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Long-term exposure to residential green and blue spaces and anxiety and depression in adults: A cross-sectional study

Mireia Gascon[a,b,c,*], Gonzalo Sánchez-Benavides[d,e], Payam Dadvand[a,b,c], David Martínez[a,b,c], Nina Gramunt[d,e], Xavier Gotsens[d], Marta Cirach[a,b,c], Cristina Vert[a,b,c], José Luis Molinuevo[d,e], Marta Crous-Bou[d,f,**], Mark Nieuwenhuijsen[a,b,c]

[a] ISGlobal, Barcelona, Spain
[b] Universitat Pompeu Fabra (UPF), Barcelona, Spain
[c] CIBER Epidemiología y Salud Pública (CIBERESP), Barcelona, Spain
[d] Barcelonaβeta Brain Research Center - Pasqual Maragall Foundation, Barcelona, Spain
[e] CIBER Fragilidad y Envejecimiento Saludable (CIBERFES), Madrid, Spain
[f] Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston, MA, USA

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ABSTRACT

Background: Although exposure to natural outdoor environments has been consistently associated with improved perceived general health, available evidence on a protective association between this exposure and specific mental health disorders such as depression and anxiety is still limited.
Objective: The aim of this study was to evaluate the effects of long-term exposure to residential green and blue spaces on anxiety and depression and intake of related medication. Additionally, we aimed to explore potential mediators and effect modifiers of this association.
Methods: The study was based on an existing adult cohort (ALFA – Alzheimer and Families) and includes 958 adult participants from Barcelona recruited in 2013–2014. For each participant residential green and blue exposure indicators [surrounding greenness (NDVI), amount of green (land-cover) and access to major green spaces and blue spaces] were generated for different buffers (100 m, 300 m and 500 m). Participants reported their history of doctor-diagnosed anxiety and depressive disorders and intake of related medication. Logistic regression models were applied to assess the corresponding associations.
Results: Increasing surrounding greenness was associated with reduced odds of self-reported history of benzodiazepines [e.g. Odds ratio - OR (95%CI) = 0.62 (0.43, 0.89) for 1-interquartile range (IQR) increase in NDVI in a 300 m buffer] and access to major green spaces was associated with self-reported history of depression [OR (95%CI) = 0.18 (0.06, 0.58)]. No statistically significant associations were observed with blue spaces. Air pollution (between 0.8% and 29.6%) and noise (between 2.2% and 5.3%) mediated a proportion of the associations observed, whereas physical activity and social support played a minor role.
Conclusion: Our findings suggest a potential protective role of green spaces on mental health (depression and anxiety) in adults, but further studies, especially longitudinal studies, are needed to provide further evidence of these benefits and of the mediation role of exposures like air pollution and noise.

1. Introduction

Over the last decade a growing body of literature has provided evidence of the links between natural outdoor environments and improved health and well-being (WHO Regional Office for Europe, 2016). Proposed mechanisms of these health benefits are diverse: a main hypothesis is that the direct contact or viewing of these environments increases stress recovery and attention (restoring capacities). However, previous research also suggests that the presence of green and/or blue spaces reduces exposure to harmful environmental exposures (e.g. air pollution, noise, extreme temperatures) and may contribute to building capacities (e.g. encouraging physical activity and facilitating social cohesion) thereby providing the health benefits observed in many studies (Burkart et al., 2016; Grellier et al., 2017; Hartig et al., 2014;

* Correspondence to: Barcelona Institute for Global Health (ISGlobal), Parc de Recerca Biomèdica de Barcelona – PRBB, C/Doctor Aiguader, 88, 08003 Barcelona, Spain.
** Corresponding author at: Barcelonaβeta Brain Research Center - Pasqual Maragall Foundation, C/Wellington, 30, 08005 Barcelona, Spain.
E-mail addresses: mireia.gascon@isglobal.org (M. Gascon), mcrous@fpmaragall.org (M. Crous-Bou).

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Markevych et al., 2017; Shanahan et al., 2015; Wolf and Robbins, 2015).

One of the main health outcomes evaluated in relation to these natural outdoor environments has been mental health, partly because of the burden that mental disorders represent in our society, particularly depression and anxiety (Alonso et al., 2004; Bloom et al., 2011; WHO, 2013), but also because of the potential of these environments to promote health, including mental health, through the different mechanisms described above. Two recent systematic reviews evaluated the existing evidence of the association between exposure to green (e.g. trees, grass, forests, parks) (Gascon et al., 2015) and blue spaces (e.g. lakes, rivers, coastal water, springs) (Gascon et al., 2017) and mental health. The first systematic review concluded that there was limited evidence for a causal relationship between residential surrounding greenness and mental health in adults, whereas the evidence was inadequate for children and the other exposure indicators evaluated (access to green spaces, quality of green spaces, and blue spaces) (Gascon et al., 2015). The second systematic review, focusing on any blue space exposure (not only residential), also observed limited evidence of the mental health benefits of exposure to blue spaces among adults (Gascon et al., 2017). However, both systematic reviews highlighted the limited number of studies available – most of them of cross-sectional design –, the high heterogeneity in the methodologies used in each study and the few studies exploring the potential mechanisms explaining the associations (Gascon et al., 2017, 2015). Additionally, few studies specifically focused on anxiety and depression and there is a high heterogeneity among them in terms of exposure assessment to green (Araya et al., 2007; Beyer et al., 2014; de Vries et al., 2016; Duncan et al., 2013; Maas et al., 2009a; Melis et al., 2015; Mukherjee et al., 2017; Nutsford et al., 2013; Reklaitiene et al., 2014; Triguero-Mas et al., 2015; Weich et al., 2002) and blue spaces (de Vries et al., 2016; Triguero-Mas et al., 2015).

Using information from an already existing cohort, the aim of the present study was to evaluate the association between long-term exposure to residential green and blue spaces and mental health, particularly anxiety and depression and its related medication, in an adult population residing in Barcelona (Spain). Additionally, we aimed to evaluate the mediation of these associations by air pollution, noise, physical activity and social support and the effect modification by gender and education attainment.

2. Materials and methods

2.1. Study design and population

The study population used for the present cross-sectional analysis and the details of the recruitment of the original cohort, conducted between 2013 and 2014, have been described in details elsewhere (Molinuevo et al., 2016; Vert et al., 2017). Briefly, participants come from the ALFA (ALzheimer and FAmilies) cohort, which aims to understand the natural history of the Alzheimer disease (AD) and to identify risk factors and biological indicators that could contribute to its development. Participant's inclusion criteria were (1) having normal cognition according to study definition, (2) being Spanish and/or Catalan-speaker, (3) aged between 45 and 74 years (4) agreeing with the study procedures and tests, and with the involvement of a close relative who would be implicated in the participant's functional evaluation. Exclusion criteria included (1) cognitive performance falling outside the established cut-offs, (2) having serious health conditions that could interfere with cognition, (3) severe auditory and/or visual disorder, neurodevelopment and/or psychomotor disorder, (4) brain injury, (5) suspected pattern of family history of autosomal dominant AD, (6) major active psychiatric disorders according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) criteria (American Psychiatric Association, 2000), including schizophrenia, dementia, bipolar disorder, current general anxiety disorder or major depression. The reason to exclude subjects with active major psychiatric disorders from the baseline recruitment was because those could affect cognition and mask results regarding the development of AD, which was the main objective of the ALFA parent cohort study (Molinuevo et al., 2016). As described in Molinuevo et al. (2016), from the 3102 volunteers assessed, 2743 subjects met the selection criteria or decided to remain in the study. Out of these, 958 resided in the city of Barcelona and had reliable geocoded data to allow allocating an exposure to them based on the address of residence and were therefore included in this study (Vert et al., 2017). The local Ethics Committee approved the ALFA study, and all subjects and their accompanying close relative signed an informed consent form (Molinuevo et al., 2016).

2.2. Residential exposure to green and blue spaces assessment

We used different indicators of exposure to residential green and blue spaces.

2.2.1. Surrounding greenness

We used the normalized difference vegetation index (NDVI) to define surrounding greenness. The NDVI is an indicator of greenness and is based on land surface reflectance of visible (red) and near-infrared parts of the spectrum (Weier and Herring, 2000). Its values range from − 1 to 1, with higher positive numbers indicating more greenness (i.e. photosynthetically active vegetation). The index was derived from the Landsat 4–5 TM data at 30 m × 30 m resolution. The Landsat 5 imagery data atmospherically corrected was acquired for 26/07/2009 covering Barcelona city area. As we wanted to treat separately the effect of green and blue spaces, and as water bodies are characterized for having NDVI values below 0, we excluded water bodies from the NDVI assessment for surrounding greenness. Since we have observed that other artificial surfaces may also have negative values, we used a land use layer (Urban Atlas) to remove water bodies from the NDVI imagery by means of a “mask”. Afterwards, surrounding greenness was defined based on the NDVI average within 100 m, 300 m, and 500 m buffers around participant's residences.

2.2.2. Amount of green and access to green and blue spaces

We used “Map of Land Covers of Catalonia (2009)” (Centre de Recerca Ecològica i Aplicacions Forestals (CREAF), 2013), which is based on orthophotos with a minimum map unit of 500 m^2 (0.5 ha). The map contains a total of 241 simple covers, which can be hierarchically grouped into different levels. To conduct this study, three green spaces categories were created: *agricultural green*, which included arboreal and herbaceous crops, *forest green*, which included sclerophyllous, deciduous and conifer forests, and *urban green*, which included artificial green areas and urban woodland. *Blue spaces* included continental waters (natural course, lakes, natural and artificial ponds, rivers, reservoir, coastal lagoons) and beaches. Using residential address of the participants, which was reported by them at recruitment (2013–2014), we calculated the hectares of green and blue spaces using buffers typically used in previous studies (Gascon et al., 2015). Based on this information we created the following exposure variables: 1) *amount of green*, which included all the hectares of any green space type within specific buffers (buffers 100 m, 300 m and 500 m), 2) *access to major green spaces*, defined in previous literature as having access to green spaces of at least 0.5 ha in a buffer of 300 m (WHO Regional Office for Europe, 2016) – all three categories of green spaces were included –, 3) *access to blue spaces*, defined as the presence of blue spaces of any type and size represented in the map around the residential address (buffers of 100, 300 m and 500 m). We also created the exposure variables of amount of green and access to major green spaces by type of green space (agricultural, forest and urban green).