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.

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Exposure to nature and mental health outcomes during COVID-19 lockdown. A comparison between Portugal and Spain

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ABSTRACT

Background: To control the spread of the SARS-CoV-2 virus, countries around the world implemented lockdowns with varying intensities. Lockdowns, however, have been associated with a deterioration of mental health, including post-traumatic stress symptoms, anger and anxiety. Exposure to nature might reduce stress and provide relaxation opportunities.

Objective: Firstly, we aimed to determine which sociodemographic, housing and lockdown-related characteristics were associated with changes in exposure to nature during the COVID-19 lockdown in Portugal and Spain. Secondly, we sought to estimate the associations of these changes with mental health, and test whether these associations differed according to sociodemographic characteristics and between the two countries, which experienced different restrictions and epidemiological situations.

Methods: A cross-sectional study was conducted between March 27 and May 6, 2020, using an online questionnaire to measure changes in exposure to nature (including private green space and other greenery, views of nature from home and public natural spaces); sociodemographic, housing and lockdown-related characteristics; stress levels (visual stress scale); psychological distress (General Health Questionnaire – 12 items) and somatization (somatization scale). Adjusted regression models were fitted to estimate associations.

Results: This study included 3157 participants (1638 from Portugal, 1519 from Spain). In Portugal, maintaining/increasing the use of public natural spaces during the lockdown was associated with lower levels of stress (adjusted beta −0.29; 95%CI −0.49, −0.08) and maintaining/increasing the frequency of viewing nature from home was associated with reduced psychological distress (0.27; −0.51, −0.03), somatization (−0.79; −1.39, −0.20), and stress levels (−0.48; −0.74, −0.23). In Spain, maintaining/increasing contact with private green space and greenery was associated with lower stress levels: for contact with indoor plants (−0.52; −0.96, −0.07) and for use of private community green spaces (−0.82; −1.61, −0.03).

Conclusion: Exposure to nature was associated with better mental health outcomes during lockdowns, but the natural features associated with improved mental health differed between the two countries. Nature should be

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incorporated into urban planning interventions and housing design and exposure to nature should be promoted during lockdowns.

1. Introduction

Research has shown that nature can provide many benefits for public health. Exposure to nature, particularly to public green and blue spaces, is associated with numerous health benefits including better cardiovascular and respiratory health (Lane Kevin, 2017; Cavaleiro Rufo, 2020), improved immune (Cavaleiro Rufo, 2020) and cognitive function (de Keijzer, 2018), and lower risk of disease (Twohig-Bennett and Jones, 2018) and mortality (Gascon, 2016). Although most of the research has focused on the physical health benefits of nature exposure, there is growing evidence showing that both physical and visual contact with nature is associated with better mental health outcomes (Wendelboe-Nelson, 2019) such as lower levels of stress, anxiety (Triguero-Mas, 2017) and rumination (Bratman, 2015), reduced prevalence of somatization symptoms (Triguero-Mas, 2017), improved biomarkers of stress (Ribeiro, 2019), and overall better psychological well-being (Pearson and Craig, 2014). Commonly proposed mechanisms that explain these mental health benefits include the provision of opportunities for physical and social activities along with restoration from stress and mental fatigue (Markevych, 2017). Moreover, evidence suggests that nature exposure may help individuals develop and enhance their resilience (Wu, 2013); i.e., the ability to cope with stressful life events and adversity (van den Berg, 2010; Marselle et al., 2019; Berto, 2014). For instance, van den Berg and colleagues, in the Netherlands, found that individuals with a high percentage of green space within 3 km from the residential location were less affected by experiencing a stressful life event (e.g. unemployment, financial crisis) than those with less (van den Berg, 2010).

By the beginning of 2020, societies worldwide were experiencing an unprecedented, disruptive event – the coronavirus disease 2019 (COVID-19) pandemic. The first confirmed case of COVID-19 in Europe was identified on January 23, 2020 (Spiteri, 2020), officially reaching Spain on January 31 and Portugal on March 1, 2020. According to the latest data available (from December 11, 2020), there were a total of 340,287confirmed cases of COVID-19 and 5373 deaths in Portugal, while in Spain the total number of cases reached 1,741,439 with 47,624 related deaths (DGS, 2020). In the absence of effective pharmacological solutions, the COVID-19 pandemic led many governments to implement general residential lockdowns, where non-essential mobility, services and events were suspended, and people were requested to stay-at-home and practice physical distancing.

Due to the different epidemiological situations, the timeline and intensity of mobility restrictions on the Iberian Peninsula were substantially different. In Portugal, the State of Emergency was declared on March 19, 2020 and was renewed biweekly until May 2, 2020 (PortugueseGov., 2020), while in Spain the State of Emergency was declared on March 14, 2020 and remained applicable until June 21, 2020 with a de-escalation period in three phases (SpanishGov., 2020). In both countries, the State of Emergency enforced similar mobility constraints, including the closure of international borders and the suspension of non-essential services and events. Residents could leave their homes only to shop for basic needs, to take care of vulnerable people, to walk their dogs or dispose daily residuals, and to go to work. In Portugal and Spain, travelling to work was limited to those in essential jobs (only during two weeks over the State of Emergency, in Spain), and working from home was encouraged. Public spaces such as playgrounds and fenced parks/gardens and some beaches were closed in both countries. The main difference between the lockdowns in the two nations was the fact that, in Portugal, residents were allowed to go out for short periods to exercise outdoors (e.g. walking or running alone), making it possible to visit public natural spaces, while in Spain these activities were expressly prohibited until May 2nd.

While lockdowns have helped to contain the spread of the SARS-CoV-2 virus, they have been associated with worsening mental health and well-being, including post-traumatic stress symptoms, confusion, anger and anxiety (Armitage and Nellums, 2020; Brooks, 2020; Pfefferbaum and North, 2020; Rajkumar, 2020; Torales et al., 2020). These problems seem to originate from the social isolation and disrupted daily routines, but also from the health and financial concerns that emerged from COVID-19 public health crisis (Brooks, 2020). In this context, exposure to nature might reduce stress and provide relaxation opportunities to cope with the lockdown (Berto, 2014; Tendais and Ribeiro, 2020). Indeed, coincidentally, mobility data from Google shows that, in countries with more lenient lockdowns, such as Sweden, more people used parks during this time, possibly to escape from home confinement (Google, 2020). However, socioeconomic differences are decisive for nature exposure during lockdown. Population with the highest incomes usually have better access to green space and other natural spaces (Hoffimann et al., 2017), while most vulnerable populations, especially in large cities live in small apartments with limited access to natural spaces. Precisely, the most vulnerable and socioeconomically deprived populations were found to be at higher risk of psychological distress associated with COVID-19 pandemic (Pierce, 2020). Lack of contact with natural environments might in part contribute for their worst mental health outcomes (Tendais and Ribeiro, 2020).

Yet, as far as we know, no investigation to date has been conducted to assess to what extent regular exposure to nature alleviates the negative mental health effects of COVID-19 lockdowns. As conceptualized in Fig. 1, it is important to take into account that, for people in stricter lockdowns such as in Spain, exposure to private green spaces and greenery (such as indoor and balcony plants, home/courtyard gardens, community private gardens and green roofs) and views of nature might be greater than the exposure to public natural spaces (e.g. public parks and gardens, woodlands, water bodies). Thus, all types of natural features and environments, indoors and outdoors, public and private, must be taken into consideration.

Bearing this in mind, the main research hypothesis underlying this study is that individuals with greater exposure to nature would suffer less from the negative mental health effects of COVID-19 lockdown compared to those with less exposure. Also, due to the different mobility restrictions, a second hypothesis is that the beneficial effects of private greenery and green space might be more prominent in Spain than in Portugal, while those of public natural spaces would be more relevant in Portugal.

Specifically, this study aimed to explore: (i) the sociodemographic, housing and lockdown-related factors associated with changes in exposure to nature during the COVID-19 lockdown; (ii) the associations between changes in exposure to nature and mental health outcomes during the COVID-19 lockdown; and (iii) whether these associations differed according to sociodemographic characteristics and country, as Portugal and Spain were under different mobility restrictions and epidemiological situations.

2. Material and methods

2.1. Study design and procedures

A cross-sectional study was conducted between March 27 and May 6, 2020. The online questionnaire was launched first in Spain (on March 27, 2020) and, then, the Portuguese team translated, culturally adapted, and launched the online questionnaire (on April 23, 2020). During this period, both countries were under a strict general lockdown.

The questionnaire was created using Microsoft Forms and distributed by email and social networking platforms such as Twitter, WhatsApp, LinkedIn, Instagram, and Facebook. We also requested contacts to circulate the survey link among their respective personal and professional networks. Moreover, the communication offices of the Public Health Institute University of Porto (ISPUP) and the Institute of Environmental Science and Technology (ICTA-UAB) published press releases in various media outlets to reach a wider audience and university mailing lists were used to distribute the questionnaire as well.

Because of the questionnaire design and its dissemination strategy, the response rate could not be ascertained as it was not possible to estimate how many people were reached by email, social media, or via media outlets.

The questionnaire included 25 questions developed by the team to measure exposure to nature (private green space and greenery, views of nature and public natural spaces), sociodemographic, housing and lockdown-related characteristics, stress levels, psychological distress and somatization (the English translation of the questionnaire is provided in Supplementary Material 1). Before launching it, we conducted a pilot questionnaire among a convenience sample of participants (Portugal = 8; Spain = 7) to assess its comprehension and acceptability. To participate in the survey, participants had to be 18 years old or older and reside in Portugal or Spain during the lockdown. The questionnaire took on average 8 min to complete.

Aiming at a statistical power of 80% and using the 95% confidence interval to assess the absence/presence of associations, a sample size of roughly 1500 individuals (for each country), gives an effect size of 0.1, i.e., detects differences between averages or proportions even if these differences are only 0.1 of the value of the standard deviation (Cohen, 2013).

Ethical approval was obtained from each country's corresponding authority: Ethics Committee on Animal and Human Experimentation (CEEAH), Spain (approval number 5141) and Ethics Committee of the ISPUP, Portugal (approval number 20147). The study was carried out according to the Helsinki Declaration and all participants provided informed consent.

2.2. Exposure to nature

Exposure to nature was assessed using seven questions covering the frequency of visits, views, care of different types of natural elements and environments before and during the lockdown, each with a five-category response scale: 1 = do not have access/not applicable, 2 = never or less than once per week, 3 = once or twice per week, 4 = three to six times per week and 5 = every day. Being this a cross-sectional study, the questionnaire was applied once and the data on the exposure to nature before the lockdown was assessed retrospectively.

We considered private green space and greenery, views of nature and public natural spaces, summarized in Fig. 1. More precisely, the following types of natural elements and environments were included: (i) indoor plants; (ii) balcony plants; (iii) home/courtyard garden; (iv) private community green spaces (gardens, green roofs, etc.); (v) views of nature from home (i.e. green spaces and other natural environments that the person can observe from their home); (vi) public natural spaces (i.e. outdoor natural spaces of public use, such as street greenery, public parks and gardens, woodlands, water bodies, etc.); and (vii) others (open-ended question where the participant could specify the type of natural environment they were referring to). Whenever answers from (vii) matched to one of the previous types of natural elements and environments, the variable was recoded accordingly; those that did not match were kept in this 'others' category.

Based on this information, a variable measuring change in exposure to nature was created by comparing the level of exposure before and during the lockdown. A dichotomous variable was created to distinguish individuals who maintained or increased exposure to nature from those whose exposure to nature decreased during the lockdown. This was used as our main exposure variable.

2.3. Mental health outcomes

2.3.1. Psychological distress

Psychological distress was measured using the General Health Questionnaire (GHQ-12) (Goldberg and Williams, 2000), a self-assessment screening tool to measure common mental disorders. This questionnaire has been successfully used in Portuguese (Laranjeira, 2008) and Spanish (del Pilar Sánchez-López and Dresch, 2008) populations and has good psychometric properties. The questionnaire consisted of 12 items. In the first six items, response options assumed the following categories – much less than usual, less than usual, same, more than usual, and do not know/do not answer – while responses to the remaining six items assumed these categories – not at all, no more than usual, a bit more than usual, much more than usual, and do not know/do not answer. The study used Goldberg's original scoring method (Goldberg and Williams, 2000). Scores for all items were then summed, resulting in a score ranging from 0 to 12.

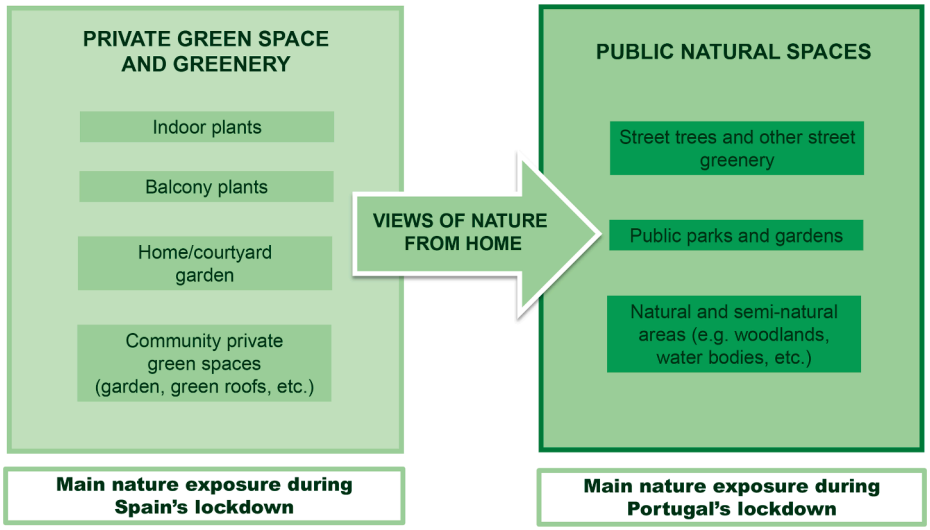

Fig. 1. Schematic representation of studied types of natural elements and environments.

2.3.2. Somatization

As in a previous study (Triguero-Mas, 2017), seven questions were used from an adaptation of the four-dimensional symptom questionnaire (4DSQ) (Terluin, 2006) to measure somatization plus two additional questions (Cronbach's $\alpha = 0.82$ for Portugal and Cronbach's $\alpha = 0.78$ for Spain). Specifically, participants were asked: "During lockdown, have you suffered from: (i) dizziness/light-headed, (ii) painful muscles, (iii) back and/or shoulder pain, (iv) headache, (v) nausea, (vi) pain in the abdomen or stomach area, (vii) pain in the chest. And the additional items were (viii) ache in the back of the head, and (ix) fatigue. The questionnaires were translated and adapted to Spanish and Portuguese following the WHO guidelines (WHO. Process of translation and adaptation of instruments., 2020). The nine questions aiming to measure somatization had five possible responses scored as: no with a 5, sometimes with a 4, regularly with a 3, often with a 2, very often with a 1. We constructed a sum score of all the items ranging between 9 and 45, with high scores indicating no perceived somatization symptoms (i.e. higher scores of no somatization indicated better mental health).

2.3.3. Perceived stress

Perceived stress was assessed using a question applied in a previous study on the topic (Triguero-Mas, 2017): "Please, indicate how stressed (in general terms) have you felt during the lockdown on this scale". Responses were recorded using a visual scale from 0 ("not at all ") to 10 ("as bad as it could be"), with a mid-point labelled "usual stress level". Because this scale was composed of a single item, it was not possible to compute measures of internal consistency, such as Cronbach's α. However, convergent validity (how closely the new scale is related to other measures of the same construct, namely from well-established and validated scales (Krabbe, 2016) was possible to assess by measuring the correlation between perceived stress and the other mental health outcomes using the Spearman's rank correlation coefficient (ρ). From this analysis, we observed – despite the limitations of our perceived stress measure – a moderate and statistically significant correlation between perceived stress and psychological distress (ρ for Portugal 0.53 and ρ for Spain 0.42) and somatization (ρ for Portugal 0.48 and ρ for Spain 0.41) (Supplementary material 2).

2.4. Covariates

2.4.1. Sociodemographic and housing characteristics

We collected information on gender (male, female, other); age group (≤24 years, 25–39 years, 40–64 years, 65–79 years and ≥ 80); country of birth (native, other European country, Non-European country); individual monthly disposable income before the lockdown (<600, 600–1199, 1200–1999, 2000–2999, 3000–4999, ≥5000 euros, do not know/do not answer); education attainment (primary, secondary and tertiary); household size (number of cohabitants); and dependents in the household (none, children, elderly, disabled and other dependents). Because exposure to certain types of green spaces/greenery (e.g. balcony plants, home/courtyard gardens) may be influenced by housing characteristics, we also collected data on housing typology (rural single-family house, urban single-family house, apartment and top-floor apartment - which often have access to rooftop outdoor space) and house size in square meters (≤45, 46–75, 76–105, 106–150, 151–200, and ≥200).

2.4.2. Lockdown-related characteristics

Several questions about the lockdown characteristics were included in the questionnaire, more precisely: (i) change in income during the lockdown (severely reduced, moderately reduced, remained the same, increased, do not know/do not answer); (ii) type of housing where they stayed during the lockdown (primary home, second-home, home from family/friends); (iii) the duration of the lockdown (in days) at the time of the survey response; (iv) outside activities during the lockdown (1-obtain essential goods and services, such as food, medication, healthcare, etc.; 2-going to work; 3-assisting vulnerable people (e.g. elderly, disabled); 4-walk the companion animal; 5-walk and exercise; 6-take out the garbage; 7-never went out); and (v) frequency with which respondents left their homes during the lockdown (1-less than once a week or never, 2-one to two times a week, 3-three to six times a week, 4-once a day, 5-several times a day).

Note that since data on income (both monthly disposable and change during lockdown) and house size had a large amount of missing values in Portugal (over 15%) these variables were not included as covariates in the adjusted models.

2.5. Statistical analyses

For the descriptive analysis, we calculated the mean or median and standard deviation or interquartile range (IQR), as well as counts and proportions for each variable. For group comparisons, Chi-squared tests (or Fisher's exact tests) were used for categorical variables, while for continuous variables we used T-tests, Mann-Whitney tests or Wilcoxon-tests, according to variable type and distribution. The statistical significance was considered at $p < 0.05$.

We fitted logistic regression models with adjustment for covariates to understand the sociodemographic, housing and lockdown-related characteristics associated with change (maintenance/increase versus decrease) in nature exposure. These associations were expressed using the odds ratio (OR) and 95%CI. Additionally, crude and adjusted linear regression models were used to estimate the associations between change in the exposure to nature during the lockdown (maintenance/increase vs. decrease) and (i) psychological distress, (ii) stress levels, (iii) somatization. We selected the variables to be included in the adjusted model based on our theoretical understanding of the importance of each available variable in contributing to mental health during lockdown. We first verified that all model assumptions were met for each variable and combination of variables. Adjusted models included mental health outcomes and change in exposure (maintenance/increase in nature exposure), plus the following covariates: age, gender, household size and dependents in the household, education attainment, house typology, country of birth, frequency of going out during the lockdown, outside activities during the lockdown, duration of the lockdown, and type of housing during the lockdown. The correlation matrix of the included covariates is shown in Supplementary Material 2. Note that since data on income (both monthly disposable and change during lockdown) and house size had a large amount of missing values in Portugal (over 15%) these variables were not included as covariates in the adjusted models. However, income was significantly ($p < 0.001$) associated with education (included in adjusted models) and house size was significantly ($p < 0.001$) associated with house typology (also included in adjusted models), minimizing the risk of residual confounding. . Separate models were run for each country and type of natural element and environment. Associations were expressed using beta and 95% Confidence Intervals (95% CI).

Effect modification by gender, age and socioeconomic factors was explored by assessing the statistical significance of multiplicative interactions using likelihood ratio tests comparing models with and without interaction terms. All analyses were run in R statistical package (version 3.5.1).

3. Results

3.1. Participants' characteristics

Table 1 depicts the sociodemographic characteristics of the study participants. This study includes a total of 3157 participants, of which 1638 were residents from Portugal and 1519 from Spain. The majority of the participants in both countries were women and were between 40 and 64 years old. Participants from Spain were significantly older than those from Portugal. In both countries, more than 85% of participants were

Table 1
Sample characteristics according to country (Portugal and Spain, n = 3157).

Variable	Portugal (n = 1638)		Spain (n = 1519)		p-value country differences[a]
	n/ mean	%/SD	n/ mean	%/SD	
Sociodemographic and housing characteristics					
Gender					
Female	1229	75.1	1125	74.1	0.012
Male	407	24.9	386	25.4	
Other	0	0.0	8	0.5	
Age group					
≤24 y	406	24.8	78	5.1	<0.001
25–39 y	558	34.1	518	34.1	
40–64 y	638	38.9	827	54.4	
≥65y	36	2.2	96	6.3	
Education attainment					
Primary or no education	23	1.4	22	1.4	<0.001
Secondary	379	23.1	153	10.1	
Tertiary (university degree)	1236	75.5	1344	88.5	
Household size (no. inhabitants)	4.5	2.0	3.4	1.7	<0.001
Dependents in the household					
Yes, children	473	28.9	525	34.6	<0.001
Yes, elderly	113	6.9	52	3.4	<0.001
Yes, person(s) with physical/mental disabilities	23	1.4	18	1.2	0.699
Yes, other type of dependent person	55	3.4	20	1.3	<0.001
No	982	60.0	850	56.0	0.023
Housing typology					
Rural single-family house	413	25.2	135	8.9	<0.001
Urban single-family house	314	19.2	240	15.8	
Apartment	869	53.1	970	63.9	
Top-floor apartment	33	2.0	171	11.3	
Other	9	0.5	3	0.2	
House area					
<45 sq. m	52	3.8	60	4.0	<0.001
46–75 sq. m	155	11.2	370	24.7	
76–105 sq. m	297	21.5	489	32.6	
106–150 sq. m	305	22.0	285	19.0	
151–200 sq. m	194	14.0	129	8.6	
More than 200 sq. m	381	27.5	167	11.1	
Individual monthly disposable income before the lockdown					
<600 euros	158	9.6	95	6.3	<0.001
600–1199 euros	578	35.3	266	17.5	
1200–1999 euros	378	23.1	535	35.2	
2000–2999 euros	167	10.2	390	25.7	
3000–4999 euros	33	2.0	126	8.3	
5000 euros or more	12	0.7	14	0.9	
Country of birth					
Native	1466	89.5	1326	87.3	0.137
Other European country	75	4.6	89	5.9	
Non-European country	97	5.9	104	6.8	
Lockdown related variables					
Income change during the lockdown					
Severely reduced	200	14.2	191	13.2	0.394
Moderately reduced	238	16.9	224	15.5	
Remained the same	958	68.0	1023	70.7	
Increased	13	0.9	9	0.6	
Type of housing during the lockdown					
Main home	1506	92.0	1432	94.3	0.002
Second-home	61	3.7	23	1.5	
Family/friends home	66	4.0	59	3.9	
Other	4	0.2	4	0.3	
Lockdown duration (days)	32.8	10.9	14.1	8.7	<0.001
Outside activities during the lockdown					
Obtaining essential goods and services (e.g. food, medicines, healthcare)	1373	83.8	1306	86.0	0.101
Going to work	396	24.2	159	10.5	<0.001
Assisting vulnerable people (e.g. elderly, disabled)	270	16.5	123	8.1	<0.001
Walk the companion animal	248	15.1	163	10.7	<0.001
Walk and exercise	787	48.0	–	–	–
Take out the garbage	1008	61.5	1020	67.1	0.001
Never went out	67	4.1	119	7.8	<0.001
Other	5	0.3	8	0.5	0.489
Frequency of leaving the house					
Less than once a week or never	432	26.4	102	7.9	<0.001
1–2 times a week	601	36.7	729	56.3	
3–6 times a week	297	18.1	252	19.5	
Once a day	233	14.2	120	9.3	
Several times a day	75	4.6	91	7.0	
Mental health outcomes					
Psychological distress	2.9	2.0	2.7	1.9	<0.001
Perceived stress	5.8	2.1	5.1	2.3	<0.001
Somatization	15.0	5.2	13.6	4.2	<0.001

[a] Chi-squared test (or Fisher's exact test) was used for categorical variables, while for continuous variables we used T-test, Mann-Whitney test or Wilcoxon-test, according to variable type and distribution.

natives (i.e. born in Portugal or Spain).

Most participants had a university degree, but this proportion was significantly larger in Spain (88.5%) than in Portugal (75.4%). In terms of geographical coverage, in Portugal, roughly 50% of the participants resided in the Northern region, while in Spain, circa 85% resided in Catalonia. Regarding housing characteristics, the majority of the participants resided in apartments, but, compared with Spain, in Portugal, there was a significantly higher proportion of individuals residing in single-family homes located in rural areas. In Portugal, there was also a higher proportion of individuals residing in houses that were 200 square meters or larger and the average number of cohabitants per household was significantly larger than in Spain. Overall, Spanish households were more likely to have dependents than those from Portugal. In Portugal, the proportion of households with older adults was significantly higher than in Spain, while the opposite was observed for the proportion of households with children, which was more common in Spain. Monthly disposable income differed between countries as well: in Portugal, the most common income bracket was '600–1199 euros', while in Spain it was '1200–1999 euros'.

More than one-quarter of the participants, in both countries, experienced moderate to severe reduction in income during the lockdown period. In both countries, more than 90% of the participants remained in their primary home during the lockdown period (particularly in Spain). Regarding mobility, although in Spain movement restrictions were stricter, there was a higher proportion of Spanish participants leaving the home several times a day (7.0% vs. 4.6% in Portugal) and a lower proportion saying they left the home less than once a week or never (7.9% vs. 26.4% in Portugal). In both countries, the main reasons for leaving the home were obtaining essential goods and services (83.8% in Portugal and 86.0% in Spain) and taking out the garbage (61.5% in Portugal and 67.1% in Spain). In Portugal, 48.0% of the participants referred leaving the home to walk or exercise, while in Spain those activities were not allowed. Due to the different survey starting dates, there was a large difference in the time spent in lockdown when participants answered the questionnaire between the two countries (32.8 days in Portugal vs. 14.1 days in Spain on average). There were also small but significant differences in health outcomes between the two countries. Portuguese participants presented significantly higher scores of psychological distress (2.9 in Portugal vs. 2.7 in Spain) and somatization (15.0 in Portugal vs. 13.6 in Spain), as well as higher levels of stress (5.8 in Portugal vs. 5.1 in Spain).

3.2. Nature exposure before and during COVID-19 lockdown

In Fig. 2, we show the frequency of nature exposure before and during the COVID-19 lockdown according to country by different natural elements and environments. In both countries, as expected, there was a significant reduction in the use of public natural spaces. For instance, in Spain, the proportion of people that visited this type of spaces everyday went from 20.8% (before the lockdown) to 9.0% (during the lockdown).

Regarding other types of natural elements and spaces, changes in patterns of exposure before and during the lockdown were less pronounced or even in the opposite direction. For instance, the frequency of exposure to private green space and greenery increased in both countries. The overall frequency of the remaining forms of nature exposure (views from home and community private green spaces) was not significantly altered, as there were equivalent proportions of people that increased and reduced their utilization after the implementation of the lockdown, in both countries.

The proportion of participants who increased or maintained the exposure to nature during the lockdown were: 92.4% in Portugal and 91.2% in Spain for indoor plants; 94.0% and 92.6% for balcony plants; 95.4% and 95.3% for home/courtyard gardens; 90.9% and 90.8% for community private green spaces; 80.0% and 87.2% for views of nature from home; 46.2% and 34.0% for public natural spaces; and finally, 92.3% and 89.8% for the other natural spaces.

3.3. Characteristics associated with changes in nature exposure

Table 2 shows the sociodemographic, housing and lockdown-related characteristics associated with maintenance/increase in nature exposure during the lockdown. As mentioned before, the frequency of exposure to private green space and greenery increased during the lockdown. In Spain, both presence of children (OR 3.14; 95%CI 1.20, 7.95) and total absence of dependents in the household (OR 2.90; 95%CI 1.21, 6.53) were both associated with a greater likelihood of exposure to indoor plants. Residing in apartments or top-floor apartments was also associated with a greater likelihood of increased or maintained exposure to home/courtyard gardens in Portugal (OR 3.49; 95%CI 1.88, 6.68) and in Spain (OR 2.75; 95%CI 1.17, 6.03) in comparison to residing in rural single-family houses. A similar trend was seen for balcony plants in Portugal (OR 2.01; 95%CI 1.22, 3.32). On the other hand, spending the lockdown in second-homes or the homes of family/friend (in comparison to spending it in the main home) was associated with lower likelihood of increasing/maintaining exposure to indoor (Portugal: OR 0.41; 95%CI 0.24, 0.74; Spain: OR 0.43; 95%CI 0.21, 0.95) or to balcony plants (Spain: OR 0.23; 95%CI 0.12, 0.47). Another detrimental circumstance for contact with indoor plants was living in households with more cohabitants (Spain: OR 0.82; 95%CI 0.71, 0.96) or being older (Spain: OR 0.28; 95%CI 0.07, 0.95).

The frequency of outside activities during lockdown was positively associated with increase/maintenance of exposure to house home/courtyard gardens, chiefly in Portugal. Leaving the house for work (Portugal: OR 0.34; 95%CI 0.18, 0.63) and to obtain essential goods/services (Spain: OR 0.16; 95%CI 0.09, 0.77) were negatively associated with maintaining/increasing the use of house gardens.

Concerning community private green spaces, in Portugal, individuals staying in second-homes or family/friends' home during the lockdown (OR 0.42; 95%CI 0.25, 0.74) and those who left home to work (OR 0.59; 95%CI 0.38, 0.94) were less likely to maintain/increase the use of these natural elements and environments, although the frequency of leaving home showed a positive association with this outcome. In Spain, adults aged $\geq$ 65 years (OR 0.07; 95%CI 0.01, 0.28) were less likely to maintain/increase the exposure to community private green spaces and the likelihood of use also decreased with time spent in lockdown (OR 0.98,

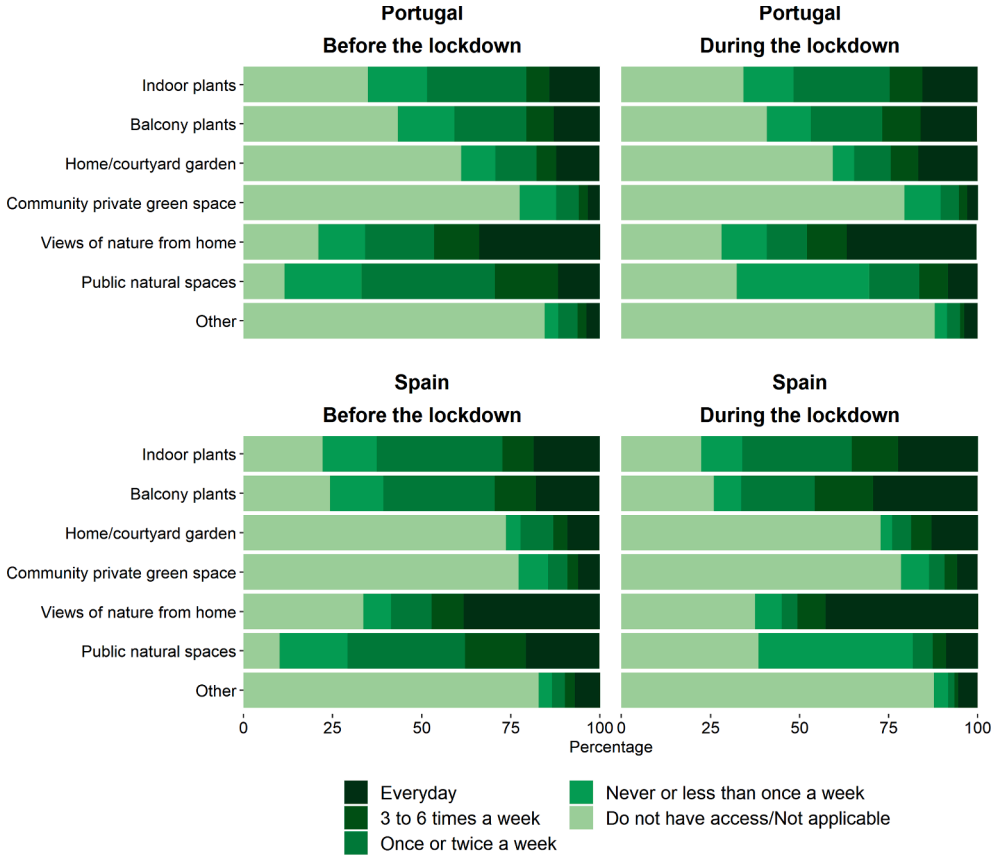

Fig. 2. Exposure to nature before and during COVID-19 lockdown, according to country (Portugal and Spain, n = 3157).

Table 2
Adjusted associations (odds ratio and 95% confidence intervals) between sociodemographic, housing and lockdown-related variables and maintenance/increase in nature exposure during COVID-19 lockdown (Portugal and Spain, n = 3157).

Variable	Indoor plants		Balcony plants		House/courtyard garden		Community private green space		Views of nature		Public natural spaces		Other	
	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain
Sociodemographic and housing characteristics														
Male (ref: female)	1.38 (0.87–2.24)	0.84 (0.54–1.32)	1.00 (0.61–1.67)	0.80 (0.49–1.32)	0.81 (0.46–1.46)	1.12 (0.60–2.21)	0.69 (0.47–1.05)	1.19 (0.75–1.95)	1.12 (0.82–1.53)[a]	1.07 (0.74–1.59)	1.08 (0.85–1.38)	1.30 (1.00–1.71)	1.54 (0.97–2.41)	1.43 (0.92–2.28)
Age group (ref: ≤24 years)														
25–39 years	1.29 (0.70–2.38)	0.83 (0.22–2.47)	1.54 (0.80–2.98)	0.83 (0.18–2.80)	1.66 (0.75–3.72)	0.48 (0.03–2.79)	1.52 (0.88–2.62)	0.38 (0.06–1.44)	1.38 (0.95–2.01)	0.53 (0.17–1.39)	**1.49 (1.08–2.07)***	1.06 (0.55–2.08)	0.78 (0.43–1.42)	**0.14 (0.01–0.73)***
40–64 years	0.79 (0.43–1.44)	0.59 (0.16–1.64)	1.63 (0.82–3.27)	0.70 (0.16–2.25)	1.19 (0.54–2.63)	0.41 (0.02–2.27)	1.59 (0.90–2.83)	0.32 (0.05–1.18)	**2.26 (1.50–3.41)***	0.51 (0.16–1.32)	**1.74 (1.24–2.44)***	1.28 (0.68–2.48)	0.78 (0.42–1.44)	**0.12 (0.01–0.57)***
≥65 years	0.93 (0.29–4.18)	**0.28 (0.07–0.95)***	0.78 (0.26–2.89)	0.35 (0.07–1.38)	1.53 (0.27–28.95)	0.15 (0.01–1.02)	0.95 (0.32–3.49)	**0.07 (0.01–0.28)***	1.69 (0.70–4.72)	0.51 (0.14–1.74)	1.78 (0.86–3.73)	1.68 (0.78–3.69)	0.54 (0.18–1.98)	**0.11 (0.01–0.61)***
Tertiary education (ref: primary/secondary)[b]	1.27 (0.79–2.00)	1.29 (0.70–2.26)	1.13 (0.67–1.87)	1.02 (0.48–1.99)	1.32 (0.74–2.33)	0.51 (0.15–1.35)	0.85 (0.54–1.32)	1.69 (0.95–2.93)	1.03 (0.75–1.41)	1.17 (0.66–1.99)	1.29 (0.99–1.68)	0.79 (0.54–1.16)	1.54 (0.97–2.41)	1.55 (0.86–2.71)
Household size (no.)	1.01 (0.90–1.14)	**0.82 (0.71–0.96)***	1.05 (0.92–1.19)	0.96 (0.81–1.14)	0.87 (0.75–1.01)	0.89 (0.72–1.11)	0.98 (0.88–1.09)	0.88 (0.75–1.03)	**0.91 (0.84–0.98)***	0.92 (0.81–1.04)	1.02 (0.96–1.08)	0.98 (0.89–1.08)	0.95 (0.85–1.07)	1.01 (0.88–1.18)
Dependents in the household														
Yes, children (ref. no)	1.02 (0.40–2.60)	**3.14 (1.20–7.95)***	1.03 (0.37–2.97)	2.24 (0.71–6.62)	1.10 (0.33–3.91)	1.86 (0.43–7.04)	0.53 (0.22–1.31)	1.76 (0.66–4.57)	1.08 (0.54–2.15)	0.47 (0.16–1.21)	0.65 (0.38–1.11)	0.58 (0.32–1.07)	0.69 (0.27–1.77)	1.07 (0.41–2.68)
Yes, older adults (ref. no)	1.36 (0.53–3.91)	2.27 (0.72–7.99)	0.55 (0.21–1.61)	2.70 (0.66–14.38)	0.92 (0.31–3.18)	1.78 (0.32–14.60)	**0.41 (0.18–0.98)***	1.17 (0.38–4.07)	0.97 (0.49–1.98)	0.52 (0.17–1.66)	0.89 (0.52–1.52)	0.82 (0.37–1.79)	0.54 (0.23–1.39)	0.40 (0.15–1.10)
Yes, disabled or dependent person(s) (ref. no)[b]	0.63 (0.24–1.81)	1.43 (0.44–5.72)	0.78 (0.25–2.87)	0.67 (0.19–2.76)	0.80 (0.23–3.34)	0.97 (0.20–7.34)	1.90 (0.57–8.83)	0.70 (0.23–2.58)	1.71 (0.74–4.25)	4.30 (0.78–80.72)	1.23 (0.66–2.31)	1.53 (0.66–3.49)	**0.34 (0.13–0.97)***	0.80 (0.25–3.12)
No (ref. yes)	1.17 (0.47–2.81)	**2.90 (1.21–6.53)***	0.79 (0.28–2.16)	1.51 (0.55–3.73)	1.14 (0.32–4.11)	1.76 (0.46–5.62)	0.66 (0.27–1.61)	1.55 (0.64–3.52)	1.00 (0.51–1.94)	0.45 (0.16–1.08)	0.90 (0.54–1.50)	0.82 (0.48–1.40)	0.50 (0.19–1.27)	0.91 (0.38–2.02)
Housing typology (ref: Rural single-family house)														
Urban single-family house	0.87 (0.50–1.52)	0.94 (0.43–1.97)	1.40 (0.79–2.55)	0.97 (0.41–2.22)	1.14 (0.64–2.10)	1.12 (0.45–2.70)	1.07 (0.63–1.86)	1.05 (0.46–2.35)	0.81 (0.56–1.18)	**0.28 (0.10–0.67)***	**0.71 (0.52–0.96)***	**0.49 (0.30–0.82)***	0.78 (0.45–1.34)	0.44 (0.16–1.07)
Apartment or top-floor apartment[b]	0.98 (0.61–1.57)	1.17 (0.58–2.23)	**2.01 (1.22–3.32)***	1.23 (0.56–2.53)	**3.49 (1.88–6.68)***	**2.75 (1.17–6.03)***	0.78 (0.50–1.20)	1.14 (0.54–2.21)	0.84 (0.61–1.15)	**0.30 (0.11–0.66)***	**0.67 (0.52–0.87)***	**0.54 (0.35–0.84)***	1.03 (0.64–1.65)	**0.44 (0.17–0.98)***
Country of birth (ref: native)														
Other European country	0.96 (0.45–2.38)	0.60 (0.28–1.38)	0.99 (0.41–2.96)	1.73 (0.59–7.44)	**0.35 (0.16–0.87)***	1.49 (0.42–9.53)	0.54 (0.27–1.23)	0.62 (0.30–1.43)	1.01 (0.56–1.93)	0.72 (0.39–1.40)	1.20 (0.74–1.95)	0.64 (0.36–1.11)	0.73 (0.35–1.72)	0.82 (0.41–1.85)

(*continued on next page*)

Table 2 (*continued*)

Variable	Indoor plants		Balcony plants		House/courtyard garden		Community private green space		Views of nature		Public natural spaces		Other	
	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain	Portugal	Spain
Other World country	1.17 (0.55–2.88)	1.00 (0.46–2.50)	0.85 (0.38–2.29)	0.71 (0.32–1.80)	0.80 (0.32–2.48)	3.87 (0.81–69.62)	0.92 (0.47–1.98)	0.68 (0.34–1.55)	0.76 (0.46–1.30)	0.70 (0.39–1.33)	1.17 (0.76–1.80)	0.64 (0.36–1.07)	0.94 (0.46–2.22)	1.25 (0.59–3.10)
Lockdown-related variables														
Type of housing during the lockdown (ref: main home)														
Second-home or family/ friends' home [b]	**0.41 (0.24–0.74)***	**0.43 (0.21–0.95)***	0.79 (0.41–1.65)	**0.23 (0.12–0.47)***	0.66 (0.31–1.52)	0.79 (0.28–2.87)	**0.42 (0.25–0.74)***	1.24 (0.50–3.76)	0.81 (0.53–1.28)	**0.31 (0.17–0.60)***	0.77 (0.52–1.15)	0.64 (0.34–1.15)	0.95 (0.50–1.96)	0.77 (0.35–1.88)
Lockdown duration (days)	1.00 (0.98–1.02)	1.02 (0.99–1.04)	1.01 (0.99–1.04)	1.02 (0.99–1.06)	1.01 (0.99–1.04)	1.02 (0.98–1.06)	1.01 (0.99–1.02)	**0.98 (0.96–1.00)***	1.00 (0.98–1.01)	**1.02 (1.00–1.04)***	**0.99 (0.98–1.00)***	1.00 (0.99–1.02)	**0.98 (0.96–1.00)**	**1.03 (1.01–1.06)***
Outside activities during the lockdown														
Obtain essential goods/ services (ref: no)	0.90 (0.48–1.59)	1.16 (0.52–2.38)	1.37 (0.73–2.46)	0.66 (0.21–1.67)	0.71 (0.29–1.55)	**0.16 (0.01–0.77)***	1.24 (0.73–2.04)	0.49 (0.17–1.15)	1.05 (0.72–1.51)	**0.38 (0.14–0.87)***	0.91 (0.66–1.25)	0.72 (0.45–1.16)	0.84 (0.44–1.50)	0.82 (0.33–1.79)
Going to work (ref: no)	0.94 (0.58–1.58)	0.59 (0.33–1.08)	0.62 (0.36–1.08)	0.60 (0.32–1.17)	**0.34 (0.18–0.63)***	0.84 (0.36–2.22)	**0.59 (0.38–0.94)***	0.63 (0.34–1.20)	0.95 (0.68–1.35)	0.61 (0.38–1.03)	**0.72 (0.55–0.95)***	1.41 (0.96–2.07)	0.82 (0.51–1.36)	1.47 (0.75–3.19)
Assisting vulnerable people (ref: no)	1.19 (0.72–2.08	0.80 (0.42–1.63)	1.17 (0.64–2.29)	1.28 (0.57–3.43)	0.83 (0.44–1.66)	0.72 (0.32–1.84)	0.91 (0.56–1.52)	1.04 (0.53–2.26)	1.40 (0.97–2.07)	1.93 (0.98–4.29)	1.25 (0.95–1.66)	1.12 (0.73–1.70)	0.86 (0.53–1.43)	**2.38 (1.07–6.35)***
Walk the companion animal (ref: no)	0.95 (0.56–1.67)	0.50 (0.25–1.04)	1.65 (0.84–3.57)	0.90 (0.40–2.17)	0.99 (0.48–2.19)	0.61 (0.22–1.87)	0.73 (0.44–1.26)	1.18 (0.55–2.70)	1.17 (0.81–1.72)	0.63 (0.34–1.22)	1.18 (0.87–1.60)	**1.75 (1.10–2.77)***	1.14 (0.67–2.03)	**0.39 (0.20–0.77)***
Walk and exercise (ref: no)	1.03 (0.68–1.55)	na	0.99 (0.62–1.58)	na	1.06 (0.63–1.80)	na	1.21 (0.83–1.77)	na	1.22 (0.93–1.60)	na	**1.49 (1.20–1.86)***	na	0.91 (0.60–1.37)	na
Take out the garbage (ref: no)	1.02 (0.67–1.54)	1.16 (0.72–1.83)	0.96 (0.60–1.52)	1.30 (0.76–2.16)	1.23 (0.72–2.07)	1.12 (0.58–2.08)	0.92 (0.62–1.34)	1.03 (0.63–1.65)	1.14 (0.87–1.50)	1.21 (0.81–1.79)	0.91 (0.73–1.15)	0.96 (0.72–1.29)	0.90 (0.59–1.36)	0.70 (0.42–1.12)
Frequency of leaving the house (ref: Less than once a week or never)														
1–2 times a week	1.30 (0.75–2.23)	0.72 (0.22–1.98)	1.00 (0.55–1.80)	0.54 (0.13–1.73)	1.14 (0.58–2.20)	2.20 (0.58–6.72)	1.34 (0.85–2.09)	1.60 (0.70–3.46)	0.87 (0.62–1.22)	1.68 (0.75–3.50)	1.31 (0.98–1.75)	0.97 (0.57–1.69)	1.23 (0.71–2.11)	2.25 (0.98–4.85)
3–6 times a week	0.86 (0.46–1.63)	1.21 (0.34–3.80)	1.78 (0.79–4.19)	0.79 (0.18–2.99)	2.06 (0.86–5.13)	**4.96 (1.06–21.68)***	**4.23 (2.14–8.85)***	1.95 (0.75–4.97)	1.15 (0.74–1.82)	1.20 (0.50–2.71)	1.39 (0.97–1.99)	0.73 (0.40–1.36)	0.88 (0.46–1.67)	2.12 (0.85–5.14)
Once a day	0.78 (0.40–1.54)	0.82 (0.22–2.69)	0.91 (0.42–2.01)	0.34 (0.08–1.30)	**2.99 (1.08–9.36)***	2.22 (0.47–9.60)	**3.07 (1.55–6.43)***	1.09 (0.39–2.98)	0.76 (0.48–1.22)	2.50 (0.91–6.87)	**1.88 (1.28–2.78)***	1.43 (0.73–2.82)	1.03 (0.51–2.11)	2.27 (0.81–6.38)
Several times a day	1.62 (0.55–6.04)	3.23 (0.71–16.36)	0.96 (0.32–3.34)	0.58 (0.12–2.71)	**4.71 (1.08–33.57)***	3.14 (0.48–20.86)	**3.64 (1.36–11.75)***	1.23 (0.38–4.18)	0.88 (0.44–1.83)	1.57 (0.53–4.70)	**1.80 (1.02–3.20)***	1.56 (0.73–3.35)	0.58 (0.24–1.52)	**5.19 (1.57–18.12)***

[a] Odds ratio (95% Confidence Interval); [b]categories were merged due to small counts; bold and asterisk denotes significant association.

Table 3
Crude and adjusted associations (beta and 95% Confidence Intervals) between mental health outcomes and maintenance/increase in nature exposure during COVID-19 lockdown (Portugal and Spain, n = 3157).

	Psychological distress				Somatization				Stress level			
	Portugal		Spain		Portugal		Spain		Portugal		Spain	
Nature exposure	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
Indoor Plants	−0.35 (−0.72, 0.01)	−0.36 (−0.72, 0.00)	−0.18 (−0.52, 0.16)	−0.35 (−0.72, 0.03)	0.04 (−0.89, 0.98)	0.13 (−0.76, 1.02)	−0.41 (−1.16, 0.34)	−0.70 (−1.48, 0.09)	−0.28 (−0.67, 0.11)	−0.29 (−0.66, 0.10)	−0.30 (−0.72, 0.11)	**−0.52 (−0.96, −0.07)***
Balcony plants	−0.25 (−0.66, 0.16)	−0.22 (−0.61, 0.19)	0.18 (−0.19, 0.54)	0.01 (−0.41, 0.42)	0.74 (−0.31, 1.78)	0.79 (−0.22, 1.79)	0.30 (−0.52, 1.11)	0.03 (−0.85, 0.92)	−0.13 (−0.57, 0.30)	−0.14 (−0.57, 0.28)	0.27 (−0.17, 0.72)	−0.07 (−0.57, 0.43)
Home/ courtyard garden	0.02 (−0.45, 0.48)	0.08 (−0.39, 0.54)	0.27 (−0.18, 0.71)	0.33 (−0.18, 0.84)	0.57 (−0.62, 1.76)	0.62 (−0.53, 1.78)	0.11 (−0.89, 1.11)	0.32 (−0.78, 1.42)	0.01 (−0.48, 0.51)	−0.01 (−0.51, 0.48)	0.60 (0.05, 1.15)	0.55 (−0.07, 1.17)
Community private green space	−0.29 (−0.63, 0.05)	−0.23 (−0.56, 0.11)	−0.10 (−0.43, 0.22)	−0.28 (−0.65, 0.09)	−0.50 (−1.36, 0.37)	−0.37 (−1.20, 0.46)	−0.40 (−1.13, 0.34)	**−0.82 (−1.61, −0.03)***	−0.31 (−0.67, 0.05)	−0.26 (−0.61, 0.10)	0.35 (−0.05, 0.76)	0.17 (−0.28, 0.61)
Views of nature	**−0.36 (−0.60, −0.12)***	**−0.27 (−0.51, −0.03)***	0.12 (−0.17, 0.41)	0.16 (−0.15, 0.46)	**−1.15 (−1.76, −0.53)***	**−0.79 (−1.39, −0.20)***	−0.05 (−0.69, 0.59)	−0.25 (−0.90, 0.41)	**−0.61 (−0.87, −0.35)***	**−0.48 (−0.74, −0.23)***	0.13 (−0.22, 0.48)	0.21 (−0.16, 0.58)
Public natural spaces	**−0.23 (−0.42, −0.04)***	−0.15 (−0.34, 0.05)	−0.09 (−0.29, 0.11)	0.02 (−0.20, 0.24)	**−0.78 (−1.28, −0.28)***	−0.43 (−0.92, 0.06)	**−0.79 (−1.24, −0.34)***	−0.44 (−0.91, 0.04)	**−0.43 (−0.64, −0.23)***	**−0.29 (−0.49, −0.08)***	**−0.39 (−0.64, −0.15)***	−0.13 (−0.40, 0.14)
Other natural space/ element	−0.17 (−0.54, 0.19)	−0.17 (−0.53, 0.19)	0.00 (−0.31, 0.31)	−0.08 (−0.42, 0.26)	−0.75 (−1.68, 0.18)	−0.58 (−1.48, 0.31)	**−0.78 (−1.48, −0.08)***	**−1.06 (−1.79, −0.32)***	−0.13 (−0.52, 0.26)	−0.13 (−0.51, 0.25)	0.07 (−0.31, 0.46)	0.12 (−0.29, 0.54)

Adjusted models included mental health outcomes and change in exposure (maintenance/increase in nature exposure), plus the following covariates: age, gender, household size and dependents in the household, education attainment, house typology, country of birth, frequency of going out during the lockdown, outside activities during the lockdown, duration of the lockdown, and type of housing during the lockdown.
Bold and asterisk denotes significant association.

95%CI 0.96, 1.00).

Although almost the same proportion of people maintained/increased and decreased the frequency of viewing nature from home during the lockdown, the maintenance/increase of that exposure showed association with several variables. In Portugal, individuals aged 40–64 years were more likely than other age groups to maintain/increase views of nature (OR 2.26; 95%CI 1.50, 3.41), while those living in households with more cohabitants were less likely to do so (OR 0.91; 95%CI 0.84, 0.98). In Spain, individuals residing in urban single-family houses (OR 0.28; 95%CI 0.10, 0.67), in apartments/top-floor apartments (OR 0.30; 95%CI 0.11, 0.66), those who stayed in second homes or family/friends' homes during the lockdown (OR 0.31; 95%CI 0.17, 0.60), and those who went out to obtain essential goods and services (OR 0.38; 95%CI 0.14, 0.87) were less likely to maintain/increase views of nature. Conversely, time spent in lockdown was positively associated with maintaining/increasing views of nature in Spain (OR 1.02; 95%CI 1.00, 1.04).

Concerning public natural spaces, keeping in mind the most common scenario was the reduction of exposure, we see that the emergence of the opposite trend was favored by increasing age, both in Portugal and in Spain. Housing typology also played a role, as in the two countries individuals living in urban single-family houses (Portugal: OR 0.71; 95%CI 0.52, 0.96; Spain: OR 0.49; 95%CI 0.30, 0.82) and apartments/top-floor apartments (Portugal: OR 0.67, 95%CI 0.52–0.87; Spain: OR 0.54, 95% CI 0.35–0.84) were less likely to maintain or increase the use of public natural spaces during the lockdown. The circumstances involving lockdown were also important, namely in Portugal: the likelihood of maintaining/increasing exposure to public natural spaces was slightly reduced with more time spent in lockdown (OR 0.99; 95%CI 0.99, 1.00); those who went to work were less likely to maintain/increase exposure (OR 0.72; 95%CI 0.55, 0.95); whereas the likelihood of increasing/maintaining exposure was greater for those who went out for exercise than those who did not (OR 1.49; 95%CI 1.20, 1.86). In Spain, only walking a companion animal showed a significant association (OR 1.75; 95%CI 1.10, 2.77) with maintaining or increasing exposure to public natural spaces. In both countries and principally in Portugal, maintaining/increasing the use of public natural spaces was positively associated with frequency of leaving the house.

Finally, regarding any other types of natural elements and environments (like, for instance, agricultural fields and workplace greenery), we observed that in Spain those living in apartments and top-floor apartments (OR 0.44, 95%CI 0.17, 0.98) and those who left the house to walk with companion animals (OR 0.39, 95%CI 0.20, 0.77) were less likely to maintain/increase the use of these elements/environments; the reciprocal happened with younger people and with those who went out more frequently (several times a day: OR 5.19, 95%CI 1.57, 18.12). In Spain, lockdown duration was positively associated with maintaining or increasing the use of these type of elements/environments, but the opposite trend was observed in Portugal. In addition, in Portugal, those living in households with disabled and vulnerable individuals were less likely (OR 0.34, 95%CI 0.13, 0.97) to report using these other natural spaces.

3.4. Exposure to nature and mental health outcomes

Table 3 shows the association between maintaining/increasing exposure to nature during the lockdown and the three studied mental health indicators.

We observed that, in Portugal, maintaining/increasing exposures to public natural spaces (via visits) and views of nature from home were associated with lower levels of psychological distress. Yet, after adjustment for sociodemographic, housing and lockdown-related characteristics, only the second association remained, where we observed that participants maintaining/increasing views to nature during the lockdown had significantly lower levels of psychological distress (adjusted beta −0.27; 95%CI −0.51, −0.03).

In both countries, crude models showed that maintaining/increasing exposure to public natural spaces and views of nature were associated with lower levels of somatization. After adjustment, only the negative relationship between views of nature and somatization in Portugal

remained (adjusted beta −0.79; 95%CI −1.39, −0.20). In Spain, adjusted models revealed that maintaining/increasing the exposure to community private green spaces (adjusted beta −0.82; 95%CI −1.61, −0.03) and other spaces (adjusted beta −1.06; 95%CI −1.79, −0.32) was significantly and negatively associated with somatization.

Finally, in Portugal, in both crude and adjusted models, maintaining/increasing exposure to public green spaces (adjusted beta −0.29; 95%CI −0.49, −0.08) and views of nature were negatively associated with stress (adjusted beta −0.48; 95%CI −0.74, −0.23). In Spain, we found that individuals who maintained//increased exposure to indoor plants presented significantly lower levels of stress even after accounting for confounding variables (adjusted beta −0.52; 95%CI −0.96, −0.07).

No significant interaction effects according to gender, age, or socioeconomic factors were observed, suggesting that the mental health benefits of nature exposure were felt equally across sociodemographic groups.

Supplementary material 3 shows the regression equations from the adjusted models.

4. Discussion

We found that exposure to nature brought mental health benefits during the lockdown period established to prevent the spread of the COVID-19 pandemic. We also found a significant reduction in the utilization of public natural spaces in both Portugal and Spain (despite access was only explicitly forbidden in Spain) and a slight increase in contact with private green space and greenery (indoor plants, home/courtyard gardens, etc.). In Portugal, maintaining or increasing the routine of visiting public natural spaces and contemplating those spaces from home was associated with lower levels of stress, somatization and psychological distress, while in Spain, exposure to private green space and greenery, namely indoor plants and community private green spaces, were found to be associated with lower levels of stress and less somatization of symptoms.

This finding is in accordance with our initial hypothesis that in Spain, where mobility restrictions during the lockdown were more severe, private green space and greenery would play a more prominent role than in Portugal, where brief outdoor leisure and physical activities were allowed. Although evidence on the health benefits of private green space/greenery is less documented, a few studies have demonstrated that taking care of and having contact with indoor plants is associated with reduced psychological stress (Lee, 2015), reduced strain and better recovery among hospitalized patients (Park and Mattson, 2009), and better mood (Shibata and Suzuki, 2001). For example, an experimental study found active interaction with indoor plants can reduce physiological and psychological stress (subjects felt more comfortable and soothed) compared with mental/computer work (Lee, 2015). No significant associations were observed between maintaining/increasing home/courtyard garden exposure and mental health outcomes, but, in Spain, a significant beneficial effect was observed for private community green spaces, where those that maintained or increased their exposure to these spaces presented lower levels of somatization. Because these are communal spaces (gardens, green roofs, etc.), it is plausible that, beyond gardening and gazing, these spaces offer opportunities for socialization with neighbors, thus improving social integration and community cohesion (Yotti Kingsley and Townsend, 2006) which is critical in adverse life moments (Wu, 2013). They also offer greater opportunity for sports and other physical activities, which might also help alleviate stress and anxiety.

In Portugal, maintaining or increasing the frequency of visiting public natural spaces (e.g. public parks, street greenery, woodlands, water bodies etc.) was associated with better mental health outcomes, more precisely, with lower levels of stress. This is in accordance with a growing body of literature demonstrating the mental health benefits of contact with outdoor green space and natural environments (Triguero-Mas, 2015; van den Berg, 2016; Gascon, 2015). The mechanisms beyond these associations may be related to two widely known complementary theories: stress-recovery theory (SRT) and the attention restoration theory (ART). According to the STR, contact with nature can reduce physiological responses to stress (Ulrich, 1983), while the ART suggests that exposure to nature may reduce directed attention fatigue through attention restoration (Kaplan, 1995). Besides, residential proximity to public green spaces was shown to promote physical activity, which may be a relevant pathway in the association between mental health and public green spaces observed in Portugal (Mitchell, 2013), as brief outdoor physical activity was allowed during the lockdown period.

In Portugal, views of nature were beneficial to mental health, regardless of the specific outcome, which is in accordance with the published literature about the nature-health interconnection. Window views of natural environments were found to reduce perceived stress levels and stress-related biological markers (Nutsford, 2016; Kaplan, 2001). In Spain, this effect was not significant, which might be related with the type of landscapes that are visible from the homes of the studied sample; while in Portugal 25.2% of individuals resided in single-family houses in rural areas, in Spain this percentage was only 8.9%, suggesting that they are more likely to be living in urban or semi-urban landscapes with less natural features, which do not bring the same relaxation and restorative effects as rural and wild landscapes (Ulrich, 1979).

4.1. Strengths and limitations

This study has some important limitations. First, the data and analyses were derived from a cross-sectional study, making it difficult to make causal inferences. Second, internet-based voluntary recruitment could have introduced important selection bias, first by excluding people without internet access or who do not use social media, and second by introducing self-selection bias, perhaps attracting respondents with particular interest in the topic. According to the latest data, the proportion of households with connection to Internet at home is 84.5% in Portugal (INE, 2020) and 95.4% in Spain (Encuesta, 2020) and the percentage of individuals using social media is 80.2% (Inquérito, 2019) and 64.7% (Encuesta, 2020), in Portugal and Spain, respectively. This means that a non-negligible share of individuals was unable to answer to the questionnaire. In our study we have a highly unbalanced gender ratio (more than 70% of women as observed in other web-based surveys (Rossi, et al., 2020), an overrepresentation of highly educated individuals and of individuals from Catalonia (85% of the Spanish sample) and the Portuguese Northern region (50% of the Portuguese sample). Supplementary material 4 compares the demographic composition of our sample with the population composition of both countries and shows that our sample is composed of individuals who are more educated than the overall population, with an overrepresentation of women and an underrepresentation of older adults. This unbalanced composition might have limited our capacity to detect socioeconomic differences and interactions between nature exposure and mental health outcomes, which is particularly important given the inequities in housing quality and size by socioeconomic status with important implications for access to green space at home. Plus, this fact also implies that our results cannot be straightforwardly generalized to the overall population. While the questionnaire was disseminated throughout all the community, regardless their level of interest on the topic, it is plausible that those who accepted to participate were more interested on the health benefits of nature exposure and that could possibly add some form of selection and information bias. Third, all data used in this investigation (both exposure and outcome) is self-reported which can be a source of recall or social desirability bias, which may have skewed reporting of time spent outside or use of secondary homes during lockdown as these activities were strictly regulated during the lockdown, particularly in Spain. In addition, data on nature exposure before the lockdown were obtained retrospectively. While retrospective data collection may introduce recall errors, in this study recall errors are likely non-differential, which is considered a less serious problem in

epidemiological studies (as compared to differential recall errors) and usually lead to an increase in variability and reduces the power of the study. Forth, despite it has been used in previous studies in similar contexts (Triguero-Mas, 2017) and the stress measure is moderately correlated with the other, well-established and validated measures of mental well-being we studied (see Supplementary material 2), revealing a reasonable convergent validity, this variable presents a set of limitations that should be discussed. Because it is composed by a single item we cannot compute measures of internal consistency such as Cronbach's α. Consequently, the psychometric characteristics of our stress measure are unknown and, therefore, there is a possibility that a different construct is measured. In addition, the item formulation "how stressed have you felt" may not mean the same for every respondent, since people might conceptualize stress in many different ways. Thus, our results for such a complex construct, as stress, should be taken with caution. Fifth, for the sake of simplicity, no questions on personality type, reactions, coping mechanisms and adaptations were included in the questionnaire. These factors, particularly personality, are well-established predictors of mental health and well-being (Kokko et al., 2015). Thus, they could constitute important effect modifiers of the studied associations and their inclusion could provide a more in-depth knowledge on the mechanisms connecting exposure to nature and mental health during COVID-19 pandemic. Finally, due to the relatively few changes in the frequency of nature exposure during the lockdown in the studied sample, our main exposure variable was dichotomous (maintained/increased vs. decreased exposure) which did not allowed us to assess the impacts different degrees of change in the exposure to nature.

The main strength of the present study is that we were able to conduct the study in real time, that is during the period of strict lockdown in both countries, minimizing the risk of recall bias; accounted for a wide range of natural elements and environments available to the population, including those found in the home environment, which have been poorly addressed in the literature about the connections between nature and public health. Other strengths of the study include a large sample size, the cross-national design, the use of validated instruments for mental health assessment, and the collection of and adjustment for a wide range of potential confounding variables.

4.2. Policy implications and future research

Mental disorders have an important impact on individuals, families and communities. Indeed, mental disorders rank second in terms of Years of Life Lost due to Disability (YLDs) accounting for about 15% of all YLDs in Spain and in Portugal. Subsequently, mental disorders cost more than US$ 1 trillion per year to the global economy (WHO, The WHO special initiative for mental health, 2019). Pandemics and associated lockdowns might exacerbate this already heavy burden by worsening the symptoms of those with mental illness (Kozloff, 2020) and by inducing fear, depression stress and anxiety in the general population (Armitage and Nellums, 2020; Rajkumar, 2020; Rossi, et al., 2020). The most vulnerable and socioeconomically deprived populations were found to be at higher risk of psychological distress associated with COVID-19 pandemic (Pierce, 2020) and are also more likely to live in small apartments with limited access to natural spaces, which makes them an important vulnerable group and has clear implications for environmental and health equity. Here, planners play a key role in encouraging and supporting the development of private and community green spaces within building premises, in working-class neighborhoods in particularly, following the example of what municipalities such as Barcelona have done in the past by co-sponsoring or supporting initiatives on balconies, terraces, and rooftops.

Our study uses a cross-sectional and observation design based on a sample of residents, which do not allow proving the effectiveness of specific greening and nature-based interventions on mental health outcomes. Thus, future research should conduct local studies that take into account the built environment where people live to identify specific greening strategies that would work in that specific geographic, physical and social context. In addition, future investigations should ascertain the risk of infection in public natural spaces in order to better balance the mental health effects of lockdowns with the need to protect residents from infection.

5. Conclusion

Maintaining or increasing exposure to private green space and greenery, to public natural spaces and views of nature was associated with improved mental health outcomes during the COVID-19 pandemic and subsequent general lockdowns, both in Portugal and Spain. These associations varied between countries possibly reflecting the different mobility restrictions and epidemiological situation experienced by the two nations. In light of these results, we suggest that policy-makers and public authorities should facilitate and organize safe and controlled opportunities for exposure to natural elements and environments (for visits, viewing or taking care of) during the highly unique and dynamic pandemic, especially for those with low (or no) exposure to private green space/greenery.

6. Contributions

AIR participated in the design of the study, performed literature revision, data cleaning and manipulation and analysis, interpretation of the results and drafted the manuscript. MTM participated in the conception, design and planning of the study, assisted data cleaning and supervised data analysis. CJS participated in data cleaning, manipulation, and analysis and helped draft the manuscript. IA and HC participated in the conception, design and planning of the study. AGN and contributed in the interpretation of the results and helped draft the manuscript. FB led the conception, design and planning of the study, supervised the data analysis and contributed in the interpretation of the results. All authors reviewed and approved the final version of the manuscript.

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.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envint.2021.106664.

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