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Research note

# Research note: Urban street tree density and antidepressant prescription rates—A cross-sectional study in London, UK

Mark S. Taylor[a,*], Benedict W. Wheeler[a,b,c], Mathew P. White[b], Theodoros Economou[a,b,c], Nicholas J. Osborne[b]

[a] Department of Public Health, Fakulta Zdravotnictva a Socialnej Prace, University of Trnava, Trnava, Slovakia
[b] European Centre for Environment & Human Health, University of Exeter Medical School, University of Exeter, Truro Campus, Knowledge Spa, Royal Cornwall Hospital, Truro TR1 3HD, UK
[c] Exeter Climate Systems, University of Exeter, Exeter, UK

## HIGHLIGHTS

- Routine data are used to investigate a link between urban greenery and mental health at an area level.
- Street trees are a common and accessible form of urban nature.
- Robust data are available concerning prescribing rates and number of trees per linear km of street.
- Relationship with antidepressant prescribing persists after controlling for main confounders.

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## ABSTRACT

Growing evidence suggests an association between access to urban greenspace and mental health and wellbeing. Street trees may be an important facet of everyday exposure to nature in urban environments, but there is little evidence regarding their role in influencing population mental health. In this brief report, we raise the issue of street trees in the nature-health nexus, and use secondary data sources to examine the association between the density of street trees (trees/km street) in London boroughs and rates of antidepressant prescribing. After adjustment for potential confounders, and allowing for unmeasured area-effects using Bayesian mixed effects models, we find an inverse association, with a decrease of 1.18 prescriptions per thousand population per unit increase in trees per km of street (95% credible interval 0.00, 2.45). This study suggests that street trees may be a positive urban asset to decrease the risk of negative mental health outcomes.



## 1. Introduction

Growing urbanization appears to be a threat to mental health and well-being (Peen, Schoevers, Beekman, & Dekker, 2010). Modern lives are often busier and more hectic (Kegan, 1995) than the more traditional rural lifestyles which humans have experienced for much of their recent history, and to which they are thus best psychologically adapted (Wilson, 1984). Consequently, the demands of urban living may be greater than some people's abilities to cope which can result in feelings of stress, perhaps not unlike behaviors shown by many species when removed from their natural habitat (Broom, 1993). Importantly, chronic stress is associated with a range of mental and physical illnesses, including psychiatric disorders such as unipolar depression (Kessler, 1997), which may help explain why rates of depression are often higher in highly urbanized areas (Maas et al., 2009; Peen et al., 2010).

There is also evidence that exposure to the kinds of natural environments and elements to which we may be more accustomed can help reduce feelings of stress (Ulrich et al., 1991). In turn this may help to explain why indices of poor mental health and symptoms of depression tend to be lower in urban areas with more natural elements such as parks and gardens (Astell-Burt, Mitchell, & Hartig, 2014; White, Alcock, Wheeler, & Depledge, 2013). That is, people who live in urban areas who have better access (physically or visually) to elements of nature such as parks may be coping better with

* Corresponding author. Tel.: +421 33 5939 444.
*E-mail addresses:* mark.trnava@gmail.com, marktrnava@gmail.com (M.S. Taylor), b.w.wheeler@exeter.ac.uk (B.W. Wheeler), Mathew.White@exeter.ac.uk (M.P. White), T.Economou@exeter.ac.uk (T. Economou), n.j.osborne@exeter.ac.uk (N.J. Osborne).

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the day-to-day demands of urban living because of the physiological and psychological "restoration" these natural environmental elements promote (Ulrich, 1986).

To date, however, much of this literature has relied on self-reported psychological states, with the various limitations entailed, and correlated this with the *amount* of natural elements near individual's homes using land cover data such as the amount of local space taken up by parks and gardens. Far less work has used objective indices of psychiatric disorders, such as anti-depressant prescription rates, or examined the impact of specific elements of nature, such as street trees (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013). Such an examination is important both theoretically and practically. In terms of theory, a park may promote stress reduction, and thus help prevent depression in the long-term, through various mechanisms including encouraging physical activity or socialization (Hartig, Mitchell, de Vries, & Frumkin, 2014). Street trees, by contrast, are more likely to aid stress reduction via a visual amenity pathway, although they may also provide an urban cooling effect and reduce some types of pollution (Hartig et al., 2014).

Some studies have measured the associations between urban nature and mental health; individuals score worse on the General Health Questionnaire when living in less green urban areas in England (Astell-Burt et al., 2014; White, Alcock, Wheeler, & Depledge, 2013), and higher rates of depression and anxiety disorder have been found in less green areas of the Netherlands (Maas et al., 2009). Depression is a common form of mental illness, with a prevalence in Britain of around 11%, similar to elsewhere in Europe (Martin-Merino, Ruigomez, Johansson, Wallander, & Garcia-Rodriguez, 2010). The epidemiology of depression is complex, but its impact on society in terms of both economic costs and social burden is great (Pincus & Pettit, 2001). A recent meta-analysis of studies from developed countries concluded that urban living is associated with an increased risk of developing psychiatric disorders, including depression, compared with residing in a rural area (Peen et al., 2010). It has been reported that walking in a nature reserve is restorative to markers of positive affect, and decreases levels of anger, when compared with the same activity in urban areas (Hartig, Evans, Jamner, Davis, & Gärling, 2003), and taking exercise in green spaces has been shown to be associated with bigger improvements in psychological factors such as self-esteem, than the same activity in urban spaces (Pretty, Peacock, Sellens, & Griffin, 2005).

Street trees are a widespread, common form of urban nature, found in cities and towns even in the absence of nearby parks and other green spaces. The aim of the current study was to examine these issues in London, which benefits from comprehensive street tree audits and highly detailed prescription data, using spatial and Bayesian analyses. Our basic hypothesis was that areas with more trees are those with lower levels of depression as indicated by anti-depressant prescription rates, after controlling for appropriate confounders.

## 2. Methods

London, United Kingdom (UK), is a large conurbation with just over 8 million inhabitants (Office for National Statistics, 2010). The city is divided administratively into 33 boroughs, with mean population around 250,000 and mean area of approximately 50 $km^2$. Primary health care is provided largely through National Health Service (NHS) general practitioners (GPs), at the time of data collection working within local Primary Care Trusts (PCTs). PCT and borough boundaries are mostly co-terminous.

This is an ecological study using several openly accessible data sources from the city.

### 2.1. Prescribing data

The quantity of antidepressant prescriptions in financial years 2009–2010 in the PCTs serving each London borough, was obtained from the publicly available repository at data.london.gov.uk (Greater London Authority, 2011). Antidepressant drugs are defined here as pharmaceutical agents included in the British National Formulary (BNF) Chapter 4, Section 4.03, (Joint Formulary Committee, 2011). In the UK, all citizens who consult their physician are registered with the NHS as standard, and are entitled to receive health provision. The proportion of UK citizens opting to use private health care instead is approximately 11–12% (Klein, 2005), and antidepressant drugs are only legally available in the UK with a prescription (Wheeler, Gunnell, Metcalfe, Stephens, & Martin, 2008). Populations of each London borough for the year 2009 were obtained from the Greater London Authority (GLA), (Office for National Statistics, 2010), allowing calculation of borough rates of antidepressant prescriptions per 1000 population.

### 2.2. Street tree data

Data concerning the quantity of street trees in each London borough were obtained from the same source (Greater London Authority, 2011). These figures are required for the borough to claim a per-tree maintenance allowance from central government. All street trees are counted together, whether they are deciduous or evergreen. The data concern only street trees, as opposed to those in non-residential/non-commercial areas such as parks. Figures may omit a few recently planted trees, but are thought to be complete with regard to mature trees (London Assembly Environment Committee, 2011). The routinely collected data did not provide information on the number or length of streets in each borough. Consequently we calculated this information from street data from the Ordnance Survey (April 2010), using ArcGIS 9.3, giving a density of trees per linear kilometer of street. Streets are treated equally, regardless of traffic lanes or private residences, as even those without housing may form important thoroughfares.

### 2.3. Analysis

Linear regression models were used to explore the association between borough street tree density and antidepressant prescribing rates, adjusting for potential confounders. Confounders considered included: socio-economic status (SES) using mean scores from the Government's 2010 Index of Multiple Deprivation (McLennan et al., 2011), percentage of residents claiming job seekers' allowance (JSA), prevalence of smoking (HM Government, 2013), and borough mean age. The number of GP consortia in each borough was used as a proxy for service accessibility.

The boroughs of City and Hackney are served by the same PCT, as are Sutton and Merton. In these cases data were combined as sum totals or population-weighted means as appropriate.

Owing to concern regarding unknown/unmeasured confounders at borough level, Bayesian mixed effects models were employed. This predicts effect size with associated credible intervals, after adjustment for measured confounders and an additional parameter representing unknown and random area-level influences. In the Bayesian framework, parameters are treated as random variables whose "prior" distribution expresses our uncertainty about their value before any data are observed. Prior distributions (priors) are combined with the observed data through Bayes' theorem to produce the posterior distributions for each parameter (posteriors). The posteriors express the uncertainty about model parameters after data are observed and all statistical inference is based solely on the posteriors. Markov chain Monte Carlo (MCMC) is a numerical technique which produces samples