citizen Survey.

The survey questions were formulated as statements, and participants responded on a 10-point scale, ranging from 1 to 10 or "no opinion". In the analysis, these variables were treated as continuous variables and no opinion as missing.

The following three questions/statements were used for the analysis.

1. How do you view access to parks, green spaces, and nature (in your municipality)? (Perceived access to green spaces) 1 = not at all good, 10 = very good.

[1] The DeSO system was introduced in Sweden in 2018. It was meant for statistical purposes to standardize geographical areas that are smaller than the municipalities boarders. On average, DeSO areas cover around 1500 residents (range 600–3500 residents). DeSO areas largely follow geographical boarders such as streets and waterways. For more on DeSO see https://www.scb.se/hitta-statistik/artiklar/2018/demografiska-statistikomraden-en-ny-regional-indelning-under-kommuner/.

2. How satisfied are you with your municipality as a whole as a place in which to reside? (Municipal satisfaction) 1 = not at all satisfied, 10 = highly satisfied.
3. How do you view the level of safety and security when spending time outdoors during evenings and/or at night? (Perceived safety) 1 = not at all good, 10 = very good.

In the analysis, *perceived access* to green spaces was used as an independent continuous variable, whereas *perceived safety* and *municipal satisfaction* were treated as continuous dependent variables. Additionally, perceived safety was treated as an independent variable and a moderator between perceived access to green spaces and municipal satisfaction in one of the analyses.

The socio-demographic variables age, education level, gender, region of birth, and civil status were used as covariates in the analyses to adjust for potential confounding factors. All socio-demographic variables were treated as categorical variables. Age in years was divided into four categories (<=29, 30–49, 50–67, and >67), education level had three categories (elementary school, high school/< two years post-high school, and university for two years or more), gender had two categories (men/women), region of birth two categories (Sweden/not Sweden), and civil status had four categories (married, unmarried, divorced, and widow/widower).

2.5. Statistical analyses

The statistical analyses were conducted using IBM SPSS version 26.0. Initially, we computed descriptive statistics (i.e., frequencies, proportions, mean, min, max, and standard deviations) for all key variables. We then computed Pearson correlation coefficients between green space indicators and the outcome variables of perceived safety and municipal satisfaction, including the corresponding *p*-values. Only green space indicators that significantly correlated with perceived safety or municipal satisfaction ($p < 0.05$) were further included in regression models. To examine associations between access to green spaces, perceived safety, and municipal satisfaction, we fitted two linear regression models, one for each outcome variable. Perceived safety was regressed dependent on socio-demographic characteristics and perceived access to green space (Model 1). In the model for municipal satisfaction (Model 2), perceived safety was also included as an independent variable. All variables were simultaneously entered into both models to adjust for potential biases. Regression coefficients (B) with 95% confidence intervals are reported, and $p < 0.05$ was considered statistically significant. Finally, in line with Lachowycz and Jones (2013), as well as Neal (2020), we explored whether perceived safety acted as a moderator in the relationship between green space access and municipal satisfaction. Hence, we fitted a model where we included the following interaction term: perceived access to green space*perceived safety. Both variables were standardised before they were entered into the model. A significant interaction term corresponded to a moderation effect. Next, we stratified the dataset depending on whether the participants scored above or below median perceived safety. Two models were fitted, one for each stratum, corresponding to Model 2, and the covariates were added to adjust for potential cofounding factors.

3. Results

3.1. Descriptive statistics

Table 1 shows the distribution of the variables characterizing the study sample. The typical participant was a woman (51.6%) with a university degree (59.6%) aged 55.8 years. Most of the participants were born in Sweden (85.4%) and married (62.0%). The participants perceived their access to green spaces in Täby as very good, with a mean value of 8.4 (SD = 1.7) on a 10-point scale. Overall, the participants felt relatively safe when spending time outdoor in the evenings and at night (mean 6.6 (SD = 2.3)). Women reported lower perceived safety than men, while inhabitants between 50 and 67 years, as well as participants with a university degree, married, and inhabitants not born in Sweden, reported highest perceived safety. Overall, the participants were very satisfied with their municipality as a place to live and they perceived their access to green space as good.

Table 2 shows how access to green space is distributed among the 38 statistical units (DeSO) in Täby. Vegetation cover is in general high (0.66) and mean distance to the nearest green space was 89.0 m. Nevertheless, the range within the municipality is large, and some districts are sparsely green (4%) and have longer distance to their nearest green space (198.2 m).

The correlation analysis reported in Table 3 shows that most of the objective green space indicators were correlated. However, the perceived green space indicator did not correlate with the objective green space indicators, except for a very weak correlation with the

Table 2
Descriptive statistics for access to green space variables.

Access to green space variables	Min	Max	Mean	SD
Vegetation cover (NDVI)	0.46	0.81	0.66	0.08
Proportion of green areas (%)	4	86	35	24
Total proportion of green spaces (%)	4	58	24	16
Mean dist. to nearest green space (m)	29.5	198.2	89.0	34.7
Perceived access to green spaces	1	10	8.4	1.7

Table 1
Descriptive statistics for the analytical sample n = 1,189, Täby Citizen Survey.

		n (%)	Perceived safety M (SD)	Neighbourhood satisfaction M (SD)	Perceived access to green space M (SD)
All		1189 (100)	6.6 (2.3)	7.9 (1.7)	8.4 (1.7)
Gender	Women	598 (50.3)	6.1 (2.4)	7.9 (1.7)	8.4 (1.6)
	Men	591 (49.7)	7.2 (2.1)	7.9 (1.7)	8.4 (1.8)
Age	<30 years	82 (6.9 %)	6.4 (2.5)	8.0 (1.7)	8.0 (2.1)
	30–49 years	349 (29.4 %)	6.6 (2.4)	7.9 (1.6)	8.5 (1.6)
	50–67 years	414 (34.8 %)	6.8 (2.6)	7.8 (1.6)	8.4 (1.7)
	>67 years	344 (28.9 %)	6.4 (2.3)	8.0 (1.8)	8.3 (1.7)
Education	Elementary school	80 (6.7 %)	6.0 (2.5)	7.8 (2.1)	8.2 (1.9)
	High school	400 (33.6 %)	6.2 (2.4)	7.8 (1.8)	8.2 (1.8)
	University	709 (59.6 %)	6.8 (2.2)	8.0 (1.6)	8.5 (1.6)
Civil status	Unmarried	260 (21.9 %)	6.6 (2.4)	7.8 (1.8)	8.3 (1.8)
	Married	737 (62.0 %)	6.8 (2.4)	8.0 (1.6)	8.4 (1.7)
	Divorced	144 (12.1 %)	6.3 (2.4)	7.8 (1.9)	8.4 (1.7)
	Widow/widower	48 (4.0 %)	5.9 (2.5)	8.1 (1.5)	8.2 (1.6)
Region of birth	Swedish	1016 (85.4 %)	6.6 (2.3)	7.9 (1.7)	8.4 (1.7)
	Not Swedish	173 (14.6 %)	6.8 (2.2)	7.8 (1.6)	8.5 (1.7)

M = mean, SD= Standard deviation.

Table 3
Correlation coefficients for the key variables in the analyses.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Green space variables							
1. NDVI							
2. Proportion of green area (%)	**0.425***						
3. Total proportion of GS (%)	**0.604***	**0.842***					
4. Mean dist. to nearest GS	**0.305***	−0.040	−0.041				
5. Perceived access to GS	**0**.018	**−0.076***	−0.012	−0.056			
Outcome variables and potential moderator							
6. Perceived safety	0.050	0.015	0.001	0.030	**0.289***		
7. Municipal satisfaction	−0.028	−0.055	−0.055	−0.009	**0.538***	**0.415***	

Pearson's correlation coefficients are reported. *$p < 0.01$. GS = green space.

proportion of green areas (r = −0.076, p < 0.01). None of the objective green space indicators correlated with the outcome variables municipal satisfaction or perceived safety. However, perceived access to green spaces was significantly correlated with perceived safety (r = 0.289, p < .001) and municipal satisfaction (r = 0.538, p < 0.001).

3.2. Associations between perceived green spaces and perceived safety and municipal satisfaction

The results from the adjusted regression models estimating the relationships between perceived access to green spaces, perceived safety, and municipal satisfaction are presented in Table 4. We found a positive relationship between perceived access to green spaces and perceived safety (B = 0.39; 95% CI = 0.32, 0.46) (Model 1). Otherwise, only gender and education were significantly associated with perceived safety; p < 0.001 for both associations. Women were less safe than men and safety decreased with lower education level.

A similar association for perceived access to green space was found for municipal satisfaction (Model 2), where a one-unit increase in perceived access to green spaces resulted in a 0.45 (95% CI = 0.41, 0.50) higher municipal satisfaction score. We also found significant associations between age and municipal satisfaction (p = 0.004) as well as region of birth (p = 0.030), gender (p = 0.006), and education (p = 0.006). We observed that women more than men, the oldest and youngest age groups, and inhabitants born in Sweden reported most satisfaction with their municipality. Perceived safety was also significantly and positively associated with municipal satisfaction (p < 0.001).

When testing whether safety moderated the relationship between perceived access to green spaces and perceived municipal satisfaction, we found a statistically significant moderation effect (p < 0.001). When stratified on perceived safety, and controlled for covariates, we observed that the magnitude of the effect between perceived access to green space and municipal satisfaction was higher for individuals feeling less safe (B = 0.53, 95 % CI: 0.47–0.59) compared to individuals feeling safer (B = 0.42, 95 % CI: 0.34–0.50) (Table 5).

Table 5
Adjusted association between perceived assess to green space and neighbourhood satisfaction for inhabitants with low or high perceived safety.

	Municipal satisfaction	
	B (95% CI)	
	Low perceived safety	High perceived safety
Access to green space	0.53 (0.47–0.59)***	0.42 (0.34–0.50)***

B: Unstandardized regression coefficients, CI: Confidence interval, ***$p < 0.001$, **p < 0.01, *p < 0.05.

4. Discussion

4.1. Perceived access to green space is associated with inhabitants feeling safer and more satisfied

This study revealed that people's perceptions of access to green spaces were positively related to their perceived safety as well as their satisfaction with their municipality as a place to reside. In other words, inhabitants with access to green space were more safe and satisfied than inhabitants with less access to green space. These associations were evident even after controlling for socio-demographic variables. Both

Table 4
Adjusted results from linear regression analyses, including perceived safety (Model 1) and municipal satisfaction (Model 2), as outcome variables.

		Model 1	Model 2 '
		Perceived safety	Municipal satisfaction
		B (95% CI)	B (95% CI)
Perceived access to green spaces		0.39 (0.32–0.46) ***	0.45 (0.41–0.50) ***
Age	<30 yrs	0.12 (−0.49–0.73)	0.34 (−0.04–0.73)
	30–49 yrs	−0.09 (−0.44–0.26)	−0.18 (−0.39–0.04)
	50–67 yrs	0.22 (−0.10–0.54)	−0.23 (−0.42–0.27) *
	>67 yrs	Reference	Reference
Gender	Women	−1.3 (−0.88–1.37) ***	0.22 (0.63–0.38) **
Region of birth	Outside Sweden	0.39 (−0.68–0.02)	−0.24 (−0.46–0.23) *
Civil status	Unmarried	0.15 (−0.58–0.88)	−0.42 (−0.87–0.04)
	Married	0.16 (−0.55–0.77)	−0.15 (−0.56–0.26)
	Divorced	−0.15 (−0.88–0.57)	−0.22 (−0.67–0.23)
	Widow/widower	Reference	Reference
Education	Elementary school	−0.80 (−1.32–0.29) **	0.10 (−0.22–0.43)
	High School	−0.39 (−0.66–0.12) **	0.05 (−0.11–0.22)
	University	Reference	Reference
Perceived safety		–	0.22 (0.19–0.26) ***
R^2		0.15 (15 %)	0.38 (38 %)

B: Unstandardized regression coefficients, CI: Confidence interval, ***$p < 0.001$, **p < 0.01, *p < 0.05.

safety and municipal satisfaction are also key priorities in the UN's sustainability goals and on the local political agenda in Täby (Täby Municipality, 2022). The results of this study, as well as other studies (Björk et al., 2008; de Jong et al., 2012; Mouratidis, 2019, 2020; Zhang et al., 2017), support such priorities. It stresses the importance of protecting green spaces, particularly in the coming years, when the pressure for new housing is expected to increase according to the predicted residential increase in Täby (Täby Municipality, 2022) as well as in many other cities and towns nationally and internationally. This study provides planners with evidence to convince politicians to prioritize access to green spaces. It also adds to the relatively limited international body of research linking access to green spaces with perceived safety and neighbourhood satisfaction.

Two of the demographic variables were also significantly associated with perceived safety in our adjusted model. Women felt less safe than men, and safety decreased with lower education level. This is slightly different from a Norwegian study where Mouratidis (2020) found that only education was associated with perceived safety. However, the gender differences found in our study are supported elsewhere, for example, in studies of use of green space it is common that women feel less safe in comparison to men (Evensen et al., 2021; Jorgensen et al., 2012). It is hence crucial that municipalities undertake measures that promote perceived safety to enhance women's mobility. Even if women felt less safe, we observed that women, the oldest and youngest age groups, and inhabitants born in Sweden were most satisfied with their municipality. In Oslo, Norway (Mouratidis, 2020), neighbourhood satisfaction was related to age, unemployment (not included in our study), living with partner, and education. Results from a British study also differed from ours (Parkes et al., 2002). They found that women were less satisfied with their neighbourhood than men and that satisfaction decreased with age. This diverse results across studies, calls for more research exploring socio-demographics and municipal satisfaction in different contexts. The present study explored whether safety acted as a moderator between perceived access to green spaces and municipal satisfaction. Referring to Lachowycz and Jones (2013), we expected that the association between green spaces and municipal satisfaction would be strengthened in neighbourhoods where people also felt safe. However, our results showed the opposite of what their model suggested. We observed that in residential areas in which people felt safe, the magnitude of the association between perceived access to green spaces and overall municipal satisfaction weakened. Exploring the results further, we found that among individuals who scored low on perceived safety, green space was more important for municipal satisfaction compared with those who scored high on perceived safety. We speculate if our finding could be explained by an argument parallel to what Rigolon et al. (2021) suggest in their review about green space, socio-economic status, and health. They found evidence that "green space had greater protective effects for low-SES people and neighbourhoods than for more affluent groups" (p. 16). Since education is strongly linked to safety in Täby, our finding may show a socio-economic effect rather than an effect of safety.

In Lachowycz and Jones (2013), the outcome variable was health, while the outcome variable in our study was municipal satisfaction. However, the extent to which safety acts as a moderator between different exposure and outcome variables varies between studies. In another study from the same project (Juul & Nordbø, 2023), perceived safety did not act as a moderator for the association between access to green spaces and levels of physical activity, which is also found elsewhere (Loh et al., 2019). However, in Hong et al. (2018), safety acted as a moderator between green spaces and neighbourhood social capital. This calls for more studies exploring the mechanisms that determine the associations between access to green spaces and neighbourhood satisfaction and health and well-being.

4.2. Perceived versus objective access to green space

An interesting result of this study is the discrepancy between perceived access to green spaces and objective access to green spaces, a topic also addressed by others (Leslie et al., 2010; Mazumdar et al., 2020). The discrepancy is surprising because perceived access to green space is assumed to be a result of objective indicators of access to green space (Campbell et al., 1976). The important factor in Täby seems to be whether people perceive having access to green spaces in their neighbourhood rather than if they have access to green space in objective (measurable) terms. This calls for more studies comparing different green space indicators and a literature review exploring the pros and cons of perceived and objective green space indicators and their use to study outcomes, such as health and well-being in addition to safety and satisfaction, which was the focus in the current study. Furthermore, it stresses the importance of planners not only using objective indicators when mapping access to green spaces but encourages municipalities to collect their own data on residents' experiences with access to green spaces. Our results show that a standardized or universal recommendation should be used with caution. An example is the WHO's recommendation that all people should reside within 300 m of green space (WHO Regional office for Europe, 2016). Such a recommendation is important to safeguard green spaces located near people's homes, but it is not a guarantee that people will find them accessible or of sufficient quality. As noted in this study, objectively derived GIS indicators do not consider inhabitants' perceived experience of distance to the nearest green space. Embedded in the perceived indicators are barriers of various kinds, including physical (e.g., major roads, railways, and waterbodies) and psychological (e.g., fear of crime in specific locations). These barriers may impact people's perceptions of their access to green spaces. In a buffer analysis in GIS (on which this study relied), such barriers were not considered. This is a criticism of the current study. There are possibilities for conducting more advanced network analyses in GIS where such barriers are included. Hence, we encourage researchers and planners to use both perceived and objective indicators and consider that objective indicators also account for potential physical barriers in the environment using more advanced GIS techniques.

Gathering data on people's perceptions can be accomplished in many ways. This study used data from an existing national citizen survey (Medborgarundersökningen) conducted by Statistics Sweden. Similar national surveys are important because questions are standardized and data are collected annually, which allows for analysis across many years and comparisons across municipalities. However, we also encourage municipalities to gather local data both quantitatively (e.g., through surveys) and qualitatively (e.g., in seminars, workshops, or interviews) from local inhabitants.

4.3. Methodological concerns

This study applied an epidemiological approach linking survey data on access to green spaces, perceived safety, and municipal satisfaction to objective GIS-derived indicators of access to green spaces. Because the objectively GIS-derived indicators did not correlate with the perceived green space indicator, we built a regression model on the perceived green space indicator. However, this may have resulted in a common source bias effect (Hernan et al., 2004) or common method bias (Kock et al., 2021). A common effect, such as a personality trait, is assumed to be associated with (affect) perceived green spaces, perceived safety, and municipal satisfaction. The direct and indirect impact of personality traits was investigated by Neal and Brutzman (2023). They did not find any indirect path via perceived neighbourhood characteristics, but direct effects only. This strengthens our finding about a direct association about perceived neighbourhood characteristics and neighbourhood satisfaction. Kock and coworkers (2018) suggest fitting an explanatory factor analysis model including the three variables on satisfaction (municipality, green space, and safety) and study the percentage

variability explained by the first factor. Our study showed that the first factor explained 59.3 % of the variability and therefore common method bias was detected in our study.

Using existing survey data has some limitations with regards to adapting the survey to our research aim. For example, it would have been interesting to know more about green space usage such as minutes of use, quality of green space etc. However, we had no chance to influence the wording of the items in the survey. We also had to rely on single-item measures with all the reliability concerns that implies (Allen et al., 2022).

The objective green space indicators were computed using GIS. We used available land cover, land use maps from Lantmäteriet, and vegetation cover maps from Copernicus. Within each DeSO area, we calculated vegetation cover, proportion of green areas, total proportion of green spaces, and mean distance to the nearest green space. Täby consists of 38 DeSO areas that vary in size, both geographically and in the number of inhabitants. This has implications for the calculation of indicators. For example, within each DeSO area, people lived, on average, 89 m from the nearest green space. If we had used another geographical area with a different resolution or based our calculations on network distances instead, then the results would likely have been different. The optimal approach would have been to build the study around address points; however, for ethical reasons and anonymity, we did not have access to the participants' addresses. From a planning perspective, researchers generally do not operate with distinct neighbourhood borders when analysing geographical data. It is more common to take a holistic municipal approach. However, for the purpose of this study, calculating objective indicators in the DeSO areas worked well.

The Citizen Survey data used in this study were gathered prior to the Covid-19 pandemic (2019) and during the pandemic (2020). It is possible that people's perceptions and uses of neighbourhood green spaces changed during the pandemic (Korpilo et al., 2021; Venter et al., 2020). However, the country was never under lock down during this period, hence we do not think it had any impact on the results.

We conducted a simulation study to evaluate the expected number of participants who could potentially have participated in both surveys. We found that the expected number was 5 participants (0.4 % of the participants of the two surveys), with a corresponding 95 % confidence interval ranging from 1 to 10. The low number and its uncertainty were not considered as a threat to our study. The response rate was below 50% in both years, and we cannot rule out the possibility that this could have affected our results. The response rates in Täby were equivalent to the response rates in other Swedish municipalities (Statistics Sweden, 2020; 2022b). The distribution of participants' age and education were relatively equal to the inhabitants in Täby (Aamodt et al., 2023).

Notably, the cross-sectional study design prevented us from drawing conclusions about the causal effects between the variables. Finally, the epidemiological approach linking green space indicators with perceived safety and satisfaction neither provided information on what qualities people appreciated most in their green spaces nor gave planners any advice on governance strategies for protecting and developing green spaces. For such advice, please see elsewhere (e.g. Jansson & Randrup, 2020). Instead, this study gives arguments for the importance of green space for both perceived safety and municipal satisfaction.

5. Conclusion

This paper demonstrates the importance of access to green spaces in people's everyday living environments. As this study from Täby in Sweden shows, people who perceived they have good access to green spaces are more satisfied with their municipality as a place to reside than people who do not perceive they have access to such spaces. Higher perceived green space access also covaries with inhabitants' perceptions of feeling safe and secure when they are outdoors in the evening and at night. Furthermore, for individuals feeling less safe, access to green space is more important for municipal satisfaction compared with those who feel more safe. The approach to measuring access to green spaces was crucial for the results. Perceived access to green spaces did not correlate with objective access to green spaces, and perceived access was the only green space indicator associated with perceived safety and municipal satisfaction. In studies on safety and municipal satisfaction, objective green space indicators, such as the proportion of green spaces or the average distance to the nearest green space from where people live, should be complemented with perceived indicators. Objective indicators may be necessary to safeguard accessibility to green spaces, but indicators based on experiences of access consider both geographical and personal barriers, which allow for a more complete representation of reality. Therefore, we argue that both perceived and objective indicators are needed in future practice and research. Our results clearly demonstrate the importance of providing green space access to promote municipal satisfaction, particularly in neighbourhoods where safety is a concern. It also demonstrates the importance of targeting different socio-demographic groups in planning and policy in order to ensure that everyone feel safe and are satisfied with their living environments.

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CRediT authorship contribution statement

Helena Nordh: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Geir Aamodt:** Writing – review & editing, Validation, Methodology, Formal analysis, Conceptualization. **Emma C. A. Nordbø:** Writing – review & editing, Validation, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

None.

References

Aamodt, G., Nordh, H., & Nordbø, E. C. A. (2023). Relationships between socio-demographic/socio-economic characteristics and neighborhood green space in four Nordic municipalities – results from NORDGREEN. *Urban Forestry and Urban Greening, 82*, Article 127894. https://doi.org/10.1016/j.ufug.2023.127894

Allen, M. S., Iliescu, D., & Greiff, S. (2022). Single item measures in psychological science: A call to action. *European Journal of Psychological Assessment, 38*(1), 1–5. https://doi.org/10.1027/1015-5759/a000699

Barboza, E. P., Cirach, M., Khomenko, S., Iungman, T., Mueller, N., Barrera-Gómez, J., Rojas-Rueda, D., Kondo, M., & Nieuwenhuijsen, M. (2021). Green space and mortality in European cities: A health impact assessment study. *The Lancet Planetary Health, 5*(10), e718–e730. https://doi.org/10.1016/S2542-5196(21)00229-1

Björk, J., Albin, M., Grahn, P., Jacobsson, H., Ardo, J., Wadbro, J., Östergren, P.-O., & Skarback, E. (2008). Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. *Journal of Epidemiology & Community Health, 62*(4), e2. https://doi.org/10.1136/jech.2007.062414

Campbell, A., Converse, P. E., & Rodgers, W. L. (1976). *The quality of American life: Perceptions, evaluations, and satisfactions*. Russell Sage Foundation.

de Jong, K., Albin, M., Skärbäck, E., Grahn, P., & Björk, J. (2012). Perceived green qualities were associated with neighborhood satisfaction, physical activity, and general health: Results from a cross-sectional study in suburban and rural scania, southern Sweden. *Health & Place, 18*(6), 1374–1380. https://doi.org/10.1016/j.healthplace.2012.07.001

Eizenberg, E., & Jabareen, Y. (2017). Social sustainability: A new conceptual framework. *Sustainability, 9*(1). https://doi.org/10.3390/su9010068

Evensen, K. H., Nordh, H., Hassan, R., & Fyhri, A. (2021). Testing the effect of hedge height on perceived safety—a landscape design intervention. *Sustainability, 13*(9), 5063. https://doi.org/10.3390/su13095063

Guest, A. M., & Lee, B. A. (1983). Sentiment and evaluation as ecological variables. *Sociological Perspectives, 26*(2), 159–184. https://doi.org/10.2307/1389089

Hernan, M. A., Hernández-Díaz, S., & Robins, J. M. (2004). A structural approach to selection bias. *Epidemiology, 15*(5), 615–625. https://doi.org/10.1097/01.ede.0000135174.63482.43

Hong, A., Sallis, J. F., King, A. C., Conway, T. L., Saelens, B., Cain, K. L., … Frank, L. D. (2018). Linking green space to neighborhood social capital in older adults: The role of perceived safety. *Social Science & Medicine, 207*, 38–45. https://doi.org/10.1016/j.socscimed.2018.04.051

Jansson, M., Fors, H., Lindgren, T., & Wiström, B. (2013). Perceived personal safety in relation to urban woodland vegetation – a review. *Urban Forestry and Urban Greening, 12*(2), 127–133. https://doi.org/10.1016/j.ufug.2013.01.005

Jansson, M., & Randrup, T. B. (2020). *Urban open space governance and management.* London & New York: Routledge.

Jorgensen, L. J., Ellis, G. D., & Ruddell, E. (2012). Fear perceptions in public parks: Interactions of environmental concealment, the presence of people recreating, and gender. *Environment and Behavior, 45*(7), 803–820. https://doi.org/10.1177/0013916512446333

Juul, V., & Nordbø, E. C. A. (2023). Examining activity-friendly neighborhoods in the Norwegian context: Green space and walkability in relation to physical activity and the moderating role of perceived safety. *BMC Public Health, 23*(1), 259. https://doi.org/10.1186/s12889-023-15170-4

Kearney, A. R. (2006). Residential development patterns and neighborhood satisfaction: Impacts of density and nearby nature. *Environment and Behavior, 38*(1), 112–139. https://doi.org/10.1177/0013916505052776

Kock, F., Berbekova, A., & Assaf, A. G. (2021). Understanding and managing the threat of common method bias: Detection, prevention and control. *Tourism Management, 86*, Article 104330. https://doi.org/10.1016/j.tourman.2021.104330. ISSN 0261-5177.

Korpilo, S., Kajosaari, A., Rinne, T., Hasanzadeh, K., Raymond, C. M., & Kyttä, M. (2021). Coping with crisis: Green space use in Helsinki before and during the COVID-19 pandemic. *Frontiers in Sustainable Cities, 3*. https://doi.org/10.3389/frsc.2021.713977

Lachowycz, K., & Jones, A. P. (2013). Towards a better understanding of the relationship between greenspace and health: Development of a theoretical framework. *Landscape and Urban Planning, 118*, 62–69. https://doi.org/10.1016/j.landurbplan.2012.10.012

Leslie, E., Sugiyama, T., Ierodiaconou, D., & Kremer, P. (2010). Perceived and objectively measured greenness of neighbourhoods: Are they measuring the same thing? *Landscape and Urban Planning, 95*(1), 28–33. https://doi.org/10.1016/j.landurbplan.2009.11.002

Loh, V. H. Y., Veitch, J., Salmon, J., Cerin, E., Thornton, L., Mavoa, S., … Timperio, A. (2019). Built environment and physical activity among adolescents: The moderating effects of neighborhood safety and social support. *International Journal of Behavioral Nutrition and Physical Activity, 16*(1), 132. https://doi.org/10.1186/s12966-019-0898-y

Mak, B. K. L., & Jim, C. Y. (2022). Contributions of human and environmental factors to concerns of personal safety and crime in urban parks. *Security Journal, 35*(1), 263–293. https://doi.org/10.1057/s41284-020-00277-9

Mantey, D. (2021). Objective and subjective determinants of neighborhood satisfaction in the context of retrofitting suburbs. *Sustainability, 13*(21). https://doi.org/10.3390/su132111954

Maruthaveeran, S., & van den Bosh, C. K. (2015). Fear of crime in urban parks – what the residents of Kuala Lumpur have to say? *Urban Forestry and Urban Greening, 14*(3), 702–713. https://doi.org/10.1016/j.ufug.2015.05.012

Mazumdar, S., Dunshea, A., Chong, S., & Jalaludin, B. (2020). Tree canopy cover is best associated with perceptions of greenspace: A short communication. *International Journal of Environmental Research and Public Health, 17*(18). https://doi.org/10.3390/ijerph17186501

Mouratidis, K. (2019). The impact of urban tree cover on perceived safety. *Urban Forestry and Urban Greening, 44*, Article 126434. https://doi.org/10.1016/j.ufug.2019.126434

Mouratidis, K. (2020). Neighborhood characteristics, neighborhood satisfaction, and well-being: The links with neighborhood deprivation. *Land Use Policy, 99*, Article 104886. https://doi.org/10.1016/j.landusepol.2020.104886

Municipality, T. (2010). *Det nya Täby. Översiktsplan 2010-2030. [The new Taby. Municipal comprehensive plan 2010-2030]*.

Municipality, T. (2022). *Översiktsplan Täby 2050 – staden på landet. [Taby comprehensive plan - the city in the countryside]*.

Neal, Z. (2020). Does the neighbourhood matter for neighbourhood satisfaction? A meta-analysis. *Urban Studies, 58*(9), 1775–1791. https://doi.org/10.1177/0042098020926091

Neal, Z. P., & Brutzman, B. (2023). The role of personality in neighborhood satisfaction. *PLoS One, 18*(3), Article e0282437. https://doi.org/10.1371/journal.pone.0282437

Parkes, A., Kearns, A., & Atkinson, R. (2002). What makes people dissatisfied with their neighbourhoods? *Urban Studies, 39*(13), 2413–2438. https://doi.org/10.1080/0042098022000027O

Rigolon, A., Browning, M. H. E. M., McAnirlin, O., & Yoon, H. (2021). Green space and health equity: A systematic review on the potential of green space to reduce health disparities. *International Journal of Environmental Research and Public Health, 18*, 2563. https://doi.org/10.3390/ijerph18052563

Schusler, T., Weiss, L., Treering, D., & Balderama, E. (2018). Research note: Examining the association between tree canopy, parks and crime in Chicago. *Landscape and Urban Planning, 170*, 309–313. https://doi.org/10.1016/j.landurbplan.2017.07.012

Sezavar, N., Pazhouhanfar, M., Van Dongen, R. P., & Grahn, P. (2023). The importance of designing the spatial distribution and density of vegetation in urban parks for increased experience of safety. *Journal of Cleaner Production, 403*, Article 136768. https://doi.org/10.1016/j.jclepro.2023.136768

Sreetheran, M., & van den Bosch, C. C. K. (2014). A socio-ecological exploration of fear of crime in urban green spaces – a systematic review. *Urban Forestry and Urban Greening, 13*(1), 1–18. https://doi.org/10.1016/j.ufug.2013.11.006

Statistics Sweden. (2020). SCB:s medborgarundersökning 2020 Bengtsfors kommun. Retreived from https://www.bengtsfors.se/download/18.3617253d17724b7819ad9b2/1612167318610/Medborgarunders.%20Bengtsfors%20Rapport%202020.pdf. (Accessed 28 June 2023).

Statistics Sweden. (2021). Folkmängd i riket, län och kommuner 30 september 2021 och befolkningsförändringar 1 januari–30 september 2021. Retreived from https://www.scb.se/hitta-statistik/statistik-efter-amne/befolkning/befolkningens-sammansattning/befolkningsstatistik/pong/tabell-och-diagram/kvartals–och-halvarsstatistik–kommun-lan-och-riket/kvartal-13-2021/. (Accessed 29 August 2022).

Statistics Sweden. (2022a). SCB:s medborgarundersökning. Retreived from https://www.scb.se/vara-tjanster/bestall-data-och-statistik/regionala-statistikprodukter/scbs-medborgarundersokning/. (Accessed 26 August 2022).

Statistics Sweden. (2022b). SCB:s medborgarundersökning 2022 Mullsjö kommun. *Resultatrapport_2022 Mullsjö.xlsx.pd Retreived from*. https://www.mullsjo.se/download/18.1f5ba0c21864b7bedb9bb78/1676630383677/Resultatrapport_2022%20Mullsj%C3%B6.xlsx.pdf. (Accessed 4 December 2023).

Ta, N., Li, H., Zhu, Q., & Wu, J. (2021). Contributions of the quantity and quality of neighborhood green space to residential satisfaction in suburban Shanghai. *Urban Forestry and Urban Greening, 64*, Article 127293. https://doi.org/10.1016/j.ufug.2021.127293

Troy, A., Morgan Grove, J., & O'Neil-Dunne, J. (2012). The relationship between tree canopy and crime rates across an urban–rural gradient in the greater Baltimore region. *Landscape and Urban Planning, 106*(3), 262–270. https://doi.org/10.1016/j.landurbplan.2012.03.010

United Nations. (2015). Sustainable development goals [Online]. Retreived from https://sustainabledevelopment.un.org/. (Accessed 21 March 2022).

Venter, Z. S., Barton, D. N., Gundersen, V., Figari, H., & Nowell, M. (2020). Urban nature in a time of crisis: Recreational use of green space increases during the COVID-19 outbreak in Oslo, Norway. *Environmental Research Letters, 15*(10), Article 104075. https://doi.org/10.1088/1748-9326/abb396

WHO Regional office for Europe. (2016). *Urban green spaces and health. A review of evidence*. Copenhagen.

Wolfe, M. K., & Mennis, J. (2012). Does vegetation encourage or suppress urban crime? Evidence from Philadelphia, PA. *Landscape and Urban Planning, 108*(2), 112–122. https://doi.org/10.1016/j.landurbplan.2012.08.006

Zhang, Y., Van den Berg, Van Dijk, T., & Weitkamp, G. (2017). Quality over Quantity: Contribution of Urban Green Space to Neighborhood Satisfaction. *International Journal of Environmental Research and Public Health, 14*(5). https://doi.org/10.3390/ijerph14050535