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Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews

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ABSTRACT

Increasing urbanisation, changing disease scenarios, and current predictions of climate change impacts require innovative strategies for providing healthy and sustainable cities, now and in the future. The recently coined concept, Nature-based solutions (NBS), is one such strategy referring to *actions that are inspired by, supported by, or copied from nature*, designed to address a range of environmental challenges. The objective with this article is to evaluate the evidence on public health benefits of exposure to natural environments and explore how this knowledge could be framed within the NBS concept. We conducted a systematic review of reviews following established methodology, including keyword search in several databases, predefined inclusion criteria, and a data extraction in accordance with the PICOS structure. We reviewed literature on associations between public health and natural environments in relation to pathways – sociobehavioural/cultural ecosystem services (e.g. stress and physical activity) and regulating ecosystem services (e.g. heat reduction) – or defined health outcomes (e.g. cardiovascular mortality). The results show that there is strong evidence for improved affect as well as on heat reduction from urban natural environments. These conditions may mediate the effect seen on cardiovascular disease (CVD)-related mortality by exposure to natural environments. By also reviewing existing literature on NBS and health, we phrase the results within the NBS context, providing guidelines on how public health and well-being could be integrated into implementation of NBS for resilient and liveable urban landscapes and health in a changing climate.

1. Introduction

1.1. Urbanisation and health

Urban populations are expanding rapidly across the world, putting pressure on cities' resources and the equal distribution of those. In combination with the current predictions of climate change impacts, suggesting, for example, increase in urban temperatures, storms, extreme drought/precipitation, and other environmental hazards, this puts urban areas under a lot of stress to provide environments that support human health and well-being.

Another challenge, related to urban environments and lifestyles, is the epidemic of non-communicable diseases (NCDs). NCDs, such as diabetes, obesity, chronic respiratory diseases, cancer, mental and cardiovascular disorders, are dominating the current global disease burden and are expected to increase in prevalence also in low- and middle income countries (Vos et al., 2015). These conditions are best prevented by societal and environmental interventions (WHO, 2012).

Finally, urban environments are also characterised by an excessive load of toxic exposures, such as air pollution and noise, from, for example, motorised traffic and industries. Air pollution alone accounts for around 600,000 deaths annually in the pan-European region (van den Bosch, et al., 2016) and noise is a major health problem, causally linked to, for example, mental and cardiovascular disorders (WHO, 2011).

Mitigating impacts and adapting to actual or expected effects of changes in the climate involve a range of potential actions to help reduce risks and vulnerability and improve resilience capacity. Equally, sustainable prevention of NCDs and reduction of harmful exposures require multisector approaches and actions (McMichael, 2015). These actions could be effective on different spatial and temporal scales, proactively planned, or results of socio-political drivers such as e.g. new planning regulations, market demand, or even social pressure (IPCC, 2014). They may work in isolation or in synergies, and can include co-benefits or trade-offs.

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1.2. Nature-based solutions and health

"Nature-based solutions (NBS) are actions which are inspired by, supported by, or copied from nature", and that are designed to address a range of environmental challenges in an efficient and adaptable manner, while at the same time providing economic, social, and environmental benefits (ECDG, 2015). Types of NBS that have been identified by the European Commission Directorate-General (ECDG, 2015) as relevant to cities include: ecosystem restoration, greening of grey surfaces (e.g., green rooftops, green walls or greened brownfields), and integrated broad scale climate change mitigation and adaptation measures, e.g., afforestation, natural flood control, and constructed wetlands. In a review carried out by Pauleit et al. (forthcoming) a broader view of the term NBS is taken, proposing NBS as an umbrella term, incorporating terms such as Green Infrastructure (GI), Ecosystem-based adaption, and ecosystem services (ESS). How the concept of NBS is presented in scientific literature and to what extent it is related to public health protection have been unclear. We therefore conducted a review of existing literature on (i) NBS and on (ii) NBS and health. The search terms were correspondingly (i) "Nature based solution*" and (ii) "nature based solution*" AND health (search carried out in April 2016 using 4 databases; Scopus, Web of Science, CAB and PubMed) and resulted in 27 papers covering NBS and only 3 of those were retrieved if including health in the search terms. The papers were categorised with regards to (i) type of paper (empirical, review, conceptual), (ii) focus of the paper, and (iii) environmental adaptation and health (see Appendix A). The results showed that most of the current articles are conceptual, with their discourse mainly being 1) NBS in relation to Green Infrastructure (e.g. H. Chen et al., 2016; Clabby, 2016; Derkzen et al., 2017; Kazmierczak, 2016); 2) NBS for mitigating and or adapting to climate change (e.g. Bennett et al., 2016; Brink et al., 2016; Kabisch et al., 2016); and 3) NBS in relation to ESS (e.g. J. Chen et al., 2016; Fink, 2016; Haase, 2016; Lafortezza and Chen, 2016). The three papers explicitly relating NBS to human health and well-being, were all in a conceptual form and presented different perspectives (Annerstedt van den Bosch and Depledge, 2015; Beatley, 2016; Richardson et al., 2016). Beatley (2016) discusses urban nature from a perspective of city planning, through the discourse of biophilic cities, where health is the main motivating factor. Richardson et al. (2016) provides a summary of the evidence of the value of the natural environment to well-being followed by how this could inform the wider practice and epistemology in ergonomics. The paper by Annerstedt van den Bosch and Depledge (2015) draws on earlier research on the effect nature has of evoking psychological and physiological reactions and suggest that NBS could be used to automatically foster pro-environmental behaviour and indirectly improve public health by reducing climate change impact. The relative lack of literature on the possible relation between NBS and public health indicates that the intimate relation between environmental conditions and human health is insufficiently explored within the NBS-context. NBS are often considered as mainly related to environmental/ecological issues. However, as human health is, to a large extent, depending on surrounding social and physical environments, the public health realm should be as relevant for NBS considerations and trans-sectoral and trans-disciplinary efforts are required for improved human health.

2. Natural environments and health

Current literature on hypotheses, theories, and studies on associations between contact with natural environments and health refers to either pathways – sociobehavioural/cultural ESS (e.g. stress reduction and physical activity) and regulating ESS (e.g. heat reduction) – or defined health outcomes (e.g. cardiovascular mortality) (Hartig et al., 2014) (see Table 1).

The ecological model of health, originally developed by (Dahlgren and Whitehead, 1991) and further developed by (Barton and Grant, 2006) and (Coutts and Hahn, 2015), identifies the importance of the natural environment for our health and well-being. Several frameworks have been put forward and also been frequently cited, theoretically further outlining the link between human health and well-being and the natural environment (Bedimo-Rung et al., 2005; Calogiuri and Chroni, 2014; Hartig et al., 2014; Lachowycz and Jones, 2011; Shanahan et al., 2015; Tzoulas et al., 2007).

The focus of these frameworks have mostly been on socio-behavioural pathways such as physical activity (e.g. Bedimo-Rung et al., 2005, Lachowycz and Jones, 2011) stressing the impact of user as well as green space characteristics for explaining activity. Other frameworks, such as the one proposed by (Calogiuri and Chroni, 2014), stress only the motivational processes underlying the relationship between natural environments and physical activity, leaving out the characteristics of the environment as a moderating factor. Frameworks taking an ESS approach – looking at human health as a service provided by ecosystems – consider the function and health of the ecosystem as determinants of potential health outcomes (Shanahan et al., 2015; Tzoulas et al., 2007). Within this context, sometimes the so called "Old Friends hypothesis" is considered, where a dysfunctional immune system is suggested to be due to minimised contact with biodiverse natural environments and consequentially a non-sustained human microbiome (Rook, 2013; Rook et al., 2014). This means that by increased exposure to natural environments, and thereby biodiverse microbiota, a protective effect against infectious and autoimmune disorders may be achieved (Rook et al., 2015, 2014).

In a recent meta-review of the evidence on associations between human health and natural environments (Hartig et al., 2014) a framework of the various pathways, including both cultural and regulating ESS, was provided. While this article was published no later than 2014, the literature search was conducted in the first half of 2013, and the evidence between pathways and respective health outcomes was not considered. The study design was not firmly aligned to a systematic review method and, for example, the direct health effects of the regulating heat reduction service were not considered in terms of reduced heat related morbidity and mortality. The research area has increased exponentially the latest three to four years, and a plethora of reviews, systematic or not, has emerged since 2013 around health effects of exposure to urban natural environments. These reviews have considered sociobehavioural pathways, regulating ESS, or direct health outcomes respectively. A few have evaluated any health related outcome, i.e. including two or three of the categories (pathways, ESS, or direct health outcomes).

To our knowledge, no previous systematic review of reviews on natural environments and health has been conducted, following a systematic review design. Considering that several reviews, reports, and systematic reviews are now available, some with overlapping themes, it is of value to synthesise the results from those to conclude in which areas evidence is already at hand and for what topics additional systematic reviews are required. In this article, we will approach the topic from an NBS-perspective and will thus focus on the physical, natural environment, rather than the social environment, although those are often related. We aim to establish a specific level of evidence for suggested pathways between any urban natural environment and any pathway or health outcome by conducting a systematic review of systematic reviews, restricting our inclusion criteria to only studies with defined search terms, inclusion criteria, and quality assessments, providing a more precise assessment of what evidence is actually available. By using strict inclusion criteria we aim for as high quality appraisal as possible. The above mentioned criteria – defined search terms, inclusion criteria, quality assessment – are fundamental in any systematic review and without predetermined inclusion/exclusion criteria the review is of lower quality and the interpretation of results is less reliable. Equally, defining search terms and conducting a quality assessments are crucial for the quality of the review. These endpoints are also outlined in the AMSTAR tool for assessing quality in systematic reviews (Shea,