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Review article

Residential green spaces and mortality: A systematic review

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A B S T R A C T

Background: A number of studies have associated natural outdoor environments with reduced mortality but there is no systematic review synthesizing the evidence.
Objectives: We aimed to systematically review the available evidence on the association between long-term exposure to residential green and blue spaces and mortality in adults, and make recommendations for further research. As a secondary aim, we also conducted meta-analyses to explore the magnitude of and heterogeneity in the risk estimates.
Methods: Following the PRISMA statement guidelines for reporting systematic reviews and meta-analysis, two independent reviewers searched studies using keywords related to natural outdoor environments and mortality.
Discussion: Our review identified twelve eligible studies conducted in North America, Europe, and Oceania with study populations ranging from 1645 up to more than 43 million individuals. These studies are heterogeneous in design, study population, green space assessment and covariate data. We found that the majority of studies show a reduction of the risk of cardiovascular disease (CVD) mortality in areas with higher residential greenness. Evidence of a reduction of all-cause mortality is more limited, and no benefits of residential greenness on lung cancer mortality are observed. There were no studies on blue spaces.
Conclusions: This review supports the hypothesis that living in areas with higher amounts of green spaces reduces mortality, mainly CVD. Further studies such as cohort studies with more and better covariate data, improved green space assessment and accounting well for socioeconomic status are needed to provide further and more complete evidence, as well as studies evaluating the benefits of blue spaces.

Contents

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1. Introduction

About half of the world population is currently living in cities and it is projected that by 2030 three of every five persons will live in urban areas (Martine and Marshall, 2007). As the world continues to urbanize, sustainable development and liveability challenges in cities will increase (United Nations Department of Economic and Social Affairs, 2014). Certain environmental factors in urban settings, such as air pollution, noise and extremely high temperatures have been associated with increased mortality (Selander et al., 2009; Basagaña et al., 2011; Hoek et al., 2013). Some studies have suggested that natural outdoor environments might help reduce the levels of air pollution and noise, as well as extreme temperatures in cities, and therefore reduce the impact of these environmental factors on our health and life-expectancy (Shanahan et al., 2015; Wolf and Robbins, 2015). Moreover, studies have observed that people living near or having access to natural outdoor environments are more likely to be physically active and have better mental health and therefore to be healthier (Shanahan et al., 2015; Wolf and Robbins, 2015).

Previously a number of studies have associated natural outdoor environments with reduced mortality (Shanahan et al., 2015; Wolf and Robbins, 2015) but there is no systematic review synthesizing the evidence, nor a precise and global estimate of the reduction of the risk of mortality in adults in relation to these types of environments. These synthesis and estimates are of importance for healthcare professionals and policymakers while translating available evidence into salutogenic interventions and policies to improve public health in urban areas. We aimed to systematically review the evidence of an association between residential natural outdoor environments, particularly green and blue spaces (e.g. lakes, rivers, beaches, etc.), and mortality in adults. As a secondary aim we also conducted meta-analyses to explore the magnitude of and heterogeneity in the risk.

2. Materials and methods

2.1. Search strategy and selection criteria

We followed the PRISMA statement guidelines for reporting systematic reviews and meta-analysis (Moher et al., 2010). The bibliographic search was carried out by two independent reviewers (MG and MTM) using MEDLINE (National Library of Medicine) and SCOPUS search engines using keywords related to natural outdoor environments (greenspace, green space, natural environment, urban design, built environment, blue space, park, forest) combined with keywords related to mortality (mortality, survival, life expectancy). The search was limited to the English language and studies on humans and the last search was conducted on November 11th 2014. Identification and first screening of the articles were performed using the information available in the title and the abstract. Doubts regarding the inclusion or exclusion of studies were resolved by discussion between the two independent researchers. After the first selection, both reviewers read through the articles to decide whether they were eligible or not. We also checked the references of the relevant articles to find other articles following the inclusion criteria.

2.2. Study eligibility criteria and quality of the studies

Following the criteria used in a previous review on green spaces and obesity (Lachowycz and Jones, 2011), the selection criteria were: a) original research article, b) report of mortality in relation to green or blue space exposure, c) the green or blue spaces were measured objectively by use of a satellite system, land cover maps, or an assessment by trained auditors using a consistent tool, d) green or blue space exposure was assigned based on location of residence, e) green or blue space exposure was included as a separate variable within the analysis and results were reported specifically for green or blue space, even if these were not the primary aim of the study. We excluded studies which did not evaluate greenness directly (N = 1) (Donovan et al., 2013) or those reporting only on infant mortality (N = 2) (Lara-Valencia et al., 2012; Kihal-Talantikite et al., 2013).

We evaluated the basic characteristics and quality of the methodology of the studies included in the systematic review by extracting the following data: author, year of publication, country, study design, study population, sample size, exposure assessment, outcome assessment, confounding factors, and other relevant information including information on potential biases (Table 1 and see Supplemental material, Table A). The two reviewers independently worked on data extraction, evaluation of study quality and classification of the evidence. Agreement was reached via consensus. Based on an adapted version of the criteria used in a previous review (Lachowycz and Jones, 2011) (see Supplemental material, Table B) we evaluated the quality of the studies and obtained a quality score (%) for each study (see Supplemental material, Table A).

2.3. Meta-analysis

We limited the meta-analyses to those outcomes of mortality for which at least three studies were available. To conduct the meta-analyses we contacted the corresponding authors of those studies missing essential information (Table 1).

Two different approaches were conducted in which exposure was treated differently. In the first approach we calculated the risk based on a 10% increase of residential greenness (measured as the percentage of green space in an area or as the normalized difference vegetation index [NDVI]). According to the type of exposure (quartiles, IQR or unit increment) used in each study, we conducted different transformation approaches to calculate the effect estimates for an increment of 10% of the exposure. If quartiles of exposure were used in the study we calculated the difference between the mean value of the 1st and the 4th quartiles, considering that the estimated effect was for this difference. In a second step we transformed the effect estimate to obtain a new one based on an increment of 10% of the exposure. If the original study calculated the effect estimate based on the IQR of the exposure we assumed a uniform distribution of the exposure and considered that the increment of 10% of the exposure was equivalent to the IQR divided by 5. We calculated the effect estimate based on this new increment of the exposure. Finally, in those studies where the effect estimate was calculated for each unit increase of the exposure, we calculated the exposure value that corresponded to 10% of the increment with respect to the median of the exposure and calculated the new effect estimate.

In the second approach, in order to obtain risks for a higher contrast of exposure, we calculated the interquartile range increase (i.e. the difference between the first and third quartiles of greenness) as a proxy of the highest vs. the lowest categories of exposure, which in each study might represent different amounts of greenness. Except for one (Tamosiunas et al., 2014), all studies evaluated surrounding greenness – the amount of greenness within a certain distance from the residence – applying land cover maps (LCM) (Hu et al., 2008; Mitchell and Popham, 2008; Richardson and Mitchell, 2010; Richardson et al., 2010, 2012; Mitchell et al., 2011; Lachowycz and Jones, 2014) or the NDVI (Uejio et al., 2011; Villeneuve et al., 2012; Harlan et al., 2013; Wilker et al., 2014). Only one study (Tamosiunas et al., 2014) evaluated access to green spaces – the presence of a green space within a walkable distance from the residence – (Table 1). In this study the exposure was defined as the distance from the residence to the nearest park, and therefore increasing exposure represented living farther from a park (less greenness). We thus turned around the estimate in order to be able to combine the study with the other studies, in which increasing exposure represented more greenness. No studies evaluating the relationship between blue spaces and mortality were found and thus the current work only includes studies evaluating green spaces and mortality.