



# Green spaces and General Health: Roles of mental health status, social support, and physical activity



Payam Dadvand<sup>a,b,c,\*</sup>, Xavier Bartoll<sup>d,e</sup>, Xavier Basagaña<sup>a,b,c</sup>, Albert Dalmau-Bueno<sup>a,b,c</sup>, David Martinez<sup>a,b,c</sup>, Albert Ambros<sup>a,b,c</sup>, Marta Cirach<sup>a,b,c</sup>, Margarita Triguero-Mas<sup>a,b,c</sup>, Mireia Gascon<sup>a,b,c,f</sup>, Carme Borrell<sup>b,c,d,e</sup>, Mark J. Nieuwenhuijsen<sup>a,b,c</sup>

<sup>a</sup> Centre for Research in Environmental Epidemiology (CREAL), Barcelona, Spain

<sup>b</sup> Universitat Pompeu Fabra (UPF), Barcelona, Spain

<sup>c</sup> CIBER Epidemiología y Salud Pública (CIBERESP), Madrid, Spain

<sup>d</sup> Agència de Salut Pública de Barcelona, Barcelona, Spain

<sup>e</sup> Institut de Recerca Biomèdica Sant Pau (IIB Sant Pau), Barcelona, Spain

<sup>f</sup> ISGlobal, Barcelona Ctr. Int. Health Res. (CRESIB), Hospital Clínic, Universitat de Barcelona, Barcelona, Spain

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## ABSTRACT

Green spaces are associated with improved health, but little is known about mechanisms underlying such association. We aimed to assess the association between greenness exposure and subjective general health (SGH) and to evaluate mental health status, social support, and physical activity as mediators of this association. This cross-sectional study was based on a population-based sample of 3461 adults residing in Barcelona, Spain (2011). We characterized outcome and mediators using the Health Survey of Barcelona. Objective and subjective residential proximity to green spaces and residential surrounding greenness were used to characterize greenness exposure. We followed Baron and Kenny's framework to establish the mediation roles and we further quantified the relative contribution of each mediator. Residential surrounding greenness and subjective residential proximity to green spaces were associated with better SGH. We found indications for mediation of these associations by mental health status, perceived social support, and to less extent, by physical activity. These mediators altogether could explain about half of the surrounding greenness association and one-third of the association for subjective proximity to green spaces. We observed indications that mental health and perceived social support might be more relevant for men and those younger than 65 years. The results for objective residential proximity to green spaces were not conclusive. In conclusion, our observed association between SGH and greenness exposure was mediated, in part, by mental health status, enhanced social support, and physical activity. There might be age and sex variations in these mediation roles.

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## 1. Introduction

Contact with natural environments including green spaces has been associated with improved perceived and objective health outcomes and wellbeing (James et al., 2015). Increasing physical activity, reducing psychological stress, anxiety and depression, increasing social contacts and cohesion and reducing exposure to environmental hazard such as air pollution have been suggested as possible mechanisms underlying health benefits of green spaces (Dadvand et al., 2015; de Vries et al., 2013; Maas et al., 2009; Sugiyama et al., 2008). However, the available evidence investigating mediation roles of these mechanisms and their relative contributions to the observed health benefits of green spaces remains scarce.

Moreover, these mediation roles might vary across strata of sex and age, but the available evidence on such a variation is non-existent. An additional issue that remains unexplored is whether the method applied to characterize greenness exposure (e.g. residential surrounding greenness, objective or subjective residential proximity to green spaces, etc.) could have implications when investigating the underlying mechanisms linking green spaces and health.

The aim of this study was to assess the association between exposure to greenness (including residential surrounding greenness and subjective and objective measures of residential proximity to green spaces) and subjective general health (SGH) and to evaluate mental health status, social support, and physical activity as potential mediators of this association, if any. As secondary aims, we also assessed relative contributions of aforementioned mediators to greenness exposure-SGH association and evaluated the variations in their mediating roles across strata of age and sex.

\* Corresponding author at: CREAL, Doctor Aiguader, 88, 08003 Barcelona, Spain.  
E-mail address: [pdadvand@creal.cat](mailto:pdadvand@creal.cat) (P. Dadvand).

## 2. Methods

### 2.1. Study setting

This cross-sectional study was based on data obtained from a population-based randomized sample of adults residing in Barcelona, Spain. The data was collected in the context of the 2011 Barcelona Health Survey aimed to study the health status, life-styles and use of health services among Barcelona residents (Bartoll et al., 2011). A face-to-face interview survey by trained interviewers was conducted at the residential place of a sample of 4000 people residing across the 10 districts of Barcelona. The subjects were randomly selected from the Barcelona municipal register of residents in a way to represent the age and sex structure of districts. An invitation letter was sent to selected subjects, informing them about the objectives of the survey and asking them to participate. In total 9969 persons were contacted to attain planned sample size of 4000 participants (i.e. response rate of 43%). The non-responders (those who refrained from participating in the study or could not be approached after five visits to their homes) were substituted by randomly-selected persons of same district, age and sex. For this study, we limited the participants to those with age  $\geq 18$  years resulting in 3461 adults being included in our analyses.

Barcelona is a port city of 1.6 million inhabitants situated on the North-eastern part of the Iberian Peninsula. It has a Mediterranean climate characterized by hot and dry summers, mild winters, and maximum precipitation and vegetation during autumn and spring.

### 2.2. Questionnaire data

The data on the outcome (SGH), mediators (mental health status, perceived social support, and physical activity), and relevant socio-demographic covariates were obtained from the Barcelona Health Survey questionnaire.

#### 2.2.1. Subjective general health

In order to characterize SGH, we asked participants: "In general, would you say that your health is..." with possible responses being: excellent/very good/good/moderate/bad (Ware and Sherbourne, 1992). The answers were dichotomized with cut-off at "less than good", following the same methodology used in previous studies (Maas et al., 2006; Triguero-Mas et al., 2015). We considered "less than good" answers as the reference category, therefore a positive association between greenness exposure and this variable could be interpreted as better SGH.

#### 2.2.2. Mental health status

Participants answered the twelve questions of the General Health Questionnaire (GHQ-12) (Goldberg, 1978). GHQ-12 has been reported to be a valid and reliable tool for screening non-psychotic psychiatric problems (i.e. mental health status) in the Spanish population (Sánchez-López and Dresch, 2008). The general score was dichotomized with those having a general score  $\geq 3$  being classified as being at risk of psychiatric problems following the methods described by Goldberg (Goldberg, 1978). We considered being at risk of psychiatric problems as the reference category; therefore, a positive association between greenness exposure and this variable could indicate better mental health status.

#### 2.2.3. Perceived social support

Participants answered the eight questions of the Duke-UNC Functional Social Support Questionnaire (FSSQ) (Broadhead et al., 1988). This questionnaire covers two dimensions of social support: the confidant support reflecting availability of people with whom one can share important life issues and concerns and receive advice and support, and emotional support characterizing expressions of

love, affection, esteem, and etc. The Duke-UNC FSSQ has been shown to have an adequate validity and reliability for the Spanish population to assess social support (Bellón Saameño et al., 1996). The questionnaire was scored based on the Duke-UNC FSSQ guidelines (Bellón Saameño et al., 1996). The distribution of scores was skewed. We therefore dichotomized the score using the 75th percentile (based on the scores of all participants) as the cut-off. We considered a score less than 75th percentile as the reference category, therefore a positive association between greenness exposure and this variable could indicate stronger perceived social support.

#### 2.2.4. Physical activity

Participants answered the seven questions of the International Physical Activity Questionnaire (IPAQ-Short version) (Craig et al., 2003). The IPAQ has been reported to have an acceptable validity and reliability for the Spanish population (Roman-Viñas et al., 2010). We developed a binary variable indicating whether the participant could be considered as having moderate or high physical activity levels based on the IPAQ guidelines (i.e. moderate/high vs. low levels of physical activity) (IPAQ Research Committee, 2005). We considered low physical activity level as the reference category, therefore a positive association between greenness exposure and this variable could be interpreted as more likelihood of achieving moderate to high levels of physical activity.

### 2.3. Greenness exposure

We characterized greenness exposure using three indicators: residential surrounding greenness and objective and subjective residential proximity to green spaces.

#### 2.3.1. Residential surrounding greenness

Our assessment of residential surrounding greenness was based on Normalized Difference Vegetation Index (NDVI) obtained from the NASA's Earth Observing System Data and Information System (EOSDIS) website. NDVI is an indicator of greenness based on land surface reflectance of visible (red) and near-infrared parts of spectrum (Weier and Herring, 2011). It ranges between  $-1$  and  $1$  with higher numbers indicating more photosynthetically active greenness. We generated our NDVI map using the image obtained on 5 July 2013 by the Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) at  $30\text{ m} \times 30\text{ m}$  resolution. Surrounding greenness was abstracted as the average of NDVI in buffers of 100 m, 250 m, and 500 m (Dadvand et al., 2012a,b,c; Lovasi et al., 2011; Markevych et al., 2014) around the main home address of each study participant, which was geocoded according to the address where the interviews were conducted.

#### 2.3.2. Residential proximity to green spaces

We used proximity to green spaces as a surrogate for access to green spaces (Expert Group on the urban environment, 2001). We assessed both subjective (perceived) and objective residential proximity to green spaces.

**2.3.2.1. Subjective residential proximity to green spaces.** The participants answered the question (yes/no) whether they have a park within 10 min walk from their home.

**2.3.2.2. Objective residential proximity to green spaces.** To define green spaces we utilized the Parks and Garden Map of Barcelona (Parcs i Jardins de l'Ajuntament de Barcelona, 2013) developed by the Barcelona city council. Based on the European Commission recommendation on access to green spaces, we constructed a binary variable (yes/no) indicating whether the participant's home address was within 300 m of a major green space, defined as a green space with an area  $\geq 5000\text{ m}^2$  (Expert Group on the urban environment, 2001).

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