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Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city

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ABSTRACT

As urbanisation escalates globally, urban neighbourhood features which may improve physical and mental health are of growing importance. Using a cross-sectional survey of adults and the application of novel geospatial techniques, this study investigated whether increased visibility of nature (green and blue space) was associated with lower psychological distress (K10 scores), in the capital city of Wellington, New Zealand. To validate, we also tested whether visibility of blue space was associated missing teeth in the same sample. Cluster robust, linear regression models were fitted to test the association between visibility of nature and K10 scores, adjusted for age, sex, personal income, neighbourhood population density, housing quality, crime and deprivation. Higher levels of blue space visibility were associated with lower psychological distress ($\beta = -0.28$, $p < 0.001$). Importantly, blue space visibility was not significantly associated with tooth loss. Further research is needed to confirm whether increased visibility of blue space could promote mental well-being and reduce distress in other cities.

1. Introduction

The last decade has seen mounting evidence to suggest that the presence of natural environments in urban neighbourhoods is associated with positive physical and mental health. These environments, often called “green space” and “blue space”, are places for recreational opportunities (Barton and Pretty, 2010), social connection and enhanced social ties (Nutsford et al., 2013), often providing respite in urban settings to assist mental and physical recuperation (White et al., 2010; De Ridder et al., 2004). While the definition of green space may vary slightly between users, this term tends to include open areas of vegetation (e.g. parks, sports fields) and conservation areas (e.g. forests), but can also include backyard gardens, farms or any other space predominantly covered in vegetation. Blue space includes water bodies (e.g. lakes, oceans, rivers, etc.) but rarely includes human-made features (e.g. water fountains or sculptures). The mental health benefits of green and blue spaces have become increasingly of interest, with mental health contributing significantly to the global disease burden (Lim et al., 2012). Anxiety and depression are also precursors for chronic physical conditions such as asthma, arthritis, diabetes, stroke and heart disease (Pretty et al., 2005). As such, exploration of the ways in which urban neighbourhood features, such as exposure to green and blue spaces, may promote mental health, is of great importance to reducing this major source of global disease burden.

In our previous work (Nutsford et al., 2015) we outlined three primary causal pathways through which green and blue spaces may directly or indirectly influence mental health. First, there is strong evidence of an indirect pathway whereby increased physical activity has been associated with improved mental health (Barton and Pretty, 2010; Pretty et al., 2005). The benefits of physical activity include reduced blood pressure, increased self-esteem and reduced anxiety (Pretty et al., 2005), all of which may improve mental health. Nearby green spaces, particularly useable green spaces, provide recreational opportunities and are associated with higher levels of physical activity (Sugiyama et al., 2008). Particularly relevant to the research here, the proximity to both green (Pretty et al., 2005), and blue space (Barton and Pretty, 2010) has shown a significant impact on self-esteem, especially amongst the mentally ill. A weakness of this research is that proximity to green or blue space is often used as a proxy for use or engagement in physical activity. In fact, a recent review associations between proximity, in particular to green spaces, and physical activity concluded that findings are inconsistent across studies (Bell et al., 2014).

Second, green and blue spaces offer opportunities for social interaction, whether planned or not, which is also linked to

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improved moods (Sugiyama et al., 2008; Miles et al., 2012). Increased social interaction is particularly beneficial for the elderly, where increased social interactions improve community cohesiveness and has been associated with lower suicide rates, lower fear of crime and better physical health (Kweon et al., 1998). However, Bell et al., (2014) identify a number of limitations underpinning extant research and conclude that there is limited evidence to support the social interaction pathway. The vast majority of research makes the assumption that green space use is correlated with locational access measures, although actual use os often not directly measured. Much of this work argues that such use of green spaces are also driven by personal characteristics and the amentities and quality of the green spaces.

Last and most salient to the present study, green and blue spaces are recognised as therapeutic or salutogenic places and may lower psychological distress by serving as calming backdrops in residential neighbourhoods, in contrast to built-up features of the urban setting (White et al., 2010; Pretty et al., 2005; Ulrich et al., 1991). This backdrop is theorised to reduce sensory stimuli and thus promote mental relaxation (Ulrich et al., 1991). In fact, it is theorised that humans have an innate imperative to favour natural environments in contrast to urban environments due to their evolutionary importance as key resources (Newell, 1997). As a result of this evolutionary connection, the human brain processes natural environments more efficiently than built-up environments, thereby further increasing opportunity for relaxation (Ulrich et al., 1991; Heerwagen and Orians, 1986) and combating the onset of stress (Igarashi et al., 2015). Kearney (Kearney, 2006) conducted a qualitative study which found that prisoners in England with non-natural views had a 24% higher frequency of sick calls than prisoners with a view of farm land. Similarly, it was observed that increased views of nature from residential windows increased neighbourhood satisfaction, which has been linked to improved psychological stress (Kearney, 2006). A literature review conducted by Völker and Kistemann (2013), identified numerous benefits of visible waterscapes including emotional, recreational and direct health benefits. Specifically, they identify work by Karmanov and Hamel (2008) conducted in the Netherlands that found blue spaces to stress-reduce and enhance mood in urban environments. Other research by Laumann et al. (2003) observed increased levels of attentiveness in study participants when exposed to a simulated coastal environment as opposed to an urban setting.

The majority of existing studies evaluating relationships between exposure to green and blue spaces and indicators of mental health have employed basic measures of proximity (e.g. distance from home) (Wheeler et al., 2012; White et al., 2013) or the proportion of parks within a given distance from home (Nutsford et al., 2013; Richardson et al., 2013, 2010). These measures of locational access are useful when exploring the potential pathways of physical activity and social interactions in reducing psychological distress, as easy access to a park from one's home could facilitate such processes. However, proximity measures are unable to accurately characterise one's visual exposure to natural environments and thus to explore the potential salutogenic aspects of green or blue backdrops. Advances in geospatial technologies permit more precise quantification of the visibility of green and blue spaces (Nutsford et al., 2015) and thus offer a new way to test the effect of visibility of green and/or blue space on psychological distress, to complement existing qualitative evidence (Herzog, 1985; Rose, 2012).

Quantitative measures of green and blue space visibility have been employed in various disciplines. However, they have not yet been employed in health research. For example, Hamilton and Morgan (2010) incorporated views of blue space into house valuation price models and found a clear favouritism and willingness-to-pay for houses with ocean views. In 2005, Putra and Yang (2005) developed a GIS-based 3D visibility analysis in the hope that it would map environmental perceptions of the built environment. Similarly Miller et al. (2009) employed spatial analysis tools to quantify the visual perception of green spaces for a case study in Edinburgh, UK. Their work illustrates the potential for including visual measures in future research and concludes that three aspects could influence access to green spaces: locational access, cultural access and visual exposure. These studies highlight that the visual structure of residential environments is important and quantifiable, however, to date these advances in visibility quantification have not been applied to understanding the relationship between the visual exposure of green and blue spaces and mental health.

This study serves as the first of its kind, to our knowledge, and investigated whether self-reported psychological distress was associated with visibility of green and blue spaces in residential neighbourhoods for a sample of adult New Zealanders in Wellington, using the New Zealand Health Survey (NZHS). To validate, we also tested whether visibility of blue space was associated with missing teeth in the same sample (a theoretically unrelated outcome). The study made use of a novel geospatial method for measuring the visibility of natural environments (Nutsford et al., 2015).

2. Methods

2.1. Ethical approval

Approval to access the NZHS data was granted by the New Zealand Ministry of Health. Spatial data were linked to survey responses, then participant identifying information was removed, both conducted by the Ministry of Health. As such, all data used in analyses were anonymized prior to our use and did not require University ethical approval for use. All de-identified data were password protected and kept in a secure computer facility.

2.2. Spatial data and the creation of the visibility measures

Spatial data on green spaces and oceanic blue spaces were compiled from three national datasets (the Land Class DataBase II, Department of Conservation land register, and the Land Information New Zealand parcel database), as previously used by Richardson et al. (2010). Freshwater blue space features such as lakes and rivers were made available by Land Information New Zealand (LINZ) and obtained from an online spatial data archive (www.koordinates.com, downloaded April 2013). See Fig. 1 for the spatial distribution of green and blue spaces across the study area.

Visibility measures were generated for population-weighted centroids of meshblocks, called viewpoints hereafter, in which study participants resided (New Zealand's finest administration boundary, study area n=46, national n=46,263, mean area $=0.1\ km^2$ in 2006) across each cell in a 5 m resolution gridded digital elevation surface and extended 15 km from each viewpoint. A novel method of visibility was applied, termed the Vertical Visibility Index (VVI), which accounts for the slope, aspect, distance and elevation of visible areas relative to the observer location (see Fig. 2). This method is described in detail elsewhere (Nutsford et al., 2015).

In brief, the VVI is a visual summation of green and blue spaces expressed as degrees of visibility. For observers, green and blue spaces are visible across a broad spectrum of degrees, both vertically and rotationally. Observers surrounded by buildings, for example, are likely to have limited visibility of green and blue spaces and this visibility may be limited to specific angles. These