International Journal of Hygiene and Environmental Health 220 (2017) 711–718

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

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

Relationship between neighbourhood socioeconomic position and neighbourhood public green space availability: An environmental inequality analysis in a large German city applying generalized linear models

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ARTICLE INFO

Article history:
Received 26 August 2016
Received in revised form 24 February 2017
Accepted 24 February 2017

Keywords:
Green space
Neighbourhood
Environmental justice
Generalized linear models
Health inequalities
Environmental inequalities

ABSTRACT

Background: The environmental justice framework states that besides environmental burdens also resources may be social unequally distributed both on the individual and on the neighbourhood level. This ecological study investigated whether neighbourhood socioeconomic position (SEP) was associated with neighbourhood public green space availability in a large German city with more than 1 million inhabitants.

Methods: Two different measures were defined for green space availability. Firstly, percentage of green space within neighbourhoods was calculated with the additional consideration of various buffers around the boundaries. Secondly, percentage of green space was calculated based on various radii around the neighbourhood centroid. An index of neighbourhood SEP was calculated with principal component analysis. Log-gamma regression from the group of generalized linear models was applied in order to consider the non-normal distribution of the response variable. All models were adjusted for population density.

Results: Low neighbourhood SEP was associated with decreasing neighbourhood green space availability including 200 m up to 1000 m buffers around the neighbourhood boundaries. Low neighbourhood SEP was also associated with decreasing green space availability based on catchment areas measured from neighbourhood centroids with different radii (1000 m up to 3000 m). With an increasing radius the strength of the associations decreased.

Conclusions: Social unequally distributed green space may amplify environmental health inequalities in an urban context. Thus, the identification of vulnerable neighbourhoods and population groups plays an important role for epidemiological research and healthy city planning. As a methodical aspect, log-gamma regression offers an adequate parametric modelling strategy for positively distributed environmental variables.

1. Introduction

The influence of the neighbourhood built environment on urban health and the impact of environmental disparities on health inequalities within cities have become important issues in epidemiological research. There is increasing evidence that built environmental factors are associated with individual health outcomes and health behaviours, such as physical activity, overweight, or cardiovascular diseases (Feng et al., 2010; Renalds et al., 2010; Schüle and Bolte, 2015; Van Holle et al., 2012).

Both socioeconomic characteristics of individuals or neighbourhoods and built environmental factors play an important role in explaining health inequalities between neighbourhoods. Various conceptual models were developed describing pathways how contextual factors of the neighbourhood environment are linked with individual health behaviours, health outcomes, and well-being of city residents (Diez Roux and Mair, 2010; Gee and Payne-Sturges, 2004; Morello-Frosch and Shenassa, 2006; Schulz and Northridge, 2004). These models share a hypothesis of vulnerability. They suggest that deprived areas or individuals with a low socioeconomic

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http://dx.doi.org/10.1016/j.ijheh.2017.02.006
1438-4639/

position (SEP) are exposed to higher environmental burdens and have minor environmental resources available than more affluent neighbourhoods or individuals. Aspects of vulnerability are also captured in conceptual models derived from the environmental justice framework. It is hypothesized that environmental exposures are social unequally distributed (exposure variation by SEP) and that neighbourhoods or individuals with a low SEP are more vulnerable to environmental exposures in terms of effect modification (Bolte et al., 2011).

The concept of 'deprivation amplification' assuming an amplification of individual disadvantage due to environmental burdens has been critically discussed. Evidence suggests that there is no consistent pattern that socioeconomic area deprivation is correlated with a lack of environmental resources which makes further research in this field necessary (Macintyre, 2007).

Epidemiological research often does not refer to a theoretical background on the measurement of neighbourhood SEP. There is a great heterogeneity in neighbourhood studies on how SEP on the neighbourhood level is operationalized. Measures of income, education, and employment on the level of administrative areas are the most often used indicators describing neighbourhood SEP (Leventhal and Brooks-Gunn, 2000; Rajaratnam et al., 2006; Sellström and Bremberg, 2006; van Vuuren et al., 2014).

In terms of environmental resources and their potential health benefits urban green space within cities has received increasing attention in epidemiological, environmental justice, and urban planning research (Corkery, 2015; Jennings et al., 2012; Tzoulas et al., 2007; WHO, 2016; Wolch et al., 2014). There are studies which found out that urban green space is associated with better health and health-promoting behaviours, such as with lower mortality, better perceived general health, better mental health, lower risk of cardiovascular diseases, or increased physical activity (Astell-Burt et al., 2014b; Maas et al., 2009; Mitchell et al., 2011; Mitchell and Popham, 2007; Richardson et al., 2013; van Dillen et al., 2012; Villeneuve et al., 2012). A deeper understanding to what extent green space is distributed by socioeconomic neighbourhood characteristics is a prerequisite to assess whether a socioeconomic unequal distribution of green space enhances environmental health inequalities.

Previous studies in cities in the USA, Canada, New Zealand, Australia, Britain, and Germany showed already that a low neighbourhood SEP is associated with decreasing green space availability (Astell-Burt et al., 2014a; Lakes et al., 2014; Mitchell et al., 2011; Pham et al., 2012; Richardson et al., 2010; Wen et al., 2013). However, there is still need for further studies investigating how neighbourhood SEP is related to green space availability. There is a great heterogeneity across existing studies on how green space availability within and around a neighbourhood is defined and measured. Predominantly, local or national land use data are used to define urban green space mostly in terms of public parks, public urban forests, or other types of vegetated land use types (Astell-Burt et al., 2014b; de Vries et al., 2003; Jones et al., 2009; Mitchell and Popham, 2007, 2008; Wen et al., 2013). Thereby, most studies focus on public green space and do not include domestic gardens. Other studies define urban green space by the use of the normalized difference vegetation index based on remote sensing which does not distinguish between different types of urban green space (Lakes et al., 2014; Villeneuve et al., 2012).

When it comes to the measurement of green space availability on the neighbourhood level, two methods stick out. One the one hand, the percentage of green space in the neighbourhood is calculated based on administrative boundaries, such as census tracts or postal codes (Mitchell et al., 2011; Mitchell and Popham, 2008; Richardson et al., 2010). Thereby, most studies determine the proportion within the neighbourhood itself, however, there are also studies considering a buffer (of e.g. 1000 m) around the neighbourhood additionally (Richardson et al., 2012). On the other hand, there are studies measuring green space availability based on different radii around the neighbourhood centroid (Astell-Burt et al., 2014a; de Vries et al., 2003; Maas et al., 2009). Catchment areas based on different radii around the centroid are not inhibited by administrative neighbourhood boundaries which can vary in their geographic extension and may provide a more precise application of walking distances. There is still a lack of knowledge to what extent such different methods of green space measurement influence relationships between neighbourhood deprivation and green space availability.

Moreover, analysing data of green space availability within and around neighbourhoods as a response variable on a continuous scale with standard linear regression models may be problematic because values can become only zero or positive. Distributions of positive continuous data are often highly skewed and, thus, violate the assumption of a normal distribution. Transforming the response variable or applying nonparametric methods are potential options to overcome this problem, however, they have their drawbacks when it comes to the precision of the estimates and interpretation of results (Feng et al., 2014; Manning and Mullahy, 2001). Previous studies which analysed associations between neighbourhood SEP and urban green space applied bivariate methods, such as analysis of variance (Mitchell et al., 2011) or correlation analysis (Mitchell and Popham, 2008). Others applied ordinary least squares regression in combination with spatial regression models where most of the green space variables were transformed (Shanahan et al., 2014) or negative binomial regression where green space availability was treated as a count variable (Astell-Burt et al., 2014a).

Therefore, this study followed two research questions. Firstly, we investigated whether neighbourhood SEP was associated with neighbourhood green space availability applying generalized linear models with a log-gamma regression in order to consider the non-normal distribution of green space availability as our response variable. Secondly, we analysed whether variations in size and kind of catchment areas of green space availability on the neighbourhood level influenced relationships between neighbourhood SEP and green space.

2. Data and methods

2.1. Neighbourhood delineation

Neighbourhood boundaries of 108 sub districts subdividing 24 main districts were obtained from the city council of Munich, Germany. The 108 sub districts serve for municipal administration and population statistics.

2.2. Green space availability within and around neighbourhoods

Spatial data on various land use types including public green space from 2011 were obtained from the city council of Munich. In our analysis public urban green space included land use types of public parks and public urban forests (deciduous forests, coniferous forests, and mixed forests). Domestic gardens and small green spaces, such as roadside greenery, were not considered.

Five buffers in steps of 200 m (from 200 m up to 1000 m) were generated around each administrative neighbourhood boundary. Firstly, percentages of green space availability were calculated within neighbourhoods only, as most previous studies did. Secondly, neighbourhood green space availability with the additional