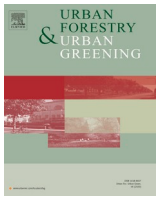
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Urban Forestry & Urban Greening 59 (2021) 126919

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

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



Particularities of having plants at home during the confinement due to the COVID-19 pandemic

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ARTICLE INFO

Handling Editor: Wendy Chen

Keywords:
Contemporary planting systems
Human-plant interactions
Emotional well-being
Indoor vegetation
Living walls
Psychological impact

ABSTRACT

The present study evaluated the role of having plants at home during the confinement period as a result of the COVID-19 pandemic that deprived people of freely visiting open green spaces. Preferences concerning the quantity of the desired vegetation as well as the ways in which the COVID-19 crisis affected the change of perceptions with regard to having plants at home were also evaluated. A questionnaire, which was filled by 4205 participants, provided an undistracted evaluation of the impact of indoor and outdoor plants on their emotional welfare considering behavioural, social, and demographic variables. The emotional state of the respondents was neutral and a significant proportion expressed positive emotions. Having indoor plants was correlated with more positive emotions, and confined inhabitants allocated more time for plant maintenance. By contrast, negative emotions prevailed in respondents who related to a positive COVID-19 case, which was more frequent in females and young participants living in small houses that received low levels of natural light and had few or no plants. A few indoor plants placed in strategic positions were also preferred compared with a high number of plants. By contrast, an increased amount of vegetation accompanied by living walls was preferred for outdoor settings. Living walls were considered as advantageous for increasing indoor vegetation, but they were also associated with technical and economical hurdles.

1. Introduction

Urban green space (UGS) can play a key role in well-being (Mavoa et al., 2019; Navarrete-Hernandez and Laffan, 2019) and people tend to visit them for leisure, to practice sports, to relax or socialise as frequently as possible. But what happens if this is impossible? The health crisis caused by the SARS-CoV-2 virus led to an imposed confinement in many countries around the world (Tobías, 2020). In this unprecedented situation, people were forced to remain at home for several weeks without the possibility of moving around freely. Although house confinement has been proven to be a key factor in controlling the spread of the disease, it has also resulted in the occurrence of undesired effects such as a reduction of economic activity and the cause of psychological repercussions related to the compulsory home reclusion (Shigemura et al., 2020). More specifically, preliminary studies performed with regard to human psychological reactions to the COVID-19 pandemic indicate that anxiety and depression (16–28 %) as well as self-reported stress (8%) were among the most common symptoms (Rajkumar, 2020). Moreover, Bezerra et al. (2020) observed that having a household with an open area, such as a terrace, or with a green area proved helpful during the period of isolation.

Many studies have reported a number of psychological benefits to

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https://doi.org/10.1016/j.ufug.2020.126919
Received 24 July 2020; Received in revised form 17 November 2020; Accepted 19 November 2020
Available online 24 November 2020

humans who are exposed to nature. For instance, White et al. (2013) investigated the relation between urban green space and well-being and mental distress and demonstrated that individuals living near green spaces exhibit both lower mental distress and higher well-being. Visual and physical exposure to plants has been related to increased positive behaviours and pleasant feelings in conjunction with reduced negative feelings such as anger, fear, and stress (Adachi et al., 2000; Kamitsis and Francis, 2013). These psychological benefits might be related to the so-called biophilia concept (i.e., a preference for interacting in a natural environment as a consequence of our evolutionary course) and based on theories of restorative effects (i.e., regaining psychological, social, and physical capacity) (Grinde and Patil, 2009). In this regard, a study by Hernández and Hidalgo (2005) showed that urban environments with natural elements yielded higher restorativeness (reducing mental fatigue and stress). This nature-perceived restorativeness (through cognitive reappraisal) can help to promote appreciation of nature and act as a motivator for pro-environmental behaviour, creating more environmentally aware citizens (Berto and Barbiero, 2017; Carrus et al., 2015; Panno et al., 2020).

Furthermore, evidence shows that there is an implicit link between "nature" and "outdoors" that results in lower attention attributed to indoor vegetation settings (Bringslimark et al., 2009). However, in contemporary societies, the increasing amount of time spent indoors often results in separation from the natural environment (Aries et al., 2010). Living in environments with minimal or absent use of plants could lead to negative behaviours, such as irritation or hostility (Lederbogen et al., 2011). These behaviours might be particularly applicable to the COVID-19 pandemic confinement, which was aggravated by additional negative emotions of fear, disappointment, uncertainty, and stress (Brooks et al., 2020). Therefore, in such difficult circumstances, the inclusion of natural and living elements, such as plants, could reintroduce nature into human living spaces and reconnect humans with natural environments. Connections of this type have been proven to induce positively-valued changes in cognition and emotion and to express a beneficial impact on stress level, health, and well-being (Grinde and Patil, 2009). It is interesting to point out that Han and Ruan (2019) reviewed 50 studies and concluded that the most noticeable effect of indoor plants on people's behaviour was their capacity to increase positive emotions and to reduce negative feelings. For instance, a decrease in the perception of pain, fear, unhappiness, and aggressiveness has been found to be associated with the presence of indoor plants (Burchett et al., 2008). In addition, stress seems to be reduced in indoor environments enriched with vegetation compared with indoor spaces without plants (Park et al., 2008; Thomsen et al., 2011).

Vegetation can be introduced in living spaces in various ways and forms, which are usually determined by the specific characteristics of the property and the building, including space and natural light availability. When outdoor spaces are available, vegetation can be introduced as lawns, bushes, or even trees in backyards, front gardens, terraces, patios, or accessible green roofs. However, in contemporary cities the prevalent architecture with apartment houses and skyscrapers has resulted in reduced outdoor spaces, which are often mainly reserved for suburban areas. Therefore, many inhabitants seek alternative ways to introduce plants within their living spaces. In most cases, this is achieved either by traditional techniques, such as pots and flower beds, or contemporary approaches, such as vertical greening systems. Innovative indoor living walls are systems that use advanced techniques to enable the covering of walls, or any other vertical or inclined surfaces, with plants that are rooted in and growing on specialised media along the vertical surfaces (Pérez-Urrestarazu et al., 2015). These contemporary indoor greening techniques are aesthetically pleasing while being used as a means of introducing an increased number of plants within a limited area inside the house.

The aim of the current study was twofold: a) to evaluate the impact of having plants at home during the COVID-19 pandemic confinement on people's emotional welfare considering behavioural, social, and demographic variables and b) to determine participants' preferences towards different ways of introducing indoor vegetation by comparing traditional and modern greening techniques. The research was conducted on a worldwide scale, but focused on four countries based on interviewee responses: Brazil, Greece, Spain, and Italy. The main research questions can be summarised as follows:

1 Did having plants at home contribute to the emotional welfare of the people during the COVID-19 confinement period?
2 Was there a difference before and after the COVID-19 confinement period with regard to people's perception of having plants at home and interacting with them?
3 What are the preferences towards different types and levels of vegetation?
4 Are living wall systems known and appreciated as an option to increase indoor vegetation?

2. Methodology

2.1. Questionnaire design and survey distribution

The questionnaire was developed to be anonymously responded online using Google Forms. It was translated into English, Italian, French, Greek, Portuguese, and Spanish. At the beginning of the questionnaire, the rationale and the goals of the study were introduced to the potential respondents while general information, including the participating universities, the confidentiality of the research, and the intended management of the collected data, was also provided. The questionnaire comprised 38 questions distributed in six different sections (Table 1 in Annex A). Section 1 of the questionnaire concerned basic personal and demographic information, confinement duration and exposure to any COVID-19 related incident within the family and social circle. In Section 2, the participants were asked to provide information regarding their houses, such as surface, room number, availability of outdoor spaces, and number of inhabitants. In Section 3, the aim was to evaluate people's attitudes towards nature based on their interest in gardening, their visiting frequency of outdoor green areas as well as the number of plants hosted at home.

The fourth section comprised a series of questions aimed at determining the respondents' emotional state during the COVID-19 confinement period and its correlation with plant number along with plant maintenance and position (indoor or outdoor) in the household. In this section, two questions (#28 and #29) were considered as the cornerstones in detecting a potential correlation between inhabitants' emotional welfare and plants during the pandemic confinement period. In Question #28, participants were provided with different positive (optimistic, calm, cheerful) and negative (depressed, fearful, stressed, sad) emotional states and were asked to state the frequency of experiencing these feelings ranging from 'never' to 'many times'. These results were used to calculated an 'Overall emotional well-being' indicator. In Question #29, the participants were asked to express their opinion on whether having vegetation at home positively contributed to their mood during the COVID-19 confinement period.

In section 5, the aim was to fine-tune the participants' preference

Table 1
Distribution of respondents according to the type of settlement in which they were raised and are currently living.

Type of settlement according to its population	Were originally raised (%)	Are currently living (%)
High density city (>1,000,000)	31.3	36.4
Large city (1,000,000−300,000)	18.6	21
Medium city (100,000−300,000)	13.4	14
Large town (10,000−100,000)	21.6	18.4
Town (2,500−10,000)	8.7	6.1
Village/ Rural area (<2500)	6.4	4.2

with regard to the type and amount of indoor and balcony vegetation. This was further reinforced by the inclusion of three sets of pictures. Each set included a photograph of the same house location having different quantity and quality levels of vegetation (Fig. 1): (A) no plants, (B) few (5–7) plants in pots, (C) many (more than 7) plants in pots, (D) many plants in conjunction with living walls. The four scenarios were simulated using Photoshop (CS6 Extended).

The majority of the questions were of the closed-form type and formulated in the 'multiple choice' format. The questions and the different response options are presented in Table 1 (Annex A).

The distribution of the questionnaire was performed mainly through social networks (WhatsApp, Twitter, LinkedIn, Facebook), although other communication channels, such as emails and links in web pages, were also used. Though this method does not allow to control the characteristics of the potential respondents, it permits to acquire a bigger sample within the tight time limits of the confinement period. The questionnaire was open from April 25th until May 4th, 2020. During that period, as a preventative measure against coronavirus, people were still confined and/or in lockdown in most of the participating countries.

2.2. Participant numbers and countries of origin

The total number of participants who answered the questionnaire was 4205. Responses were obtained from 46 countries from all over the world (Fig. 2). Most responses were received from Brazil (29.6 %), Greece (23.8 %), Spain (19.6 %), and Italy (9.4 %). The number of responses from those four countries was enough to be statistically significant considering the population in those countries, with a confidence level of 95 % and a margin of error ≤5% (Kotrlik and Higgins, 2001).

The distribution of participants based on gender and age is provided in Fig. 3 as well as the distribution of responses according to the participants' highest level of education. From the total collected data, 43.6 % of the respondents were male and 56.1 % female. Only 19.9 % were between 18 and 26 years, while most of them were within the 26−40 (39.1 %) and 41−65 (39.5 %) age ranges. The responses obtained by elderly people were particularly important for this study since 4.5 % of the participants were over 65 years old and comprised an age group especially susceptible to the effects of COVID-19 (Du et al., 2020; K. Liu et al., 2020; Onder et al., 2020).

2.3. Baseline information on the occurrence and control strategies for the COVID-19 pandemic crisis in Spain, Italy, Brazil, and Greece

The responses obtained from Brazil, Greece, Spain, and Italy represented 82.4 % of the total number of questionnaires. The impact of the COVID-19 pandemic differed in those countries due to the timing and the severity of the disease, the timing and type of governmental reactions, and consequences of the disease on health systems and civilian hospitalisation and deaths. More specifically, Italy and Spain exhibited similar reactions and the disease spreading and impact was devastating with a high number of officially confirmed positive COVID-19 cases and deaths, while the impact was less severe in Greece (Fig. 4). By contrast, Brazil differed from all the other countries in that various degrees of confinement depending on state, municipality, or city were adopted, and the number of confirmed cases and deaths was just beginning to increase during the time the questionnaire was distributed (Table 2 in Annex A). Due to the particularities of the COVID-19 pandemic impact on each of these countries, the 'Overall emotional well-being' indicator

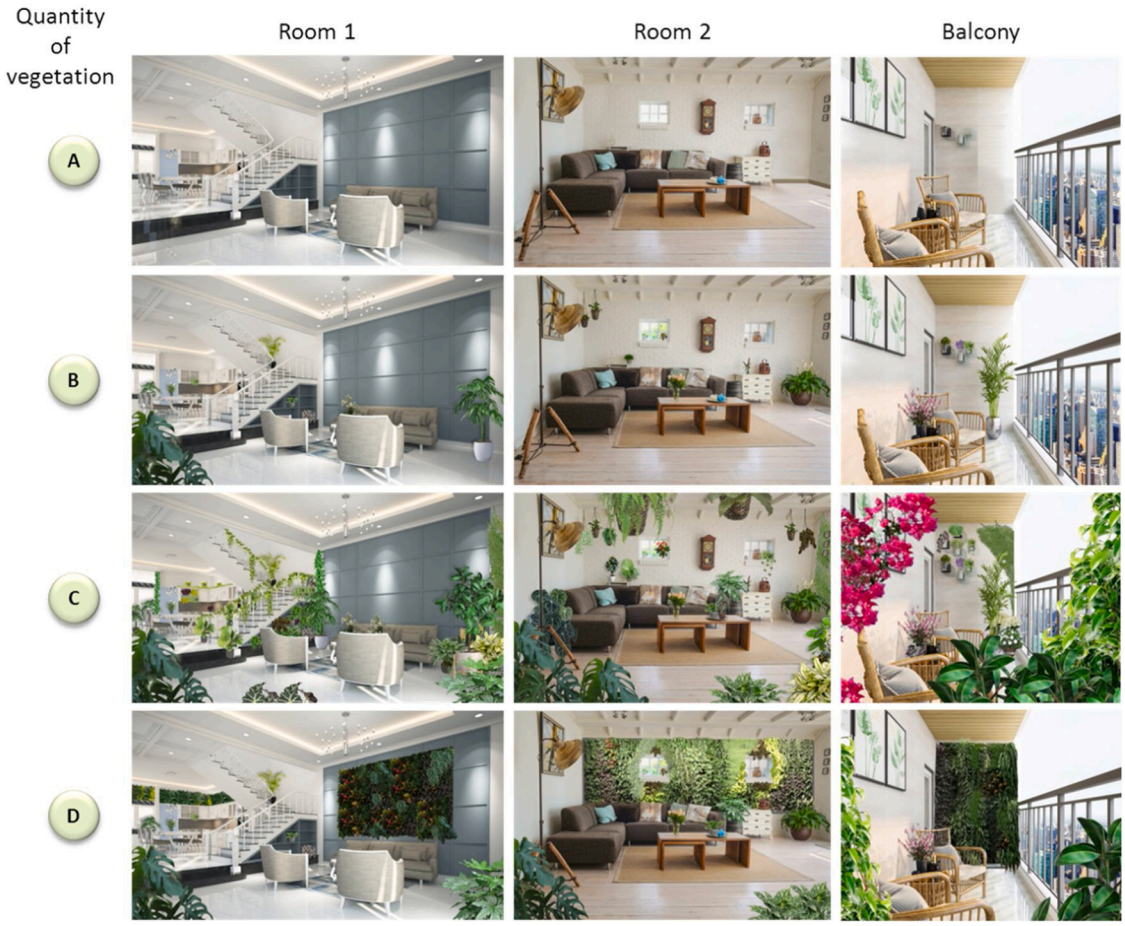

Fig. 1. Scenarios simulation of two rooms and one balcony with increasing quantity of vegetal elements: (A) no plants, (B) few (5-7) plants, (C) many (more than 7) plants, (D) many plants in conjunction with living walls (the scenarios were simulated using Photoshop CS6 Extended).

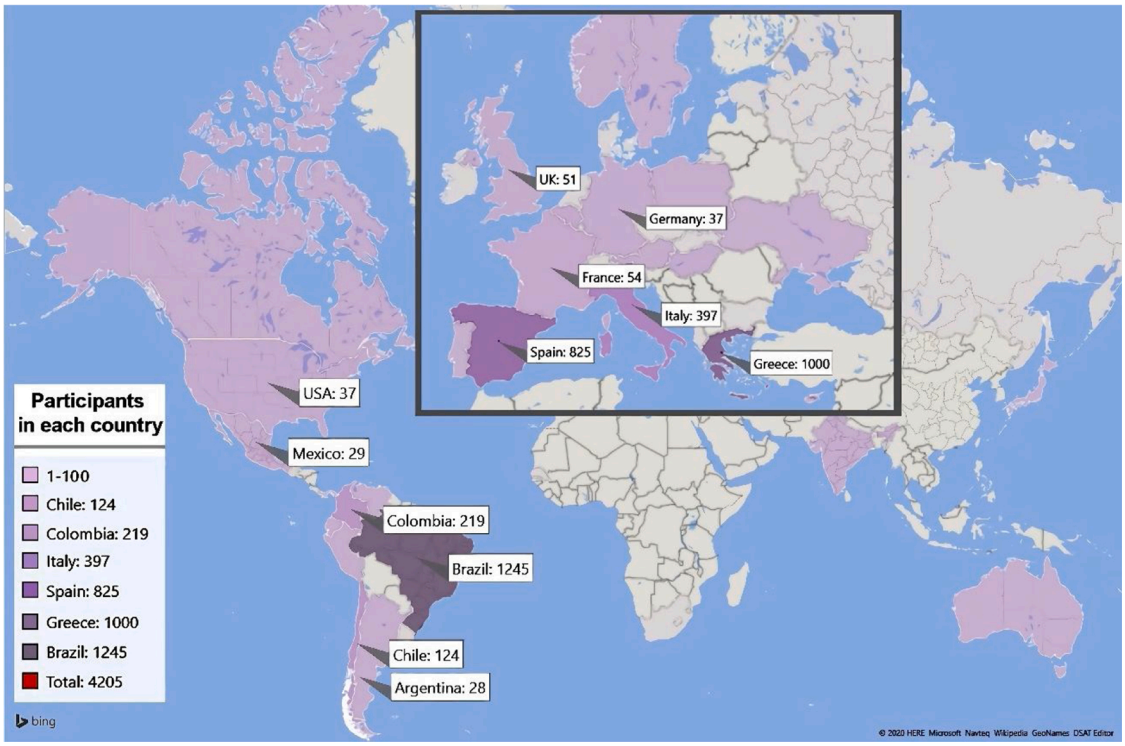

Fig. 2. Distribution of the collected questionnaire responses based on the different countries and their colorimetric categorisation based on the total number of responses per country.

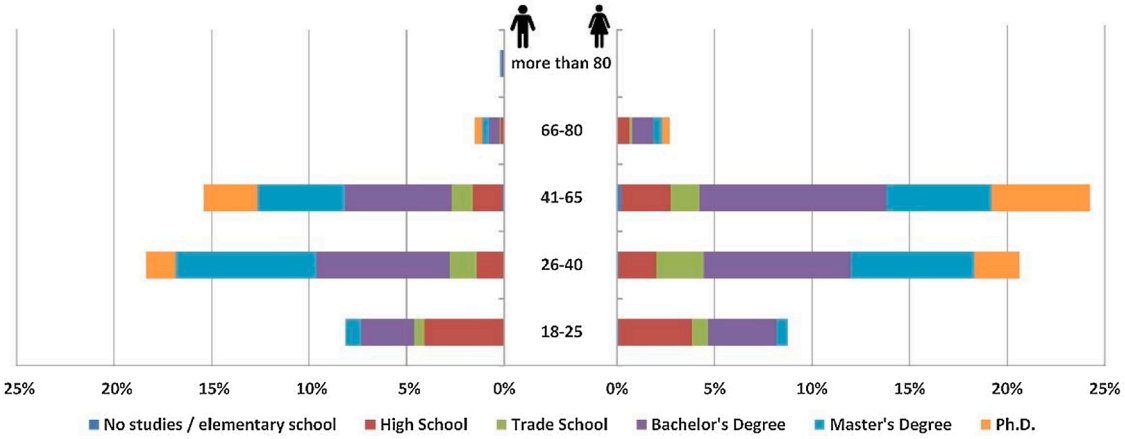

Fig. 3. Distribution of the questionnaire respondents based on their gender (male to the left and female to the right), age, and level of education.

was calculated separately for each one.

The timing of the questionnaire distribution also differed based on which stage of the sanitary crisis each country was at. Participants responding to the survey were already approaching the termination of the confinement period in Spain, Italy, and Greece; on the other hand, Brazil was only at the initial stages of the crisis (Fig. 4, Table 2 in Annex A). During the survey period, differences were also attested concerning the impact of the COVID-19 pandemic on each of the participating countries, in that Spain and Italy approached 25,000 officially confirmed COVID-19 related deaths, while Brazil had reported less than 5000 and Greece less than 150 (Fig. 4).

All the above-mentioned differences were caused by different governmental approaches and responses towards the COVID-19 pandemic. National strategic planning against the COVID-19 pandemic is summarised in Table 2 in Annex A for each of the four countries, which includes the timeline of milestone events and decisions, such as the 1st and 50th case confirmed, closing of schools, universities, and businesses and countries lockdown. Out of the four countries, only Brazil did not reinforce an official nation-wide lockdown, although people were urged to stay at home. When the questionnaire was distributed, Spain and Italy were already 6 weeks and Greece nearly 5 weeks under strict confinement.

2.4. Data treatment and statistical analysis

The statistical analyses were performed using IBM SPSS Statistics 20. In order to facilitate the analysis of the data, an 'Overall emotional well-being' indicator was calculated after adding up all the answers to Question #28 regarding positive and negative emotions during the confinement period. Responses about negative emotions were ranked as: never = 1, sometimes = 2, many times = 3. The values of the frequencies of positive feelings were reversed (never = 3, sometimes = 2, many

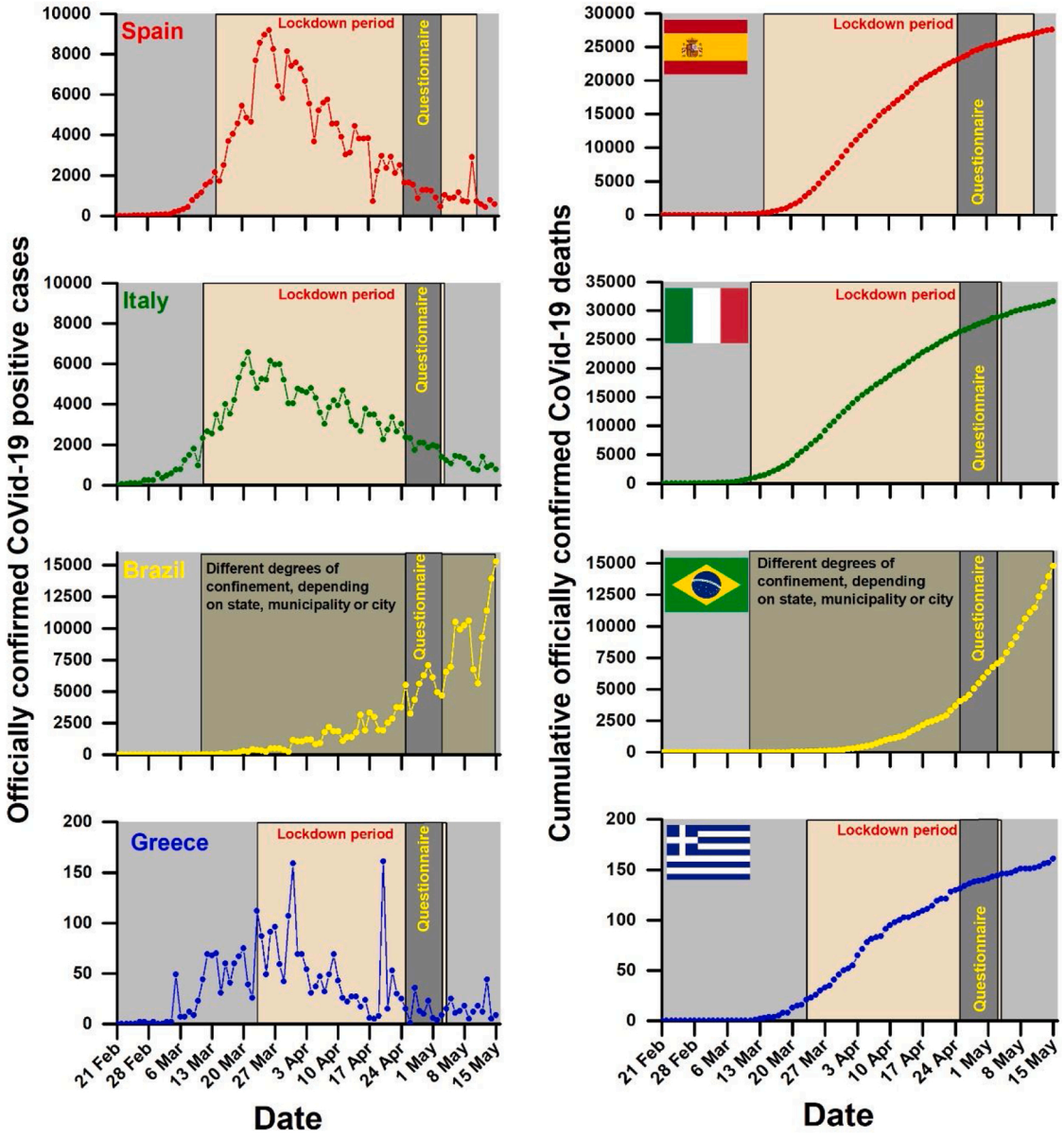

Fig. 4. Evolution of daily officially confirmed COVID-19 positive cases and cumulative officially confirmed deaths due to the disease in Spain, Italy, Brazil, and Greece. The dark grey areas represent the period during which the questionnaires were available to the participants. The beize and olive green areas represent the lockdown/confinment period for each country based on data retrieved from ministries announcements and official data (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Table 2
Distribution of inhabitants per household according to age range.

Age range	< 6	6–12	12–18	18–25	26–40	41–65	> 65
Frequency (%)	13.5	12.2	15.0	22.6	42.8	55.5	13.8

times = 1). Therefore, the indicator measuring the degree of emotional well-being was on a scale of 7 (=perfect emotional state) to 21 (=very bad emotional state). Following that, this score was used in the ANOVA and Regression models in order to assess the factors affecting the emotional state of the participants during the COVID-19 confinement period.

3. Results

3.1. General information about participants

Most respondents (75.9 %) declared that they had a middle household income (ranges are not provided due to differences among countries), while 10.7 % had a high and 13.4 % a low income. Most participants were confined at home for 5–6 weeks (43.9 %) or more than 6 weeks (43.9 %) due to the COVID-19 crisis, while 9% were confined for 3–4 weeks, 4.4 % for 1–2 weeks and 4.8 % were not confined at all. Most of the respondents (84.1 %) declared that neither themselves nor their relatives had a positive COVID-19 case that could affect their emotional state.

A high number of participants (57.4 %) were currently living in big cities having more than 300,000 inhabitants, while only 4.2 % lived in villages or rural areas (Table 1). When they were asked about the size of the settlements where they were raised, these percentages were slightly

lower for bigger cities and higher for towns and villages.

3.2. Description of the households

Regarding the type of buildings the respondents lived in, 57.6 % resided in flats or apartments and 42.4 % in standalone houses. The size of the residences reported was equally distributed between 40–70 m^2 (22.9 %), 80–100 m^2 (29.7 %), 100–130 m^2 (21.2 %), and more than 130 m^2 (20.8 %). Only 5.4 % of the respondents lived in places with a surface of less than 40 m^2. There was no difference with regard to the number of rooms comprising the house, with 3 rooms being the most frequent (35.4 %). In most cases, the household was composed of 3–4 people (49.6 %), although having 1–2 people was also very common (38.9 %). The distribution of the different age ranges of the inhabitants in each household is provided in Table 2.

Regarding current conditions within their households, 54 % of the respondents reported that their houses received quite a lot of or a lot of direct sunlight indoors, while 14 % received little or no natural light. In most cases, the respondents reported that outdoor spaces were available, while only 10.5 % reported that they were not available. In the majority (69.6 %) of households, at least a balcony or terrace was available, 30.4 % had a garden, 20.6 % a patio, and 18.1 % an accessible rooftop.

3.3. Attitudes towards nature

Most respondents were quite (38.5 %) or very (28.3 %) interested in gardening, while 19.1 % declared to be slightly interested and 5.8 % not interested at all. Only 2% reported that they had never visited a public green space, while 12.5 % stated a frequency of visits lower than once per month, 43.1 % on weekly intervals, and 26.9 % on a daily basis. Most of the respondents strongly agreed (56.2 %) or agreed (33.3 %) that green spaces were necessary for their psychological well-being, while only 2.3 % disagreed. It is worth noting that only 3.9 % of the participants who reported visiting green spaces less than once a month or never, disagreed with the positive impact of green spaces on their psychological well-being.

There was a clear preference for having plants outdoors rather than indoors. A great number of respondents had none or only a few plants inside their houses, while more than half had plenty (more than 8 plants) outside. More specifically, 55 % had more than 7 outdoor plants compared with only 19.3 % of households with more than 7 indoor plants (Table 3). Despite the fact that many households included a low number of indoor plants, the respondents' perception indicated a strong belief that the existence of plants within the house produced a beneficial effect on their emotional welfare (76.0 %), while 20.8 % declared to be indifferent, and a minimum percentage (3.2 %) believed that indoor plants did not influence their emotional welfare.

The most common way of introducing vegetation in the house involved using pots or flower beds in both indoor and outdoor settings (Fig. 5). Trees and shrubs were among the most frequent types of outdoors vegetation. Other ways of greening, such as climbing or hanging plants, lawns or vegetable gardens, were less common, while living walls were not a popular option since they were only used by less than 4% of the respondents.

3.4. Emotional state and attitudes towards plants during the COVID-19 confinement period

The participants exhibited moderate feelings during the confinement period since, in most cases (41.9–63.5 %), the most frequent response was "sometimes" in relation to the frequency of their feelings and mood during the confinement period. However, certain feelings prevailed in some cases. More specifically, 54.3 % responded that in many instances they were calm, with 39.7 % being optimistic and 35.4 % cheerful. Further support for the respondents' positive attitude during the confinement period may be derived from the fact that 38.2 % reported that they never felt depressed, 32.3 % never felt fear, and 25.8 % never felt sadness.

Table 3
Distribution of indoor and outdoor plant number per household.

Number of plants	0	1–3	4–7	8–10	> 10
Indoors (%)	26.5	35.6	18.6	7.2	12.1
Outdoors (%)	7.8	13.2	14.5	10.2	44.8

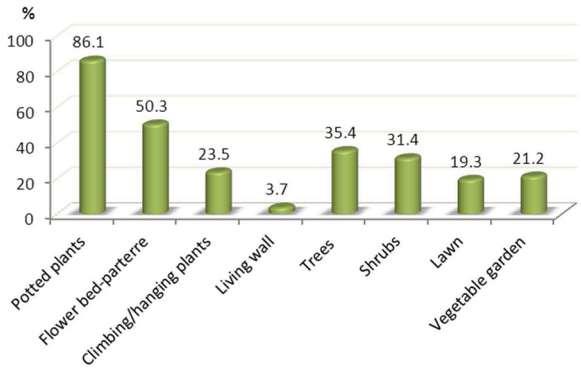

Fig. 5. Different categories of indoor and outdoor vegetation per household.

The variables that were determined to significantly affect the 'Overall emotional well-being' indicator of the participants during the COVID-19 crisis are presented in Table 4. A higher mean value of the indicator implied more frequent negative emotions and less frequent positive emotions. More frequent negative emotions were experienced by those respondents who were directly related to a positive COVID-19 case, were of female gender, and belonged to the 18–25 age group. Furthermore, negative emotions were more frequently experienced by

Table 4
Variables significantly affecting the 'Overall emotional well-being' indicator (mean and standard deviation [SD]) of the participants during the COVID-19 crisis. Higher mean values indicate more frequent negative emotions and less frequent positive emotions. Different letters within the same variable indicate significant differences between the options using Tukey's honest significant difference (HSD) at 5% probability level ($P < 0.05$).

Factor	Option	N	Mean	SD	
Directly affected by COVID-19 ($F = 110.5$; $p < 0.001$)	Yes	667	13.23	2.7	a
	No	3538	12.07	2.6	b
Age group ($F = 45.88$; $p < 0.001$)	18–25	710	12.95	2.8	a
	26–40	1645	12.5	2.6	b
	41–65	1662	11.83	2.5	b
	66+	188	11.23	2.6	c
Receiving natural light indoors ($F = 28.9$; $p < 0.001$)	Not at all / Little	587	12.84	2.6	a
	Some	1348	12.56	2.6	a
	Quite a lot	1487	12	2.7	b
	A lot	783	11.78	2.5	b
Frequency of visiting green spaces prior to the crisis ($F = 15.36$; $p < 0.001$)	Daily	1133	11.87	2.6	a
	Weekly	1811	12.25	2.6	b
	Monthly	649	12.59	2.7	c
	Less than once per month	611	12.62	2.8	c
House size ($F = 12.12$; $p < 0.001$)	< 40 m^2	229	12.83	2.7	a
	40–70 m^2	964	12.53	2.7	ab
	70–100 m^2	1247	12.31	2.6	b
	100–130 m^2	891	12.18	2.7	bc
	> 130 m^2	874	11.8	2.5	c
Gender ($F = 10.06$; $p = 0.002$)	Female	2358	12.36	2.7	a
	Male	1823	12.1	2.6	b
Number of indoor plants ($F = 6.75$; $p < 0.001$)	0	1115	12.47	2.7	a
	1–3	1496	12.35	2.6	a
	4–7	783	12.16	2.5	ab
	8–10	304	11.81	2.8	b
	>10	507	11.92	2.7	b

residents living in small-sized houses (<40 m^2), by those receiving low or no natural light inside their house, and by those who did not visit green spaces frequently prior to the crisis. Moreover, the frequency of negative emotions prevailed when the responders did not have many indoors plants. Surprisingly, having plants outdoors did not seem to have any significant influence on the emotional well-being of the participants during the lockdown period of the pandemic.

When the responses from the collected questionnaire data were compared with the four major contributing countries (Spain, Italy, Brazil, and Greece), several differences were detected (Table 5). The impact of a positive COVID-19 case resulted in negative emotions in all countries and for the total sample. However, the responses from the total collected questionnaires showed that Spanish and Brazilian respondents of 18−25 years experienced more frequent negative emotions, while age was not a contributing factor for Italian and Greek respondents. It is worth noting that in Brazil negative emotions prevailed in respondents of 26−40 years who lived in houses sizes ranging from 40 to 70 m^2. Negative emotions were more frequent in Spanish and Brazilian women and Greek men, while gender was not significant for the Italian respondents.

An indifferent emotional state was observed for the following factors: levels of indoor natural light in Italy; frequency of visiting green spaces prior to the crisis in Spain, Italy, and Greece; house size in Greece; number of indoor plants in Spain, Italy, and Greece. The complete results of the statistical analysis are presented in Annex B along with the differences between countries.

More than half of the respondents (55.8 %) stated that they would have preferred to have more plants in their house during the confinement. Conversely, 60.3 % of the householders declared their unwillingness to increase the number of plants after the termination of the pandemic confinement period. Similarly, 75.2 % of the householders expressed their reluctance to invest in plant purchases during the confinement period of the pandemic. It is worth noting that 52 % of the respondents reported spending more time taking care of plants at home during the confinement period and 62.5 % expressed their desire to devote more time to taking care of plants at home once normality was resumed.

3.5. Living walls as an option for increasing indoor vegetation

The questionnaire included a short description of living walls accompanied by a relevant photograph depicting their indoor application in order to concomitantly determine participants' knowledge and inform those who were not familiar with the specific technology. It was determined that only 16.1 % of the total participants were not familiar with the living wall concept. In a further elaboration for evaluating participants' perception in terms of the potential applicability of living walls, 51 % agreed and 25.5 % strongly agreed with the statement that living walls could be considered as an alternative greening technology able to provide increased vegetation at home by occupying less space, while only 5% disagreed or strongly disagreed. However, most participants had difficulty relating to the application of living walls. Among the main reasons that discouraged them from a living wall installation indoors were: maintenance, which was reported by 52 % of the participants, potential dampness problems (44 %), concerns of insects or presence of other animals within the house (39.5 %), and anticipated construction and installation costs (32.0 %).

3.6. Preference regarding different quantities and types of greening in the buildings

In all cases, the option without vegetation (A) was the least preferred (Fig. 6). In indoor spaces, few (5–7) plants in pots were desirable (option B), although in the case of Room 1, the option regarding many plants and a living wall (option D) was also well-rated. Contrary to the indoor aesthetic perception, the arrangement on the outdoor balcony which included plants and a living wall was the preferred choice, although the scenario without a living wall but with many plants was also well-accepted, with 23 % of the respondents selecting it as the 1st option and 42 % as the 2nd.

4. Discussion

Previous studies have concluded that contact and interaction of humans with nature has a positive impact on their health and well-being (Grinde and Patil, 2009; Kim and Miller, 2019; Navarrete-Hernandez and Laffan, 2019). In our study, 89.5 % of the respondents were strongly in favour of the necessity of open green spaces for their psychological well-being, which is in agreement with the results of several other researchers such as Buchel and Frantzeskaki (2015); Luck et al. (2011), and Mavoa et al. (2019). In our study, psychological benefits seemed to be linked not only to the presence of vegetation, but also to a combination of factors such as the possibility of doing exercise in open spaces, enjoying fresh air, and relaxing or connecting with other people

Table 5
List of detected differences in responses concerning the respondents' emotional state between the total collected questionnaire data and the four major contributing countries: Spain, Italy, Brazil, and Greece. The fonts in bold represent the different responses among countries compared with those of the total sample.

Questions and Factors	Total Questionnaire Sample	Four major contributing countries (82.4 % of the responses)			
		Spain (19.6 %)	Italy (9.4 %)	Brazil (29.6 %)	Greece (23.8 %)
Age group	Negative emotions were more frequent in 18−25 year olds	Negative emotions were more frequent in 18−25 year olds	**Emotional state indifferent considering age**	Negative emotions were more frequent in 18−25 **and 26−40 year olds**	**Emotional state indifferent considering the age**
Receiving natural light indoors	More frequent negative emotions with low levels of natural light indoors	More frequent negative emotions with low levels of natural light indoors	**Emotional state not influenced by the level of natural light indoors**	More frequent negative emotions with low levels of natural light indoors	More frequent negative emotions with low levels of natural light indoors
Frequency of visiting green spaces prior to the crisis	Negative emotions for respondents who visited green spaces monthly or less than once per month	**Emotional state indifferent considering frequency of visiting green spaces**	**Emotional state indifferent considering frequency of visiting green spaces**	Negative emotions for those who used to visit green spaces monthly	**Emotional state indifferent considering frequency of visiting green spaces**
House size	Negative emotions were more frequent in residents living in small-sized houses (<40 m^2)	Negative emotions were more frequent in residents living in small-sized houses (<40 m^2)	Negative emotions were more frequent in residents living in small-sized houses (<40 m^2)	Negative emotions were more frequent in residents living in houses of <40 m^2 **and also from 40 to 70 m^2**	**Emotional state indifferent considering house size**
Gender	Negative emotions were more frequent in women	Negative emotions were more frequent in women	**Emotional state not affected by gender**	Negative emotions were more frequent in women	**Negative emotions were more frequent in men**
Number of plants indoors	Negative emotions more frequent in responders having no or less than 4 plants	**Emotional state not affected by the number of indoor plants**	**Emotional state not affected by the number of indoor plants**	Negative emotions more frequent in responders with no indoors plants	**Emotional state not affected by the number of indoor plants**

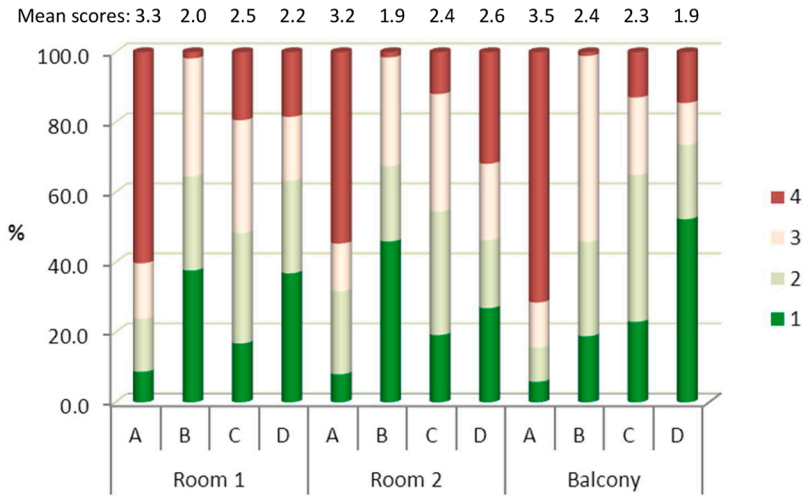

Fig. 6. Preferences regarding the level of vegetation for two indoor rooms and a balcony, rated from the most preferred [1] to the least preferred [4]. (A) No vegetation, (B) few plants, (C) many plants, (D) many plants and living walls. A lower number denotes a higher preference for each option within each column.

(Chiesura, 2004; Wang et al., 2020; Wood et al., 2017). However, there is currently very few literature explaining the feelings and their impact on people's psychological state when access to green spaces is not a feasible option. Two very recent studies showed similar results about the influence of having a green view from home (Soga et al., 2020) and the exposure to greening during the COVID-19 quarantine (Dzhambov et al., 2020). The COVID-19 pandemic emerged as a unique and global crisis that deprived people worldwide from the possibility of visiting public green spaces for a prolonged period of time, which extended to more than 6 weeks. Therefore, under the specific circumstances, a unique opportunity is provided to conduct research on the extent of the impact of nature's substitutes within a household / on a household's living standards. The respondents' view with regard to house vegetation and its impact on their emotional status under confinement conditions is expected to be a clearer and a standalone procedure, which is exempted from everyday interactions and interventions.

The primitive human urge to employ natural elements in the household is reflected in the tradition and habit of introducing indoor and outdoor plants at home. In the current study, only 3.3 % of the participants reported not having indoor plants in their home. However, there was a clear preference for outdoor rather than indoor vegetation, in the form of front gardens, balconies, backyards, and terraces. Despite the latter, the statistical analysis of the data revealed a significant influence of indoor plants on the reported emotional state. By contrast, although having more plants outdoors did not seem to affect the respondents' emotional state, this could be attributed to the inherited positive interaction between outdoor space (irrespective of having plants or not) and the amelioration of the mood.

The majority of the respondents (73.7 %) agreed that having vegetation at home positively contributed to their mood during the COVID-19 confinement period, while only 3.5 % disagreed. This seems to be reinforced by the frequency of self-reported positive (calmness, optimism and cheerfulness) and negative (stress, sadness, fearfulness and depression) emotions during the COVID-19 crisis among those with many (more than 7 plants), some (3–7 plants) and no or very few (less than 3) indoor plants at home.

A similar percentage believed that, in general, having indoor vegetation was favourable for their psychological well-being. In this sense, when people report an overall improvement of their well-being whenever indoor plants are present, they are actually experiencing the physiological manifestations of psychological effects (Fjeld, 2000), similarly to influences of the natural environment over the subconscious parts of the brain in ways that cannot easily be described (Grinde and Patil, 2009).

The production of mental health benefits resulting from the interaction between humans and nature may occur through multiple psychological causal mechanisms and pathways, including reduction of stress or replenishment of cognitive capacities (Bratman et al., 2019). The positive effects produced by the presence of indoor plants may be attributed to the visual appearance of plants, since affective responses to visual stimuli that are deemed aesthetically pleasant could contribute to the release of tension (Grinde and Patil, 2009).

Some studies point out that the effect of vegetation on human psychology differs according to demographic variations such as gender and age (Aydogan and Cerone, 2020; Bratman et al., 2019). As an example, Hennigan (2010) reported that men were more positively affected by displays of indoor vegetation than women. However, the introduction of flowering indoor plants had a more positive effect on women rather than men. In our study, women experienced negative emotions more frequently than men. However, no gender differences were detected with regard to the positive influence of house plants on the respondents' emotional state during the health crisis. Regarding the age groups, although older people felt negative emotions less frequently, they acknowledged a higher positive influence of home plants on their emotional welfare. More specifically, while 84 % of respondents between 66- and 80-years agreed that vegetation at home assisted their emotional well-being, only 70 % of respondents who were less than 40 years had the same view.

Ambrose et al. (2020) reported that females involved in household gardening experienced a higher emotional well-being, and this was also applicable to females with a low income. The results of the present study also showed that the impact of the household income on emotional well-being was significant ($p = 0.006$) since lower income levels were associated with lesser emotional well-being. Inhabitants with lower income often reside in households with reduced space and light availability and are characterised by a lack of (or very scarce) outdoor or indoor greenery. By contrast, inhabitants with higher incomes tend to live in neighbourhoods and households with more greenery (Li et al., 2015). In addition, house size had a significant influence as, in general, more negative emotions were reported by those living in smaller houses during the confinement period.

The landscape around the households can also positively affect the emotional state of their inhabitants. More specifically, several studies have shown that windows overlooking a natural landscape can potentially have a positive contribution to the mental health and well-being of urban dwellers (Kaplan, 2001; Olszewska-Guizzo et al., 2018). For instance, Chang and Chen (2005) studied the psychological responses in workplace environments having either indoor plants or windows

overlooking a natural landscape. The study participants reported to be less anxious both when looking at a natural view from a window and/or when indoor plants were present at their work environment.

In this regard, the place where people reside (urban vs. rural), and the associated residential landscape typology, also has an important influence on the inhabitants' emotional response. Based on the statistical analyses of the collected data, differences were observed in relation to the frequency that respondents experienced positive and negative feelings between those living in rural and urban areas (Fig. 7). Although the frequency of positive moods was similar, people living in rural areas reported to be less stressed or sad while they hardly felt fear. In this sense, the way of living or the proximity to natural surroundings and landscapes might have a positive influence on the well-being of the inhabitants of rural areas.

Having natural light at home seemed to be associated with an increased emotional well-being of the occupants. This can be attributed to the stimulation of positive emotions by sunlight (Beute and de Kort, 2018) as well as to the potential of hosting more indoor plants without any artificial lighting. However, even in the absence of natural sunlight, plants placed in windowless environment seem to help reduce stress (Lohr et al., 1996).

It is interesting to point out that the frequency of visiting green spaces prior to the crisis also exhibited a significant correlation, since the respondents who frequently visited public green areas also reported a higher overall emotional well-being, even when they were deprived of that activity during the confinement period. This finding is in accordance with Lafortezza et al. (2009), who ascertained that respondents visiting green spaces with a higher frequency and duration reported higher benefits and well-being compared with those with infrequent visits. Similarly, Hong et al. (2019) reported that respondents who had visited urban green spaces within the past two weeks expressed higher positive and lower negative emotions than non-visitors, indicating a follow-through phenomenon concerning the green space impact on people's well-being.

Half of the participants spent more time taking care of plants at home during the confinement period, which can be related to having more spare time, but also to the beneficial effects provided by nursing plants. Lades et al. (2020) reported gardening to be one of the most effective activities for mitigating the unpleasant effects of social isolation due to COVID-19 on people's emotional well-being. Plant maintenance may be considered not only as an enjoyable activity but also as a means of focusing the mind on a specific task, thus diverting attention from the COVID-19 situation and helping to suppress negative emotions. In fact, plant maintenance and management has been reported to induce perceptions of stress/ pressure relief, improved thinking ability, happiness, and reduced fear (F. Liu, 1999). It is perhaps for this reason that gardening has been identified as one of the activities exhibiting increased positive influence on emotional well-being (Ambrose et al., 2020).

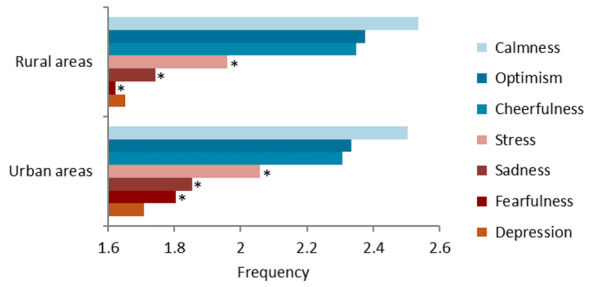

Fig. 7. Average frequency (1: never; 2: sometimes; 3: many times) of positive and negative feelings experienced by respondents from rural and urban areas. The asterisk (*) denotes the feelings in which significant differences were observed in pair-wise comparisons ($P < 0.05$ in t-test) between the same emotional state of people living either in rural or urban areas.

Mental health benefits typically co-occur with other ecosystem services and benefits (Bratman et al., 2019), such as the improvement of the indoor air quality or thermal comfort (i.e., absorption of harmful volatile elements and compounds, increasing humidity and decreasing temperature in the house), which in turn also affect emotional responses due to their direct relation to people's physical state (e.g., headaches, throat irritation, etc.). In addition, a reduction in overall mortality, especially from circulatory illnesses, has been reported in those living in indoor areas with plants (Mitchell and Popham, 2008).

The current affective state and other personal characteristics (e.g., preferences for nature) can influence the effects of vegetation on mental health and the type of benefits obtained (e.g., cognitive function, mood, and stress reduction) (Bratman et al., 2019). Another factor worth considering is the time of exposure and the duration of the effects. While there is enough evidence from experimental studies that human exposure to nature plays a causal role in improving affect in the short term, it is not fully established whether these affective changes play a causal role in influencing longer-term mental health (Bratman et al., 2019). Levels of comfort and positive emotions were reported to increase with the duration of exposure to plants (Han and Ruan, 2019), but some argue that long exposures may entail habituation to the presence of plants and so attenuation of some effects (Bringslimark et al., 2009).

The time of exposure and the duration of the effects can be the causal factor for the observed differences between the four main participating countries in the current study. More specifically, the stage of the crisis cycle in each country during the questionnaire distribution and the consequences of the pandemic wave seemed to have an influence on the respondents. The time during which the questionnaire was administered was short and, thus, the long-term effects of indoor plants on people's well-being could not be fully evaluated. However, this does not constitute a limitation of the present study, given that the main aim of the study was to explore the impact of indoor plants precisely during periods of confinement and to provide useful results in relation to using indoor plants as methodologies for phycological alleviation in future lockdowns. In that sense, the study duration and timing were not limited but rather reinforced by the unique conditions of country-wide confinement, which enabled the emergence of psychological expressions that might otherwise be concealed by daily routines and the inhabitants' lack of time.

In Italy, the only factor affecting the respondents' emotional well-being was whether they had been exposed to a COVID-19 case, while in the remaining countries exposure to coronavirus confirmed cases or deaths was indifferent. A significant correlation between having more indoor plants and a higher reported emotional well-being (which was obtained for all the dataset) was only detected in Brazil, which was the only country in which lockdown was not employed as a country-wide prevention method for coronavirus expansion. Furthermore, in Brazil the questionnaire was administered during the first stages of the disease (Table 2 in Annex A and Fig. 4) and, thus, its influence on people's emotional state was expected to have a lower impact. Therefore, other causes should be investigated to explain the increased impact of indoor plants to the emotions of Brazilian people, which may relate to their connection with the rich flora of their country. In Greece, where the impact of COVID-19 was less acute, 83.1 % of the respondents agreed that plants at home influenced their well-being. Similarly, high percentages were also reported in Spain (72.4 %) and in Brazil (78.0 %). Conversely, in Italy only 46.0 % agreed that the presence of more indoor plants had a positive effect on their emotional well-being, presumably as a result of the severity of the disease, which concealed other secondary emotions.

A number of studies point out that plants support psychological restoration by acting as visual features in the environment that evoke aesthetic experiences and hold attention (Bringslimark et al., 2009). In order to efficiently enhance this effect, the occupants' preferences and the overall visual impact of the proposed arrangement of the plants can play an important role (Park et al., 2008). This visual prominence

depends on the type of vegetated element (cut or potted, foliage or flowering, etc.), the number and size of plants, and their placement with respect to the observer. The type of plants and the species determine properties such as colour and leaf shape and have implications for the amount of greenery actually perceived (Bringslimark et al., 2009). The use of plants which display more flowers can promote positive emotions (Adachi et al., 2000) and seems to have a greater positive impact compared with foliage plants, as they influence stress-relief, pain tolerance, and perceived attractiveness of the room (Bringslimark et al., 2009). Yellowish-green and fresh-green plants may enhance comfort and calmness, whereas greenish-white plants could stimulate negative emotions (Elsadek et al., 2017).

Having many indoor plants which occupy a large volume relative to the available space may result in a simulation of an outdoor nature synthesis under indoor conditions (Bringslimark et al., 2009). In the present study, the amount of vegetation inside the house certainly affected the respondents' perception of its positive effect on their emotional state: 88.5 % of the participants having many indoor plants agreed with this view, as opposed to 73.3 % of those having few indoor plants. Moreover, when they were offered different scenarios with increasing levels of indoor vegetation, more than half of the participants selected the option without any plants as their least preferable option.

At the same time, 55.8 % of the respondents declared that they would have preferred having more plants at home during the confinement period, although this decreased with age. Conversely, the preference for more plants at home was higher for those reporting a lower emotional well-being.

During the stressful period of the pandemic confinement, the positive influence of plants was acknowledged and resulted in a shift of the participants' perception with regard to the beneficial contribution of plants towards the emotional welfare of the inhabitants. It is worth noting that nearly 40 % declared that their motivation for having plants at home had changed in favour to increasing their indoor plant numbers. Apart from the fact that people spent more time at home during the confinement period, this motivation could also be influenced by the increased time available to care for their plants during that period.

Nonetheless, respondents were reluctant to buy plants during the confinement, but it remained unclear whether this reluctance was the result of unwillingness or due to other reasons, such as difficulties in transportation, fear of being in contact with other people, reduction of their income in conjunction with insecurity for future job opportunities that made ornamental plant purchase a wrong-timed luxury. These issues were considered by the International Association of Horticultural Producers (AIPH) as some of the threats faced by ornamental plant producers during the COVID-19 pandemic. In many different parts of the world, sales of ornamental horticultural products decreased or ceased, since horticulture is considered as a non-essential service and most of the consumers were forced to focus on essential purchases only. Although online and delivery sales were encouraged (Reis et al., 2020), internet sales represented only a small portion of the whole potential market (AIPH, 2020b). The reduction in the sale of ornamental plants was further aggravated by the closure of borders, reduction of available transportation and interruption of landscaping projects (AIPH, 2020a).

Nevertheless, the shift in the participants' perception regarding the benefits of having plants at home can generate a motivation for buying more plants after the crisis. This would be a very positive outcome for the ornamental horticultural industry since the strategies to stop the spread of COVID-19 had a far-reaching effect by partially or completely closing gardens centres, flower shops, and floriculture farms all around the world.

5. Conclusions

The present study shows that, according to the majority of participants, vegetation in indoor living spaces positively influenced their emotional well-being during the confinement period. However, they preferred low levels (5–7) of indoor plants for their houses, while the participants made a wider use of the outdoor spaces of their houses for establishing their plants. The respondents' appreciation and the presence or use of plants in their living spaces was influenced by the COVID-19 restrictions, with more than half of the participants being willing to host more plants at home and allocate more time for their maintenance during the confinement period. The living wall systems were appreciated by the respondents as an option to increase the number of plants at home and there was a demonstrated preference for using them mainly outdoors (e.g., on balconies). Further research is suggested in order to further correlate certain specific characteristics of the population with the impact of indoor greening capacity to alleviate stresses resulting from confinement situations.

CRediT authorship contribution statement

Luis Pérez-Urrestarazu: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Supervision. **Maria P. Kaltsidi:** Methodology, Formal analysis, Investigation, Writing - review & editing. **Panayiotis A. Nektarios:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Georgios Markakis:** Formal analysis. **Vivian Loges:** Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Katia Perini:** Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Rafael Fernández-Cañero:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

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

Acknowledgments

We would like to thank the 4205 respondents for their time and effort in participating in the survey. We are also grateful for the financial support provided by Capes PrInt Brazil (88887.369588/2019-00).

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.2020.126919.

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