Landscape and Urban Planning 167 (2017) 410–418

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research paper

The impact of urban green space on health in Berlin, Germany: Empirical findings and implications for urban planning

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A R T I C L E I N F O

Keywords:
Self-reported health (SRH)
Urban land use
Green urban areas
GIS
Spatial analysis

A B S T R A C T

This study investigates the impact of residential access to urban green space (UGS) on self-reported health (SRH) in Berlin, Germany. Using Geographical Information Systems (GIS), survey data and Urban Atlas land cover data, we calculated the Euclidean distance between 874 respondents' georeferenced home locations and the closest edge of the nearest green space as well as the spatial coverage of green space within a 250 m buffer around the place of living. These measures serve as proxies for residential access to UGS. Using linear regression models, we find both, decreasing Euclidean distances to the nearest green space and increasing spatial coverages of UGS significantly contributing to SRH. Furthermore, we find spatial coverages of UGS of less than 2.5% and Euclidean distances of at least 200 m to the nearest green space to have negative impacts on SRH if compared to observations having largest spatial coverages of UGS around their home locations and shortest distances to the nearest green space, respectively. Based on these findings, we identify 437 of Berlin's 447 planning units that provide access to UGS negatively affecting SRH of which 297 are used for residential purposes primarily. Our results provide useful information for policy makers and urban planners on the impact of UGS on health and adequate green space provision.

1. Introduction

In response to ongoing urbanization, urban land cover will increase by approximately 1.5 million km^2 on a global scale until 2030 (Seto, Fragkias, Güneralp, & Reilly, 2011; United Nations, 2014). These urbanization processes can significantly affect urban residents by reducing access opportunities to green urban areas which already are often insufficient and spatially segregated by factors such as income, ethnicity and age (Barbosa et al., 2007; Dye, 2008; Kabisch & Haase, 2011; McConnachie & Shackleton, 2010; Turner, Nakamura, & Dinetti, 2004). Urban green space (UGS) includes public spatial entities such as parks, meadows or forests within urban landscapes and provide manifold environmental and social services such as air and water purification and recreational opportunities (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Byrne & Wolch, 2009; Jim & Chen, 2008; Martin, Warren, & Kinzig, 2004). Furthermore, research originating from medicine and psychology finds positive effects of UGS on mental and physical health. Concerning self-reported health (SRH), Maas, Verheij, Groenewegen, and de Spreeuwenberg (2006) and de Vries, Verheij, Groenewegen, and Spreeuwenberg (2003) found improvements in SRH and increases in access to UGS. Addressing physical health, Krekel, Kolbe, and Wüstemann (2015), Lovasi, Quinn, Neckerman, Perzanowski, and Rundle (2008), Mitchell and Popham (2008), Nielsen and Hansen (2007), Takano (2002), Ulrich (1984) and Richardson, Pearce, Mitchell, and Kingham (2013) describe a reduced risk of cardiovascular diseases, reduced asthma prevalence in children, reduced surgery healing times, reduced likelihood of obesity, reduced mortality and increased longevity of residents having access or being exposed to green spaces. Addressing mental health, Beil and Hanes (2013), Grahn and Stigsdotter (2003), Nielsen and Hansen (2007), Stigsdotter, Ekholm, Schipperijn, Toftager, and Kamper-Jørgensen (2010), Ratcliffe, Gatersleben and Sowden (2013), Vries, van Dillen, Groenewegen, and Spreeuwenberg (2013) and White, Alcock, Wheeler, and Depledge (2013) found evidence for lower stress levels and increased access to green spaces. Astell-Burt, Feng, and Kolt (2013); Beyer et al. (2014) and Francis, Wood, Knuiman, and Giles-Corti (2012) found residents having access to green spaces to be at lower risk of psychological distress. Bowler et al. (2010); Thompson et al. (2011) and Ulrich et al. (1991) found access to UGS to cause positive emotions.

However, existing research is incomplete for two reasons: First, studies assessing the effects of the spatial coverage of UGS on SRH did not address the immediate vicinity of residential homes. At some point, increases in access to UGS might have no additional positive effects on residential health, which could be due to increased stress intensities

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http://dx.doi.org/10.1016/j.landurbplan.2017.06.015
Received 14 March 2016; Received in revised form 19 June 2017; Accepted 23 June 2017

caused by natural factors such as raised pollen load potentially causing or increasing allergic reactions, respiratory diseases or diseases such as Lyme disease (Bergmann & Sypniewska, 2011; Patz & Norris, 2005). Second, available research on the positive impact of UGS on SRH did not distinguish between ranges of residential access to green space affecting SRH. The analysis of ranges of residential access to UGS and SRH would potentially allow to identify planning units within cities which are undersupplied concerning the provision of UGS.

This study aims at addressing the following objectives: (i) To investigate the impact of UGS on SRH in the immediate vicinity of residential homes, and (ii) To analyse ranges of residential access to UGS and SRH to identify planning units within the city of Berlin which are undersupplied with UGS. Addressing theses objectives we use 874 observations derived from a cross-sectional survey carried out in Berlin in 2014. Furthermore, we use cross-section European Urban Atlas land use data (UA, 2012) provided by the European Environment Agency for the reference year 2012, geoprocessing algorithms as well as linear regression models. We identify whether comparatively long distances to the nearest green space and/or comparatively low spatial coverages of UGS within respondents' immediate neighbourhoods negatively affect SRH if compared to respondents having shortest distances to the nearest patch of green space and/or largest spatial coverages of UGS, respectively. Lastly, we provide data on Berlin's planning units concerning the provision of residential UGS access opportunities.

2. Materials and methods

2.1. Study region

Berlin is the capital and largest city of Germany. It covers an area of approximately 892 km². In 2016, Berlin was home to 3.65 million inhabitants (ASBB, 2017) resulting in a population density of 4,092 people/km². Compared to other major cities such as Sydney (Greater Sydney = 380 people/km² in 2013), Singapore (7,797 people/km²), Los Angeles (=20,959 people/km² in 2010) and Shanghai (3,630 people/km² in 2010) (ABS, 2014; DSS, 2016; U.S. Census Bureau, 2010), Berlin represents a moderately densely populated city. According to the BSDUDE (2012), Berlin's population will increase to 3.76 million inhabitants by 2030. Population growth increases demands for housing- and related services and conflicts with the provision of UGS. This represents a major challenge for administration and urban planning in the future. In 2014, Berlin's UGS covered a total area of 13,000 ha and offers more than 2,800 public parks (Kabisch & Haase 2014).

In 2013, the city administration of Berlin defined two planning targets addressing residential access to green space: (i) at least 6 m² of available green space per capita and (ii) a maximum walking time of 15 min to the nearest patch of green space (BSDUDE, 2013). According to Kabisch and Haase (2014), most sub-districts of Berlin meet the planning target of 6 m² of green space per capita. While most sub-districts located in the periphery of the city exceed that provision target some inner-city sub-districts fail at meeting it (Kabisch & Haase, 2014).

2.2. Data base

2.2.1. Survey and environmental data

In this study, we used data originating from an online-survey conducted between June and July 2014 in Berlin. The survey on the impact of UGS on SRH was part of a larger survey on the recreational value of urban parks in the city of Berlin (for further details see Bertram et al., 2017). The survey was conducted by using web panels of two independent survey companies. Since the survey is the result of a cooperation between two research institutes, we had to choose two survey companies (Bertram et al., 2017). However, the content and order of the questions as well as the recruiting process of both survey companies were identical (Bertram et al., 2017). The randomly drawn panel members were invited from the survey companies via email. The email contained a link to the online survey but did not specify its objectives. The survey included several questions on the socio-economic and demographic attributes of respondents (e.g. age, gender and employment status) and SRH. SRH was generated using the survey question: "How would you rate your current overall health status?" and served as dependent variable for this study. The variable was coded as a 5-item Likert scale representing the reply options "very bad", "bad", "moderate", "good" and "very good" (see Fernández-Niño, Ramírez-Valdés, Cerecero-Garcia, & Bojorquez-Chapela, 2014). The survey participants also provided information on their home locations either by stating their home address or by placing a marker on a map. This aspect marked an advantage over previous studies that used comparatively imprecise neighbourhood- and postal code data, respectively (e.g. Maas et al., 2006; Vries et al., 2003). The final study sample included 874 respondents. For a descriptive statistics of the final study sample see Table 1.

Table 1
Socio-economic and demographic comparison between the study sample and Berlin's total population.

Variable	Berlin Population	Study Sample
Age		
age (mean) [years]	42.8	47.7
age group [%] [years]		
18– < 25	8.2	5.6
25– < 35	17.0	15.8
35– < 45	13.4	18.2
45 < 55	15.6	26
55 < 65	11.9	21.1
> = 65	19.2	13.4
Gender		
male [%]	48.9	48.4
female [%]	51.1	51.6
Household Income (per month)		
income (mean) [€]	1,650	2,386
income class [%] [€]		
< 900	13.4	10.6
900– < 1,300	18.2	15.2
1,300– < 1,500	9.0	4.6
1,500– < 2,000	17.9	16.2
2,000 < 2,600	14.7	22.5
> 2,600	26.8	30.9
Household size	1.8	2.1

Note: The number of observations is 874. Data for the Berlin population refer to December 2014.

Other than survey respondents' georeferenced home locations we used cross-sectional Urban Atlas data on urban land use provided by the European Environment Agency for the reference year 2012. In accordance to Vries et al. (2003), we used the land use class "Green urban areas" (GUA) in our analysis. The GUA class is defined as land for predominantly recreational use including gardens, parks and suburban natural areas used as parks. We excluded all patches of less than 0.5 ha in size in order to comply with the city administration's definition of green urban areas (> 0.5 ha) and to avoid data errors such as digitization errors. That green space dataset contained neither point features of UGS such as street trees nor private green spatial entities such as backyards or allotment gardens as they do not usually offer public access. Fig. 1 provides an overview of the spatial distribution of both, UGS and the home locations of survey respondents.

2.3. Geospatial and statistical procedure

Euclidean distances to and spatial coverages of UGS are valid proxies for residential access to UGS (e.g. Bertram & Rehdanz, 2015; Krekel, Kolbe, & Wüstemann, 2016; Li et al., 2015). Using UA 2012 land use data and survey respondents' georeferenced home locations inside