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Research Paper

Contrasting distributions of urban green infrastructure across social and ethno-racial groups

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ABSTRACT

Links between urban green infrastructure (UGI) and public health benefits are becoming well established. Despite this, how UGI is distributed varies widely. Although not a universal finding, sectors of society that are disadvantaged often suffer from poor provision, something which might be due to which UGI are examined. We assess the distribution of street trees and public greenspaces (two types of publicly-owned and accessible UGI) across the city of Bradford, UK which is characterised by high levels of inequality and variation in ethno-racial background. We do this through statistical and spatial analyses. Street tree density was distributed unevenly and was highest in neighbourhoods with a high proportion of Asian/Asian British residents and with lower socio-economic status. Conversely, neighbourhoods with better access to public greenspaces were characterised by high income and/or a high proportion of White households. While the quality of public greenspace was spatially clustered, there were only limited spatial associations with ethno-racial group or socio-economic status. Population density was a key determinant of the distribution of UGI, suggesting understanding UGI distributions should also focus on urban form. Nevertheless, within the same city we show that equitable distribution of UGI differs according to the form and characteristics of UGI. To fully realise the public health benefits of UGI, it is necessary to map provision and understand the causal drivers of unequal distributions. This would facilitate interventions that promote equitable distributions of UGI based on the needs of the target populations.

1. Introduction

Rapid expansion of urban areas and human populations began in the late 20th century and will continue in the coming decades, with around 70% of people estimated to be living in towns and cities by 2050 (United Nations, 2014). Consequently, natural landscapes are becoming less accessible to increasingly urbanized societies. As natural environments have been found to enhance human health and wellbeing (Hartig, Mitchell, de Vries, & Frumkin, 2014), such a reduction in accessibility will have detrimental effects on the quality of life of city dwellers through, for example, a lack of recreational space and increased exposure to pollutants (Lovasi, Quinn, Neckerman, Perzanowski, & Rundle, 2008; Nisbet & Zelenski, 2011).

Urban green infrastructure (UGI; including all green elements such as parks, public greenspaces, green corridors, street trees, urban forests, green roofs and private domestic gardens (Tzoulas et al., 2007)) has emerged as a concept which can help facilitate the inclusion of natural elements within the urban planning process (Sandström, 2002). By defining, and subsequently valuing, its benefits (Gómez-Baggethun & Barton, 2013), UGI provision can be weighed against competing priorities for city planners, such as housing and infrastructure development (Elmqvist et al., 2015; Groenewegen, van den Berg, Maas, Verheij, & de Vries, 2012; Norton et al., 2015). Providing UGI could, therefore, be an effective way of mitigating the loss of natural environments within cities undergoing processes of densification, and thus enhance human health and wellbeing for a wide cross-section of urbanised societies (Dallimer et al., 2011; Pauleit, Ennos, & Golding, 2005). Numerous studies point to the health benefits of UGI such as improved mental and physical health (Dadvand et al., 2014; Gascon et al., 2016 McEachan et al., 2016; van den Berg et al., 2015, 2016). Although there is considerable evidence for these benefits, knowledge of the pathways that produce them remains limited (Markevych et al., 2017). Reasons may be a combination of mechanisms, including reducing exposure to harmful pollutants, facilitating physical activity and providing stress reducing environments (Hartig et al., 2014). UGI has also been shown to reduce the impact of extreme weather events (Zhang, Xie, Zhang, &

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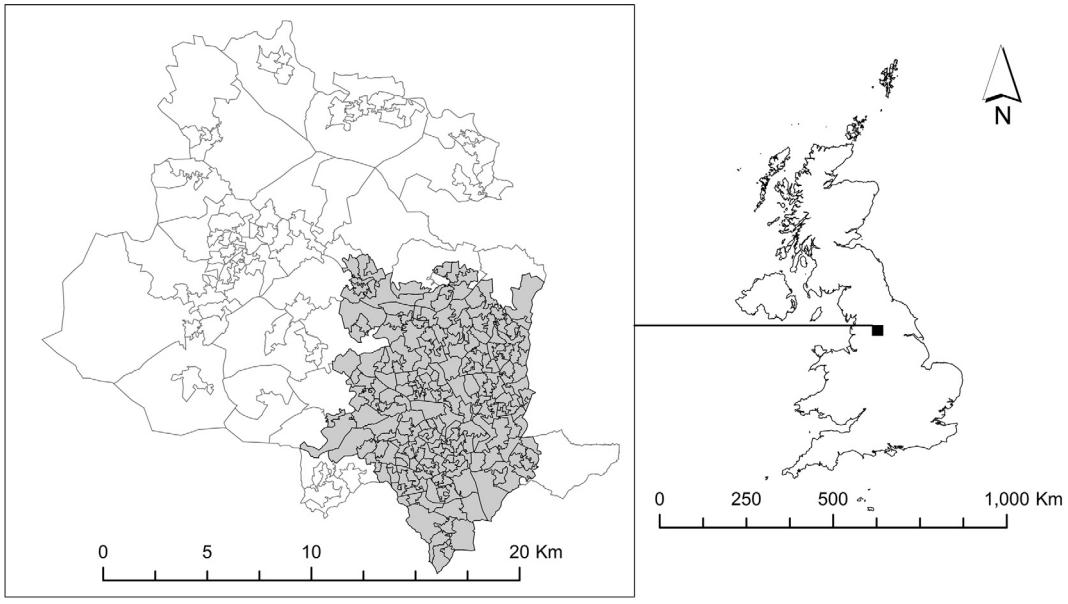

Fig. 1. The location of Bradford within the United Kingdom (right). Coordinates: 53.7960° N, 1.7594° W. The left-hand panel shows the 218 Lower Layer Super Output Areas (LSOAs) with over 15% of their area covered by built land uses, which were contiguous with the urban core of the city, are shown in grey. Unshaded LSOAs were not included in the study.

Zhang, 2012), boost economic opportunities (Conway, Li, Wolch, Kahle, & Jerrett, 2010) and strengthen community cohesion and reduce crime rates (Kaźmierczak, 2013). There is, however, potential for negative outcomes, most notably increased exposure to allergens, to which urban populations can be more susceptible (Cariñanos & Casares-Porcel, 2011), economic and social costs associated with maintenance (Heynen, Perkins, & Roy, 2006) and the possibility of spaces facilitating crime or being perceived as dangerous (Bogar & Beyer, 2016). Nevertheless, recent studies have called for an increase in greenspace provision and inclusion in health promotion policies (Nieuwenhuijsen, Khreis, Triguero-Mas, Gascon, & Dadvand, 2017; van den Bosch & Nieuwenhuijsen, 2017).

Aside from private spaces such as domestic gardens and many green roofs, urban green infrastructure is an inclusive element of towns and cities that is freely accessible to all. Therefore, given that some benefits of UGI can be considered public goods (i.e. they are non-rivalrous and non-excludable), UGI, especially when provided and maintained by municipal authorities, could be an effective way of enhancing the liveability of cities for all residents, regardless of socio-demographic background (Hughey et al., 2016; Lee & Maheswaran, 2011). Moreover, research shows a reduction in health inequalities related to income deprivation in mortality rates and circulatory disease, in greener areas, indicating deprived areas have the most to gain from urban greening (Mitchell & Popham, 2008). Despite such potential, UGI tends to be unevenly spatially distributed through urban areas, often resulting in ethnic/racial minorities (Heynen et al., 2006; Landry & Chakraborty, 2009; Wolch, Wilson, & Fehrenbach, 2013) and/or those of lower socio-economic status having comparatively worse provision, or quality of provision, than their counterparts (Vaughan et al., 2013). Numerous methodologically varied studies have shown this phenomenon in terms of accessibility, frequency, size and quality (Boone, Buckley, Grove, & Sister, 2009; Hughey et al., 2016; Schwarz et al., 2015; Tooke, Klinkenber, & Coops, 2010). However, these patterns are not universal; in some cities ethno-racial minorities or those of lower socio-economic status have better provision of UGI (Barbosa et al., 2007; Jones, Brainard, Bateman, & Lovett, 2009; Kessel et al., 2009).

Variation in the patterns of distribution of UGI may, in part, be due to which forms and characteristics of UGI are studied and how equity is assessed. Some studies examine publicly provided UGI, such as street trees (Landry & Chakraborty, 2009; Lovasi et al., 2008) or public parks (Barbosa et al., 2007; Boone et al., 2009; Comber, Brunsdon, & Green, 2008; Hughey et al., 2016; Vaughan et al., 2013; Wolch et al., 2013; Zhou & Kim, 2013); others do not distinguish between UGI which is publicly accessible and that which is not, by examining urban tree canopy cover (Heynen et al., 2006; Schwarz et al., 2015; Zhou & Kim, 2013) or the abundance of vegetation/greenness (Li, Zhang, Li, Kuzovkina, & Weiner, 2015; Pham, Apparicio, Séguin, Landry, & Gagnon, 2012; Tooke et al., 2010).

While we might expect uneven distribution of privately owned UGI, as higher income residents can both afford to own larger plots of land allowing for more private greenspace (Pearce, 2003) and often have more social capital, which allows them greater influence over their neighbourhoods (Kendal, Williams, & Williams, 2012; Pham, Apparicio, Landry, Séguin, & Gagnon, 2013; Shanahan, Lin, Gaston, Bush, & Fuller, 2014), publicly owned or maintained UGI should conceivably be subject to a higher level of distributional scrutiny. Indeed, were the health and wellbeing of all residents to be prioritised, we might expect publicly owned UGI to be evenly distributed or even to favour neighbourhoods with little provision of private greenspaces (Boone et al., 2009; Landry & Chakraborty, 2009; Pham et al., 2012).

Current findings are inconsistent in terms of provision and quality for ethnic minorities and lower socio-economic groups. Here, within the multi-ethnic and socioeconomically diverse city of Bradford, UK, we assess the distribution, and quality (an often-overlooked but important factor in assessing equity in UGI; Hughey et al., 2016) of UGI. We answer the research question that certain communities are systematically discriminated against. The environmental equity hypothesis, which states that different demographics and socio-economic groups should be equally impacted by environmental benefits and burdens, provides a framework to assess our question (Cutter, 1995; Downey & Hawkins, 2008; Wen, Zhang, Harris, Holt, & Croft, 2013).

2. Methods

2.1. Study system

Despite cities in the UK often being characterised by a diverse ethnic make-up, deprivation and income levels (Elvers, Gross, & Heinrichs, 2008; Rutt & Gulsrud, 2016) few studies of how UGI is distributed across socio-demographic or ethno-racial groups have thus far been