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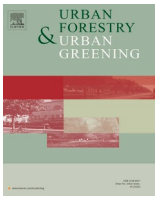

Association between indoor-outdoor green features and psychological health during the COVID-19 lockdown in Italy: A cross-sectional nationwide study

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ABSTRACT

Exposure to public green spaces was shown to be associated with psychological health. Nonetheless, evidence is lacking on the role of different green features within and/or surrounding the home environment when public green spaces are inaccessible or not usable. The overarching goal of this study is to shed light on the associations between the presence of greenness within the home and in the surrounding environment and the detrimental effects of quarantine on psychological health during the COVID-19 pandemic lockdown in Italy. A cross-sectional nationwide study involving an online survey was conducted of an Italian population-based sample of 3886 respondents on the association of indoor and outdoor green features (i.e., presence of plant pots, sunlight, green view and accessibility of private green space and natural outdoor environment) with self-reported increases in anxiety, anger, fear, confusion, moodiness, boredom, irritability, recurrent thoughts and/or dreams, poor concentration and sleep disturbance during the COVID-19 lockdown. Single-exposure regression models were performed to estimate associations between single green features and each psychological health outcome adjusted for relevant covariates. In the adjusted models, the presence of plant pots at home was associated with a lower self-reported increase in anxiety, anger, fear, irritability, and sleep disturbance. A greater amount of sunlight in the home was associated with a lower increase in anger, fear, confusion, moodiness, boredom, irritability, poor concentration, and sleep disturbance. A greater amount of green view and access to private green spaces were both associated with a lower increase in each of the psychological health outcomes except for green view and recurrent thought and/or dreams. Natural outdoor environment was associated with anxiety, fear, boredom, irritability, and sleep disturbance. Significant associations remained robust when adjusted for number of confirmed COVID-19 cases. Insights on future investigations are provided.

1. Introduction

In late December 2019, a cluster of cases of respiratory diseases caused by a novel coronavirus termed severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) were reported in Wuhan, China (Chan et al., 2020; Huang et al., 2020). Later, a similar disease caused by SARS-CoV-2 was officially named COVID-19 by the World Health Organization (WHO) (Gorbalenya et al., 2020). In mid-February, a new cluster of COVID-19 cases was detected in Northern Italy, which rapidly became one of the most strongly hit areas in Europe. The entire country was declared a COVID-19 risk area by the Italian government, which initially imposed a lockdown only in the most affected cities and surrounding localities (i.e., Lombardy region) but gradually extended restrictive measures to the entire country. Hence, on March 10, 2020, a national lockdown was declared and enforced. Italian citizens were not allowed to leave their homes; an exception was made for buying essential goods, special working demands and/or for urgent health reasons. Although such restrictive measures were necessary to contain

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the spread of the COVID-19 pandemic across the country, as suggested by major international public health agencies, an emerging body of scientific evidence highlights the detrimental effects of long-term quarantine on psychological health (Panno et al., 2020; Rajkumar, 2020; Yamada et al., 2021). Social distancing, self-isolation, and the associated stressors including fear, boredom and financial loss have produced long-lasting psychological effects, such as post-traumatic stress symptoms, confusion, anger, panic disorders, anxiety, and depression (Brooks et al., 2020; Qiu et al., 2020).

Growing evidence has shown that during the current pandemic individuals have been increasingly engaging in activities in public and open spaces, preferably natural ones, due to the perceived physical and mental well-being resulting from this interaction (Ugolini et al., 2020; Venter et al., 2020; Geng et al., 2021; Robinson et al., 2021). For example, a study based on social media data (Zhu, and Xu, 2021) showed that contents on landscapes and green plants inside a park were associated with positive emotions. Moreover, the sentiment scores were negatively correlated with confirmed cases and number of deaths from COVID-19 (Zhu, and Xu, 2021). Although exposure to natural environments is highly recommended to protect against the negative consequences of the lockdown (Slater et al., 2020), mobility restrictions have denied access to natural spaces in many countries, thus affecting vulnerable individuals and communities. In particular, prohibiting all outdoor activities and contact with green/open spaces heavily affected psychological health outcomes of the quarantine period. In this regard, Wang et al. (2020a) have recently reported that preventing Chinese children from performing outdoor activities during home confinement may lead to physical and psychological disorders, including sleep disturbance, boredom, and anxiety. In a wide sample of Chinese college students, mild to severe levels of anxiety have been reported during the COVID-19 pandemic (Cao et al., 2020). Besides children, the elderly may also be affected by banned access to public green spaces and the limitation of performing exercise, which is a key protective factor against a number of age-related physical and psychological issues, such as frailty and cognitive impairment (Spano et al., 2018; Jiménez-Pavón et al., 2020). Inconsistent evidence is available on the effect of indoor "green" activities. Exposure to home gardens was found to not be associated with self-reported change in physical and mental symptoms from pre-lockdown levels (Corley et al., 2021), while presence of indoor plants was correlated with more positive emotions (Pérez-Urrestarazu et al., 2020).

The overarching aim of the present study is to disentangle the associations between the presence of green features within and surrounding the home environment and the self-reported change in psychological health when access to public green spaces was banned or rather during the COVID-19 pandemic lockdown. For this purpose, we conducted a nationwide investigation in Italy addressing the following research questions:

RQ1: Is there an association between indoor green features such as presence of plant pots, sunlight, and green view and the self-reported change in a list of most common psychological outcomes related to the COVID-19 lockdown (i.e., anxiety, anger, fear, confusion, moodiness, boredom, irritability, recurrent thoughts and/or dreams, poor concentration, and sleep disturbance)?

RQ2: Is there an association between outdoor green features, such as accessibility of private green space and naturalness, and the self-reported change in the above-mentioned list of most common psychological outcomes related to the COVID-19 lockdown?

2. Material and methods

2.1. Study population

Data collection was conducted on a large sample of community dwellers who spent the lockdown period in Italy during the COVID-19 pandemic. Community dwellers were recruited through a nonprobability sampling technique known as "snowball sampling", or "chain-referral sampling" (Mann, and Whitney, 1947), where participants are invited to recruit other potential participants. An online survey lasting approximately five minutes was uploaded to a survey administration app and made accessible through a link launched via e-mail and a free messaging platform from March 31, 2020 (three weeks after the start of the lockdown in Italy, i.e., March 10, 2020) to April 7, 2020.

Each potential participant was informed that participation in the study was on a voluntary basis, that the questionnaire was anonymous, and that the data would be processed in an aggregate manner in compliance with national and European data protection laws for scientific and statistical purposes (GDPR 2016/679). Proceeding with the compilation of the survey, they agreed to participate in the study. Four thousand fifty questionnaires were completed (i.e., Google forms). The selection of the final sample was carried out by applying the following inclusion criteria: (a) permanence on the Italian territory during the lockdown period, and (b) age equal to or greater than 14 years. The final sample consisted of 3886 participants. The number and distribution of completed questionnaires throughout the Italian peninsula are reported in Fig. S1 (see Supplementary Materials). The most represented region was Apulia (~54 % of completed questionnaires), followed by Piedmont (~10 %) and Lombardy (~8%), whereas the least represented region was Aosta Valley with only 0.15 % of completed questionnaires on the overall number.

The study procedure was designed in accordance with the ethical standards of the Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the ethics committee of the Department of Education Science, Psychology, Communication Science, University of Bari A. Moro, Italy.

2.2. Measures

The online questionnaire was developed by the authors and consisted of three sections. The first section included questions concerning sociodemographic characteristics, covariates, and potential confounding variables. The subsequent two sections dealt with items related to the variables of interest for our study.

2.2.1. Sociodemographic characteristics and potential confounding variables

The first section of the questionnaire was composed of 8 items investigating sociodemographic characteristics, i.e., age, gender, level of education, current place of residence, and other information regarding potential covariates or confounding variables such as current working mode (e.g., smart working), presence of other people living in the home, presence of pets, and estimated decrease in income due to the COVID-19 pandemic lockdown.

2.2.2. Psychological outcomes

The second section of the questionnaire was composed of 10 items. Each participant was asked to evaluate feelings related to their psychological state in the preceding weeks, considering March 10, 2020 as the first day of the lockdown across the country. The choice of outcomes to be assessed was mainly based on the evidence reported in a recent review of the negative psychological effects of quarantine (Brooks et al., 2020). From the available evidence, quarantine is associated with poorer psychological outcomes and negative effects on mental health due to a number of stressors (for reviews see, e.g., Brooks et al., 2020; Kontoangelos et al., 2020). As far as we know, none of the studies available in the literature showed an improvement in psychological health with respect to the starting condition. Therefore, we considered it of little use to investigate well-being, but rather focused on the self-reported tendency to a detrimental effect of quarantine and the potential mitigating role of green features in this worsening effect. Hence, disagreement indicated that there had been no negative changes in the respondent's psychological state. Due to a lack of well-validated

scales assessing the perceived change from a previous condition of indicators of our interest, we asked participants to self-rate the increase in levels of anxiety, anger, fear, confusion, moodiness, boredom, irritability, recurrent thoughts and/or dreams, poor concentration, and sleep disturbance compared to the period before the lockdown ("I feel more anxious than before"). A 5-point Likert scale was used ranging from "Strongly disagree" to "Completely agree," where the first level indicated no change and the last indicated a marked worsening in the referred outcome.

2.2.3. Indoor-outdoor green features

In the third and last section of the questionnaire, 5 items were used to address indoor and outdoor green features (see Table 1). The participants were asked to provide information on: (a) the presence of plant pots (yes/no); (b) the self-reported presence of sunlight in the home using a 3-point Likert scale, i.e., "not at all or not very bright" = 0, "medium bright" = 1 and " quite or very bright " = 2; (c) the amount of green view from the home environment using a 5-point Likert scale from the lowest, or none, to the highest amount of green view ("no green space or no windows" = 0, "a little bit of the view" = 1, "some of the view but without trees" = 2, "some of the view with trees" = 3, "most of the view" = 4, "all of the view" = 5); (d) accessibility to private green spaces from the lowest to the highest amount of private green space ("no access" = 0; "terrace with presence of green" = 1, "courtyard with presence of green" = 2, "garden" = 3, "more than one access" = 4, "countryside or mountains" = 5; and (e) type of road where the house was located as a proxy for natural outdoor environment ("main or secondary extra-urban road" = 0, "urban or neighbourhood street" = 1, "seafront" = 2, "limited traffic area such as pedestrian street" = 3, "internal or private road" = 4, "road with trees or greenery" = 5, and "country or mountain road" = 6). All items related to the home environment in which each participant was spending the lockdown or quarantine period.

Table 1
Distribution of the sample participants' answers for indoor-outdoor green features.

	N = 3886 (%)
Do you have plants at home?	
Yes	3228 (83.07)
No	658 (16.93)
How do you evaluate the presence of daylight at home?	
Not at all or not very bright	139 (3.58)
Medium bright	1072 (27.59)
Quite or very bright	2675 (68.84)
From the room you are in, how much green can you see from the window? Indicates the amount of green view?	
No green space or no windows	452 (11.63)
A little bit of the view	1140 (29.34)
Some of the view but without trees	312 (8.03)
Some of the view with trees	1213 (31.21)
Most of the view	611 (15.72)
All of the view	158 (4.07)
During this period do you have access to private green spaces?	
No access	1641 (42.23)
Yes, to a terrace with presence of green	561 (14.44)
Yes, to a courtyard with presence of green	528 (13.59)
Yes, to a garden	697 (17.94)
I have more than one access	126 (3.24)
Yes, I am in the countryside or mountains	333 (8.57)
What type of road is the house where you are spending this period?	
Main or secondary extra-urban road	455 (11.71)
Urban or neighbourhood street	2641 (67.96)
Seafront	9 (0.23)
Limited traffic area (e.g., old town, pedestrian street)	72 (1.85)
Internal or private road	124 (3.19)
Road with trees or greenery	286 (7.36)
Country or mountain road	299 (7.69)

2.3. Statistical analysis

2.3.1. Descriptive statistics

Descriptive statistics were calculated to explore the characteristics and distributions of sociodemographic data and psychological health outcomes considered in the survey.

2.3.2. Regression analysis

Single-exposure regression models were used to estimate the associations between indoor-outdoor green features as explanatory variables and psychological health outcomes. For each psychological health outcome (i.e., increase in anxiety, anger, fear, confusion, moodiness, boredom, irritability, recurrent thoughts and/or dreams, poor concentration and sleep disturbance) we built a single-exposure regression model considering each green feature (i.e., presence of plant pots, sunlight, green view, accessibility of private green space and natural outdoor environment). All models were adjusted for age (continuum variable), gender identity (male, female and other), education level, working mode during the lockdown period, and estimated decrease in income due to lockdown measures. In addition, the presence of other people (yes/no) and presence of pets (yes/no) during the lockdown were used as covariates, since it has been shown that social presence at home and human–animal interactions impact overall physical and psychological well-being (Chou et al., 2006; Beetz et al., 2012; Holt-Lunstad et al., 2015). Beta coefficients were considered a quantitative measure of the associations between green-related variables as proxies of green features and psychological outcomes.

A sensitivity analysis was performed to test the robustness of the significant associations between green features and psychological health outcomes by additionally adjusting the single-exposure regression models for a potential confounding variable, i.e., confirmed COVID-19 cases per regional population. The total number of people who tested positive (confirmed cases) for COVID-19 on March 30, 2020, the day before the survey launch, was provided as official and public data from the Ministry of Health (http://opendatadpc.maps.arcgis.com/apps/opsdashboard/index.html#/b0c68bce2cce478eaac82fe38d4138b1; accessed March 30, 2020). The latest available data on the total number of regional populations from existing databases were updated to 2019 (http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPRES1; accessed May 19, 2020). Aosta Valley recorded the highest number of positive cases in relation to the total number of inhabitants, followed by the regions of Lombardy and Emilia-Romagna (Fig. S2, Supplementary Material). The lm() function from the R 'stats' package (Wilkinson, and Rogers, 1973; Chambers, and Hastie, 1992) was used to perform all the analyses; statistical significance was set at $p < 0.05$.

2.3.3. Effect modification by the Current Working Mode

The sample of participants was selected according to current working mode (CWM) and divided into two groups: smart workers and non-smart workers. The sub-sample for this analysis was composed of a total of 2729 participants, including 2059 smart workers and 670 non-smart workers. The last group was comprised of those who reported going to work as usual and those in partial smart working mode. In relation to each psychological health outcome, interaction analysis was tested between CWM and green view, and CWM and access to private green

space.

3. Results

3.1. Sample characteristics

In the total sample of survey participants, the average age was 41.9 years (standard deviation: 15.2, range: 14–93); almost 62 % was composed of women and about 38 % of men. Twelve respondents, or 0.31 % of the total, declared that they did not feel they belonged to either of the two genders previously mentioned. The most represented level of education in the total sample was high school, while the least represented was primary school; this is probably attributable to the lower threshold relating to 14 years of age. More than half of the respondents continued to work from home (i.e., in smart working mode). More than 90 % of respondents were spending the lockdown in the company of other people, and about two thirds benefitted from the company of at least one pet. More than half of the respondents foresaw that their financial income would decrease due to the COVID-19 pandemic (for percentages see Table 2. Detailed descriptive statistics of the study participants (N = 3886) and the prevalence of each psychological health outcome are reported in Table 2. The distribution of the sample participants' answers on indoor-outdoor green features are reported in Table 1.

3.2. Single-exposure regression analysis

The presence of plant pots at home was significantly associated with a lower self-reported increase in anxiety, anger, fear, moodiness, boredom, irritability, and sleep disturbance. In the adjusted model, we observed that psychological health outcomes such as anger, fear, irritability, and sleep disturbance maintained a significant association with the presence of plant pots in the home (Fig. 1). A higher level of sunlight in the home was significantly associated with a lower increase in anger, fear, confusion, moodiness, boredom, irritability, poor concentration, and sleep disturbance. The significant associations were also consistent in the adjusted model (Fig. 1). The amount of green view from home windows was significantly associated with all outcomes evaluated, both in the unadjusted and adjusted models. A greater presence of green view from the window was associated with a lower increase in each of the psychological health outcomes (Fig. 1). Consistently, a greater availability of access to private green spaces was significantly associated with a lower increase in all the psychological health outcomes (Fig. 2). Lastly, living on a road with higher levels of greenness, that we considered as a proxy of natural outdoor environment, was significantly associated with a lower increase in all the health outcomes (Fig. 2); in the adjusted model, this association remained valid for anxiety, fear, boredom, irritability, recurrent thoughts and/or dreams, and sleep disturbance (Tables S1 and S2 in Supplementary Materials).

3.3. Sensitivity analysis

Single-exposure regression models were further adjusted for number of confirmed COVID-19 cases per regional population. Significant associations between indoor-outdoor green features and psychological health outcomes remained robust. After the adjustment, presence of plant pots, anxiety and sleep disturbance resulted as being significantly associated. A slight decrease was found in the significance of the effect of sunlight on anger (from $p < 0.01$ to $p < 0.05$) and green view on poor concentration (from $p < 0.001$ to $p < 0.01$). Green view and natural outdoor environment were no longer significantly associated with recurrent thoughts and/or dreams in the adjusted model for the number of confirmed COVID-19 cases per regional population and the other aforementioned covariates (Tables S3 and S4 in Supplementary Materials).

3.4. Effect modification by the Current Working Mode

For green view, the interaction with CWM (smart workers vs non-smart workers) was statistically significant on boredom ($p = 0.02$), recurrent thoughts and/or dreams ($p = 0.04$) and irritability ($p = 0.02$). By stratifying this result for CWM, we found that in the group of non-smart workers the association between the amount of green view and each of the aforementioned outcomes was stronger than for smart workers. For access to private green space, no interaction term with CWM was significant for any of the psychological health outcome variables.

4. Discussion

To our knowledge, this study represents a first overview of the effects of green features within and surrounding the home environment and specific psychological health outcomes when access to public green spaces is banned. In fact, home confinement caused by the COVID-19 pandemic lockdown allowed us to study the effect of visual exposure to greenness and access to private green spaces when the use of public green spaces was not permitted.

Our results showed distinct associations with respect to the indoor and outdoor green features of the living environment and the assessed psychological health outcomes. We found that the presence of indoor plant pots was associated with a lower increase in anger, fear, irritability, and sleep disturbance during the lockdown. These results are of considerable importance for the extension of previous literature on health conditions in the living environment, such as the home and workplace (Dreyer et al., 2018). For example, the presence of plants in working environments seems to reduce perceived stress and, in general, to promote positive emotions and reduce negative feelings (Han, and Ruan, 2019). Interestingly, our results are inconsistent with those reporting associations between presence of indoor plants and lower level of anxiety (Hassan et al., 2018; Toyoda et al., 2020). However, these studies have focused on structured horticultural activities, and access to other forms of greenness was not prohibited. Therefore, a synergistic effect of the two conditions can be assumed, whilst our study considered the psychological benefits of the presence of indoor plants during a state of home confinement. It would be worthwhile to investigate the psychological benefits of the presence of plants in the home by involving different contexts and groups of individuals. From a therapeutic point of view, it would be interesting to learn which individuals spent most of their time indoors, such as the elderly in nursing homes (Tse, 2010).

Natural sunlight in the home was associated with a lower increase in many psychological health outcomes, such as anger, fear, confusion, moodiness, boredom, irritability, poor concentration, and sleep disturbance. These findings are consistent with those related to the reduction of sleep disturbance, depression, and agitation in groups of people who have poor self-regulation of circadian rhythms (Hanford, and Figueiro, 2013). Exposure to sunlight regulates changes in the release of serotonin in the brain, which is commonly known to affect mood and sleep quality (Lansdowne, and Provost, 1998; Lambert et al., 2002). Likewise, our results are in line with the evidence reporting improvement in mood level in individuals who spend a lot of time indoors after a brief 30-minute exposure to natural light (Kaida et al., 2007).

We found associations between green view and the entire range of psychological health outcomes evaluated. The evidence made available points out that green view provides layered benefits for individuals who are unable to freely move outside. For example, it was found that showing wall-size photographic images of natural landscapes to a sample of prisoners produced a calming and restorative effect (Moran, 2019). Furthermore, viewing nature from a window is particularly important for maintaining a healthy psychological state in healthcare environments where interactions with the outdoors can be limited (Raanaas et al., 2012). The three green variables discussed so far constitute indoor features that could act as important protective factors

Table 2
Descriptive statistics of the study participants and prevalence of psychological health outcomes.

	N = 3886 (%)	Anxiety M ± SD	AngerM ± SD	FearM ± SD	ConfusionM ± SD	MoodinessM ± SD	BoredomM ± SD	IrritabilityM ± SD	Recurrent thoughts/ dreams M ± SD	Poor concentration M ± SD	Sleep disturbanceM ± SD
Age-groups											
14–29	1039 (26.74)	3.0 ± 1.2	2.4 ± 1.3	2.8 ± 1.3	2.9 ± 1.3	3.1 ± 1.3	3.4 ± 1.4	3.0 ± 1.4	2.1 ± 1.3	3.0 ± 1.4	2.8 ± 1.5
30–44	1111 (28.59)	3.1 ± 1.2	2.3 ± 1.3	3.1 ± 1.2	2.7 ± 1.3	3.1 ± 1.2	2.7 ± 1.3	2.8 ± 1.3	2.9 ± 1.4	2.6 ± 1.3	2.3 ± 1.4
45–59	1186 (30.52)	3.1 ± 1.2	2.0 ± 1.2	3.0 ± 1.3	2.6 ± 1.3	2.6 ± 1.3	2.5 ± 1.4	2.3 ± 1.2	2.4 ± 1,4	2.6 ± 1.3	2.6 ± 1.4
60–74	520 (13.38)	2.8 ± 1.3	1.6 ± 0.9	2.7 ± 1.3	2.2 ± 1.2	2.3 ± 1.2	2.4 ± 1.4	2.0 ± 1.1	2.1 ± 1.3	2.3 ± 1.3	2.3 ± 1.3
≥75	30 (0.77)	2.8 ± 1.5	1.8 ± 1.2	3.0 ± 1.5	2.3 ± 1.3	2.6 ± 1.5	3.0 ± 1.3	2.4 ± 1.3	1.9 ± 1.2	2.1 ± 1.3	2.1 ± 1.3
Gender											
Male	1482 (38.14)	2.8 ± 1.2	1.9 ± 1.1	2.6 ± 1.2	2.4 ± 1.2	2.5 ± 1.3	3.0 ± 1.4	2.4 ± 1.3	2.1 ± 1.3	2.5 ± 1.3	2.4 ± 1.4
Female	2392 (61.55)	3.2 ± 1.2	2.2 ± 1.3	3.2 ± 1.3	2.8 ± 1.3	2.9 ± 1.3	2.8 ± 1.5	2.6 ± 1.4	2.4 ± 1.4	2.8 ± 1.4	2.8 ± 1.9
Other	12 (0.31)	3.1 ± 1.4	2.8 ± 1.5	2.8 ± 1.3	2.8 ± 1.5	3.0 ± 1.5	2.8 ± 1.3	3.0 ± 1.5	2.0 ± 1.5	3.6 ± 1.6	2.8 ± 1.6
Education level											
Primary school	7 (0.18)	4.3 ± 1.0	2.7 ± 1.7	3.7 ± 1.7	3.4 ± 2.0	3.4 ± 2.0	4.1 ± 1.5	3.1 ± 1.5	2.1 ± 2.0	2.1 ± 1.7	2.6 ± 1.8
Middle school	287 (7.39)	3.0 ± 1.3	2.4 ± 1.4	2.8 ± 1.3	2.6 ± 1.4	2.8 ± 1.4	3.2 ± 1.4	2.8 ± 1.5	2.2 ± 1.4	2.7 ± 1.5	2.6 ± 1.5
High school	1522 (39.17)	3.1 ± 1.2	2.1 ± 1.2	2.9 ± 1.3	2.7 ± 1.3	2.8 ± 1.3	3.0 ± 1.4	2.6 ± 1.4	2.2 ± 1.4	2.6 ± 1.4	2.7 ± 1.5
University	1438 (37)	3.0 ± 1.2	2.1 ± 1.2	3.0 ± 1.2	2.7 ± 1.3	2.7 ± 1.3	2.7 ± 1.4	2.4 ± 1.3	2.4 ± 1.4	2.6 ± 1.4	2.6 ± 1.4
Post-university	632 (16.26)	3.0 ± 1.3	2.1 ± 1.2	2.9 ± 1.3	2.6 ± 1.3	2.6 ± 1.3	2.5 ± 1.4	2.4 ± 1.3	2.3 ± 1.3	2.7 ± 1.4	2.6 ± 1.4
Working mode											
Smart working	2059 (52.99)	3.1 ± 1.2	2.9 ± 1.3	2.9 ± 1.2	2.7 ± 1.3	2.8 ± 1.3	2.8 ± 1.4	2.6 ± 1.3	2.3 ± 1.4	2.8 ± 1.4	2.6 ± 1.4
Working normally	361 (9.29)	3.1 ± 1.2	2.0 ± 1.1	3.0 ± 1.2	2.7 ± 1.3	2.7 ± 1.3	2.6 ± 1.5	2.5 ± 1.3	2.4 ± 1.4	2.4 ± 2.4	2.5 ± 1.4
Partial smart working	309 (7.95)	3.0 ± 1.2	1.9 ± 1.1	2.9 ± 1.1	2.5 ± 1.3	2.5 ± 1.2	2.6 ± 1.3	2.2 ± 1.2	2.2 ± 1.3	2.5 ± 1.3	2.5 ± 1.4
Suspended job	689 (17.73)	3.2 ± 1.3	2.1 ± 1.2	3.0 ± 1.3	2.7 ± 1.4	2.8 ± 1.3	3.1 ± 1.4	2.6 ± 1.3	2.4 ± 1.4	2.7 ± 1.4	2.8 ± 1.5
Lost job	81 (2.08)	3.4 ± 1.2	2.4 ± 1.4	3.1 ± 1.3	2.7 ± 1.3	3.0 ± 1.4	3.5 ± 1.4	2.9 ± 1.4	2.4 ± 1.4	3.0 ± 1.4	3.0 ± 1.5
Not classifiable*	387 (9.96)	2.9 ± 1.3	1.9 ± 1.2	2.8 ± 1.3	2.4 ± 1.3	2.5 ± 1.3	2.9 ± 1.4	2.2 ± 1.3	2.0 ± 1.3	2.3 ± 1.3	2.4 ± 1.4
Presence of other people											
Yes	3350 (91.35)	3.1 ± 1.2	2.2 ± 1.3	3.0 ± 1.3	2.7 ± 1.3	2.8 ± 1.3	2.9 ± 1.4	2.6 ± 1.3	2.3 ± 1.4	2.7 ± 1.4	2.7 ± 1.5
No	336 (8.65)	2.9 ± 1.3	1.8 ± 1.1	2.9 ± 1.3	2.5 ± 1.3	2.7 ± 1.4	2.9 ± 1.4	2.2 ± 1.3	2.2 ± 1.3	2.7 ± 1.4	2.7 ± 1.5
Presence of pets											
Yes	1398 (64.02)	3.1 ± 1.2	2.1 ± 1.2	2.9 ± 1.3	2.6 ± 1.3	2.7 ± 1.3	2.8 ± 1.4	2.5 ± 1.3	2.3 ± 1.4	2.7 ± 1.4	2.6 ± 1.4
No	2488 (35.98)	3.1 ± 1.2	2.1 ± 1.2	2.9 ± 1.3	2.7 ± 1.3	2.7 ± 1.3	2.9 ± 1.4	2.5 ± 1.3	2.3 ± 1.4	2.7 ± 1.4	2.6 ± 1.5
Decrease in income											
Yes	2128 (54.76)	3.2 ± 1.2	2.2 ± 1.3	3.0 ± 1.3	2.7 ± 1.3	2.9 ± 1.3	2.9 ± 1.4	2.6 ± 1.3	2.3 ± 1.4	2.8 ± 1.4	2.8 ± 1.5
No	1434 (36.90)	2.9 ± 1.2	1.9 ± 1.1	2.8 ± 1.2	2.5 ± 1.3	2.5 ± 1.3	2.7 ± 1.4	2.3 ± 1.3	2.2 ± 1.3	2.4 ± 1.4	2.4 ± 1.4
Rather not say	324 (54.76)	3.1 ± 1.2	2.3 ± 1.3	2.9 ± 1.3	2.8 ± 1.3	2.9 ± 1.3	3.0 ± 1.4	2.7 ± 1.3	2.3 ± 1.3	2.7 ± 1.4	2.6 ± 1.4

* Includes retirees and the unemployed since before the lockdown. M ± SD = mean plus or minus standard deviation.

Outcome		Plant pots β	Sunlight β	Green view β
Anxiety	Unadjusted	-.09	-.02	-.06
	Adjusted	-.08	-.02	-.05
Anger	Unadjusted	-.12	-.07	-.10
	Adjusted	-.08	-.05	-.07
Fear	Unadjusted	-.10	-.03	-.07
	Adjusted	-.10	-.04	-.07
Confusion	Unadjusted	-.05	-.07	-.10
	Adjusted	-.02	-.06	-.08
Moodiness	Unadjusted	-.10	-.09	-.11
	Adjusted	-.05	-.07	-.08
Boredom	Unadjusted	-.16	-.07	-.11
	Adjusted	-.07	-.04	-.07
Irritability	Unadjusted	-.15	-.07	-.10
	Adjusted	-.10	-.05	-.06
Recurrent thoughts/dreams	Unadjusted	.01	-.01	-.03
	Adjusted	-.005	-.02	-.04
Poor concentration	Unadjusted	-.03	-.07	-.08
	Adjusted	.01	-.06	-.05
Sleep disturbance	Unadjusted	-.14	-.09	-.10
	Adjusted	-.10	-.08	-.08

Legend
n.s.
p < 0.05
p < 0.01
p < 0.001

Fig. 1. Heat map chart displaying the associations between indoor green features and psychological health outcomes for each unadjusted and adjusted single-exposure regression model.
β =Beta coefficient of the regression model. n.s.=not significant. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Outcome		Private green spaces β	General outdoor naturalness β
Anxiety	Unadjusted	-.09	-.04
	Adjusted	-.09	-.04
Anger	Unadjusted	-.08	-.04
	Adjusted	-.06	-.03
Fear	Unadjusted	-.10	-.04
	Adjusted	-.09	-.04
Confusion	Unadjusted	-.07	-.04
	Adjusted	-.05	-.03
Moodiness	Unadjusted	-.09	-.04
	Adjusted	-.07	-.03
Boredom	Unadjusted	-.11	-.06
	Adjusted	-.09	-.04
Irritability	Unadjusted	-.09	-.06
	Adjusted	-.07	-.04
Recurrent thoughts/dreams	Unadjusted	-.05	-.03
	Adjusted	-.05	-.03
Poor concentration	Unadjusted	-.05	-.04
	Adjusted	-.04	-.03
Sleep disturbance	Unadjusted	-.10	-.06
	Adjusted	-.08	-.05

Legend
n.s.
p < 0.05
p < 0.01
p < 0.001

Fig. 2. Heat map chart displaying the associations between outdoor green features and psychological health outcomes for each unadjusted and adjusted single-exposure regression model.
β =Beta coefficient of the regression model. n.s.=not significant. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

for psychological well-being, hence it would be profitable to consider them as fundamental elements in the interior design of workplaces and homes (Gray, and Birrell, 2014; Ebrahimpour et al., 2018).

Regarding outdoor green features, access to private green spaces was strongly associated with all the psychological health outcomes considered, in line with previous evidence (de Bell et al., 2020d). On the contrary, natural outdoor environment was found to be moderately associated with only a minor increase in anxiety, fear, boredom, irritability, recurrent thoughts and/or dreams, and sleep disturbance. Evidence of the effects of outdoor green spaces on psychological and mental health is inconsistent. While numerous studies have reported positive associations between access to private green space and psychological and mental health (Wu et al., 2015; Cox et al., 2017; Korpela et al., 2017; Richardson et al., 2017; Dadvand et al., 2019; Kruize et al., 2020; Spano et al., 2020a; Giannico et al., 2021) and an inverse association between surrounding greenness and depression (Banay et al., 2019), others have found poor evidence on the effect of access to green spaces on mental health in adults and children (Gascon et al., 2015). Still others have reported a stronger association for surrounding greenness than for access to green spaces with mental health (Triguero-Mas et al., 2015). These inconsistencies may reflect the fact that access to green spaces and surrounding/neighbourhood greenness has been evaluated using a number of different tools, methods, contexts, and sample groups. However, few available studies have investigated the association between the aforementioned outdoor green variables and well-being when visiting public residential green spaces is not allowed. A recent measure of street view exposure of visible green space called “Green View Index” may assist in overcoming this gap. The tool accurately reproduces the human perception of greenness at street scale and could be useful for evaluating the effect of visual perception of surrounding greenness on health and well-being. (Larkin, and Hystad, 2019).

The observed associations between indoor-outdoor green features and psychological health outcomes have also been adjusted for number of confirmed COVID-19 cases per regional population. In a previous study, the confirmed COVID-19 cases proved to affect the emotions expressed inside and outside an urban park in Beijing city during the pandemic (Zhu & Xu, 2021). However, our findings did not remarkably change by adjusting for number of confirmed COVID-19 cases per regional population. This result is not surprising as the restrictive measures of the lockdown have been extended at national level. Therefore, the individuals’ perception of limitations and the behavioral adjustment of daily life involved the entire Italian population, regardless of the epidemiological specificities at the regional level. The only notable change observed was that green view and natural outdoor environment were no longer significantly associated with recurrent epidemic-related thoughts and/or dreams. This supports recent findings that living in an area highly exposed to COVID-19 infection can arouse traumatic experiences leading to the development of event-related recurrent and intrusive thoughts and dreams (Wang et al., 2020b).

Our preliminary results discussed so far highlight the differentiated effects of indoor and outdoor green features on different psychological health outcomes and suggest the potential role of green features in preventing the deterioration of specific aspects of psychological health. This provides preliminary insight into the possible differentiation of nature-based interventions and therapies fostering well-being.

The interaction of current working mode and green view

significantly affected boredom, recurrent thoughts and/or dreams, and irritability. This represents a further potential insight on the established essential role of smart working in workers' health and quality of life during the COVID-19 containment period (Zhang et al., 2020). Besides the aforementioned importance of being surrounded by nature-based elements and having access to greenness near the workplace (Marquet et al., 2020), it is worth promoting the use of nature-based elements also inside the home environment to promote the well-being of all users. Our results show that the associations between green view and the above-mentioned psychological health outcomes are stronger in non-smart workers than in smart workers demonstrating that exposure to green features at home can play a key role in perceived health and well-being, regardless of the presence of green features in the workplace.

Altogether, our findings, combined with those on the significant role of interaction of the working mode for smart workers and non-smart workers, allow to apply the results of our study to broader contexts. The importance of a home environment that predisposes contact with green elements can constitute a protective factor for psychological health not only in individuals forced to spend much time indoors, such as the elderly in their own home or in nursing homes, but also in adults who lead an active lifestyle, i.e., non-smart workers. In addition, our findings offer interesting insights to further explore the tendency of people to develop a pro-environmental behavior in household settings and the underlying drivers to this preference (Miao, and Wei, 2013).

5. Strength and limitations of the study

Several studies have investigated and confirmed the great value of public green during the COVID-19 pandemic (e.g., Ugolini et al., 2020; Venter et al., 2020; Xie et al., 2020). Only one study (Amerio et al., 2020) attempted to investigate the role of the housing-built environment on mental health during the COVID-19 lockdown, albeit on a large sample of university students. Thus far, no attempts have been made to systematically explore the mitigation of a number of green features (within and surrounding the home environment) on psychological health decline in the general population due to the COVID-19 lockdown.

Despite the sound evidence provided herein to support our study hypotheses, we realize that a number of limitations exist. The sample of survey participants is not uniformly distributed geographically and balanced according to demographic variables and, therefore, may not be representative of the entire Italian population. Moreover, we are aware of the potential effect of self-selection of the sample, since people who are less prone to use smartphones or e-mail are less likely to respond to an online survey. In addition, the cross-sectional research design does not provide baseline measures on psychological health outcomes; for this reason, we advise caution when discussing the associations between variables rather than a causal relationship.

Although the retrieval of self-reported data via a web-based survey was functional in reducing acquisition times and reaching all Italian regions, the survey was not composed of internationally validated measuring instruments for investigating psychological health outcomes, but rather of single items on the self-reported decline in psychological state. We cannot rule out that a certain amount of awareness of one's emotional state is required to provide such a reliable estimate.

Most of these limitations are the consequence of the exceptional nature of the situation under consideration. Numerous studies have used online data collection tools to investigate the psychological effects of quarantine through cross-sectional analyses. For example, Burhamah et al. (2020) report the bias resulting from a cross-sectional study with a non-representative sample and suggest further follow-up studies. Khan et al. (2020) recognize a further bias in addition to those mentioned, namely that internet access would exclude the less wealthy segment of the population. We also point out the exclusion of the elderly who, being a less computerized population group than others, are more difficult to reach (e.g., in our case, participants 75 years of age and older did not reach 1% of the total sample interviewed). Confinement and restrictions have made field data very difficult to collect, thus web-based data collection has become a valid alternative. However, web-based surveys must be self-reported and brief; thus, for our study and others (e.g., Ara et al., 2020; Corley et al., 2021) questionnaire items were created to satisfy this specific purpose.

The information on green features was also self-reported. This method of data collection is in line with a recent study from Ugolini et al. (2020) who investigated the perception of urban green spaces and the social isolation effects of not using them during lockdown. The study, through web-based data collection on an international scale, provided useful insights on the need for confined residents to benefit from green spaces, which confirms the results of our study. Lastly, in our study the availability of private green spaces was investigated in terms of amount and not of usage. Mediation variables could intervene, such as physical activity carried out in private green spaces that would lead to relevant mental health benefits (Dadvand et al., 2016). Likewise, we did not consider the potential mediating effect of gardening activities in private green spaces, which has been proven to generate benefits on health and well-being (Clatworthy et al., 2013; Spano et al., 2020b; Yeo et al., 2020). Further studies addressing these matters are strongly recommended.

6. Conclusions and future studies

Our research has shown that there are associations between indoor and outdoor green features and self-reported change for the most common psychological outcomes related to the COVID-19 lockdown (i.e., anxiety, anger, fear, confusion, moodiness, boredom, irritability, recurrent thoughts and/or dreams, poor concentration, and sleep disturbance). This result is particularly important in the current times we are experiencing, because it points out that the home can represent another means for promoting contact with nature and mental health and wellbeing. We believe it is also useful for more general considerations in this field of research. In this regard, there are still many questions to be investigated. For example, besides the presence or absence of indoor plants, as assessed in our study, it would be of great importance to further define what is meant by indoor green and how much of it is needed to significantly affect human health and well-being. Furthermore, as previously mentioned, focusing on indoor horticultural activities as therapeutic tools for categories at risk, such as individuals with age-related diseases, is worthy of further investigation. It would also be worth investigating extent or type of greenness in order to understand whether a restorative or beneficial health effect is attributable to distinctive components (e.g., flowers, plants, and landscapes) or to the combination thereof.

It is reasonable to conclude that a number of scenarios and research questions can be drawn from our findings. Further studies are recommended to replicate our findings in different contexts, evaluating other possible green elements in and surrounding the home environment. In addition, evaluating the long-term effects of the presence of these elements on psychological health through longitudinal studies is strongly endorsed.

CRediT authorship contribution statement

Giuseppina Spano: Conceptualization, methodology, investigation, writing and revising. **Marina D'Este:** Conceptualization, statistical analysis, investigation, and revising. **Vincenzo Giannico and Mario Elia:** Editing and Revising. **Rosalinda Cassibba, Raffaele Lafortezza, and Giovanni Sanesi:** supervising, editing and revising.

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Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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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.2021.127156.

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