



The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes



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ABSTRACT

Background: The health benefits of greenspaces have demanded the attention of policymakers since the 1800s. Although much evidence suggests greenspace exposure is beneficial for health, there exists no systematic review and meta-analysis to synthesise and quantify the impact of greenspace on a wide range of health outcomes.

Objective: To quantify evidence of the impact of greenspace on a wide range of health outcomes.

Methods: We searched five online databases and reference lists up to January 2017. Studies satisfying *a priori* eligibility criteria were evaluated independently by two authors.

Results: We included 103 observational and 40 interventional studies investigating ~100 health outcomes. Meta-analysis results showed increased greenspace exposure was associated with decreased salivary cortisol -0.05 (95% CI $-0.07, -0.04$), heart rate -2.57 (95% CI $-4.30, -0.83$), diastolic blood pressure -1.97 (95% CI $-3.45, -0.19$), HDL cholesterol -0.03 (95% CI $-0.05, < -0.01$), low frequency heart rate variability (HRV) -0.06 (95% CI $-0.08, -0.03$) and increased high frequency HRV 91.87 (95% CI 50.92, 132.82), as well as decreased risk of preterm birth 0.87 (95% CI 0.80, 0.94), type II diabetes 0.72 (95% CI 0.61, 0.85), all-cause mortality 0.69 (95% CI 0.55, 0.87), small size for gestational age 0.81 (95% CI 0.76, 0.86), cardiovascular mortality 0.84 (95% CI 0.76, 0.93), and an increased incidence of good self-reported health 1.12 (95% CI 1.05, 1.19). Incidence of stroke, hypertension, dyslipidaemia, asthma, and coronary heart disease were reduced. For several non-pooled health outcomes, between 66.7% and 100% of studies showed health-denoting associations with increased greenspace exposure including neurological and cancer-related outcomes, and respiratory mortality.

Conclusions: Greenspace exposure is associated with numerous health benefits in intervention and observational studies. These results are indicative of a beneficial influence of greenspace on a wide range of health outcomes. However several meta-analyses results are limited by poor study quality and high levels of heterogeneity. Green prescriptions involving greenspace use may have substantial benefits. Our findings should encourage practitioners and policymakers to give due regard to how they can create, maintain, and improve existing accessible greenspaces in deprived areas. Furthermore the development of strategies and interventions for the utilisation of such greenspaces by those who stand to benefit the most.

1. Introduction

The idea that greenspaces are beneficial for the health of the population became a generally accepted principle as early as the 1800s, when various London-based organisations including the Commons Preservation Society and the National Health Society called for the preservation, creation, and accessibility of open spaces and parks within crowded residential areas, referring to them as the “lungs” of the town or city (Hickman, 2013). More recent Healthy City guidelines from the WHO support this view, defining a healthy city as “one that continually creates and improves its physical and social environments

and expands the community resources that enable people to mutually support each other in performing all the functions of life and developing to their maximum potential” (World Health Organisation, 2016a). However, increasing urbanicity and modern lifestyles can mean that opportunities for human contact with nature become less frequent.

The term greenspace is typically defined as open, undeveloped land with natural vegetation (Centres for Disease Control, 2013), although it also exists in many other forms such as urban parks and public open spaces as well as street trees and greenery. Recognition of the health benefits of greenspace exposure was one of the motivations of Oxford General Practitioner William Bird MBE in establishing the UK's first

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health walk scheme at his practice in 1995, leading to the foundation of the English Walking for Health programme (WfH) (Walking for Health, 2016). Collaborations between health care providers and local nature partnerships are becoming increasingly common across the UK (Bloomfield, 2014; Kent Nature Partnership, 2014; Naturally Healthy Cambridgeshire, 2016; West of England Nature Partnership, 2016) and further afield (New Zealand Ministry of Health, 2016), and aim to better capitalise on ways the health of the natural environment is intrinsically linked to human health, striving for “healthy communities in healthy environments” (Naturally Healthy Cambridgeshire, 2016). Yet a challenge is to ensure those who might benefit the most have sufficient opportunities for exposure to greenspace.

Socioeconomic health inequalities have consistently commanded the attention of researchers and policymakers, with evidence that inequalities are currently increasing (Townsend et al., 1982). Environmental factors form one of the many potential explanations as to their cause (World Health Organisation, 2016b). Research has shown that low income neighbourhoods have reduced greenspace availability (Thomas Astell-Burt et al., 2014a, 2014b), and residents of more deprived neighbourhoods are less likely to use those greenspaces that exist (Jones et al., 2009). Park quality and frequency of park use have both been found to be higher amongst high-socioeconomic status (SES) residents (Leslie et al., 2010). It should also be noted that living in a greener neighbourhood has been linked with stronger greenspace-health associations (Fuertes et al., 2014; McEachan et al., 2015; Mitchell and Popham, 2007) and that income-related health inequalities have been shown to be lower in greener neighbourhoods (Mitchell and Popham, 2008). Greenspace may currently be overlooked as a resource for health and as part of a multi-component approach to decrease health inequalities.

Several hypotheses have been suggested to explain the relationship between nature and health and well-being. The first, is that natural and green areas promote health due to the opportunities for physical activity that they present. The health benefits of physical activity are well understood, with literature suggesting that exercising in a green environment may be more salutogenic than exercising in an indoor gym environment (Thompson Coon JB et al., 2011). Secondly, public greenspaces have been associated with social interaction, which can contribute towards improved well-being (Maas et al., 2009). Thirdly, exposure to sunlight, which is thought to counteract seasonal affective disorder (Rosenthal et al., 1984) and a source of vitamin D (van der Wielen RdG et al., 1995) has been suggested as a causative pathway for this relationship. A fourth is the “Old friends” hypothesis, which proposes that use of greenspace increases exposure to a range of micro-organisms, including bacteria, protozoa and helminths, which are abundant in nature and may be important for the development of the immune system and for regulation of inflammatory responses (Rook, 2013). Further potential mechanisms include the cooling influence of bodies of greenspace on surface radiating temperature (SRT), which has been documented as beneficial for health (Shin and Lee, 2005), as well as the mitigation of greenspace against environmental hazards such as air (Dadvand et al., 2012a; Yang et al., 2005) and noise pollution (De Ridder et al., 2004; Wolch et al., 2014).

Whilst there is a growing body of literature attempting to quantify the links between nature and improved health and well-being, systematic reviews in this area have largely focused on the association between greenspace and a specific health outcome or behaviour such as mortality (Gascon et al., 2016; van den Berg et al., 2015), obesity (Lachowycz and Jones, 2011), birth weight (Dzhambov et al., 2014), physical wellbeing (Thompson Coon JB et al., 2011) as well as the acute health benefits of short term exposure to greenspace (Bowler et al., 2010). Associations have been reported with improved perceived general health, perceived mental health, as well as linking quality of neighbourhood greenness with improved general health (van den Berg et al., 2015). Physical activity in a natural outdoor environment has been associated with reduced negative emotions and fatigue, increased

energy (Bowler et al., 2010; Thompson Coon JB et al., 2011), improved attention, as well as greater satisfaction, enjoyment and a greater intent to repeat the activity (Bowler et al., 2010). Additionally, meta-analyses have shown increased residential greenspace to be significantly associated with reduced cardiovascular and all-cause mortality (Gascon et al., 2016), and increased birth weight (Dzhambov et al., 2014). Yet no systematic review has attempted to determine the impact of greenspace on a wide range of health outcomes.

With this systematic review, we aim to address a major gap in the evidence by identifying a set of health outcomes that have been investigated as being potentially associated with exposure to greenspace. Health outcome terms were taken from the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), a medical classification list produced by the World Health Organisation (World Health Organisation, 2015), with greenspace terms taken from a previous systematic review (Lachowycz and Jones, 2011). The clarification of the magnitude of associations facilitates the investigation of potential underlying mechanisms in the relationship between nature and health. Furthermore, clinicians may use these findings to make recommendations to patients, which may convey health benefits or assist in tackling socio-economic health inequalities.

2. Methods

This systematic review followed Cochrane systematic review guidelines (Deeks et al., 2011), requirements of the NHS National Institute of Health Research Centre for Reviews and Dissemination (PROSPERO, 2015) and the PRISMA statement for reporting studies that evaluate healthcare interventions (Liberati et al., 2009; Moher et al., 2009). Methods of the analysis and inclusion criteria were specified in advance and documented in a protocol registered as CRD42015025193 (PROSPERO, 2015) available on the PROSPERO database <http://www.crd.york.ac.uk/prosperto/>.

2.1. Data sources

We searched electronic databases including MEDLINE (US National Library of Medicine, Bethesda, Maryland, U.S.), EMBASE (Reed Elsevier PLC, Amsterdam, Netherlands), AMED (Wolters Kluwer, Leicestershire, UK), CINAHL (EBSCO Publishing, Massachusetts, U.S.) and PsycINFO (American Psychological Association, Washington D.C., U.S.) from inception to the end of September 2015, using specific search terms. The search was then updated to include studies published until mid-January 2017. Databases were selected to best represent source material in health, allied health and human science. Additionally, reference lists from included studies and previous systematic reviews on greenspace and health were hand searched.

2.2. Search strategy

Search terms associated with greenspace were developed with reference to a previous systematic review on greenspace and obesity (Lachowycz and Jones, 2011). For this review, we defined ‘greenspace’ as open, undeveloped land with natural vegetation as well as urban greenspaces, which included urban parks and street greenery. Health outcomes were taken from ICD-10 and then expanded to include the relevant metrics, for example “diabetes” was expanded to include “blood glucose” and glycated haemoglobin, commonly referred to as “HbA1c.” To limit the scope of work, mental health and communicable diseases were excluded from this review due to the volume of literature after including them in initial scoping searches. Outcomes associated with weight status and birth weight were also excluded, as systematic reviews investigating them have recently been published (Dzhambov et al., 2014; Lachowycz and Jones, 2011; Thompson Coon JB et al., 2011).

The search strategy identified studies that contained at least one

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