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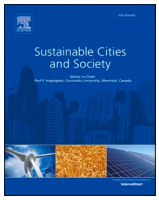

How do urban parks, neighborhood open spaces, and private gardens relate to individuals' subjective well-being: Results of a structural equation model

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ABSTRACT

As urban areas become more densely populated worldwide, the allocation of limited urban green infrastructure to promote well-being among users is becoming increasingly challenging. This study aims to understand the relationships of three types of urban green infrastructure (urban parks, neighborhood green open spaces and private gardens) with subjective well-being (SWB). We construct a structural equation model to examine these relationships in an integrated fashion. We consider both direct and indirect effects of green spaces on SWB. Data were collected through an online questionnaire involving a sample of 322 individuals in the Netherlands. Results indicate that the direct relationship between neighborhood green satisfaction and SWB is positive and stronger than the relationship between satisfaction with urban parks and SWB. Private garden size has an indirect positive effect on SWB mediated by neighborhood green satisfaction. Interestingly, an individual with higher satisfaction with green tends to have higher SWB independently of the frequency of using the green space. Overall, our method and results bring new insights to optimize urban green space planning to enhance users' SWB.

1. Introduction

Urban green space is one of the most accessible forms of green infrastructures that is capable of enhancing social cohesion (Liu et al., 2020; van den Berg et al., 2019), health (Pfeiffer & Cloutier, 2016; Velarde et al., 2007) and subjective wellbeing (SWB) (Groenewegen et al., 2006; Wolch et al., 2014), and mitigating stress (Hartig et al., 2014; Mennis et al., 2018) for individuals. Urban green spaces vary in size, ownership and functions. Therefore, to better investigate their benefits and tailor interventions, green space is usually classified into different types. Regarding the study of the relationship between green public spaces and individuals' welfare benefits, urban green space is generally categorized into three spatial types: urban parks (Liu et al., 2020; Van den Berg et al., 2014; Wright et al., 2012), neighborhood open spaces (NOS) (Sugiyama et al., 2008; Wright et al., 2012; Zhao et al., 2022), and private gardens (Cervinka et al., 2016; Poortinga et al., 2021). With the need for higher urban density due to the worldwide ongoing urbanization process, it is increasingly difficult to make room for new green spaces. Thus, for determining the allocation of urban space to different types of green – city parks, NOS, and private gardens – an important question is what the relationships of these types of green are with individuals' SWB. Will a large but less accessible (regarding distance) urban park contribute more to SWB than several smaller NOS? Will a private garden compensate and reduce the need for public greening? A considerable quantity of literature has investigated the relationship between urban green and SWB focusing on one specific type (e.g., urban parks). However, few studies have investigated the distinct relationships of the three types of green with SWB simultaneously.

Given that the relationships between green spaces and SWB exist, the next question to be answered is how are these relationships generated? Green spaces can have both direct and indirect effects on users' SWB, and these effects can be explained through satisfaction with green and frequency of using green spaces (e.g., Hartig et al. 2014, Ettema and Smajic 2015, Kothencz and Blaschke 2017). Satisfaction with green refers to the fulfillment of one's expectations of the quantity and quality of green while use frequency indicates the number of times an individual visits public spaces for various activities within a particular period. Evidence was found that a higher frequency of visits to public spaces is positively related to individuals' physical and mental health (Groenewegen, 2006; Nisbet et al., 2011; White, 2013; Hong et al., 2019) and that use frequency has a stronger relationship with physical health, compared with the duration of use (van den Berg et al., 2019). The evidence is mixed, however. Some studies did not find a direct effect of green space use frequency on SWB (Hong et al., 2019; Carrus et al.,

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2015; Hartig et al., 2014) while some others did (Mitchell & Popham, 2008; Thompson Coon et al., 2011; Schnell et al., 2019). Several studies indicate that a view on green (even without physical usage of it) already has positive effects (Ulrich, 1984; Van den Berg et al., 2003). When it comes to satisfaction with green public space and its relationship with SWB, fewer studies have been carried out. Until now, there is no general agreement about whether individuals' satisfaction with green can contribute to their SWB or whether this depends on the frequency of use. More evidence is required to understand the distinct roles of satisfaction with green and use frequency in enhancing individuals' SWB.

Against this background, our study aims to analyze in an integrated fashion the relationships between private gardens, green in neighborhood open spaces, urban parks, on the one hand, and SWB, on the other hand, using a structural equation model. Our model allows that satisfaction with green has both a direct and indirect effect on SWB through the use frequency of green spaces. In particular, this paper will examine the following two research questions: How are different types of green spaces related to SWB and to what extent do these impacts on SWB depend on use frequency? And what are the relative strengths of the relationships between the three types of green spaces and SWB? As socio-demographics have been found to significantly affect the strength of effects that green spaces have on SWB (e.g., Ayala-Azcárraga et al. 2019, Bergefurt et al. 2019b, Diener 2009), we will also control for socio-demographics when investigating the relationships. The structure of this paper is as follows. Section 2 reviews relevant literature. Based on the review, a conceptual model and detailed hypotheses are formulated in Section 3, followed by a discussion of the methodology. Section 4 describes the results. Section 5 discusses the results, limitations, and implications. The paper ends with a conclusion summarizing our major findings in Section 6.

2. Literature review

In this section, we review the literature regarding the relationships between SWB and three types of green: urban parks, green in neighborhood open spaces and private gardens. We focus on each of the three types in turn and introduce the findings on how satisfaction with green and use frequency are related to SWB, directly or indirectly. In the last subsection, we briefly summarize the findings and review studies that have investigated the relationship with SWB of two or more types of green simultaneously.

2.1. Urban parks and SWB

Urban parks or municipal parks are open green spaces which are accessible to all citizens and visitors. Compared with neighborhood green spaces and private gardens, urban parks are usually larger in size (e.g., 1 km^2 or more). Numerous studies have found that exposure to urban parks can enhance SWB (e.g., Cini et al. 2013, Nisbet et al. 2011, Ayala-Azcárraga et al. 2019, Hong et al. 2019, Guo et al. 2021). Satisfaction with green and frequency of use are two behavioral aspects widely considered in studies on how urban parks can benefit users' SWB. It has been found that satisfaction with green is directly associated with individuals' momentary SWB (e.g., Weijs-Perrée et al. 2019) and positively related to long-term SWB (e.g., Chiesura 2004, Birenboim 2018, Ettema and Smajic 2015). Regarding the frequency of use, longer time spent in green spaces and a higher frequency of visits are directly associated with a higher level of SWB (e.g., Lafortezza et al., 2009, Thompson Coon et al. 2011, Schnell et al. 2019). However, some studies detected only a small (Bergefurt et al., 2019b; Carrus et al., 2015) or statistically insignificant (Cini et al., 2013; van Dinter et al., 2022) direct effect of use frequency on SWB. Also, the examined positive relationship could be conditional. For example, park visitors show a higher SWB only when they are more intrinsically motivated (Cini et al., 2013).

However, when considering the effects of satisfaction and use patterns together, it is not yet clear whether they are independently related to SWB, or if indirect effects exist in the sense that one can act as a mediator for the other. Evidence suggests that satisfaction with green can contribute to SWB independently of use frequency: people can feel mentally satisfied with green spaces without using them physically (Groenewegen et al., 2006). This mechanism is based on stress and restoration theories, which indicate that individuals' experiences can be enhanced by merely looking at natural elements (Kaplan, 2001; Van den Berg et al., 2003). During the process, when stress is relieved, people feel satisfied with the green scenery and their SWB may be further improved. However, still, the intensity of interacting with a green environment may vary between individuals and affect SWB as well. More investigation is needed to understand to what extent the frequency of using a green space has an additional impact on users' SWB.

2.2. Neighborhood open spaces and SWB

Neighborhood open spaces (NOS) are the most accessible type of public space which an individual can immediately interact with (Bronfenbrenner, 1979; Kemperman & Timmermans, 2014). Scholars have studied the multiple contributions of green in NOS to users' health, which is a widely discussed sub-theme of SWB. However, less attention has been paid to this small-scaled type of green regarding its benefit to individuals' overall SWB. Several studies have investigated the overall neighborhood environment regarding building characteristics, facilities and green and found a significant impact on individuals' SWB. Results show that the effects of neighborhood characteristics on SWB are larger than the effects of accessibility variables (distance to facilities) on the urban level (e.g., Maas et al. 2006, Ettema and Schekkerman 2016). Few studies have specifically investigated the direct and indirect effects of green in NOS on individuals' SWB or health. For example, Sugiyama et al. (2008) collected data from a large sample of adults in Australia and found that people with higher perceived neighborhood greenness have a higher level of physical and mental health. Wang et al. (2019) reported that neighborhood greenery correlates with mental well-being. Zhang et al. (2017) indicate that satisfaction with neighborhoods is positively related to SWB, and this relationship is explained by accessible and usable NOS. Perceived greenness in a neighborhood can also enhance social contacts (Kemperman & Timmermans, 2014) and mental health (Van den Berg et al., 2019). Existing studies in general on the relationship between green in NOS and SWB considered predominantly a single aspect, such as perceived greenness, satisfaction with green, or frequency of visiting. From these studies, it is not clear how the use of and satisfaction with green in NOS are directly and indirectly related to SWB.

2.3. Private gardens and SWB

Compared with urban parks and neighborhood green public spaces, far less attention has been paid to the private garden in the study of SWB. Just like public green, private gardens can provide both mental and physical health benefits for users (Brindley et al., 2018; Cervinka et al., 2016; Dennis & James, 2017; Krols et al., 2022; Poortinga et al., 2021). Yet, the effect of the private garden on SWB has received only limited attention, which may be because of its non-public nature or exclusion in land use data (e.g., Mitchell and Popham 2008). Most of the existing studies about private gardens and SWB have focused on how the use of private gardens influences the use of public green spaces. Studies show contradictory findings. Maat and de Vries (2006) proposed the compensation hypothesis, contending that people with more private green spaces are less likely to visit public green spaces and vice versa. This hypothesis received some support (Poortinga et al., 2021; Strandell & Hall, 2015). For example, Poortinga et al. (2021) collected data from a large sample of people in the UK. Supporting evidence for the compensation effects of private gardens was found, whereby the effects are conditional on the perceived access to the nearest public green space. Together with evidence that the frequency of using public green positively contributes to SWB (e.g., Mitchell and Popham 2008,

Thompson Coon et al. 2011, Schnell et al. 2019), the above findings support the idea that private gardens indirectly affect SWB by influencing the use pattern of public green spaces. However, a study by Lin et al. (2014) shows that people who stay in their own gardens more regularly also tend to visit public green spaces more often. Other studies that find no statistically significant effects that support the compensation theory are Lin et al. (2014) and de Bell et al. (2020).

Less research has been done regarding the direct effect of private gardens on SWB. Schnell et al. (2019) found that having a private garden is not significantly associated with SWB. In contrast, more recent evidence shows that owning a private garden is associated with a higher level of SWB and self-rated health (Poortinga et al., 2021). Given the abovementioned contradictory findings, a more in-depth investigation into the relationship between private gardens and SWB is needed. Also, further analysis of the relationship considering both private and public green in an integrated fashion is desirable.

2.4. Relationships between green on the three types

To conclude, studies on urban parks, green in neighborhood open spaces, and private gardens separately provide evidence that the three types of green all have direct effects on individuals' SWB. However, there are rather few studies that analyzed the relationships between all three types of green and SWB in an integrated fashion. Only a small number of studies considered urban and neighborhood (green) environments together and found that they all have positive relationships with individuals' health and SWB (e.g., Mitchell and Popham 2008, Wright et al. 2012, White et al. 2013). But regarding the relative magnitude of the association between different types of green with SWB, the findings are inconsistent. Some researchers found that the relationships between the quantity of green space in a smaller and a larger radius around one's dwelling with health are equally strong (Maas et al., 2006), whereas other studies show that neighborhood characteristics (evaluation of facilities, accessibility and attractiveness) have larger effects on SWB than spatial variables on the urban level (Ettema & Schekkerman, 2016; Guo et al., 2021). To the best of our knowledge, no research has systematically investigated the relationship between urban parks, green in neighborhood open spaces, and private gardens with SWB. The limitation of evidence reduces the relevance of previous findings for optimizing the allocation of green space to the three types. In addition, a wealth of literature has found that socio-demographic variables can influence individuals' SWB and the use of and satisfaction with green spaces (e.g., Ayala-Azcárraga et al. 2019, Bergefurt et al. 2019b, Diener 2009, Ettema and Schekkerman 2016). Those variables (e.g., age, gender, working hours, house ownership, and household composition) should therefore also be considered when studying the relationship between green spaces and individuals' SWB.

3. Conceptual model, hypotheses and data

To analyze the relationships between private gardens, green in neighborhood open spaces, urban parks and SWB in an integrated fashion, we propose a conceptual model defining the relationships between these concepts. This section introduces the model and the data collection.

3.1. Conceptual model

Fig. 1 represents the conceptual model used for the analysis. Based on the review above, we propose three major hypotheses. The first hypothesis (H1) concerns the relationship between three types of green. Following the compensation theory (Maat & De Vries, 2006), we assume that green spaces close to individuals' dwellings can compensate for a deficiency in accessibility to green spaces. This brings three sub-hypotheses. Firstly, (H1a) the size of a private garden has a direct and negative effect on the frequency of using public green spaces. Secondly, (H1b) the size of the private garden has also direct positive effects on satisfaction with green in the city and the neighborhood (one is more easily satisfied with public green if one has a large garden). Thirdly, (H1c) based on the same reasoning, higher satisfaction with green in the neighborhood can lower the need for (the more distant) public green spaces in the larger-scale urban environment. That is, satisfaction with

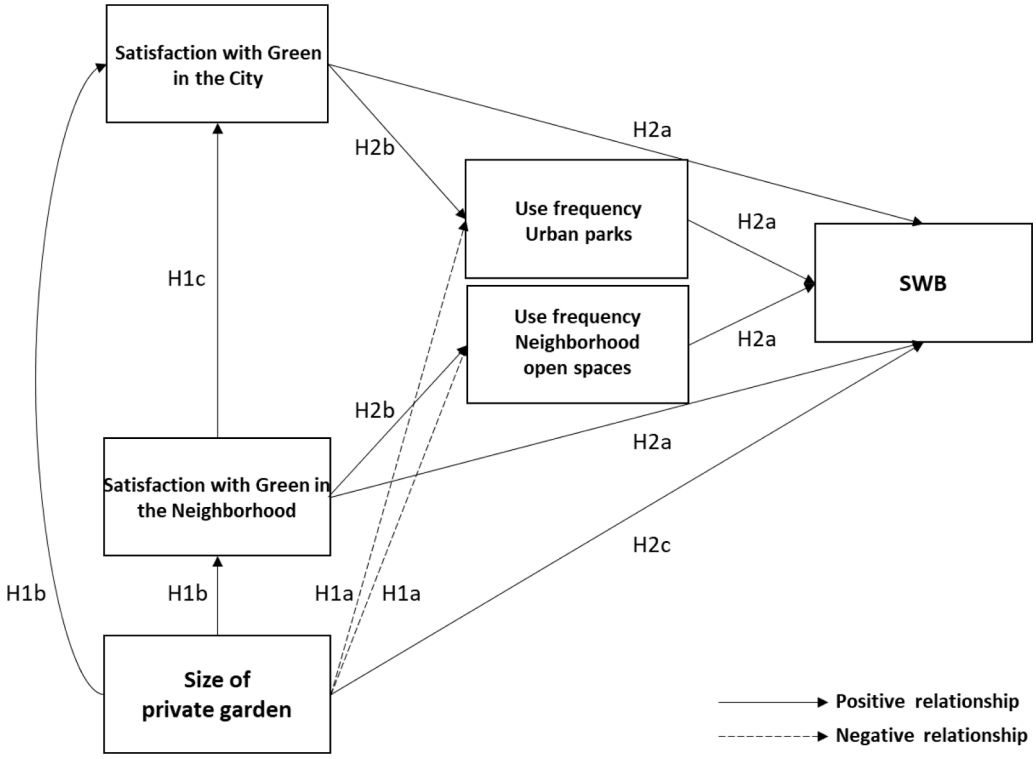

Fig. 1. Conceptual model describing the relationships between green in the city, neighborhood, private gardens, and SWB.

green in the neighborhood also has a positive direct effect on satisfaction with green in the wider urban environment. The second hypothesis (H2) concerns the direct and indirect effects of green spaces on SWB, which is also based on the literature (e.g., Wang et al. 2019, Weijs-Perrée et al. 2019, Poortinga et al. 2021). We assume that frequency of use and satisfaction with urban parks and neighborhood open spaces have direct and positive effects on SWB (H2a), and indirect positive effects on SWB through use frequency (H2b). Besides, the size of a private garden has both a direct effect on SWB (H2c) and an indirect effect on SWB mediated by satisfaction with two types of public green (H2d). Finally, the third hypothesis (H3) states that the magnitude of the direct effect of satisfaction with green in the neighborhood on SWB is higher than the direct effect of satisfaction with green in the city. This is based on studies that found accessibility of green spaces is positively related to SWB (e.g., Ettema and Schekkerman 2016, Guo et al. 2021). Socio-demographics are considered control variables. They are entered as exogenous variables which may have relationships with all the endogenous variables in the model.

3.2. Data collection

Data were collected by an online questionnaire that consisted of four parts. The first part measured respondents' frequency of using neighborhood open spaces. The frequency of use was asked for six types of activities in a public green space, namely, walk or stroll, meet and chat with people, sit and relax, let children play, outdoor fitness, and picnic or games. These activities were chosen based on previous studies of public space use (e.g., Aspinall et al. 2010, Schipperijn et al. 2013, Van Hecke et al. 2018). the frequency of use was measured by six levels: never or less than once a year, several times per year, monthly, weekly, several times per week, and daily. These types were coded from 1 (never or less than once a year) to 6 (daily). Before presenting the scale, respondents were asked to indicate if there is any urban park/neighborhood green space available in their living area. If not, the use frequency scale was not shown. In the second part, respondents were asked to indicate on a five-point scale their satisfaction with green concerning the quantity and quality of green in their cities and their neighborhoods respectively (four items in total). The third part of the questionnaire was focused on private gardens. As the private garden is attached to an individual's dwelling, and one may enter it multiple times a day, it is difficult for respondents to define and answer the frequency of using a private garden. Thus, we asked whether the respondents have a private garden and if yes, to indicate the size (m^2) of the garden. The last section measured individuals' SWB. We used the five-question Satisfaction with Life Scale (Diener, 2009) which has been widely used and has shown good reliability and validity. Definitions of terms were given to help respondents distinguish urban parks and green in neighborhood open spaces before showing corresponding questions. Neighborhood in this questionnaire refers to the area people can walk through within 10 min from home. Green in neighborhood open spaces was defined in the questionnaire as 'Green in small-scale open areas (small neighborhood parks, playgrounds for children, sports fields, etc.) for public use in a neighborhood'. Urban parks are defined as 'Large green spaces for recreational use that are assessable for all residents and visitors. There are usually only a few urban parks in a city.'

The data were collected in April 2021. A total of 322 online questionnaires were completed by individuals from a national panel. A screening question was included to select respondents from medium to large cities in the Netherlands (the top 32 cities with 100,000 or more inhabitants in 2021). These areas are more likely to have urban parks and neighborhood green spaces and are challenged more by densification and greenification, compared with small cities and rural areas. Questionnaires where all scale questions had the same scores as well as those completed in a very short time ($n = 6$), were removed and so were the questionnaires from respondents who indicated there were no public green spaces available in their living environment (also $n = 6$). After removing these cases, 310 questionnaires remained for analysis.

4. Results

This section first introduces the sample characteristics and descriptive statistics of green spaces and SWB variables. Secondly, the results of structural equation modeling estimation are presented and described.

4.1. Sample description

The characteristics of the sample ($N = 310$) are summarised in Table 1. As can be seen, all adult age groups are represented. Compared with the Dutch population distribution, the age group of 18–24 in the sample is somewhat underrepresented, whereas the 25–44 years old group is overrepresented. The gender distribution (male: 48.4 %) corresponds closely to that of the population (male: 49.6 %). The majority of respondents have a Dutch background, medium to high household income, and paid work. In terms of household composition, the single-person household group has a slightly higher share (27.1 %) compared with the population (22.9). Thus, one should bear in mind the possible bias in the findings of this study.

Table 2 represents descriptive statistics of three types of green spaces and SWB variables. Respondents on average have lower satisfaction regarding the quality of urban parks ($M = 0.62$), compared with neighborhood open space (NOS) ($M = 0.70$). Also, the satisfaction with the quantity of green in NOS ($M = 0.74$) is higher than in the city ($M = 0.61$). More than half (64.50 %) of our respondents own private gardens. The average size of their gardens is 80.92 m^2. As for the SWB, according to the well-being categories, the mean score shows respondents on average feel slightly satisfied with their life ($M = 24.36$; SD = 6.39). As shown in Fig. 2, respondents generally visit NOS more often than urban parks. For all kinds of activities, NOS has a lower percentage of respondents who selected 'never or less than a year', compared with urban

Table 1
Socio-demographic characteristics of the sample.

Variable	Levels	Sample	Cities with 100,000 or more inhabitants, Netherlands*
Age	Mean	46.8 (min=19, max=84)	
	18–24	6.5 %	9.5 %
	25–44	40.3 %	29.3 %
	45–64	37.1 %	25.6 %
	65 or older	16.1 %	16.3 %
Gender	Male	48.4 %	49.6 %
Ethnic group	Dutch background	92.3 %	
Household Income	Less than 10,000 euros	2.9 %	
	10,000 to 29,999 euros	23.9 %	
	30,000 to 49,999 euros	29.7 %	
	50,000 euros or more	32.5 %	
Work hours	No paid work	26.5 %	
	Part-time	33.6 %	
	Full-time	40.0 %	
Household composition	Single	27.1 %	22.9 %
	Multi-person with children	30.3 %	
	Multi-person without children	42.6 %	
House ownership	Owner-occupied	61.6 %	
	Rented	37.7 %	
Total	N	310	

*(Statistics Netherlands, January 2021).

Table 2
Descriptive statistics of green spaces and SWB variables.

Variable	Statistics
Urban parks	
Satisfaction with green: quantity, *M* (*SD*) (0= Completely dissatisfied, 1= Completely satisfied)	0.61 (0.27)
Satisfaction with green: quality, *M* (*SD*) (0= Completely dissatisfied, 1= Completely satisfied)	0.62 (0.25)
Neighborhood open spaces	
Satisfaction with green: quantity, *M* (*SD*) (0= Completely dissatisfied, 1= Completely satisfied)	0.74 (0.25)
Satisfaction with green: quality, *M* (*SD*) (0= Completely dissatisfied, 1= Completely satisfied)	0.70 (0.25)
Private gardens	
Ownership (=Yes)	64.50 %
Size (m^2), *M* (*SD*)	80.92 (60.13)
Subjective well-being (5= Extremely dissatisfied, 35= Extremely satisfied), *M* (*SD*)	24.36 (6.39)
N	310

parks. Also, for all the six types of activities, NOS shows a higher percentage of respondents who do the activities several times per week or daily than in urban parks.

4.2. SEM estimation results

We use structural equation modeling (SEM) to analyze the relationships between green spaces and SWB. SEM is 'a collection of statistical techniques that allow a set of relationships between one or more independent variables, either continuous or discrete, and one or more dependent variables, either continuous or discrete, to be examined.' (Ullman & Bentler, 2012). The SEM is constructed based on our conceptual model (Fig. 1). Five latent variables (the ellipses) are included in the model, namely, satisfaction with green in the city (urban parks), satisfaction with green in the neighborhood open spaces, use frequency of urban parks, the use frequency of neighborhood open spaces, and SWB. These five latent variables are measured by a series of indicators obtained from the questionnaire. The size of a private garden is included as an observed exogenous variable. Socio-demographic characteristics have been dummy coded and are entered into the model as exogenous variables as well. Relationships between socio-demographics and all endogenous variables are tested. To keep the diagram readable, error terms and covariance tested in the model are not displayed.

The maximum likelihood method was used to estimate the model. The fit indices indicate a good model fit (SRMR = 0.060; RMSEA = 0.049; CFI= 0.947). The parsimony-adjusted NFI (0.745) and parsimony goodness-of-fit index (0.789) are higher than 0.5, indicating the model is parsimonious. Both the structural model representing the hypothesized relationships and the measurement models defining the relationships between the latent variables and their indicators are estimated. As can be seen (Table 3), most of the factor loadings of the use frequency indicators are higher than the acceptable value (0.4) (Hulland, 1999). Only, the loading of 'walk or stroll' in the neighborhood is slightly lower. The factor loadings of satisfaction with green and SWB indicators are higher than the preferred value of 0.6. The composite reliability values of the five latent variables range from 0.622 to 0.908, which meet the rule of thumb that a value of 0.60 or higher is acceptable (Fornell & Larcker, 1981). Thus, overall, the constructs related to the latent variables adequately fit the data.

Fig. 3 and Table 4 show the estimation results of the structural model. Regarding H1a, we find no statistically significant (at 5 % level) direct effect of a private garden on the use frequency of public green spaces. However, we do find a direct effect ($\beta = 0.143$; $p = 0.014$) of the private garden size on satisfaction with green in the neighborhood (H1b), and an indirect effect of private garden size on satisfaction with green in the city through neighborhood open spaces (NOS) ($\beta = 0.069$; $p = 0.007$). Furthermore, a direct effect also exists ($\beta = 0.484$; $p < 0.001$) from satisfaction with NOS to satisfaction with green in the city (H1c). These findings confirm H1 stating that private gardens can compensate for a shortage of public green spaces. That is, people feel more satisfied with the quality and quantity of public green when they have larger private gardens. As for H2, the results support the hypothesis that satisfaction with green on the city and neighborhood green all have a positive direct effect on individuals' SWB (H2a). Interestingly, only satisfaction with the two types of green have statistically significant associations with SWB. None of the two frequency-of-use latent variables has a statistically significant direct effect on SWB, which is not as

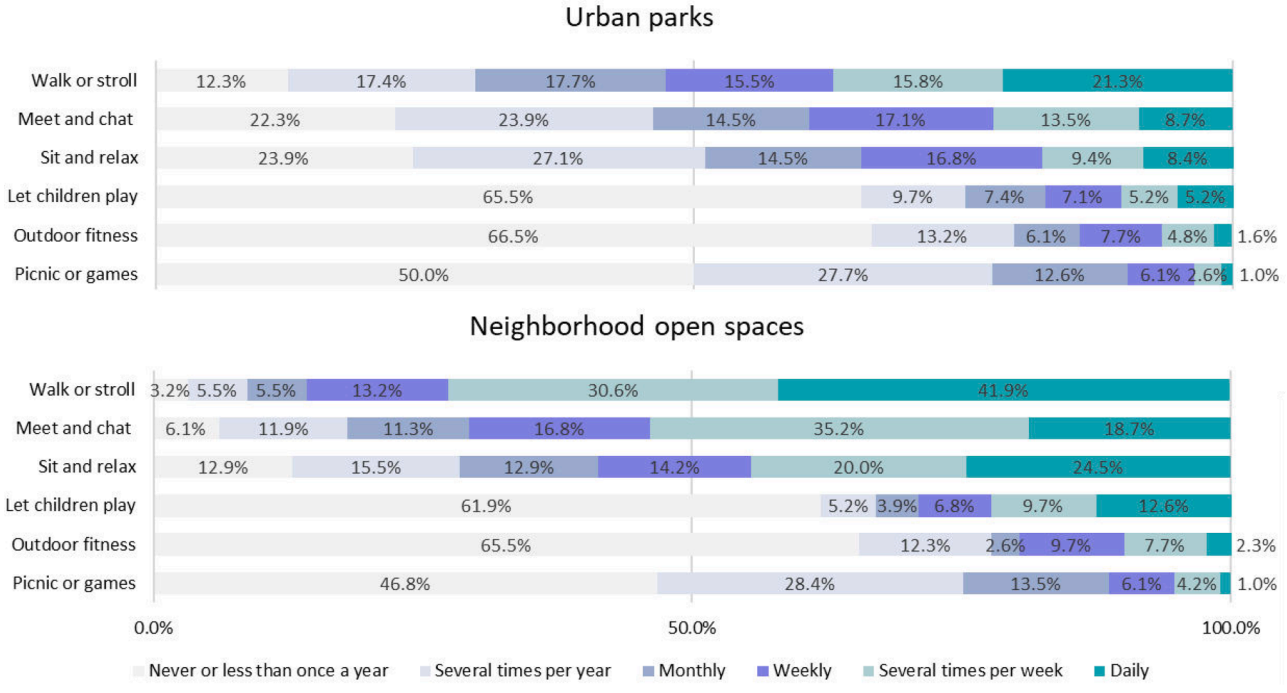

Fig. 2. Frequency distribution of urban parks and NOS use frequency ($N = 310$).

Table 3
Factor analysis results of indicators of the latent variables in the SEM model.

Indicators/Latent variables	Satisfaction with Green: City			Satisfaction with green: Neighborhood			Use frequency: Urban parks			Use frequency: Neighborhood open spaces			SWB		
	Est.[1]	STD Est.[2]	p	Est.	STD Est.	p	Est.	STD Est.	p	Est.	STD Est.	p	Est.	STD Est.	p
Satisfaction with green indicators															
Quality of green	1	1.059	–	1.286	0.979	<0.001	–	–	–	–	–	–	–	–	–
Quantity of green	0.752	0.754	<0.001	1	0.780	–	–	–	–	–	–	–	–	–	–
Use frequency indicators															
Walk or stroll	–	–	–	–	–	–	1	0.700	–	1	0.349	–	–	–	–
Meet and chat	–	–	–	–	–	–	1.066	0.77	<0.001	1.641	0.517	<0.001	–	–	–
Sit and relax	–	–	–	–	–	–	1.092	0.817	<0.001	2.419	0.640	<0.001	–	–	–
Let children play	–	–	–	–	–	–	0.817	0.641	<0.001	1.966	0.479	<0.001	–	–	–
Outdoor fitness	–	–	–	–	–	–	0.641	0.591	<0.001	1.535	0.492	<0.001	–	–	–
Picnic or games	–	–	–	–	–	–	0.616	0.652	<0.001	1.605	0.639	<0.001	–	–	–
Subjective well-being indicators															
In most ways my life is close to my ideal.	–	–	–	–	–	–	–	–	–	–	–	–	1	0.912	–
The conditions of my life are excellent.	–	–	–	–	–	–	–	–	–	–	–	–	0.954	0.889	<0.001
I am satisfied with my life.	–	–	–	–	–	–	–	–	–	–	–	–	0.961	0.897	<0.001
So far I have gotten the important things I want in life.	–	–	–	–	–	–	–	–	–	–	–	–	0.720	0.657	<0.001
If I could live my life over, I would change almost nothing.	–	–	–	–	–	–	–	–	–	–	–	–	0.713	0.597	<0.001

1 The unstandardized estimates.
2 The standardized estimates.

H2a and H2b stated. These results indicate that an individual with higher satisfaction with green tends to have higher SWB independent of the frequency of using the public green space. Furthermore, we do not find a direct effect between private-garden size and SWB as H2c stated. But we find supporting results for H2d that the size of the private garden also has an indirect positive relationship with SWB *via* the satisfaction with urban parks and NOS. However, the indirect effect is rather small ($\beta = 0.049$; $p = 0.025$). To compare the magnitude of direct effects of neighborhood and urban green spaces on SWB, a Z-test of coefficient difference (see Clogg et al. 1995, Paternoster et al. 1998) is conducted. The Z value is 1.646, which indicates that the two estimates are significantly different (at 5 % level). That means the direct effects of neighborhood green ($\beta = 0.24$; $p < 0.001$) on SWB is stronger than the direct effect of city level green on SWB ($\beta = 0.17$; $p = 0.003$). This result supports H3.

Apart from the above results which answer the two research questions, some other findings are also worth noticing. Gender, household composition, work hours, and house ownership are found to have direct effects on some of the latent variables in the model. People who work full-time are more likely to use urban parks and NOS more often. The single-person household group has a negative direct effect on the frequency of visiting NOS. Regarding the relationship between socio-demographics and SWB, several direct effects are observed as well. Males tend to have a lower level of SWB than females. Single persons tend to have lower SWB compared with individuals of other household compositions. Homeowners are more likely to feel satisfied with their life, compared with people who rent their houses.

5. Discussion

Given the scarcity of research on the relationships between different urban green spaces and SWB, in this paper, we examined how the three types of green, i.e., urban parks, neighborhood open spaces, and private gardens are associated with differences in SWB. We constructed a structural equation model to evaluate the direct and indirect effects of both satisfaction with green and the use frequency variables on SWB. In this section, the results are discussed and compared with previous literature and next the limitations and implications are introduced.

5.1. Three types of green and their relationship with SWB

The results partially support H1 that the size of a private garden has a direct positive effect on satisfaction with green in the neighborhood, and the latter also has a direct effect on satisfaction with green in the city. A possible explanation is that availability of extra private green spaces lower the demands for public greening so that individuals having a private garden are more easily satisfied with green in the neighborhood and city. This finding partly supports the compensation hypothesis (Maat & De Vries, 2006) when it comes to satisfaction with green, and is in line with findings in other studies(Chalmin-Pui et al., 2021; Krols et al., 2022; Van Den Berg & Custers, 2010) However, we do not find a compensation relationship on the level of use pattern as some studies did (Strandell & Hall, 2015; Poortinga et al., 2021). These findings suggest that private gardens, though often not taken into account in green spaces studies, should be considered together with public green spaces in urban planning as that has an impact on people's satisfaction with urban green and long-term well-being.

We then test H2 and find supporting evidence that both urban and neighborhood types of green have direct positive effects on individuals' SWB. Furthermore, we find that the direct effects of green spaces on SWB only arise through satisfaction with green; the frequency of use has no direct relationship with SWB. This result is in contrast with findings from some earlier studies (Lafortezza et al., 2009; Schnell et al., 2019) which did find that the use frequency of green spaces is positively related to SWB. Comparison is however difficult as the latter studies did not include the level of satisfaction with green as a variable in the model.

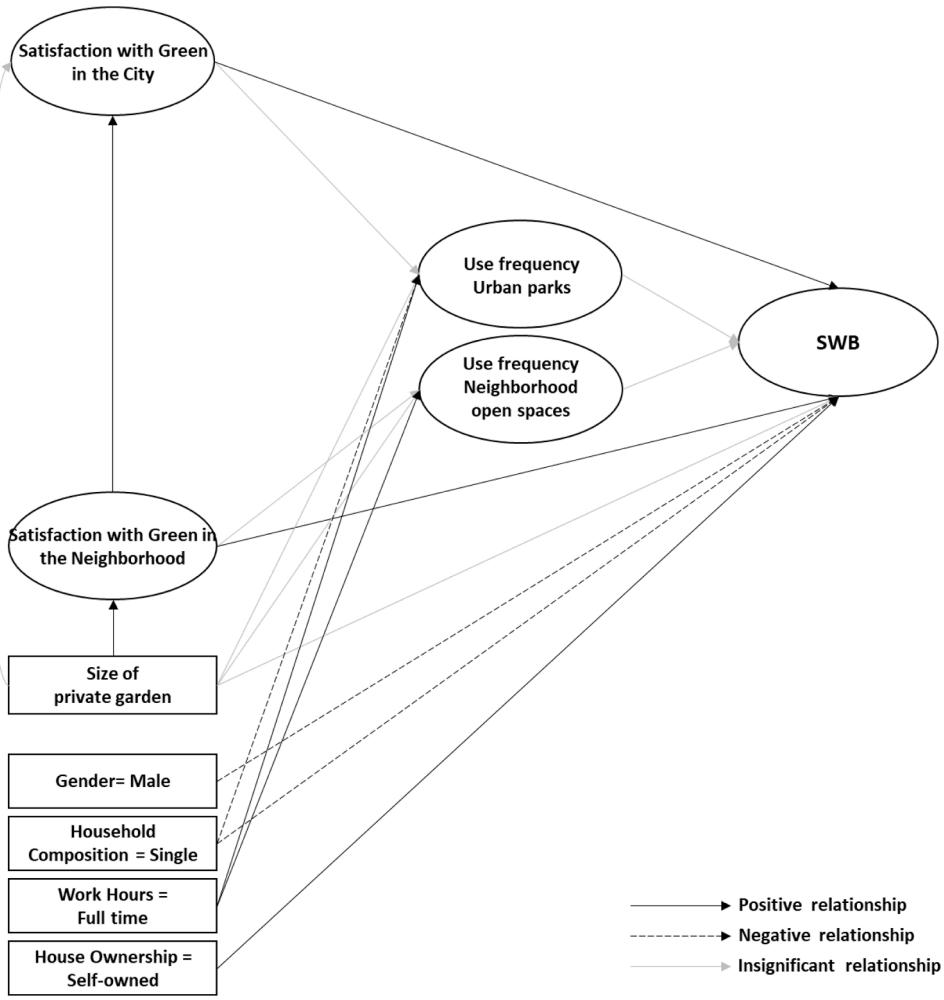

Fig. 3. SEM Model estimation results. ($N = 310$).

Moreover, our study is not the first that finds no significant relationship between use frequency and SWB at all. Several studies (Carrus et al., 2015; Cini et al., 2013; Hartig et al., 2014; Yuen & Jenkins, 2020) found that compared to the frequency of visits, other factors such as biodiversity, motivation to visit, and accessibility of nearby green spaces (distance) are more closely related to peoples' SWB. Given that leisure activities have been widely found to contribute to SWB (Marina & Iva, 2011), one possible explanation is that some important leisure activities may be conducted more often elsewhere (e.g., in indoor facilities or at home) rather than in green spaces, and that influence of green spaces on SWB depends more on perceived environment quality (e.g., perceived naturalness), which is independent of green space use frequency.

Regarding the direct effects of satisfaction with public green on SWB, attention restoration theory indicates: viewing nature environments without engaging in any activity can improve an individual's feelings (Kaplan, 2001; van den Berg et al., 2003). Neighborhood public spaces are close to individuals' homes and, therefore, the restoration effects may take place when people pass by green spaces on a daily basis. Another explanation is based on the stress reduction theory which contends that looking at green spaces without visiting them (e.g., from the windows) creates positive emotions and releases stress (Ulrich, 1984).

In addition, the results do not confirm the hypothesis (H2c) that private gardens can also have a direct effect on SWB. There is both support (Schnell et al., 2019) and lack of support (Poortinga et al., 2021; Krols et al., 2022) in previous literature for this finding. Although we did not find a direct relationship, an indirect effect of private gardens on SWB was identified: having a private garden is associated with higher satisfaction with green in the neighborhood and in the city and, through that, a higher level of SWB.

Consistent with H3, neighborhood green has a stronger direct effect on SWB than city green. This finding adds to the former study by Ettema and Schekkerman (2016), in which also neighborhood and city-scale built environments were studied. In that study, neighborhood characteristics (e.g., subjective attractiveness) were found to be more important to people's SWB, compared to city-scale characteristics. Our study narrows the focus down to green spaces and neighborhood-scale greening is found to be more strongly associated with individuals' SWB in line with this previous study. Our findings are also in line with Guo et al. (2021) who found that built environment factors (e.g., parks and residential density) in a 300 m buffer exert a stronger relationship with SWB, compared with a 500 m buffer. Possibly, the finding that neighborhood green is more important for SWB than city green can be attributed to the higher accessibility of neighborhood green for residents compared to urban parks, which allows daily scenery view and recreational use (Bronfenbrenner, 1979). Noticing that since our study concerns neighborhood green spaces where individuals live, it is based on the residents' perspective. A private garden, especially if it is not visible, has no function in creating a livable urban environment for other residents or visitors. Thus, it is likely that for other groups such as visitors and tourists, neighborhood public green can also have the most positive effect on SWB.

Concerning the socio-demographic variables, our results indicate that everything else equal, people who have full-time jobs tend to use

Table 4
Unstandardized estimated coefficients of the structural equation model. Standardized direct effects, and standardized indirect effects.

From/to	Satisfaction with Green: City			Satisfaction with green: Neighborhood		Use frequency: Urban parks			Use frequency: Neighborhood open spaces			SWB		
	Est.[1] (S.E.)	Direct effect (p)[2]	Indirect effect (p)	Est. (S.E.)	Direct effect (p)	Est. (S.E.)	Direct effect (p)	Indirect effect (p)	Est. (S.E.)	Direct effect (p)	Indirect effect	Est. (S.E.)	Direct effect (p)	Indirect effect (p)
Satisfaction with Green: City	–		–	–	–	−0.029 (0.042)	−0.028 (0.490)	–	–	–	–	0.207 (0.071)	0.173 (0.003)	−0.003 (0.411)
Satisfaction with green: Neighborhood	0.730 (0.078)	0.484 (<0.001)	–	–	–	–	–	–	−0.010 (0.823)	−0.017 (0.722)	–	0.428 (0.114)	0.238 (<0.001)	0.083 (0.007)
Use frequency: Urban parks	–	–	–	–	–	–	–	–	–	–	–	0.140 (0.146)	0.120 (0.339)	–
Use frequency: Neighborhood open spaces	–	–	–	–	–	–	–	–	–	–	–	−0.197 (0.398)	−0.066 (0.621)	–
Size of the private garden	0 (0.000)	0.068 (0.138)	0.069 (0.007)	0.001 (0.000)	0.143 (0.014)	0 (0.000)	−0.068 (0.095)	−0.004 (0.638)	0 (0.000)	0 (0.621)	−0.002 (0.804)	0 (0.000)	−0.021 (0.693)	0.049 (0.025)
Socio-demographics														
Gender: Male	–	–	–	–	–	–	–	–	–	–	–	−0.316 (0.146)	−0.115 (0.044)	–
Household Composition: Single	–	–	–	–	–	–	–	–	−0.104 (0.048)	−0.100 (0.031)	–	−0.412 (0.174)	−0.133 (0.016)	–
Work Hours: Full time	–	–	–	–	–	0.649 (0.148)	0.270 (<0.001)	–	0.277 (0.077)	0.293 (<0.001)	–	–	–	–
House Ownership: Self-owned	–	–	–	–	–	–	–	–	–	–	–	0.589 (0.155)	0.208 (0.012)	–

1 Est.= The unstandardized estimated coefficients. S.E.= Standard error.
2 The direct effects from the variables in the column to the corresponding variables in the first row. The values of direct effects are equal to the values of the standardized estimated coefficients (β). An insignificant value indicates no direct effect exists.

urban parks as well as neighborhood green spaces more often than others do. This could be because people with full-time work seek green spaces to restore from effortful work and thus are more active green space users. They need to commute regularly, which provides them more chances to expose to green spaces.

In contrast, keeping everything else equal, single persons tend to use neighborhood green spaces less than others. This finding is consistent with studies that found that families with children and older adults tend to use green spaces nearby their dwellings more regularly than others (Thompson Coon et al., 2011; Guo et al., 2021; Kerr et al., 2012). Concerning the relationship between socio-demographics and SWB, we found that being male, being single and renting rather than owning a dwelling are negatively associated with SWB. These results agree with some previous studies (e.g., Diener 2009, Herbers and Mulder 2017, Haring-hidore et al. 2017).

5.2. Limitations and implications

Several limitations of this study need to be acknowledged. First, the study is based on cross-sectional data and thus causal directions of the dependency relationships could not be identified. To ultimately test the supposed causal relationships between SWB and green spaces, longitudinal data need to be collected. Secondly, since the data was collected from middle to large-sized cities in the Netherlands, the findings are not readily generalizable to contexts such as extremely high-density metropolitans in other countries and low-density rural areas. Thus, replication of the study in other regions and urban contexts can enrich the insights generated. Thirdly, to shed further light on factors underlying the relationships between use frequency and satisfaction with green on SWB, it is interesting to also include other explanatory variables such as stress restoration and sense of place.

Despite the limitations, our study has shed light on how different spatial types of green can contribute to peoples' SWB. An implication of the findings is that the integration of green space in the direct neighborhood is a more effective means to enhance the quality of life of residents compared to the development of (more distant) urban parks. In addition, for a built environment where no private green is available near peoples' houses, developing public green spaces would be more beneficial than private gardens considering their higher influence on individuals' SWB.

6. Conclusion

Urban green spaces represent a highly accessible form of green infrastructure which have substantial welfare benefits. Most studies in the field of green public space have considered users' interaction with green in urban parks and neighborhood open spaces as separate research subjects. Until now, the relative importance of urban parks, green in neighborhood open spaces, and private gardens on SWB were not clear. Therefore, the main goal of the present study was to analyze the direct and indirect effects of the different types of green spaces on SWB in an integrated fashion. We find that people's satisfaction with green spaces close to their dwellings is positively related to satisfaction with less accessible green spaces, as the compensatory theory predicts. Similarly, our findings support the existence of compensatory relationships between the size of private gardens, neighborhood green and urban green. Thus, indirectly through these relationships, we find that having a (larger) private garden is positively related to SWB. The frequency of use has no direct effect on SWB. Finally, we find that green in neighborhood open spaces has a stronger effect on SWB compared to urban parks. This study provides novel insights into the different relationships between SWB and urban, neighborhood, and private types of green spaces. Though the data used do not allow us to make causal inferences, we can make a cautious conclusion that allocating green space to residential neighborhoods instead of (large) urban parks is more effective as a strategy to enhance individuals' SWB.

CRediT authorship contribution statement

Yuwen Zhao: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Visualization, Writing – original draft. **Pauline E.W. van den Berg:** Supervision, Writing – review & editing, Methodology. **Ioulia V. Ossokina:** Supervision, Methodology, Writing – review & editing. **Theo A. Arentze:** Supervision, Methodology, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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