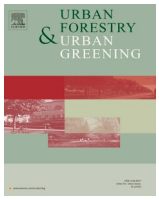
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Urban Forestry & Urban Greening 68 (2022) 127457

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug



Original article

Spatial statistical analysis of the relationship between self-reported mental health during the COVID-19 lockdown and closeness to green infrastructure

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ARTICLE INFO

Handling Editor: Wendy Chen

Keywords:
COVID-19
Green infrastructure
Lockdown
Mental health
Urban planning

ABSTRACT

The COVID-19 pandemic has produced alterations in the behaviour and psychological health of people, who have had to learn living under uncertain circumstances escaping their control. This situation has been aggravated in those countries applying strict home confinement rules to try bending their epidemic curve. This is the case of Spain, where the stringent lockdown period was extended over three months. This study aimed at proving a research hypothesis whereby living close to Green Infrastructure (GI) during the confinement period was beneficial for mental health. To this end, La Palma (Canary Islands) and Zaragoza (Peninsular Spain) were taken as case studies, since both locations distributed a questionnaire to address citizenry's self-reported mental health under strict lockdown conditions. A spatial statistical analysis of the responses collected by these questionnaires revealed that variables such as stress, anger, medication use, alcohol consumption or visits to the doctor significantly decreased if citizens were close to GI, whereas people having very high expectations of enjoying the city after the confinement were positively correlated to proximity of green areas. Although these outcomes are limited by the inferential capacity of correlation analysis, they point out to a sense of relief derived from having visual contact with vegetated landscapes and feeling stimulated about using them for recreation, aesthetical or sporting purposes. The joint consideration of these psychological gains with the social and environmental benefits provided by GI emphasizes the importance of approaching urban regeneration through the design and implementation of interconnected green spaces.

1. Introduction

The hectic lifestyle common in many cities across the globe, especially in a context of increasing urban sprawl, has boosted the study of the social and emotional benefits provided by Green Infrastructure (GI) throughout this century (Arnberger and Eder, 2015; Reyes-Riveros et al., 2021). The concept of GI is usually referred to different land covers, including open areas of vegetation (parks, sport facilities), gardens, forests, crop zones or pastures (Rusche et al., 2019). The interest in exploring this role of GI has been exacerbated by the Coronavirus SaRS-CoV-2 (COVID-19) pandemic, whose impacts have caused serious alterations in the mental health and morale of many citizens, especially during the 2020 lockdowns (Cheung and Ip, 2020).

Despite their epidemiological effectiveness to attenuate past and present waves, lockdowns have resulted in isolation, stress, depression or anxiety (Salari et al., 2020). Unlike physical needs, which can be satisfied outside green areas (Erdönmez and Atmiş, 2021), the relevance of GI in terms of mental health has been emphasized in recent studies such as Dushkova et al. (2021), where the limited access of people to green spaces produced by lockdowns was found to have negative psychological effects. This is aligned with the conclusions drawn by Venter et al. (2020) and Geng et al. (2021), who highlighted a significant increase in the recreational use of green areas under flexible confinement conditions. These findings were further ratified by da Schio et al. (2021), who argued that the value attributed to GI has increased during the pandemic.

Although the benefits entailed by GI are diluted under stringent lockdown circumstances due to accessibility restrictions, there is still room to carry out indoor activities aimed at engaging the senses through contact with nature. In this vein, a recent study by Theodorou et al. (2021) proved that gardening activities were associated with lower psychopathological distress during the lockdowns. Still,

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https://doi.org/10.1016/j.ufug.2021.127457
Received 21 June 2021; Received in revised form 2 December 2021; Accepted 28 December 2021
Available online 30 December 2021

Berdejo-Espinola et al. (2021) suggested that people with access to a backyard were more likely to increase their use of green spaces during the COVID-19 pandemic restrictions. Therefore, although gardening can help citizens build a sense of connectedness with GI, backyards would not be enough to replace the time spent in green spaces during stringent lockdowns.

Despite these findings, people living in homes without outdoor spaces can be particularly vulnerable, especially if they lack access to public green spaces within a 5-minute walk (Hubbard et al., 2021), because being close and/or having visibility of these spaces may reduce psychological distresses (Nutsford et al., 2016; Spano et al., 2021). Under this premise, Larcher et al. (2021) prepared an online questionnaire to capture people's perceptions on close green urban areas in Italy during the COVID-19 pandemic. Their results indicated that most respondents had recurrent or pressing need for GI, as well as an increased interest in visiting these areas as the first place to go at the end of the lockdown.

Italian cities were also used as case studies in a survey designed by Ugolini et al. (2021) to assess GI usage during the COVID-19 lockdown. The authors found a feeling of deprivation in those respondents without access to green areas, a fact that was exacerbated by aspects such as distance to GI or the lack of green views from their windows. A similar approach was taken by Pouso et al. (2020), who distributed an online questionnaire to analyse the association between lockdown conditions and contact with blue-green areas. The responses suggested that having access to private gardens and views of natural spaces was related to fewer symptoms of depression and anxiety. The results achieved by Soga et al. (2021) in Japan were also on the same page, highlighting the relationship between green window views and increased self-esteem, life satisfaction and subjective happiness, as well as with decreased depression, anxiety and loneliness.

These studies provide evidence of the interest in studying the effect of connectedness with GI on mental health-related variables under stringent lockdowns. However, they are based on questionnaires whose scope is specifically oriented to address the impact of GI on the psychological condition of the addressees. In consequence, the responses collected might be induced to some extent by the orientation of the surveys (Choi and Pak, 2005), whose design can be biased towards demonstrating the benefits of being in contact with green spaces.

In addition, previous investigations rely on the perceptions of the respondents about their relationship to GI; however, there is a lack of works accounting for the quantitative closeness to these areas and its effect on mental health. Considering all the existing different forms of GI, several studies have pointed out to the uneven spatial distribution of green spaces across urban dwellers (Levinger et al., 2021; Uchiyama and Kohsaka, 2020).

As a response to both issues, the overarching aim of this research was to demonstrate the positive effect of closeness to GI on mental health during stringent lockdown conditions. This was carried out by evaluating generic questionnaires aimed at collecting responses concerning the psychological and behavioural status of citizens. The processing of such responses was undertaken through a methodology to compute closeness to GI with the support of Geographic Information Systems (GIS) and statistical packages. The proposed approach was tested using the case studies La Palma and Zaragoza as representatives of the Spanish strict lockdown period. This geographic coverage resulted in a secondary objective consisting of shedding light on the interactions between the COVID-19 pandemic and GI under different social, cultural and economic contexts, in order to prove the validity of the methodology to be used elsewhere.

2. Methodology

A methodology to model the relationship between self-reported mental health-related variables under stringent lockdown circumstances and closeness to GI was conceived as depicted in Fig. 1. Because of its openness in terms of software and data requirements, the proposed approach can be easily replicated elsewhere as long as a survey aimed at accounting for the psychological condition of citizens during a strict confinement is available. Otherwise, information about land cover types and administrative boundaries can be obtained at a global scale via open-source initiatives such as Copernicus (2021) and OpenStreetMap (2021).

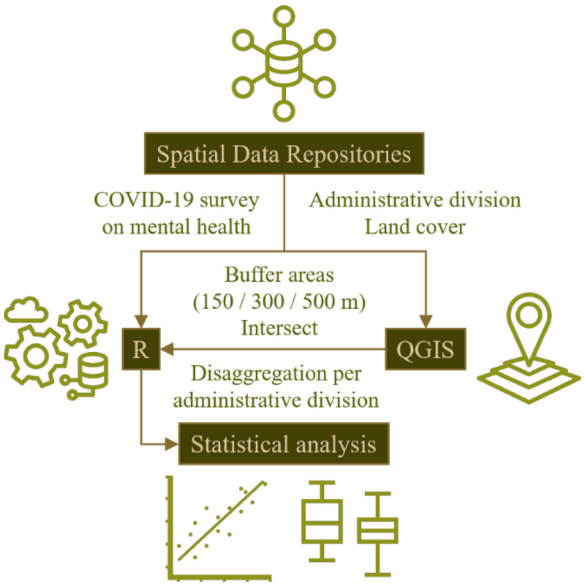


Fig. 1. Flowchart to model the association of self-reported mental health during the COVID-19 lockdown with closeness to Green Infrastructure (GI).

2.1. Case studies

A secondary objective of this research was to get insight into how the COVID-19 pandemic has affected societies living in different territories. In this line, to quantify the potential links between mental health and proximity to GI under home confinement conditions, two Spanish case studies were evaluated, as illustrated in Fig. 2: the island of La Palma, in the Autonomous Community of the Canary Islands, and the city of Zaragoza, in the Autonomous Community of Aragon.

Both places have different geographical specifics, socio-spatial dynamics and economic and population characteristics, thus presenting a high degree of complementarity for their comparative study. In both cases, massive surveys focused on addressing the self-reported mental and behavioural condition of the citizens were carried out during the period of maximum restriction of the COVID-19 pandemic. These surveys aimed at accounting for the psychological impacts caused by the strict confinement on the population. The selection of these two case studies was due to data availability, since they were the only Spanish regions disaggregating the results from self-reported mental health questionnaires according to the location of the respondents.

Regarding the inputs required for the analysis, Table 1 summarises the main datasets used to analyse each case study, arranged according to three domains: territory, mental health and GI. La Palma is an island of 708 km^2 with a population of 84,800 inhabitants in 2020, whereas Zaragoza is one of the largest cities in Peninsular Spain, with 974 km^2 of extension and more than 670,000 inhabitants (Instituto Nacional de Estadística, 2021). La Palma, considered an overseas territory of the European Union, is part of the Archipelago of the Canary Islands (Fig. 2). Due to its isolation in comparison with other regions, more than 35 % of the surface can be declared as GI (protected natural spaces in the form of parks, reserves, natural monuments, protected landscapes or sites of scientific interest). This amounts to 25,000 ha, which means a ratio of 0.299 ha of GI per inhabitant.

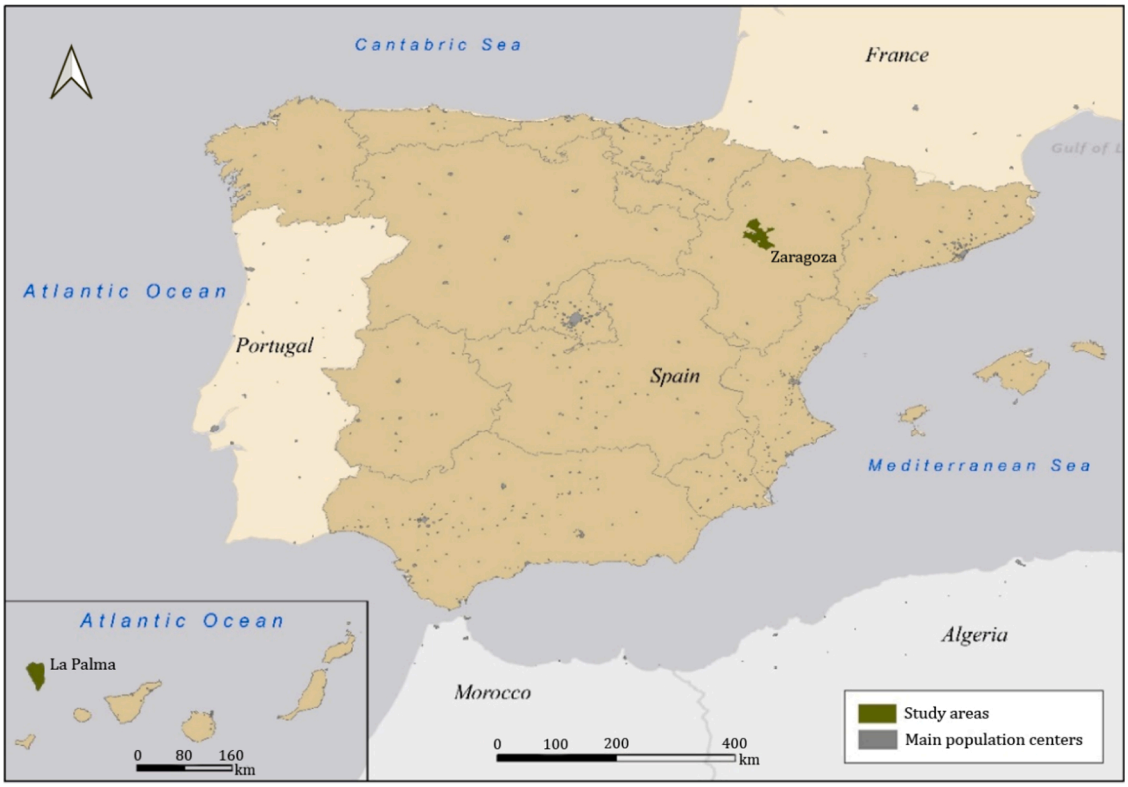


Fig. 2. Situation map of the case studies: La Palma and Zaragoza.

The conditions of Zaragoza are significantly different, since it is the fifth most populous city in Spain. Its geographical and connectivity characteristics makes it one of the most relevant urban nuclei in the Iberian Peninsula (Fig. 2). The surface covered by GI across the city amounts to approximately 26,900 ha, which are distributed throughout an interconnected network of urban and rural spaces with natural, agricultural or landscaped vegetation. Amongst them, there are wetland areas and river courses, mountains, forest stands and green areas within the city. As a result, Zaragoza presents a ratio of 0.040 ha per inhabitant. Therefore, the territorial characteristics of both case studies notably differ from each other, which emphasizes their suitability for representativeness purposes.

As for the mental health domain, in the case of La Palma, data was available at a public website providing official information on the COVID-19 situation in the island (Cabildo La Palma, 2021). The psychological and behavioural situation of the citizens were assessed from the responses collected through a self-reported questionnaire designed by Oliver et al. (2020). The aim of the island council with this survey was to get insight into the reality of the citizenship during the confinement period, in order to improve decision-making and contribute to palliating the effects of the pandemic more efficiently.

This initiative was promoted through social media, receiving a great acceptance that crystallised in the participation of 5,939 citizens from 2020-04-21 to 2020-05-05. The survey started by asking for some basic data such as consent for participation, municipality of residence and postal code, age range, sex and household situation. The information collected in this section enabled the spatial aggregation of La Palma's data according to its 14 municipalities.

In addition to addressing other factors like economy, labour mobility or digital divide, the questionnaire included a section focused on the self-reported health of the participants. The mental health variables considered were increase in stress, sadness, loneliness and anxiety, as well as behavioural changes possibly related to emotional problems such as increase in alcohol consumption, food intake, use of technologies, domestic violence, medication use and visits to the doctor. Participants had to state whether they had perceived an increase in any of the variables addressed by responding to questions such as "Have you noticed a significant increase in stress?". To this end, they could choose among two options: 0 and 1. Zero meant that the participant did not notice any increase in respect of the abovementioned variables, and vice versa for 1.

An English translation of the aspect of the initial and health sections of the questionnaire, as well as the responses collected through its distribution can be consulted in Appendix A. Apart from the information obtained through the questionnaire, the data corresponding to closeness to GI was extracted from the most recent version of the Corine Land Cover (CLC) map (European Union, Copernicus Land Monitoring Service, 2021a) by considering a series of land cover classes related to GI.

Instead, the data used for Zaragoza was obtained from the Geoportal of Zaragoza (IDEZAr) (Ayuntamiento de Zaragoza, 2021), which also developed a questionnaire on the life conditions, perceptions and self-reported emotional status of the citizens during the COVID-19 confinement. This questionnaire, which was developed from 2020-03-15 to 2020-06-21, was prepared by the city council of Zaragoza to collect the vision of its citizens regarding the effect of the confinement measures on their daily lives by gaining knowledge about their emotional situation, state of health, needs and expectations. The collection of this information was aimed at facilitating decision-making and contribute effectively to alleviating the effects of the COVID-19 crisis.

The questionnaire was addressed to people over 16 years residing in Zaragoza. The respondents had to choose among multiple options to express their personal perceptions according to a Likert scale. For instance, these options were very low, low, medium, high and very high for the question "Rate your expectations of enjoying the city after the lockdown". The scale was the same for level of anger, whereas mood was valued using the following options: very bad, bad, fair, good or very good. The responses collected were summarised as the number of people per neighbourhood who chose each option.

Closeness to GI was directly provided as binary measures indicating

Table 1
Datasets used for characterising the case studies under analysis.

Domain	Data	La Palma	Zaragoza
Territory	Administrative division	14 municipalities	34 neighbourhoods
	GI per capita (ha per inhabitant)	0.299	0.040
	Area (km^2)	708	974
	Population (inhabitants)	84,800	670,000
Mental health questionnaire	Participants	5,939	3,944
	Sex	62.62 % women; 37.38 % men	More than 53 % women
	Age range:	12.05 % 21−29 yr.; 23.57 % 30−39 yr.; 32.19% 40−49 yr.; 23.08% 50−59 yr.; 7.65% 60−69 yr.; 1.46% 70−79 yr.	More than 50 % 16−49 yr.
	People per household:	7.98 % 1; 28.23 % 2; 27.84 % 3; 25.79 % 4; 10.16 % 5	Most > 1; 20 % > 4
	Variables	Increase in: alcohol consumption, stress, medication use, visits to the doctor, food intake, domestic violence, use of technologies, sadness, loneliness and anxiety	Expectations of enjoying the city after the lockdown, level of anger, mood
	Measurement	Binary (No: 0; Yes: 1)	Rating scales (Very low/Very bad; Low/Bad; Medium/Fair; High/Good; Very high/Very good)
	Format	.xlsx	.shp
Closeness to Green Infrastructure (GI)	Measurement	Corine Land Cover (2018) classes assimilable to GI	Presence (1) or absence (0) of GI 150, 300 and 500 m away within each neighbourhood
	Format	.shp	.json

either the presence or absence of green areas 150, 300 and 500 m away from the residential blocks located within each neighbourhood. An English translated version of these data, as well as the synthetised responses of the citizens to the survey are provided in Appendix B. The methods used to couple GI-related distances with the self-reported psychological and behavioural inputs collected is detailed below.

2.2. Spatial analysis

The proposed methodology started with the spatial processing of the data summarised in Table 1. Fig. 3 depicts the spatial tasks carried out in the format of the Model Designer available at the 3.16 version of QGIS (QGIS Development Team, 2021). This scheme represents a generic scenario fitting the specifics of La Palma, where the only input required is a questionnaire designed to address self-reported mental health-related variables, including a disaggregation per administrative division. Hence, some of the steps represented in Fig. 3 can be omitted if data repositories provide any of the intermediate outputs straightforwardly, as in the case of Zaragoza (Table 1).

The first step consisted of creating buffer areas around those land cover types identified as GI. Based on the proposal made by Rusche et al. (2019) and the breakdown defined in the CLC project, the consideration of GI included the following classes: artificial, non-agricultural vegetated areas (1.4), arable land (2.1), permanent crops (2.2), pastures (2.3), heterogeneous agricultural areas (2.4), forest (3.1) and shrub and/or herbaceous vegetation associations (3.2). The CLC was used as a

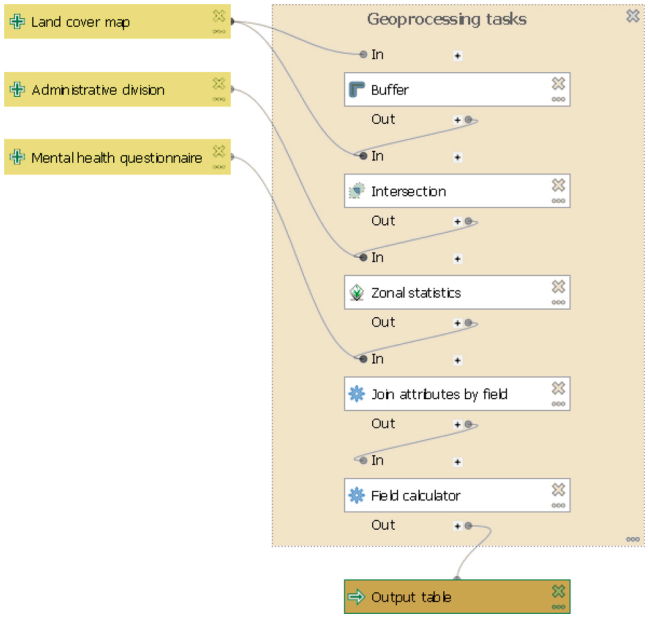


Fig. 3. Geoprocessing tasks for the modelling of self-reported mental health and Green Infrastructure (GI) variables.

baseline due to its availability at a European scale; however, other alternatives such as the Urban Atlas (European Union, Copernicus Land Monitoring Service, 2021b) have an almost direct correspondence with the classification of the CLC. These buffer areas were set at 150, 300 and 500 m, in order to replicate the conditions of the data provided by the city council of Zaragoza.

Then, the buffer areas associated with GI were intersected with a new selection corresponding to the CLC class that accounts for urban fabric occupied by dwellings and buildings (1.1). Although this class is not an exact indicator of population density, it is the only category in the CLC that includes items such as residential buildings, permanent residential built-up areas, residential suburbs or areas of multi-flat or multi-storey houses. Therefore, its combination with the GI-related classes was deemed appropriate to determine people's closeness to green spaces by calculating the ratio of intersected area to the whole area covered by each municipality in La Palma.

Once the different degrees of proximity to GI were computed as new fields, they were joined with the disaggregated results of the questionnaire in psychological and behavioural terms. Fig. 4 exemplifies this process using a buffer area of 300 m and increase in stress as a mental health-related variable.

In the case of Zaragoza, the intersection step was replaced by counting the number of sites within each neighbourhood that were 150, 300 or 500 m away from GI. Since each of these spots included a binary codification to indicate whether they had access to GI (0) or not (1), next was aggregating the resulting values per neighbourhood. Finally, the ratio of population being close to GI was determined through the division of the sum of spots having access to GI by the total count of sites included within each neighbourhood. Fig. 4 refers these tasks to the graphical representation prepared for the generic case of La Palma, using level of anger as psychological indicator. The outputs produced in both cases were ready to be examined through a statistical analysis in the next step of the methodology.

2.3. Statistical analysis

The statistical analysis was carried out using R 4.1.0 (R Core Team, 2020) through the following packages: foreign (R Core Team et al., 2020), Hmisc (Harrell and Dupont, Charles, 2021), ggplot2 (Wickham et al., 2021, p. 2), extrafont (Chang, 2014), fabricatr (Blair et al., 2021)

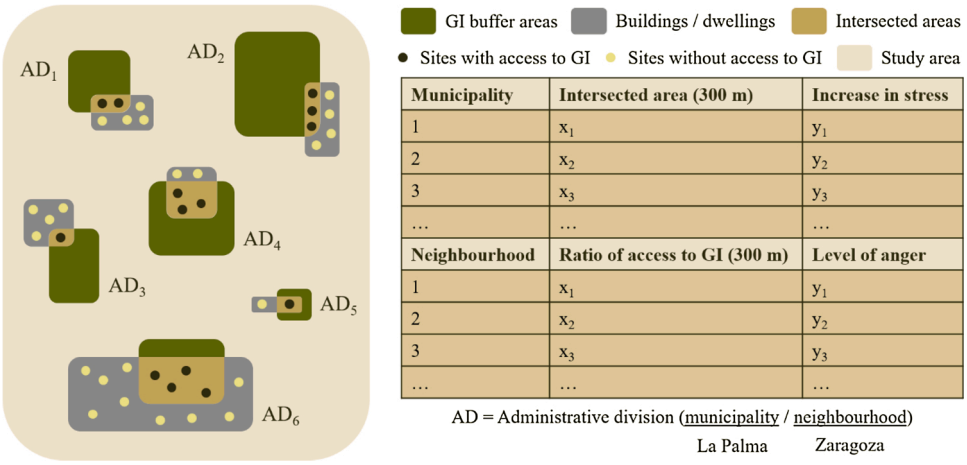


Fig. 4. Scheme of the tasks required to couple closeness to Green Infrastructure (GI) with self-reported mental health variables.

and car (Fox et al., 2021). First was calculating the degree of association between GI and self-reported mental health-related variables through a correlation analysis. As a result of the spatial analysis, the variables to be modelled represented continuous data in the form of areas or ratios. As such, this first part of the analysis was undertaken with the support of the Pearson's correlation coefficient (Schober and Schwarte, 2018).

The existence or absence of correlation among variables was measured according to the p-value, which represents the probability of wrongly rejecting a null hypothesis (H_0) when it is true (Nickerson, 2000). To this end, the p-value was compared with a significance level (α) of 0.05 (Fisher, 1992). In this context, H_0 concerned the lack of a statistically significant correlation between closeness to GI and mental health-related variables, and vice versa for the alternative hypothesis (H_1). Consequently, H_1 was accepted in those cases in which the p-value was below 0.05, indicating the presence of statistically significant relationships.

To further confirm the trends detected through the correlation analysis, inferential statistics were applied to prove whether proximity to GI can produce statistically significant differences in the mental health and behavioural response of urban dwellers or not. Given the sample size of the datasets used, this step was only carried out for the case study of Zaragoza, where the GI-related variables were split into two groups according to their medians. These two groups accounted for neighbourhoods with low and high closeness to GI, respectively. The use of inferential statistics consisted of the application of different tests to compare both groups. The specific test to use depended on whether the datasets met the assumptions of normality and homoscedasticity.

The former was checked using the Shapiro-Wilk test, which is particularly suitable for small sample sizes (Ghasemi and Zahediasl, 2012). If the p-value was above the significance level, then the data followed a normal distribution and H_0 could be accepted. Homoscedasticity was verified through the Levene's test, which assesses the equality of variances for a variable split into two or more groups (Gastwirth et al., 2009). In case H_0 was also met, the data could be assumed to be homoscedastic and, therefore, the Student's *t*-test was applied (Gosset, 1908). A p-value below 0.05 was an indicative of the presence of statistically significant differences between mental health-related variables and proximity to GI. In contrast, if any of the two assumptions was violated, the Mann-Whitney-Wilcoxon test (Mann and Whitney, 1947) was computed to carry out pairwise comparisons among the variables under study.

3. Results

This section presents the main results achieved through the application of the methodology designed to analyse the spatial relationships between closeness to GI and different variables accounting for the self-reported mental health and behavioural condition of citizens during the COVID-19 stringent lockdown period. The analysis of the outputs obtained is split into two parts according to the case studies under consideration, thereby enabling the assessment of its effectiveness under different conditions in terms of territorial characteristics and data availability.

3.1. Case study 1: La Palma

Data availability in La Palma required the complete data processing described in Fig. 3. As indicated in Fig. 4, the proportion of population having access to GI in each municipality was determined by creating buffer areas 150, 300 and 500 m away from the urban fabric (class 1.1 in the CLC) in each municipality. Then, they were intersected with GI-related CLC classes to obtain the ratio of population having green spaces within the buffer areas. Fig. 5 shows the disaggregation of La Palma into municipalities and the different buffer areas used to explore the relationship between closeness to GI and mental health-related variables.

The information taken from the questionnaire was processed to obtain the proportion of surveyed people in each municipality who experienced increases regarding the variables listed in Table 1 during the strict lockdown period. These variables, which concerned the mental and behavioural alterations caused by the confinement on the addressees, were modelled with respect to their closeness to GI using the Pearson's correlation coefficient (r). The statistically significant correlations found across the variables are shown in Fig. 6.

These results revealed that increase in alcohol consumption was strongly and inversely correlated to closeness to GI. Considering the negative correlation coefficients obtained, lacking GI near one's place of residence can be concluded to promote an increase in alcohol consumption and, therefore, a deterioration of the emotional stability of citizens. The other statistically significant relationship concerns the negative association between increase in stress and the existence of nearby green spaces. In this case, the closer GI, the stronger this correlation.

In the case of visits to the doctor, the greater the distance to GI, the stronger the correlation coefficient. On the contrary, being close to GI did not cause significant effects on food intake, domestic violence, use of technologies, sadness, loneliness and anxiety. Moreover, although proximity to GI may reduce stress and promote better lifestyle, these gains were found not be enough to counteract the remaining aspects that cause an anxiety episode.

As a complement to the analysis summarised in Fig. 6, the relationship between the Socio-Economic Status (SES) and the aforementioned

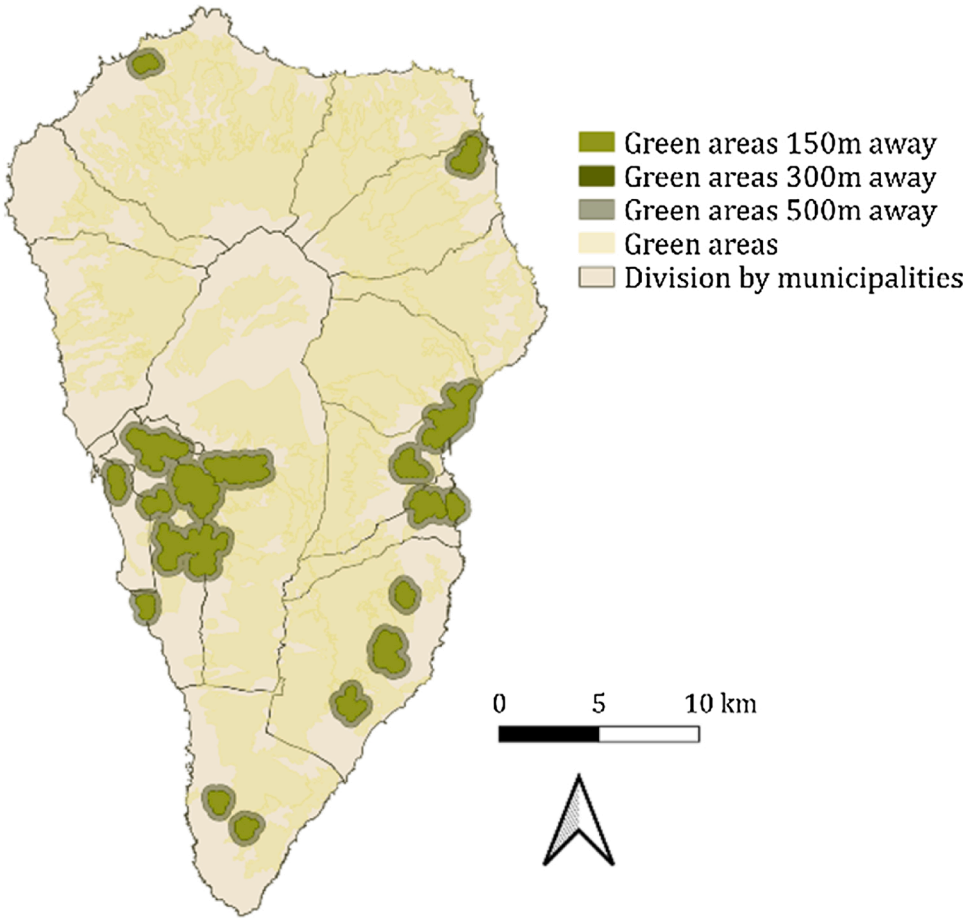


Fig. 5. Spatial breakdown of La Palma into municipalities and buffer areas indicating closeness to Green Infrastructure (GI).

variables was evaluated. This kind of associations have been frequently addressed in the literature. Ahnquist et al. (2012) showed that both economic hardships and social capital contribute to a range of different health outcomes. Another recent study (Wang and Geng, 2019) revealed that SES could affect people's physical health, but not their psychological condition. Hence, to prevent the inclusion of any bias in the outcomes, the effect of SES on the variables directly affected by nearness to GI was also evaluated.

SES was quantified using the value of tax return for each municipality in 2018, which is the last year reported by the Spanish Tax Agency (Agencia Tributaria, 2021). The analysis demonstrated that the effect of SES was statistically significant for increase in medication use ($r = -0.829$; p-value $= 0.025$). Nevertheless, it was irrelevant for increase in alcohol consumption (p-value $= 0.967$), stress (p-value $= 0.205$) and visits to the doctor (p-value $= 0.487$). Therefore, unlike these variables, which were proved to be unrelated to socioeconomic considerations (p-values > 0.05), the effect of proximity to GI cannot be affirmed to be the determining cause of an increase in medication use.

3.2. Case study 2: Zaragoza

Zaragoza's specifics enabled testing a case study where data had undergone some spatial pre-processing, as specified in Fig. 4. Fig. 7 depicts the spatial arrangement of the neighbourhoods used to disaggregate the responses collected from the COVID-19 questionnaire, as well as a layer indicating the different spots where proximity to GI was measured. This layer was associated with an attribute table containing the location of these spots and the presence or absence of GI 150 / 300 / 500 m away. For the sake of representativeness, Fig. 7 only depicts the situation for GI at 150 m distance. Hence, a value of 1 indicated that GI in the form of either urban parks, vegetated areas or natural areas is 150 away from each point, and vice versa for 0. This information enabled omitting the processing of a land cover map to determine closeness from residential areas to green spaces (Fig. 2).

The tasks preceding the statistical analysis were limited to the processing of the GI-related layers with the support of zonal statistics. First was counting the points indicating closeness to GI per neighbourhood, as well as the sum of their associated values (1 s and 0 s). Then, the ratio of locations close to GI was computed by dividing the values of sum by those of count in each neighbourhood. This process yielded the percentage of dwellers having either urban parks, vegetated areas or natural areas less than 150, 300 or 500 m away.

An inspection of the results of the questionnaire revealed that the number of responses collected was too low in some neighbourhoods. To deal with these cases, the sum of responses per level in the five-point scales was calculated to obtain the total number of participants per neighbourhood. The resulting values suggested that 8 was a minimum threshold to achieve representative results in statistical terms. In consequence, those neighbourhoods where the number of responses gathered was below 8 were discarded from next steps.

Once all the datasets were prepared, they were further processed using R, which enabled looping throughout all the potential combinations of distance to GI and self-reported mental health or behavioural variables. The results of applying the Pearson's correlation coefficient revealed that the expectations of enjoying the city after the lockdown, level of anger and mood of the respondents were correlated to 9, 9 and 1 combinations of distance and type of GI. If the response to the survey was declared constant (e.g., very high expectations of enjoyment), the strength and direction of its relationships to different distances of the same type of GI (e.g., vegetated areas 150 / 300 / 500 m away) were

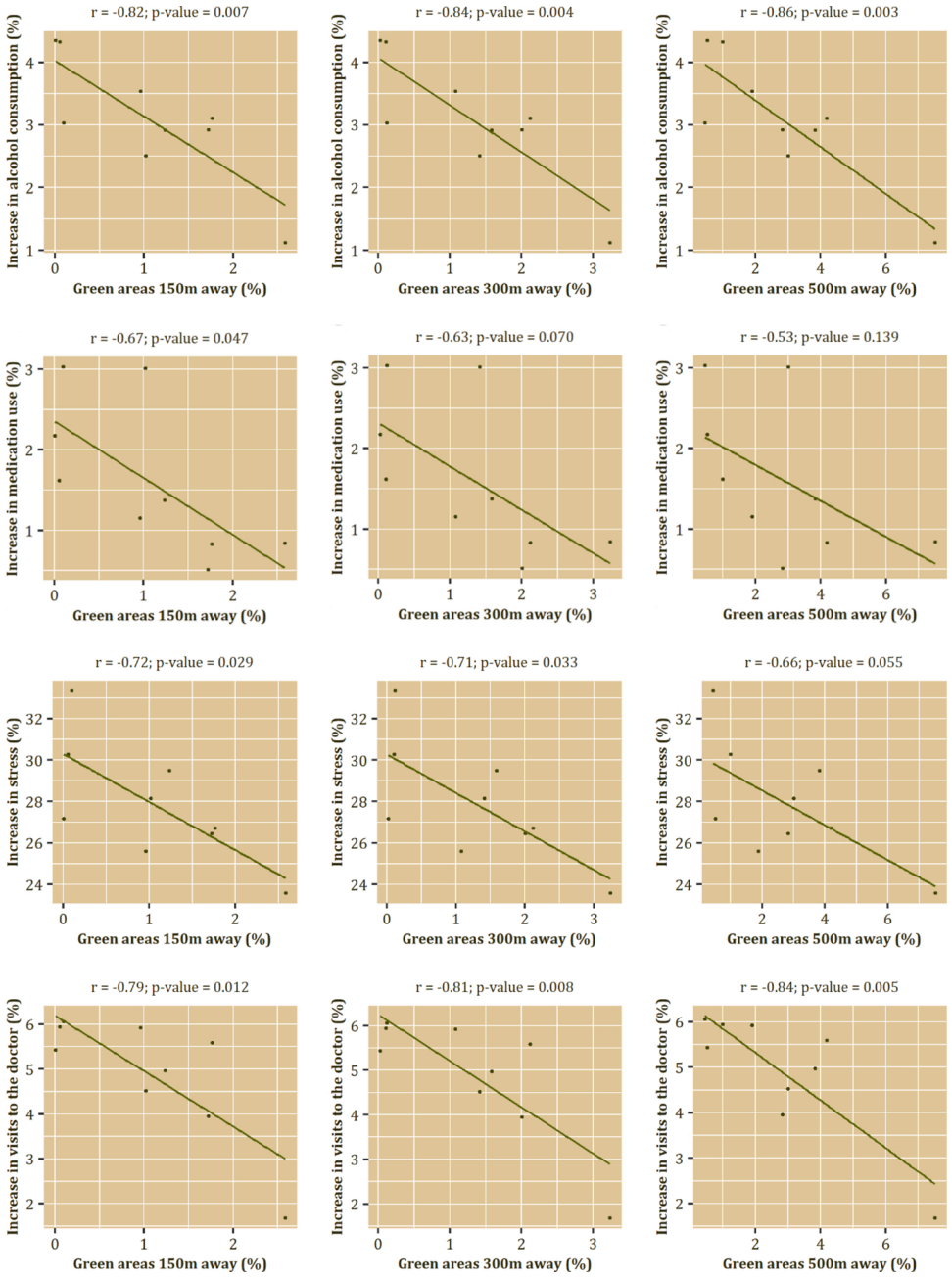


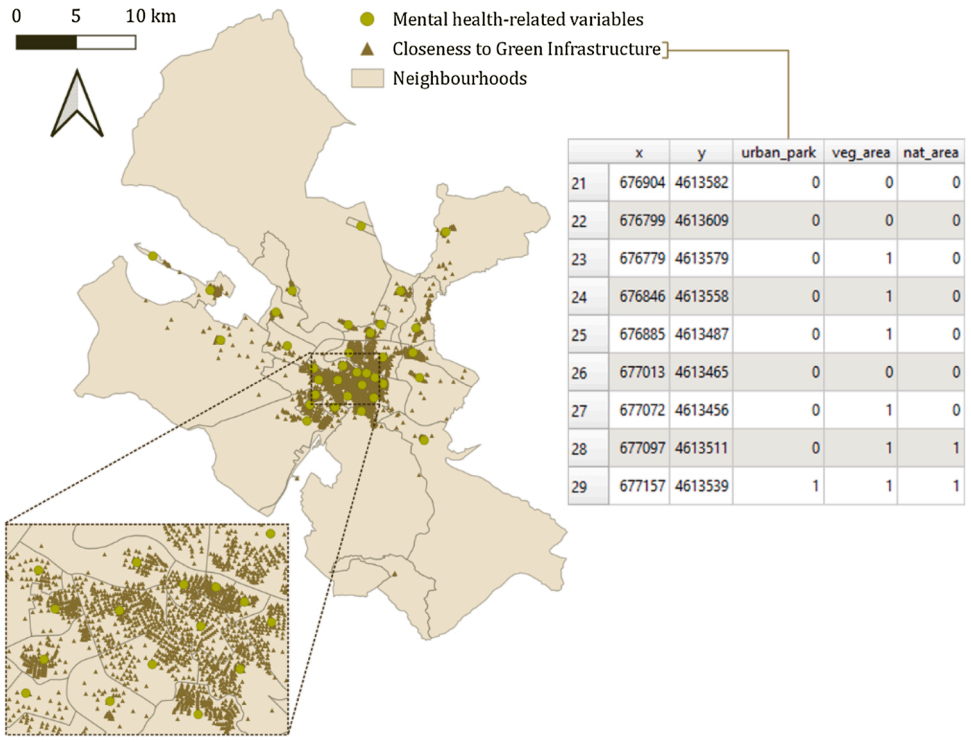
Fig. 6. Statistically significant correlations between self-reported mental health variables and closeness to Green Infrastructure (GI) in La Palma.

alike in many cases. For this reason, Fig. 8 only shows those correlations achieving the highest significant coefficient for every type of GI.

The strongest correlation found corresponded to people having very high expectations of enjoyment and vegetated areas 300 m away. Although its strength decreased slightly, this relationship was also significant for the combinations of vegetated areas at 150 m and 500 m, as well as for urban parks at 150 m and 300 m. In contrast, the other significant output reached for this variable implied a negative correlation between high expectations of enjoyment and closeness to GI. The aspect of these plots indicated that most of the respondents choosing this option lived close to GI, which in turn favoured having unbalanced distributions of responses with high and concentrated rates of dispersion.

Regarding level of anger, the highest correlation coefficient obtained corresponded to the positive relationship between low level of anger and the existence of urban parks 150 m away. This contrasted with the correlation between very high level of anger and closeness to natural areas, as well as with medium level of anger and proximity to vegetated areas. The responses referred to the mood of Zaragoza's citizens only yielded one statistically significant correlation. Although its strength was limited, it pointed out to a negative relationship between bad mood and closeness to GI.

Given the conflicts detected in the directions of some of the correlations depicted in Fig. 8, tests with two independent samples were conducted to determine if high and low ratios of proximity to GI had a significant impact on the variables plotted in Fig. 8. To this end, first was splitting the values of closeness to GI into two parts according to their median, in order to allocate each neighbourhood to a degree of proximity to GI: low or high. Then, the Shapiro-Wilk and Levene's tests were applied to check if these datasets fitted a normal distribution and were homoscedastic. Depending on the results obtained, the Student's *t*-test (t) or Mann-Whitney-Wilcoxon test (W) were used to verify the existence or absence of significant differences.



	x	y	urban_park	veg_area	nat_area
21	676904	4613582	0	0	0
22	676799	4613609	0	0	0
23	676779	4613579	0	1	0
24	676846	4613558	0	1	0
25	676885	4613487	0	1	0
26	677013	4613465	0	0	0
27	677072	4613456	0	1	0
28	677097	4613511	0	1	1
29	677157	4613539	1	1	1

Fig. 7. Distribution of Zaragoza's neighbourhoods and location of the sites where proximity to Green Infrastructure (GI) at 150 m was measured.

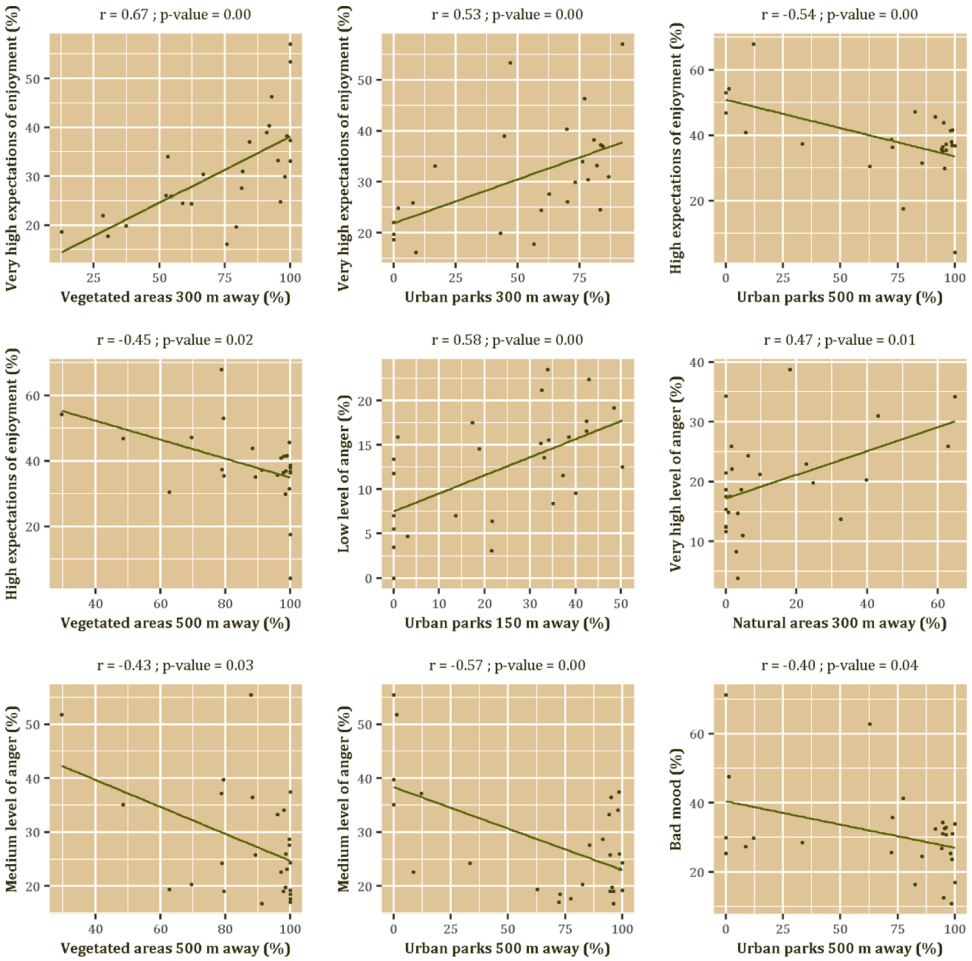


Fig. 8. Statistically significant correlations between mental health variables and closeness to Green Infrastructure (GI) in Zaragoza.

The outputs of this process indicated that only two of the mental health options available in the questionnaire yielded statistically significant differences: very high expectations of enjoyment and low level of anger. The former yielded significant results when analysed according to low and high closeness to vegetated areas (150, 300 and 500 m) and urban parks (150 and 300 m), whilst the forms of GI were reduced to urban parks (150, 300 and 500 m) in the case of the latter.

In accordance with Figs. 8 and 9 shows the boxplots corresponding to the highest correlation coefficients in each case. The results of this step were in line with the arguments posed in the correlation analysis, whereby the fact of being close to GI was positively related to the ratio of people per neighbourhood having very high expectations of enjoying the city after the lockdown and exhibiting low levels of anger.

To ensure these results were not affected by other demographic parameters, the correlations of expectations of enjoyment and level of anger (Fig. 9) with the economic status of the citizens were also determined. In particular, the demographic indicators used were the average annual net income per person and household in each neighbourhood. The p-values associated with the correlation coefficients between these two indicators and the number of people showing very high expectations of enjoyment were 0.283 and 0.096, respectively, whereas these figures increased up to 0.823 and 0.893 when explored in relation to those citizens exhibiting a low level of anger. In other words, none of them was statistically significant, which ensured the standalone validity of the results achieved in what concerns closeness to GI.

4. Discussion

4.1. Case study 1: La Palma

The first result in Fig. 6 involves reduced alcohol consumption near GI. This may relate to the capacity of green spaces for diverting attention from evasive behaviours like alcohol consumption, since they encourage motivation and self-control for activities such as running, walking, observing nature, relaxing, enjoying fresh air and social interactions (Misiune et al., 2021). The association between alcohol consumption and mental health has been documented extensively (Boden and Fergusson, 2011; Boschloo et al., 2012; Hartka et al., 1991; Wang and Patten, 2001). In this sense, the existence of an inverse relationship between quality of life and alcohol consumption was reported by dos Santos et al. (2019).

The inverse correlation found for increase in stress is aligned with the conclusions drawn from previous works (Kolokotsa et al., 2020; Mavoa et al., 2019; Poulain et al., 2020), which demonstrated that proximity to GI may reduce stress and improve people's emotional status. Some investigations have associated this benefit with the thermal regulation capacity of GI, since high ambient temperature can boost negative emotions such as stress and anger (Huang et al., 2021).

In general, the negative association between number of visits to the doctor and GI could be attributable to the existence of urbanized spaces in La Palma's municipalities, since spatial accessibility to healthcare facilities has been found to be higher in developed areas (Song et al., 2018; Wang et al., 2018). However, since the questionnaire measures an increase with respect to a basal scenario, this factor is not expected to be a covariable. Instead, this trend might suggest that the presence of green spaces close to urban residences can provide a better quality of life by promoting a healthier lifestyle (Douglas et al., 2017).

Some of the variables addressed in the questionnaire such as food intake, domestic violence and use of technologies are not directly related to mental health but are rather behavioural situations that can be altered due to psychological distress (Clevers et al., 2019; Newman et al., 2020; Seidler et al., 2020). Therefore, the absence of significant relationships in these terms does not compromise the research hypothesis. Regarding loneliness and sadness, the causes explaining their lack of statistical significance may lie on the ambiguity and subjective interpretation of these two concepts (Bogaerts et al., 2006; Hua et al., 2019). This may also relate to mobility restrictions, since the attenuation of these feelings might require close contact with GI (Slater et al., 2020).

Besides, their discrimination from the emotions derived from the lockdown situation could be complex, since there was a generalized feeling of sadness (Droit-Volet et al., 2020) that might hinder the isolation of the effect of being close to GI on the nuances of this factor. Similarly, unlinking a feeling of loneliness from the fact of living alone is not simple (Fingerman et al., 2021), because many people have gone through isolated situations during the pandemic. Therefore, the distinctive characteristics of the moment when the survey was conducted may dilute the effect of GI and explain the lack of significance with respect to these variables.

Finally, anxiety is a condition rather linked to a clinical diagnosis, resulting in a disorder that is the sum of many factors with great severity and complexity, where interpersonal considerations have a lot of weight (Anyan et al., 2020; Przeworski et al., 2011). Consequently, the lack of statistical significance for this variable can be understandable due to the number of implications associated with the concept of anxiety.

Overall, the absence of significant results in some cases might also relate to the dual concept of coping. According to Lazarus and Folkman (Lazarus, 2000; Lazarus and Folkman, 1999), coping can be defined as constantly changing cognitive and behavioural efforts developed to handle demands that exceed people's resources and endanger their well-being. A distinction can be made between two types of coping strategies: emotion-focused coping and problem-focused coping.

The former involves regulating the emotional response to what is caused by the problem and minimizing psychological distress. It includes strategies such as avoidance, minimization, distancing or wishful thinking (Xin et al., 2021). Instead, problem-focused coping concerns the identification and cost-benefit assessment of alternatives to solve the problem through an action plan. It involves an analytical process focused on the environment that includes strategies related to the interior of the subject (Zaman and Ali, 2019).

These types of strategies are most useful when the situation faced is

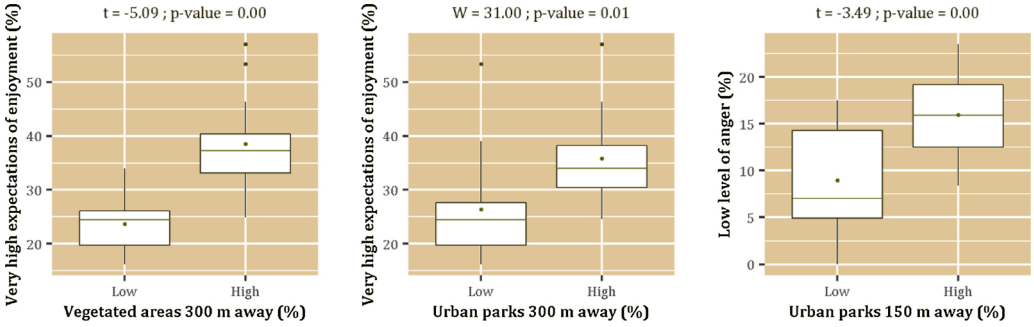


Fig. 9. Boxplots associated with the mental health variables yielding statistically significant differences between low and high ratios of closeness to Green Infrastructure (GI).

interpreted as modifiable. In the case of the COVID-19 pandemic, people had to adapt unexpectedly and quickly to a situation over which they had no sense of control, experiencing great uncertainty and alterations in almost all aspects of their life (Rolland, 2020). In view of the results depicted in Fig. 6, distance from GI was found to be statistically associated with the use of strategies focused on the problem (visits to the doctor and medication use). On the contrary, strategies based on emotions such as avoidance (food intake and use of technologies for leisure purposes), search for socio-emotional support (use of technologies for social purposes), confrontation (domestic violence), as well as emotional states such as loneliness, sadness and anxiety were not correlated to closeness to GI.

4.2. Case study 2: Zaragoza

The strongest correlation identified in Fig. 8 suggests an association of GI with willingness to enjoy the city once the lockdown period was over. This is consistent with the use and enjoyment of GI for a variety of purposes such as jogging, (dog) walking, biking, social relations or experiential and aesthetical recreation (Palliwoda et al., 2020). Activities like these were highlighted by the participants in recent surveys developed by Natural England and Scottish Natural Heritage, which revealed that 74 % and 70 % of the population in these countries visit green space at least once a month (Burnett et al., 2021).

The rationale behind low level of anger and the existence of urban parks might lay on the sense of relief derived from having visual contact with vegetated landscapes (Hedblom et al., 2019; Velarde et al., 2007), which may lead to a reduction in feelings of annoyance (Ulrich, 1979). Instead, the positive relationship between very high level of anger and closeness to natural areas may respond to the progressive loss or degradation of non-artificial vegetated areas in developed cities over the years due to urbanization (Bengtsson et al., 2019; Nguyen et al., 2020). This could justify the accumulation of responses from people lacking access to grasslands, lawns or forests.

The significant results associated with medium level of anger are not so conclusive as others because they correspond to the midpoint available in the survey, which might be the preferred choice in case of hesitation or unfamiliarity with the questions (Chyung et al., 2017). Still, the negative direction of this correlation might reflect the generalized sense of anger caused by the confinement period during the COVID-19 pandemic (Brooks et al., 2020).

The absence of a higher number of significant correlations involving mood may relate to the diffuse and global nature of the definition of this state (Morris and Reilly, 1987), which is less specific than the other variables addressed. In fact, anger might be considered a part of the mood, which is in line with the findings reported in previous literature in what concerns closeness to GI (Lin et al., 2019). Hence, similarly to the logic described for anger, greenness in proximity to people's residence might reduce stress (Campagnaro et al., 2020) and result in a better emotional status (Van Aart et al., 2018).

These findings are aligned with the results obtained for the case study of La Palma in that they both serve to demonstrate the benefits of GI across a series of variables related to the self-reported psychological and behavioural condition of citizens during lockdowns. This is also in line with the outcomes achieved in previous studies. For instance, Berdejo-Espinola et al. (2021) found that GI at a walkable distance (300 m) may have contributed to delivering urban ecosystem services during the COVID-19 lockdowns. Similarly, Frühauf et al. (2020) emphasised that having green spaces nearby to carry out moderate physical activity can provide mental benefits under periods of restricted mobility. The supporting health role of nature has also been highlighted by Robinson et al. (2021), who determined that a greater presence of green areas 250 m away from home is related to higher levels of mental wellbeing.

5. Conclusions

The results obtained throughout this study enabled proving the main hypothesis posed at the beginning of the investigation, which involved that closeness to Green Infrastructure (GI) helped alleviate mental health and behavioural problems during stringent lockdown conditions due to the COVID-19 pandemic. This relationship was demonstrated by addressing two separate case studies located in La Palma and Zaragoza (Spain). The approach used to model both regions was based on combining Geographic Information Systems (GIS), which served to process spatial data, and statistical analyses, whose application provided evidence of the significance of the correlation between a series of self-reported mental health-related variables and different forms of GI.

These variables stemmed from generic questionnaires disaggregated per administrative division, either municipality or neighbourhood. They were launched from March to May 2020, coinciding with the strict confinement in Spain, and were not specifically targeted at addressing the perceptions of the respondents on GI, but rather sought to capture their psychological and behavioural response due to the epidemiological situation. Hence, closeness to GI was computed separately from open data repositories, considering three different thresholds: 150, 300 and 500 m. This procedure prevented the incorporation of any bias into the study, since the responses collected from the questionnaire were not affected nor induced by its underlying purposes.

The outputs of the statistical analyses pointed out to positive relationships between closeness to GI and expectations of enjoying the city after the lockdown, which emphasizes the increasing use of green spaces as areas of recreation, sport and social interaction. The remaining statistically significant correlations were inversely proportional and concerned level of anger and increase in alcohol consumption, medication use and stress. All these variables had negative implications for the addressees, thereby highlighting the sense of relief and consolation of having either visual contact or physical proximity to vegetated zones. These relationships were not influenced by socioeconomic considerations, since the results of the questionnaires were statistically unrelated to the annual net income of the respondents.

In summary, the findings of this study shed light on the benefits of GI in urban areas as drivers for motivation, behavioural stability and emotional wellbeing. Considering the environmental and social gains also provided by green areas, future urban plans should rely on the implementation of GI in cities for both regeneration and welfare purposes, especially in a context of increasing mental pressure due to the information overload that govern modern societies.

Still, more research should be carried out in this line to further confirm the trends observed in this work, since the potential of the results derived from correlation analyses is limited to only infer conclusions. Additional case studies with larger sample sizes would be desirable to further corroborate the relationships between self-reported mental health and GI. The spatial relevance of the results obtained would also have improved if the questionnaire were identical in both case studies; however, finding unified or at least assimilable questionnaires is extremely difficult. Finally, although this investigation was deliberately narrowed to lockdowns, another path to explore in the future is the modelling of this correlation during de-escalation periods, in order to examine different behavioural constraints.

CRediT authorship contribution statement

Daniel Jato-Espino: Conceptualization, Data Curation, Formal analysis, Investigation, Methodology, Review & Editing, Visualization, Writing – Original Draft. **Vanessa Moscardó:** Data Curation, Formal analysis, Investigation, Methodology, Review & Editing, Visualization, Writing – Original Draft. **Alejandro Vallina Rodríguez:** Review & Editing, Visualization, Writing – Original Draft. **Esther Lázaro:** Review & Editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ufug.2021.127457.

References

Agencia Tributaria, 2021. Estadística de los declarantes del IRPF por municipios [WWW Document]. URL https://www.agenciatributaria.es/AEAT.internet/datosabiertos/catalogo/hacienda/Estadistica_de_los_declarantes_del_IRPF_por_municipios.shtml (Accessed 6.17.21).

Ahnquist, J., Wamala, S.P., Lindstrom, M., 2012. Social determinants of health – a question of social or economic capital? Interaction effects of socioeconomic factors on health outcomes. Soc. Sci. Med. 74, 930–939. https://doi.org/10.1016/j.socscimed.2011.11.026.

Anyan, F., Ingvaldsen, S.H., Hjemdal, O., 2020. Interpersonal stress, anxiety and depressive symptoms: results from a moderated mediation analysis with resilience. Ansiedad Estrés 26, 148–154. https://doi.org/10.1016/j.anyes.2020.07.003.

Arnberger, A., Eder, R., 2015. Are urban visitors' general preferences for green-spaces similar to their preferences when seeking stress relief? Urban For. Urban Green. 14, 872–882. https://doi.org/10.1016/j.ufug.2015.07.005.

Ayuntamiento de Zaragoza, 2021. Infraestructura de datos espaciales de Zaragoza (IDEZar) [WWW Document]. URL http://www.zaragoza.es/sede/portal/idezar/mapa/demografico/ (Accessed 6.17.21).

Bengtsson, J., Bullock, J.M., Egoh, B., Everson, C., Everson, T., O'Connor, T., O'Farrell, P. J., Smith, H.G., Lindborg, R., 2019. Grasslands-more important for ecosystem services than you might think. Ecosphere 10, e02582. https://doi.org/10.1002/ecs2.2582.

Berdejo-Espinola, V., Suárez-Castro, A.F., Amano, T., Fielding, K.S., Oh, R.R.Y., Fuller, R. A., 2021. Urban green space use during a time of stress: A case study during the COVID-19 pandemic in Brisbane, Australia. People Nat. 3, 597–609. https://doi.org/10.1002/pan3.10218.

Blair, G., Cooper, J., Coppock, A., Humphreys, M., Rudkin, A., Fultz, N., 2021. fabricatr: Imagine Your Data Before You Collect It.

Boden, J.M., Fergusson, D.M., 2011. Alcohol and depression: alcohol and depression. Addiction 106, 906–914. https://doi.org/10.1111/j.1360-0443.2010.03351.x.

Bogaerts, S., Vanheule, S., Desmet, M., 2006. Feelings of subjective emotional loneliness: an exploration of attachment. Soc. Behav. Personal. Int. J. 34, 797–812. https://doi.org/10.2224/sbp.2006.34.7.797.

Boschloo, L., Vogelzangs, N., van den Brink, W., Smit, J.H., Veltman, D.J., Beekman, A.T. F., Penninx, B.W.J.H., 2012. Alcohol use disorders and the course of depressive and anxiety disorders. Br. J. Psychiatry 200, 476–484. https://doi.org/10.1192/bjp.bp.111.097550.

Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessely, S., Greenberg, N., Rubin, G.J., 2020. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. Lancet 395, 912–920. https://doi.org/10.1016/S0140-6736(20)30460-8.

Burnett, H., Olsen, J.R., Nicholls, N., Mitchell, R., 2021. Change in time spent visiting and experiences of green space following restrictions on movement during the COVID-19 pandemic: a nationally representative cross-sectional study of UK adults. BMJ Open 11, e044067. https://doi.org/10.1136/bmjopen-2020-044067.

Cabildo La Palma, 2021. COVID-19 La Palma [WWW Document]. URL https://coronavirus.lapalma.es/ (Accessed 6.17.21).

Campagnaro, T., Vecchiato, D., Arnberger, A., Celegato, R., Da Re, R., Rizzetto, R., Semenzato, P., Sitzia, T., Tempesta, T., Cattaneo, D., 2020. General, stress relief and perceived safety preferences for green spaces in the historic city of Padua (Italy). Urban For. Urban Green. 52 https://doi.org/10.1016/j.ufug.2020.126695.

Chang, W., 2014. Extrafont: Tools for Using Fonts.

Cheung, D., Ip, E.C., 2020. COVID-19 lockdowns: a public mental health ethics perspective. Asian Bioeth. Rev. 12, 503–510. https://doi.org/10.1007/s41649-020-00144-0.

Choi, B.C.K., Pak, A.W.P., 2005. A catalog of biases in questionnaires. Prev. Chronic Dis. 2.

Chyung, S.Y.Y., Roberts, K., Swanson, I., Hankinson, A., 2017. Evidence-based survey design: the use of a midpoint on the Likert scale. Perform. Improv. 56, 15–23. https://doi.org/10.1002/pfi.21727.

Clevers, E., Törnblom, H., Simrén, M., Tack, J., Van Oudenhove, L., 2019. Relations between food intake, psychological distress, and gastrointestinal symptoms: a diary study. United Eur. Gastroenterol. J. 7, 965–973. https://doi.org/10.1177/2050640619839859.

Copernicus, 2021. Copernicus Land Monitoring Service [WWW Document]. URL https://land.copernicus.eu/ (Accessed 6.17.21).

da Schio, N., Phillips, A., Fransen, K., Wolff, M., Haase, D., Ostoić, S.K., Živojinović, I., Vuletić, D., Derks, J., Davies, C., Lafortezza, R., Roitsch, D., Winkel, G., De Vreese, R., 2021. The impact of the COVID-19 pandemic on the use of and attitudes towards urban forests and green spaces: exploring the instigators of change in Belgium. Urban For. Urban Green. 65, 127305 https://doi.org/10.1016/j.ufug.2021.127305.

dos Santos, M.V.F., Campos, M.R., Fortes, S.L.C.L., 2019. Relationship of alcohol consumption and mental disorders common with the quality of life of patients in primary health care. Ciênc. Saúde Coletiva 24, 1051–1063. https://doi.org/10.1590/1413-81232018243.01232017.

Douglas, O., Lennon, M., Scott, M., 2017. Green space benefits for health and well-being: a life-course approach for urban planning, design and management. Cities 66, 53–62. https://doi.org/10.1016/j.cities.2017.03.011.

Droit-Volet, S., Gil, S., Martinelli, N., Andant, N., Clinchamps, M., Parreira, L., Rouffiac, K., Dambrun, M., Huguet, P., Dubuis, B., Pereira, B., COVISTRESS network, Bouillon, J.-B., Dutheil, F., 2020. Time and Covid-19 stress in the lockdown situation: time free, «dying» of boredom and sadness. PLoS One 15, e0236465. https://doi.org/10.1371/journal.pone.0236465.

Dushkova, D., Ignatieva, M., Hughes, M., Konstantinova, A., Vasenev, V., Dovletyarova, E., 2021. Human dimensions of urban blue and green infrastructure during a pandemic. Case study of Moscow (Russia) and Perth (Australia). Sustain. Switz. 13 https://doi.org/10.3390/su13084148.

Erdönmez, C., Atmiş, E., 2021. The impact of the Covid-19 pandemic on green space use in Turkey: is closing green spaces for use a solution? Urban For. Urban Green. 64, 127295 https://doi.org/10.1016/j.ufug.2021.127295.

European Union, Copernicus Land Monitoring Service, 2021a. CORINE Land Cover. European Environment Agency (EEA), Copenhagen (Denmark).

European Union, Copernicus Land Monitoring Service, 2021b. Urban Atlas. European Environment Agency (EEA), Copenhagen (Denmark).

Fingerman, K.L., Ng, Y.T., Zhang, S., Britt, K., Colera, G., Birditt, K.S., Charles, S.T., 2021. Living alone during COVID-19: social contact and emotional well-being among older adults. J. Gerontol. Ser. B 76, e116–e121. https://doi.org/10.1093/geronb/gbaa200.

Fisher, R.A., 1992. Statistical methods for research workers. In: Kotz, S., Johnson, N.L. (Eds.), Breakthroughs in Statistics. Springer, New York, New York (U.S.), pp. 66–70. https://doi.org/10.1007/978-1-4612-4380-9_6.

Fox, J., Weisberg, S., Price, B., Adler, D., Bates, D., Baud-Bovy, G., Bolker, B., Ellison, S., Firth, D., Friendly, M., Gorjanc, G., Graves, S., Heiberger, R., Krivitsky, P., Laboissiere, R., Maechler, M., Monette, G., Murdoch, D., Nilsson, H., Ogle, D., Ripley, B., Venables, W., Walker, S., Winsemius, D., Zeileis, A., R-Core, 2021. car: Companion to Applied Regression.

Frühauf, A., Schnitzer, M., Schobersberger, W., Weiss, G., Kopp, M., 2020. Jogging, nordic walking and going for a walk - inter-disciplinary recommendations to keep people physically active in times of the covid-19 lockdown in Tyrol, Austria. Curr. Issues Sport Sci. CISS. https://doi.org/10.15203/CISS_2020.100.

Gastwirth, J.L., Gel, Y.R., Miao, W., 2009. The impact of Levene's test of equality of variances on statistical theory and practice. Stat. Sci. 24, 343–360. https://doi.org/10.1214/09-STS301.

Geng, D.C., Innes, J., Wu, W., Wang, G., 2021. Impacts of COVID-19 pandemic on urban park visitation: a global analysis. J. For. Res. 32, 553–567. https://doi.org/10.1007/s11676-020-01249-w.

Ghasemi, A., Zahediasl, S., 2012. Normality tests for statistical analysis: a guide for non-statisticians. Int. J. Endocrinol. Metab. 10, 486–489. https://doi.org/10.5812/ijem.3505.

Gosset, W.S., 1908. The probable error of a mean. Biometrika 6, 1–25. https://doi.org/10.1093/biomet/6.1.1.

Harrell Jr., F.E., Dupont, Charles, 2021. Hmisc: Harrell Miscellaneous.

Hartka, E., Johnstone, B., Leino, E.V., Motoyoshi, M., Temple, M.T., Fillmore, K.M., 1991. A meta-analysis of depressive symptomatology and alcohol consumption over time *. Br. J. Addict. 86, 1283–1298. https://doi.org/10.1111/j.1360-0443.1991.tb01704.x.

Hedblom, M., Gunnarsson, B., Iravani, B., Knez, I., Schaefer, M., Thorsson, P., Lundström, J.N., 2019. Reduction of physiological stress by urban green space in a multisensory virtual experiment. Sci. Rep. 9 https://doi.org/10.1038/s41598-019-46099-7.

Hua, A.Y., Chen, K.-H., Brown, C.L., Lwi, S.J., Casey, J.J., Rosen, H.J., Miller, B.L., Levenson, R.W., 2019. Physiological, behavioral and subjective sadness reactivity in frontotemporal dementia subtypes. Soc. Cogn. Affect. Neurosci. 14, 1453–1465. https://doi.org/10.1093/scan/nsaa007.

Huang, H., Yang, H., Chen, Y., Chen, T., Bai, L., Peng, Z.-R., 2021. Urban green space optimization based on a climate health risk appraisal – a case study of Beijing city, China. Urban For. Urban Green. 62, 127154 https://doi.org/10.1016/j.ufug.2021.127154.

Hubbard, G., Daas, C.D., Johnston, M., Murchie, P., Thompson, C.W., Dixon, D., 2021. Are rurality, area deprivation, access to outside space, and green space associated with mental health during the covid-19 pandemic? A cross sectional study (charis-e). Int. J. Environ. Res. Public Health 18. https://doi.org/10.3390/ijerph18083869.

Instituto Nacional de Estadística, 2021. Cifras oficiales de población resultantes de la revisión del Padrón municipal a 1 de enero [WWW Document]. URL https://www.ine.es/dynt3/inebase/index.htm?padre=517&capsel=517 (Accessed 6.17.21).

Kolokotsa, D., Lilli, A.A., Lilli, M.A., Nikolaidis, N.P., 2020. On the impact of nature-based solutions on citizens' health & well being. Energy Build. 229, 110527 https://doi.org/10.1016/j.enbuild.2020.110527.

Larcher, F., Pomatto, E., Battisti, L., Gullino, P., Devecchi, M., 2021. Perceptions of urban green areas during the social distancing period for covid-19 containment in Italy. Horticulturae 7. https://doi.org/10.3390/horticulturae7030055.

Lazarus, R.S., 2000. Toward better research on stress and coping. Am. Psychol. 55, 665–673. https://doi.org/10.1037/0003-066X.55.6.665.

Lazarus, R.S., Folkman, S., 1999. Stress, Appraisal, and Coping. Springer, New York (U.S.).

Levinger, P., Cerin, E., Milner, C., Hill, K.D., 2021. Older people and nature: the benefits of outdoors, parks and nature in light of COVID-19 and beyond– where to from here? Int. J. Environ. Health Res. https://doi.org/10.1080/09603123.2021.1879739.

Lin, W., Chen, Q., Jiang, M., Zhang, X., Liu, Z., Tao, J., Wu, L., Xu, S., Kang, Y., Zeng, Q., 2019. The effect of green space behaviour and per capita area in small urban green spaces on psychophysiological responses. Landsc. Urban Plan. 192, 103637 https://doi.org/10.1016/j.landurbplan.2019.103637.

Mann, H.B., Whitney, D.R., 1947. On a test of whether one of two random variables is stochastically larger than the other. Ann. Math. Stat. 18, 50–60. https://doi.org/10.2307/2236101.

Mavoa, S., Lucassen, M., Denny, S., Utter, J., Clark, T., Smith, M., 2019. Natural neighbourhood environments and the emotional health of urban New Zealand adolescents. Landsc. Urban Plan. 191, 103638 https://doi.org/10.1016/j.landurbplan.2019.103638.

Misiune, I., Julian, J.P., Veteikis, D., 2021. Pull and push factors for use of urban green spaces and priorities for their ecosystem services: case study of Vilnius, Lithuania. Urban For. Urban Green. 58, 126899 https://doi.org/10.1016/j.ufug.2020.126899.

Morris, W.N., Reilly, N.P., 1987. Toward the self-regulation of mood: theory and research. Motiv. Emot. 11, 215–249. https://doi.org/10.1007/BF01001412.

Newman, M., Fedina, L., Nam, B., DeVylder, J., Alleyne-Green, B., 2020. Associations between interpersonal violence, psychological distress, and suicidal ideation among formerly incarcerated men and women. J. Interpers. Violence, 088626052093304. https://doi.org/10.1177/0886260520933045.

Nguyen, T.T., Barber, P., Harper, R., Linh, T.V.K., Dell, B., 2020. Vegetation trends associated with urban development: the role of golf courses. PLoS One 15, e0228090. https://doi.org/10.1371/journal.pone.0228090.

Nickerson, R.S., 2000. Null hypothesis significance testing: a review of an old and continuing controversy. Psychol. Methods 5, 241–301. https://doi.org/10.1037/1082-989X.5.2.241.

Nutsford, D., Pearson, A.L., Kingham, S., Reitsma, F., 2016. Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. Health Place 39, 70–78. https://doi.org/10.1016/j.healthplace.2016.03.002.

Oliver, N., Barber, X., Roomp, Kirsten, Roomp, Kristof, 2020. Assessing the impact of the COVID-19 pandemic in Spain: large-scale, online, self-reported population survey. J. Med. Internet Res. 22, e21319 https://doi.org/10.2196/21319.

OpenStreetMap, 2021. Geofabrik Download Server [WWW Document]. URL https://download.geofabrik.de/ (Accessed 6.17.21).

Palliwoda, J., Banzhaf, E., Priess, J.A., 2020. How do the green components of urban green infrastructure influence the use of ecosystem services? Examples from Leipzig, Germany. Landsc. Ecol. 35, 1127–1142. https://doi.org/10.1007/s10980-020-01004-w.

Poulain, T., Sobek, C., Ludwig, J., Igel, U., Grande, G., Ott, V., Kiess, W., Körner, A., Vogel, M., 2020. Associations of green spaces and streets in the living environment with outdoor activity, media use, overweight/obesity and emotional wellbeing in children and adolescents. Int. J. Environ. Res. Public Health 17, 6321. https://doi.org/10.3390/ijerph17176321.

Pouso, S., Borja, Á, Fleming, L.E., Gómez-Baggethun, E., White, M.P., Uyarra, M.C., 2020. Contact with blue-green spaces during the COVID-19 pandemic lockdown beneficial for mental health. Sci. Total Environ. https://doi.org/10.1016/j.scitotenv.2020.143984.

Przeworski, A., Newman, M.G., Pincus, A.L., Kasoff, M.B., Yamasaki, A.S., Castonguay, L. G., Berlin, K.S., 2011. Interpersonal pathoplasticity in individuals with generalized anxiety disorder. J. Abnorm. Psychol. 120, 286–298. https://doi.org/10.1037/a0023334.

QGIS Development Team, 2021. QGIS Geographic Information System. QGIS Association.

R Core Team, 2020. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna (Austria).

R Core Team, Bivand, R., Carey, V.J., DebRoy, S., Eglen, S., Guha, R., Herbrandt, S., Lewin-Koh, N., Myatt, M., Nelson, M., Pfaff, B., Quistorff, B., Warmerdam, F., Weigand, S., Foundation, F.S., Inc, 2020. foreign: Read Data Stored by "Minitab", "S", "SAS", "SPSS", "Stata", "Systat", "Weka", "dBase", ….

Reyes-Riveros, R., Altamirano, A., Barrera, F.D.L., Rozas-Vásquez, D., Vieli, L., Meli, P., 2021. Linking public urban green spaces and human well-being: a systematic review. Urban For. Urban Green. 61 https://doi.org/10.1016/j.ufug.2021.127105.

Robinson, J.M., Brindley, P., Cameron, R., MacCarthy, D., Jorgensen, A., 2021. Nature's role in supporting health during the COVID-19 pandemic: a geospatial and socioecological study. Int. J. Environ. Res. Public Health 18, 2227. https://doi.org/10.3390/ijerph18052227.

Rolland, J.S., 2020. COVID-19 pandemic: applying a multisystemic lens. Fam. Process 59, 922–936. https://doi.org/10.1111/famp.12584.

Rusche, K., Reimer, M., Stichmann, R., 2019. Mapping and assessing green infrastructure connectivity in European city regions. Sustain. Switz. 11 https://doi.org/10.3390/SU11061819.

Salari, N., Hosseinian-Far, A., Jalali, R., Vaisi-Raygani, A., Rasoulpoor, Shna, Mohammadi, M., Rasoulpoor, Shabnam, Khaledi-Paveh, B., 2020. Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis. Glob. Health 16, 57. https://doi.org/10.1186/s12992-020-00589-w.

Schober, P., Schwarte, L.A., 2018. Correlation coefficients: appropriate use and interpretation. Anesth. Analg. 126, 1763–1768. https://doi.org/10.1213/ANE.0000000000002864.

Seidler, Z.E., Wilson, M.J., Rice, S.M., Kealy, D., Oliffe, J.L., Ogrodniczuk, J.S., 2020. Virtual connection, real support? A study of loneliness, time on social media and psychological distress among men. Int. J. Soc. Psychiatry, 002076402098383. https://doi.org/10.1177/0020764020983836.

Slater, S.J., Christiana, R.W., Gustat, J., 2020. Recommendations for keeping parks and green space accessible for mental and physical health during COVID-19 and other pandemics. Prev. Chronic Dis. 17, 200204 https://doi.org/10.5888/pcd17.200204.

Soga, M., Evans, M.J., Tsuchiya, K., Fukano, Y., 2021. A room with a green view: the importance of nearby nature for mental health during the COVID-19 pandemic. Ecol. Appl. 31 https://doi.org/10.1002/eap.2248.

Song, Yongze, Tan, Y., Song, Yimeng, Wu, P., Cheng, J.C.P., Kim, M.J., Wang, X., 2018. Spatial and temporal variations of spatial population accessibility to public hospitals: a case study of rural–urban comparison. GIScience Remote Sens. 55, 718–744. https://doi.org/10.1080/15481603.2018.1446713.

Spano, G., D'Este, M., Giannico, V., Elia, M., Cassibba, R., Lafortezza, R., Sanesi, G., 2021. Association between indoor-outdoor green features and psychological health during the COVID-19 lockdown in Italy: a cross-sectional nationwide study. Urban For. Urban Green. 62, 127156 https://doi.org/10.1016/j.ufug.2021.127156.

Theodorou, A., Panno, A., Carrus, G., Carbone, G.A., Massullo, C., Imperatori, C., 2021. Stay home, stay safe, stay green: the role of gardening activities on mental health during the Covid-19 home confinement. Urban For. Urban Green. 61 https://doi.org/10.1016/j.ufug.2021.127091.

Uchiyama, Y., Kohsaka, R., 2020. Access and use of green areas during the covid-19 pandemic: green infrastructure management in the "new normal". Sustain. Switz. 12, 1–9. https://doi.org/10.3390/su12239842.

Ugolini, F., Massetti, L., Pearlmutter, D., Sanesi, G., 2021. Usage of urban green space and related feelings of deprivation during the COVID-19 lockdown: lessons learned from an Italian case study. Land Use Policy 105. https://doi.org/10.1016/j.landusepol.2021.105437.

Ulrich, R.S., 1979. Visual landscapes and psychological weil-being. Landsc. Res. 4, 17–23. https://doi.org/10.1080/01426397908705892.

Van Aart, C.J.C., Michels, N., Sioen, I., De Decker, A., Bijnens, E.M., Janssen, B.G., De Henauw, S., Nawrot, T.S., 2018. Residential landscape as a predictor of psychosocial stress in the life course from childhood to adolescence. Environ. Int. 120, 456–463. https://doi.org/10.1016/j.envint.2018.08.028.

Velarde, Ma.D., Fry, G., Tveit, M., 2007. Health effects of viewing landscapes - landscape types in environmental psychology. Urban For. Urban Green. 6, 199–212. https://doi.org/10.1016/j.ufug.2007.07.001.

Venter, Z.S., Barton, D.N., Gundersen, V., Figari, H., Nowell, M., 2020. Urban nature in a time of crisis: recreational use of green space increases during the COVID-19 outbreak in Oslo, Norway. Environ. Res. Lett. 15 https://doi.org/10.1088/1748-9326/abb396.

Wang, J., Geng, L., 2019. Effects of socioeconomic status on physical and psychological health: lifestyle as a mediator. Int. J. Environ. Res. Public Health 16, 281. https://doi.org/10.3390/ijerph16020281.

Wang, J., Patten, S.B., 2001. Alcohol consumption and major depression: findings from a follow-up study. Can. J. Psychiatry 46, 632–638. https://doi.org/10.1177/070674370104600708.

Wang, X., Yang, H., Duan, Z., Pan, J., 2018. Spatial accessibility of primary health care in China: a case study in Sichuan Province. Soc. Sci. Med. 209, 14–24. https://doi.org/10.1016/j.socscimed.2018.05.023.

Wickham, H., Chang, W., Henry, L., Pedersen, T.L., Takahashi, K., Wilke, C., Woo, K., Yutani, H., Dunnington, D., RStudio, 2021. ggplot2: Create Elegant Data Visualisations Using the Grammar of Graphics.

Xin, T., Siponen, M., Chen, S., 2021. Understanding the inward emotion-focused coping strategies of individual users in response to mobile malware threats. Behav. Inf. Technol. 1–25. https://doi.org/10.1080/0144929X.2021.1954242.

Zaman, N.I., Ali, U., 2019. Autonomy in university students: predictive role of problem focused coping. Pak. J. Psychol. Res. 34, 101–114. https://doi.org/10.33824/PJPR.2019.34.1.6.