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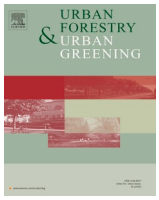

Perceptions of Change in the Natural Environment produced by the First Wave of the COVID-19 Pandemic across Three European countries. Results from the GreenCOVID study

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ABSTRACT

Although different studies have evaluated the positive impacts of the COVID-19 pandemic and lockdown measures on reducing noise pollution and traffic levels and improving air quality, how populations have perceived such changes in the natural environment has not been adequately evaluated. The present study provides a more in-depth exploration of human population perception of enhanced natural exposure (to animal life and nature sounds) and reduced harmful exposure (by improved air quality and reduced traffic volume) as a result of the COVID-19 pandemic lockdown. The data is drawn from 3,109 unselected adults who participated in the GreenCOVID survey from April to July 2020 in England, Ireland, and Spain. The findings suggest that the positive impacts to the natural environment as a result of the lockdown have been better received by the population in Spain and Ireland, in comparison to England. Participants who resided in urban areas had better perceived improvements in nature sounds, air quality, and traffic volume compared to those in rural areas. Older populations and those with lower smoking and alcohol consumption were found to perceive this improvement the most. Furthermore, the greater perception of improvements in environmental elements was also associated with better self-perceived health and improved wellbeing. In the binary logistic regression, living in Ireland or Spain, urban areas, female gender, older age, and good overall wellbeing were associated with a greater perception of improvements in the natural environment, while the factors most associated with a greater perception of reduced harmful exposure were living in Spain, had a good self-perceived health status and older age.

1. Introduction

For centuries, human progress has been supported by Earth's ecological systems, landscapes, and biodiversity (Whitmee et al., 2015). However, the current levels of nature degradation and pollution of our planet demand important changes to our economic and energy models, as well as in our consumption patterns (Antonakakis et al., 2017). Multiple national and international organisations have committed to an ecologically-informed transition based on carbon emission reduction and energy innovations (European Comission, 2019a; Kinzig and Kammen, 1998; UNFCCC, 2015; United Nations, 2015). The EU aims to be climate neutral by 2050, adopting the European Green Deal to combat climate change and environmental degradation through a sustainable, modern and efficient economy. This European agreement aims to boost resource efficiency by moving towards a clean and circular economy and to restore biodiversity and reduce pollution (European Comission, 2019b). To date, the progress achieved by these efforts has been slow and has hardly managed to reduce the substantial impact of human activities on our planet.

Since World War II, no event has had such a major impact on our production model and economies as the current COVID-19 pandemic (Zhang et al., 2020). Efforts to contain the spread of the SARS-CoV-2 virus have forced governments to restrict interactions between political regions and countries, cancelling flights and reducing transportation

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systems with consequences for tourism, commerce, and other industries, which will ultimately lead to devastating effects on employment and the global economy (Bashir et al., 2020; Lokhandwala and Gautam, 2020; Manenti et al., 2020; Saadat et al., 2020; Usman et al., 2020). The COVID-19 pandemic lockdown has moderately affected unemployment levels in the EU, which increased from 7.4 %–8.3 % between December 2019 and December 2020 (Eurostat, 2021, 2020). The small increase in the unemployment rate in the EU contrasts with developments in the United States, where mass redundancy programmes of workers caused unemployment to rise from 3.5 %–14.7 % between February 2020 and April 2020 (Anderton et al., 2020; Wilensky, 2021). However, from an environmental perspective, such lockdowns have provided opportunities for considerable and unprecedented improvements to the natural environment (Bashir et al., 2020; Basu et al., 2020; Kumar et al., 2020; Lal et al., 2020; Lutu et al., 2020; Malliet et al., 2020).

Although it is too early to draw conclusions as to the full impact of the COVID-19 pandemic on biodiversity conservation, as this must be assessed over the long term, dramatic improvements in air quality have been shown in many countries affected by the pandemic, mainly due to reductions in industry and transport (Corlett et al., 2020; Mahato et al., 2020). In addition, the crisis caused by COVID-19 is accompanied by a positive change in public awareness of nature-related issues (Rousseau and Deschacht, 2020).

Emerging evidence suggests that the COVID-19 lockdowns have led to a temporary reduction in traffic volume and created a new form of "traffic calming", which has served to substantially reduce noise (Aletta et al., 2020; Barbieri et al., 2020; Derryberry et al., 2020; Parker et al., 2020). Soundscapes, defined as the relationship between a landscape and the composition of its sounds (Pijanowski et al., 2011), have become dominated by human-produced sounds radiating from a variety of sources, such as machines, sirens, and the friction of tyres rotating on pavement, especially in urban areas (Barber et al., 2010). A reduction in urban noise pollution during the pandemic has allowed for an increase in the presence of wildlife (Lokhandwala and Gautam, 2020) and improved communication amongst songbirds such as sparrows (Derryberry et al., 2020). Further, the reduction in noise has caused birds and other animals to behave differently, lengthening their periods of reproduction and migration (Bar, 2020). Similarly, industrial closures have led to a reduction in pollutant emissions such as NO_2, SO_2 and PM2.5 emissions, allowing for improved air quality and clearer skies (Fu et al., 2020; Kroll et al., 2020; Saadat et al., 2020; Singh and Chauhan, 2020; Verma and Prakash, 2020). However, the environmental consequences of the pandemic may not have been entirely positive, as it has also fostered unsustainable consumption patterns, such as the increased consumption of single-use plastics (European Environment Agency, 2020).

Research on the relationships between green spaces, health and wellbeing has become a significant component of recent research across a number of thematic areas (Ujang et al., 2015; WHO Regional Office for Europe, 2017); and such attention has intensified during the COVID-19 pandemic (Guzman et al., 2020; Verma and Prakash, 2020). Much of the work has focused on a renewed appreciation for the value of having parks, rivers, lakes, and other natural spaces close to people (Foley and Garrido-Cumbrera, 2021).

Environmental effects, derived from the pandemic can be divided into short-term impacts and long-term or permanent impacts (Helm, 2020). Short-term effects, as a result of reduced human activity, are dominated by the direct effects of reduced human activity such as reduced gas emissions and thus improved air quality, while the continuing implications of environmental degradation, require individual, societal, and government responses (Diffenbaugh et al., 2020).

Recent data released by NASA (National Aeronautics and Space Administration) and ESA (European Space Agency) indicate that pollution in some of the epicentres of COVID-19 such as Wuhan (China), Italy, Spain and the United States was reduced by up to 30 % in the early stages of the pandemic.

As an adverse event, the COVID-19 pandemic has evidenced the positive potential of environmental exposure in a more positive, enabling, and stimulating way, which is a central idea in this study. Many of these positive and enabling effects have become more visible and audible during the pandemic with people's increased sensory awareness of birds, other wildlife, and the sounds of nature. In this vein, Bartalucci et al. (2021) study showed an increase in people's perception of nature sounds during lockdown compared to data from the pre-lockdown period. From a psychological point of view, Reese et al. (2020) showed how reduced noise pollution, stillness, and silence are related to enhanced connectedness with nature. A study in Russia revealed that respondents positively perceived the benefits of traffic and noise reduction during the pandemic lockdown (Dushkova et al., 2021). This idea of positive exposure to a more enabling and calming natural environment also suggests the need for more qualitative work that identifies the otherwise dangerous and ongoing threat to human life and health (Bavel et al., 2020).

It is important to assess the public's perception of the changes in nature triggered by the pandemic, as the pandemic has provided an effective test laboratory where suddenly a reduction in traffic, man-made noise, economic activities, and CO_2 emissions has occurred. Furthermore, it is important to assess whether the population is aware of these changes and to what extent they have perceived them, and whether this perception is different depending on the country, lockdown restrictions, degree of urbanisation, sociodemographic characteristics, life habits, and population's health status.

This paper provides a deeper exploration of the more positive dimensions of environmental exposure as a result of the first wave of the COVID-19 pandemic and lockdown measures in England, Ireland and Spain. Our aim is to assess the public's perceptions of enhanced natural exposure (to animal life and nature sounds) and reduced harmful exposure (by improved air quality and reduced traffic volume) during the first wave of the COVID-19 pandemic.

2. Methods

2.1. Survey

GreenCOVID is a cross-sectional study gathering information through an online survey of unselected adults (≥16 years) in the general population, conducted in three European countries during the strictest period of the first wave of the COVID-19 pandemic, when most of the population was prevented from leaving home (in the case of Spain), or only able to move within certain catchment areas (in the case of England and Ireland). Table 1 summarises the most relevant measures adopted by the three governments to reduce transmission of COVID-19.

The population survey was first disseminated in Spain by the University of Seville and the Spanish Association of Geography (AGE) [from 7 to 25 April 2020], then in England by the University of Winchester [from 28 May to 24 July 2020], and finally in Ireland by Maynooth University [from 3 June to 1 July 2020].

During the survey period in Spain the average number of cases of SARS-CoV-2 per day was over 3,000 (with more than 500 deaths per day) and in England around 2,500 cases per day (with more than 300 deaths per day), while in Ireland there were less than 20 cases per day (with less than 10 deaths per day). The following figure shows the trend in cases and deaths caused by COVID-19 in these three countries during the survey period (Fig. 1).

GreenCOVID aimed to assess the impact of the first wave of the COVID-19 pandemic and its lockdown measures on the population's wellbeing and mental health in three European countries: England, Ireland, and Spain. This study was led by the Health and Territory Research (HTR) group of the University of Seville, together with researchers from the PeopleScapes Research Group at the University of Winchester (England), and Maynooth University (Ireland). The questionnaire was initially designed in Spanish by researchers of the HTR

Table 1
Restrictions due to COVID-19 pandemic during data collection in Spain, Ireland and England.

Spain[1] From April 7 to April 25, 2020	England[2] From May 28 to July 24, 2020	Ireland[3] From June 3 to July 1, 2020
March 18th: Extension to the state of alarm. All non-essential workers stay at home. Extended twice on times April 24th and May 7th.	**May 13th:** The Health Protection (Amendment No. 2) Regulations 2020 (SI 500) come into effect, allowing the re-opening of garden centres, sports courts and recycling centres. In addition to outdoor exercise, open-air recreation also permitted with no more than one member of another household.	**May 18th:** Stay-at-home recommendations for the general population. Phase 1: reopening of businesses, gardens, walks within 5-km of home to meet friends outdoors observing social distancing until June 26th.
April 27th: Preparing to ease Coronavirus lockdown measures. Spanish children under the age of 14 were permitted to leave their homes.	**June 1st:** Health Protection Regulations (Amendment No. 3) 2020 (SI 558) come into force. Restrictions on leaving home, replaced by restrictions on overnight visits away from home. People from more than one household were not permitted to meet indoors but are maximum 6 people were permitted to meet outdoors.	**June 6th:** Closure of public spaces of any kind (including restaurants, entertainment venues, non-essential shops, partial or full closure of public transport, gyms and sport centres, etc.).
April 28th: 'Plan for the Transition towards a new normality in Four Phases'. Gradual and asymmetrical according to data regions.	**June 15th:** Remaining parts of the Health Protection Regulations (Amendment No. 4) 2020 (SI 588) came into force, permitting the general reopening of retail stores and businesses serving the public, except bars, nightclubs, indoor sports facilities.	**June 8th:** Phase 2. Travel up to 20 km from home, all retail stores reopened. Groups of up to 15 could meet for outdoor sporting activities.
May 2nd: General population allowed brief outdoor exercise and walks around 1 km from home.	**July 4th:** 'Super Saturday': pubs, restaurants and hotels reopened.	**June 29th:** Phase 3: opened pubs that serve food, cafes, restaurants, hotels, hairdressers, beauty salons and tourist attractions.
May 4th: Phase 0. Restaurants cater for takeaways and small service businesses opened by appointment.	**July 18th:** Greater powers given to local authorities to enforce distance rules.	**June 29th:** Protective mask use in closed public spaces/ transport on mandatory basis
–	**July 24th:** Wearing of face covering in shops and supermarkets in England becomes mandatory.	**July 15th:** Ireland delays the relaxation of confinement measures.

Sources: [1]Spanish Ministry of Health, 2021; [2]British Foreign Policy Group, 2021; [3]Government of Ireland, 2020; European Centre for Disease Prevention and Control, 2021.

group and included the following themes: socio-demographic, home/ housing, behaviours and routines, outdoor contact, wellbeing, physical health, and mental health. It was subsequently adapted for dissemination in Ireland and England.

As a result of the recruitment process in the three countries, a total of 3,109 unselected adults aged 16 years and over from the general population participated in the survey from April until July 2020. Details pertaining to data collection can be found in the flowchart (Fig. 2). Specific questions about perceptions of change in the natural environment during the pandemic were included in the analyses. These findings form the basis of our assessment of the positive dimensions of environmental exposure during the first wave of the pandemic.

2.2. Geographical distribution

In relation to the degree of urbanisation, Spain and England have the highest percentage of urban respondents (95 % and 90 % respectively), with respect to Ireland (76 %). Participants in the Spanish survey were distributed across more than 500 municipalities in Spain. The largest clusters of participants were concentrated in the metropolitan areas of Seville, Madrid, and Barcelona. The region of Andalusia, and specifically the city of Seville, where the Spanish survey was developed, stands out from the rest of the territories. There is also a notable presence of participants in the two archipelagos, and cities such as Zaragoza, Gijón, Coruña, Oviedo or Bilbao. In England, the largest number of respondents was collected in the south, around Winchester and Southampton. The high degree of concentration in Winchester is because the University of Winchester promoted this study in England. Similarly, there is a concentration of participants in London and also in Manchester, Leeds, and Sheffield in the north of England. In Ireland, which had fewer participants, there is a greater concentration around Dublin. In addition, small clusters can be identified in major cities such as Waterford, Cork, and Limerick. In Ireland, the percentages of territories participating in the survey are more balanced compared to the other two countries. Participants in the GreenCOVID survey are spatially represented by the Local Administrative Unit to which they belong (Fig. 3).

2.3. Variables

Table 2 describes the variables used in the analyses, classified into four groups: a) socio-demographic (country, degree of urbanisation, gender, educational level, and job status), b) behaviours and life habits (including smoking and alcohol consumption during lockdown), c) overall health (self-perceived health status) and wellbeing (WHO-5), and d) percepcion of natural enviroment change during the first wave of the COVID-19 pandemic (animal life, air quality, sounds of nature, and traffic volume). The area of residence was assessed based on the geolocation provided by participants and the degree of urbanisation according to Eurostat, which includes cities (densely populated areas), towns and suburbs (intermediate density areas), and rural areas (thinly populated areas) (Eurostat, 2016). To better assess differences in the degree of urbanisation, this variable was dichotomised into rural (rural areas) and urban (cities, town and suburbs).

The World Health Organization Five Well-Being Index (WHO-5): consists of five items that assess overall wellbeing on a 6-point Likert scale ranging from 0 (all the time) to 5 (at no time). The sum of the items is multiplied by 4 resulting in a total score ranging from 0 to 100. Higher values represent a worse state of wellbeing (WHO Regional Office for Europe, 1998).

2.4. Perception of changes in the natural environment

To identify the perception of changes in the natural environment due to the first wave of the COVID-19 pandemic the following question was asked: "Have any of the following increased or decreased as a result of the lockdown due to less traffic, economic activity etc?" Respondents were asked to consider this question for each of the following environmental elements: number of birds / animal life / nature sounds / air quality / traffic volume. The possible responses for each of these five environmental elements were as follows: much better/better/same/ worse/much worse. These environmental elements were re-coded from five into the following three categories: better (much better and better), same and worse (much worse and worse). The responses about the perception of the number of birds were integrated within animal life by

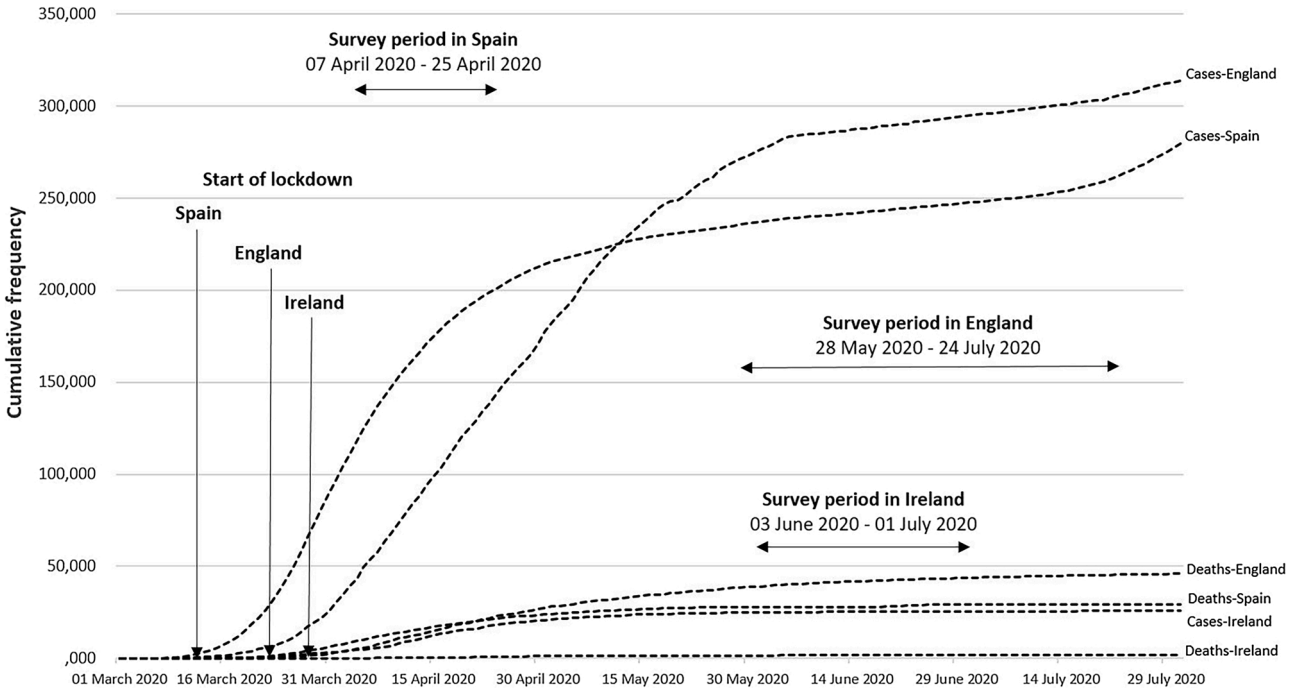

Fig. 1. Cumulative confirmed COVID-19 cases and deaths in Spain, England and Ireland.

reducing the set of environmental elements from five to four.

2.5. Statistical analysis

A descriptive analysis of all variables was performed showing the frequency and percentage for qualitative variables (i.e. age) and the mean and standard deviation for quantitative variables (i.e. area, country, gender, educational level, job status, smoking, alcohol consumption, health status, and wellbeing).

Multivariable binary logistic regression was used to assess the possible factors related to enhanced natural exposure (to animal life and nature sounds) and reduced harmful exposure (by improved air quality and reduced traffic volume). The dependent variable was coded as "1" (much better or better) and "0" (same or worse). The independent variables evaluated were: country (Spain and Ireland were dummy variables considering England as a reference), degree of urbanisation (urban), age (in years), gender (female), self-perceived health status (very good or good), and wellbeing (WHO-5 score ranging from 0 to 100). Odd Ratios (OR) and 95 % confidence intervals (CI) were shown at a significance level of 0.05.

All statistical analyses were performed using SPSS version 26.0.

3. Results

Of the 3,109 participants, 79.3 % (n = 2,464) were from Spain, 12.9 % from England (n = 402), and 7.8 % from Ireland (n = 243). The mean age was 39.7 years (SD = 14.1), 73.0 % were female, 71.9 % had a university education, and 7.2 % lived in a rural area (vs. 92.8 % urban). During the first wave of the COVID-19 pandemic, the majority of the population perceived an improvement in all environmental elements assessed, including traffic volume (95.0 %), nature sounds (91.7 %), air quality (89.3 %), followed by animal life (79.6 %).

A higher percentage of respondents from Spain and Ireland perceived such improvements in animal life (81.0 % and 86.8 %, respectively) and nature sounds (93.1 % and 88.8 %, respectively), compared to participants in England (75.1 % and 84.2 %, respectively). People who live in urban areas perceived a greater improvement of nature sounds (92.0 % vs 87.4 % in rural areas). Females perceived a greater improvement in animal life (82.0 % vs 77.3 % of males). Those who perceived an increase in nature sounds had a higher average age, while the observed improvement in animal life was similar across all age groups. Those who were furloughed (93.4 %) or working (93.2 %) perceived a greater increase in nature sounds than those who were homemakers (84.6 %) or retired (88.2 %). A higher percentage of respondents who smoked less (91.9 %) or the same as before the pandemic (92.7 %) appreciated an increase in nature sounds than those who had increased smoking (89.7 %). People with a better self-perceived health status were more likely to appreciate the improvement in animal life, (83.7 %), and nature sounds (92.3 %) than those with very poor self-perceived health (45.5 % and 81.8 %, respectively). In addition, respondents with better levels of wellbeing appreciated the improvement in nature sounds to a higher extent (Table 3).

Respondents in Spain (91.7 % and 96.8 %) and Ireland (88.4 % and 90.5 %) were more likely to appreciate the improvement in air quality and traffic volume, compared to those in England (73.9 % and 85.8 %). Furthermore, a higher percentage of people in urban areas perceived improvements in air quality (89.7 %) and traffic volume (95.3 %), compared to those living in rural areas (84.7 % and 90.5 %, respectively). Although most education categories perceived improvements in air quality and traffic volume, a smaller proportion of respondents with secondary education perceived these changes. Participants with better self-perceived health status also appreciated more the improvements in air quality and traffic volume (89.1 % and 95.0 %) (Table 4).

Living in Ireland (OR = 7.619), Spain (OR = 5.053), urban areas (OR = 1.832), female gender (OR = 1.585), older age (OR = 1.018), and having higher wellbeing scores (OR = 1.015) were associated with perception of enhanced natural exposure (to animal life and nature sounds) as a result of the COVID-19 pandemic lockdown. Additionally, the factors most associated with perception of reduced harmful exposure (by improved air quality and reduced traffic volume) were living in Spain (OR = 9.094), good self-perceived health status (OR = 2.015), and older age (OR = 1.024) (Table 5).

4. Discussion

Compared to the pre-COVID-19 period, our study found an overall

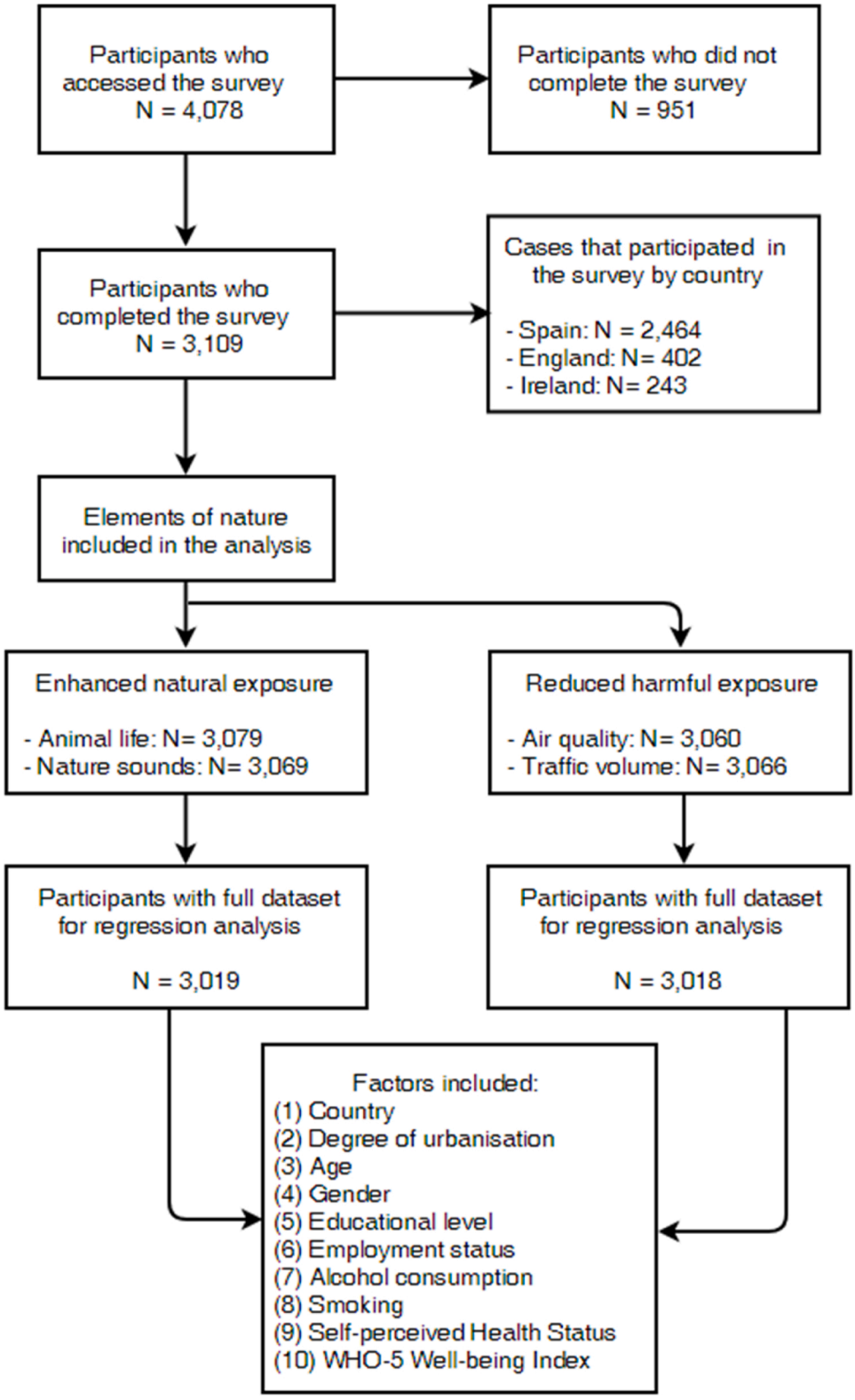

Fig. 2. Flowchart of the data collection.

improvement in people's perception of animal life, air quality, nature sounds, and traffic volume. These improvements in the natural environment due to the lockdowns were perceived to a greater extent by older populations, although significant gender differences were found for animal life, while those who smoked less or the same as before the COVID-19 pandemic were only associated with an improvement in nature sounds. Respondents who enjoyed a better self-perceived health status were the most likely to report these improvements. Furthermore, the factors most associated with perception of enhanced natural exposure were living in Ireland, Spain, rural areas, being female gender, older age, and conveyed a good wellbeing, while the factors most associated with perception of reduced harmful exposure were living in Spain,

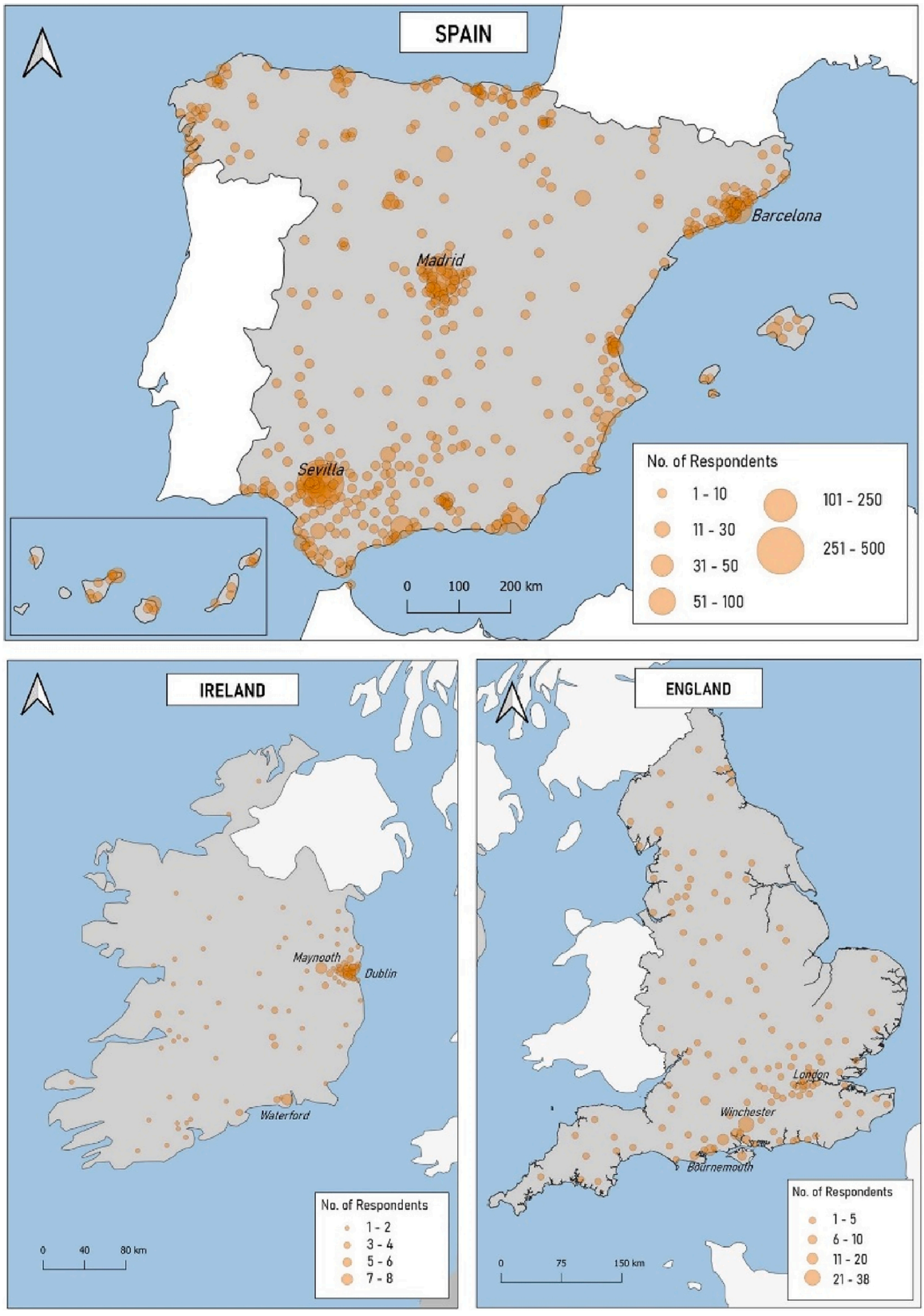

Fig. 3. Distribution of GreenCOVID survey respondents in Spain, Ireland and England.

Table 2
Description of the variables included in the study.

1) Socio-demographic characteristics	**-Country** (England/Ireland/Spain). **-Degree of Urbanisation** (Rural/ Urban) **-Age** (in years). **-Gender** (Male/Female). **-Educational level** (Primary schooling/ Secondary/High school/University). **-Job status** (Employed/Furloughed/ Unemployment/Retired/Sick-leave/ Student/Homemaker).
2) Life habits	**-Alcohol consumption during lockdown** (No consumption or decreased/Same as before/ Increased). **-Smoking during lockdown** (No smoking or decreased/Same as before/ Increased)
3) Health	**-Self-perceived health status** (Very good/Good/Regular/Bad/Very bad) **- WHO-5 Well-Being Index** (Ranging from 0 to 100)
4) Perception of natural environment change during the first wave of the COVID-19 pandemic	**Animal life** (Better/Same/Worse). **Air quality** (Better/Same/Worse). **Sounds of nature** (Better/Same/ Worse). **Traffic volume** (Better/Same/Worse).

reported a "good" self-perceived health status, and older age. In addition, participants residing in urban areas were more likely to perceive improvements in nature sounds, air quality, and traffic volume compared to those living in rural areas.

Moreover, a higher proportion of respondents in Spain and Ireland perceived improvements in the natural environment, compared to the population in England. This difference could be associated with the less strict confinement measures adopted by the English government during the first wave, which allowed visits to the boundaries of the neighbourhood, compared to the measures in Spain where most of the population was confined to their homes.

Another reason why these changes in natural environment may have been better perceived in Spain was the higher proportion of people living in urban areas (95 % of the sample), as the pandemic lockdown led to a greater reduction in traffic and economic activity in urban areas, compared to rural settings. This may therefore be the cause of increased perceptions of improvements in traffic volume, air quality and reduced noise pollution, leading to a positive perception of the sounds of nature. Furthermore, this greater perception in Spain could be explained by the fact that a higher percentage of the population lives in a flat (64.9 %), compared to England (14.8 %) and Ireland (7.8 %) (Eurostat, 2018a). Home confinement meant that the population living in flats, lacking outdoor spaces other than windows and balconies, missed access to natural environments more than those living in houses with access to private gardens. Compared to houses, blocks of flats tend to be located in

Table 3
Perception of changes in enhanced natural exposure (to animal life and nature sounds) during the first wave of the COVID-19 pandemic.

	Mean ± SD or n (%)					
	Animal life[1]			Nature sounds		
	Better 2475 (79.6 %)	Same 579 (18.6 %)	Worse 12 (0.4 %)	Better 2814 (91.7 %)	Same 209 (6.8 %)	Worse 46 (1.5 %)
Country						
Spain	1,990 (81.0)	458 (18.6)	10 (0.4)	2291 (93.1)	127 (5.2)	43 (1.7)
England	275 (75.1)	90 (24.6)	1 (0.3)	308 (84.2)	56 (15.3)	2 (0.5)
Ireland	210 (86.8)	31 (12.8)	1 (0.4)	215 (88.8)	26 (10.7)	1 (0.4)
Degree of Urbanisation						
Rural	182 (82.4)	38 (17.2)	1 (0.5)	194 (87.4)	20 (9.0)	8 (3.6)
Urban	2,281 (80.6)	537 (19.0)	11 (0.4)	2,605 (92.0)	188 (6.6)	38 (1.3)
Gender						
Women	1,829 (82.0)	396 (17.7)	6 (0.3)	2049 (91.7)	150 (6.7)	35 (1.6)
Men	641 (77.3)	182 (22.0)	6 (0.7)	760 (91.7)	58 (7.0)	11 (1.3)
Age, years	39.5 ± 14.0	40.1 ± 14.1	42.2 ± 14.5	39.9 ± 13.9	37.5 ± 15.3	31.6 ± 9.6
Educational level						
Primary	41 (82.0)	9 (18.0)	0 (0.0)	49 (98.0)	1 (2.0)	0 (0.0)
Secondary	137 (83.5)	27 (16.5)	0 (0.0)	147 (89.6)	14 (8.5)	3 (1.8)
High school	522 (82.2)	110 (17.3)	3 (0.5)	584 (92.0)	43 (6.8)	8 (1.3)
University	1,770 (80.0)	433 (19.6)	9 (0.4)	2028 (91.6)	151 (6.8)	35 (1.6)
Employment status						
Employed	1,203 (80.0)	296 (19.7)	4 (0.3)	1,404 (93.2)	85 (5.6)	17 (1.1)
Furloughed	252 (82.9)	50 (16.4)	2 (0.7)	284 (93.4)	14 (4.6)	6 (2.0)
Unemployment	248 (82.9)	49 (16.4)	2 (0.7)	275 (92.0)	14 (4.7)	10 (3.3)
Retired	132 (78.1)	35 (20.7)	2 (1.2)	149 (88.2)	20 (11.8)	0 (0.0)
Sick-leave	84 (84.8)	15 (15.2)	0 (0.0)	91 (91.9)	8 (8.1)	0 (0.0)
Student	481 (80.8)	111 (18.7)	2 (0.3)	526 (88.6)	56 (9.4)	12 (2.0)
Homemaker	39 (75.0)	13 (25.0)	0 (0.0)	44 (84.6)	7 (13.5)	1 (1.9)
Alcohol						
Not consumption or decreased	1,274 (81.8)	277 (17.8)	6 (0.4)	1434 (92.0)	101 (6.5)	24 (1.5)
Same as before	643 (78.9)	171 (21.0)	1 (0.1)	750 (91.9)	52 (6.4)	14 (1.7)
Increased	553 (81.0)	126 (18.4)	4 (0.6)	620 (90.9)	54 (7.9)	8 (1.2)
Smoke						
Not smoking or decreased	1,991 (80.8)	466 (18.9)	8 (0.3)	2,266 (91.9)	168 (6.8)	31 (1.3)
Same as before	183 (78.9)	49 (21.1)	0 (0.0)	215 (92.7)	14 (6.0)	3 (1.3)
Increased	296 (82.7)	59 (16.5)	3 (0.8)	323 (89.7)	25 (6.9)	12 (3.3)
Self-perceived health status						
Very good	456 (83.7)	87 (16.0)	2 (0.4)	502 (92.3)	36 (6.6)	6 (1.1)
Good	1,496 (81.3)	339 (18.4)	5 (0.3)	1,712 (92.9)	109 (5.9)	21 (1.1)
Fair	451 (77.5)	126 (21.6)	5 (0.9)	518 (88.5)	52 (8.9)	15 (2.6)
Bad	61 (79.2)	16 (20.8)	0 (0.0)	65 (84.4)	9 (11.7)	3 (3.9)
Very bad	5 (45.5)	6 (54.5)	0 (0.0)	9 (81.8)	1 (9.1)	1 (9.1)
WHO-5 (0-100)	45.1 ± 20.1	42.4 ± 21.3	37.0 ± 20.0	45.1 ± 20.1	42.4 ± 21.3	37.0 ± 20.0

[1] Including number of birds.

Table 4
Perception of changes in reduced harmful exposure (by improved air quality and reduced traffic volume) during the first wave of the COVID-19 pandemic.

	Mean ± SD or n (%)					
	Air quality			Traffic Volume		
	Better 2734 (89.3 %)	Same 318 (10.4 %)	Worse 8 (0.3 %)	Better 2912 (95.0 %)	Same 121 (3.9 %)	Worse 33 (1.1 %)
Country						
Spain	2251 (91.7)	198 (8.1)	5 (0.2)	2380 (96.8)	58 (2.4)	21 (0.9)
England	269 (73.9)	93 (25.5)	2 (0.5)	313 (85.8)	43 (11.8)	9 (2.5)
Ireland	214 (88.4)	27 (11.2)	1 (0.4)	219 (90.5)	20 (8.3)	3 (1.2)
Degree of Urbanisation						
Rural	188 (84.7)	34 (15.3)	0 (0.0)	201 (90.5)	18 (8.1)	3 (1.4)
Urban	2,531 (89.7)	283 (10.0)	8 (0.3)	2,696 (95.3)	102 (3.6)	30 (1.1)
Gender						
Women	1992 (89.3)	232 (10.4)	6 (0.3)	2117 (94.8)	93 (4.2)	22 (1.0)
Men	739 (89.7)	82 (10.1)	2 (0.2)	789 (95.3)	28 (3.4)	11 (1.3)
Age, years	39.7 ± 13.9	39.0 ± 14.8	35.6 ± 8.8	39.8 ± 13.9	36.0 ± 15.2	39.7 ± 15.3
Educational level						
Primary	48 (96.0)	2 (4.0)	0 (0.0)	47 (94.0)	0 (0.0)	3 (6.0)
Secondary	138 (84.7)	25 (15.3)	0 (0.0)	152 (92.7)	10 (6.1)	2 (1.2)
High school	572 (90.5)	59 (9.3)	1 (0.2)	606 (95.6)	18 (2.8)	10 (1.6)
University	1970 (89.2)	232 (10.5)	7 (0.3)	2101 (95.0)	93 (4.2)	18 (0.8)
Employment status						
Employed	1351 (90.0)	148 (9.9)	2 (0.1)	1449 (96.3)	41 (2.7)	15 (1.0)
Furloughed	274 (90.7)	26 (8.6)	2 (0.7)	289 (95.1)	14 (4.6)	1 (0.3)
Unemployment	270 (90.6)	27 (9.1)	1 (0.3)	283 (94.6)	12 (4.0)	4 (1.3)
Retired	142 (84.0)	27 (16.0)	0 (0.0)	159 (94.1)	7 (4.1)	3 (1.8)
Sick-leave	92 (92.9)	6 (6.1)	1 (1.0)	90 (90.9)	7 (7.1)	2 (2.0)
Student	525 (88.5)	67 (11.3)	1 (0.2)	549 (92.7)	36 (6.1)	7 (1.2)
Homemaker	44 (84.6)	7 (13.5)	1 (1.9)	49 (94.2)	2 (3.8)	1 (1.9)
Alcohol						
Not consumption or decreased	1413 (90.9)	139 (8.9)	3 (0.2)	1487 (95.4)	55 (3.5)	17 (1.1)
Same as before	708 (87.3)	100 (12.3)	3 (0.4)	776 (95.3)	30 (3.7)	8 (1.0)
Increased	603 (88.4)	77 (11.3)	2 (0.3)	639 (93.8)	34 (5.0)	8 (1.2)
Smoke						
Not smoking or decreased	2206 (89.7)	248 (10.1)	4 (0.2)	2342 (95.1)	97 (3.9)	24 (1.0)
Same as before	204 (88.3)	26 (11.3)	1 (0.4)	220 (94.8)	9 (3.9)	3 (1.3)
Increased	314 (87.5)	42 (11.7)	3 (0.8)	340 (94.7)	13 (3.6)	6 (1.7)
Self-perceived health status						
Very good	484 (89.1)	58 (10.7)	1 (0.2)	516 (95.0)	20 (3.7)	7 (1.3)
Good	1666 (90.6)	171 (9.3)	1 (0.1)	1770 (96.2)	55 (3.0)	15 (0.8)
Fair	503 (86.4)	74 (12.7)	5 (0.9)	538 (92.0)	39 (6.7)	8 (1.4)
Bad	67 (88.2)	9 (11.8)	0 (0.0)	71 (92.2)	3 (3.9)	3 (3.9)
Very bad	6 (54.5)	4 (36.4)	1 (9.1)	9 (81.8)	2 (18.2)	0 (0.0)
WHO-5 (0–100)	45.3 ± 20.1	41.1 ± 21.4	33.1 ± 21.2	45.0 ± 20.2	41.2 ± 22.3	40.0 ± 21.7

urban areas of higher population, building and traffic density, making the changes caused by pandemic lockdown more visible. In addition, this positive perception of biodiversity may be due to a higher frequency of being outside. In this respect, it is worth noting that the percentage of household expenditure devoted to restaurant services is higher in Ireland (14.4 %) and Spain (13.0 %), compared to a lower percentage in the UK (7.7 %) (Eurostat, 2018b). In any case, having lived a situation of strict home confinement in Spain appears to have sharpened the senses and made contact with nature more valuable. Similarly, it is possible that birds living in urban environments were able to adapt to the confinement situation in Spain, making them more detectable and easier to see (Gordo et al., 2021).

Our results confirm findings from previous studies that have shown increased appreciation for urban green spaces during the first-wave of the COVID-19 pandemic (Zhu and Xu, 2020). A similar international survey during the pandemic found that urban residents had an enhanced perceived need for accessible urban green spaces, mainly for physical exercise, relaxing, and observing nature (Ugolini et al., 2020). Another global study found that vegetation in indoor living spaces positively influenced emotional wellbeing during the confinement period, with respondents willing to have more plants at home and allocate more time to their maintenance (Pérez-Urrestarazu et al., 2020). While this had an indoor focus, this behaviour could be partly a response to the impossibility of going outdoors and having contact with the natural environment. In fact, improving environmental conditions during confinement can encourage the use of parks or gardens where there is a reduction in temperature, less pollution and noise (Dushkova et al., 2021).

In our study, people who increased their cigarette consumption were least likely to perceive improvements in nature sounds. This interpretation is also suggested by Jitnarin et al. (2015) who identified a negative male perception of environmental neighbourhood infrastructures when smoking to excess. Smoking can lead to cognitive impairment and reduced sensory abilities. Indeed, the study by Berglund and Nordin (1992) showed how regular cigarette smoking can lead to a decrease in the sensitivity of sensory systems in general. Another study by Waisman Campos et al. (2016) has shown that heavy smoking is associated with cognitive impairment and cognitive decline in middle age. In the same line, a study by Yakir et al. (2007) found that cigarette smoking in young women led to impairments in sustained attention and impulsivity control.

In line with our findings on how negative perceptions of different environmental elements were related to poorer self-perceived health, Poortinga et al. (2007) showed how negative elements of the urban environment - such as poor neighbourhood quality, neighbourhood disorder, lack of social cohesion or neighbourhood deprivation - were associated with a poorer self-perceived health status. Similarly, the study by Steptoe and Feldman (2001) identified a number of neighbourhood characteristics such as traffic density and pollution, dirty surroundings, and traffic noise as being associated with poorer health. Furthermore, in the study by Cummins et al. (2005), levels of fair to very poor self-reported health were significantly associated with a poor quality residential environment.

Table 5
Regression analysis on better perception of changes to enhanced natural exposure (to animal life and nature sounds) and reduced harmful exposure (by improved air quality and reduced traffic volume) during the first wave of the COVID-19 pandemic.

Better perception (vs same and worse)	Multivariable logistic analysis					
	Enhanced natural exposure (to animal life and nature sounds) N: 3,019			Reduced harmful exposure (by improved air quality and reduced traffic volume) N: 3,018		
	OR	95 % CI	p	OR	95 % CI	p
Country. Spain	5.053	**3.262, 7.828**	**<0.001**	9.094	**4.895, 16.895**	**<0.001**
Country. Ireland	7.619	**2.886, 20.112**	**<0.001**	1.500	0.684, 3.293	0.312
Degree of Urbanisation. Urban	1.832	**1.024, 3.278**	**0.042**	1.162	0.496, 2.724	0.730
Age	1.018	**1.004, 1.033**	**0.013**	1.024	**1.005, 1.044**	**0.015**
Gender. Female	1.585	**1.067, 2.354**	**0.022**	1.110	0.603, 2.041	0.738
Educational level. University	0.930	0.615, 1.407	0.732	1.355	0.772, 2.381	0.290
Employment status. Employed	1.025	0.698, 1.505	0.902	1.502	0.849, 2.658	0.162
Alcohol. Increased	0.979	0.873, 1.098	0.719	0.999	0.849, 1.176	0.991
Smoking. Increased	0.958	0.837, 1.096	0.533	0.877	0.730, 1.053	0.160
Self-Perceived Health. Very good or good	1.351	0.894, 2.042	0.153	2.015	**1.135, 3.578**	**0.017**
WHO-5 (0-100)	1.015	**1.005, 1.025**	**0.004**	1.005	0.991, 1.019	0.495

Several studies have shown an improvement in environmental quality by analysing atmospheric gas during the beginning of the pandemic (Kroll et al., 2020; Singh and Chauhan, 2020; Verma and Prakash, 2020; Zambrano-Monserrate et al., 2020). Our study adds to this evidence the population's perception of such changes in their natural environment, including less explored fields such as animal life and nature sounds. These findings also speak to wider research on improved nature-connection, attention-restoration (Hartig et al., 2003), and public value of environmental qualities such as peacefulness, stillness and tranquillity (Hewlett and Brown, 2018), despite such research rarely being conducted during a pandemic-driven societal lockdown. For all these reasons, we believe that this study complements other recent research on some surprisingly and perversely positive impacts of the COVID-19 pandemic linked to nature and its benefits for people's health and wellbeing.

Our results show that the positive environmental effects of the COVID-19 pandemic have been felt by the population, representing a unique and unprecedented opportunity to raise awareness of the effects of human activity in nature and reduce pollution in our environment in the long-term. Furthermore, such a situation resulting from the pandemic should serve as a basis for promoting sustainable behaviours and lifestyles that enable people to live in harmony with nature. In this sense, green spaces and nature have also benefited from the reduction of anthropic pressure and pollutants, restoring ecological function as evidenced by previous studies (Rume and Islam, 2020).

It is relevant to highlight that while the COVID-19 pandemic has had positive consequences for an appreciation of the natural environment, it has also had recognisable negative effects. As a necessary part of pandemic management in multiple settings, there has also been a massive increase in the use of personal protective equipment such as face masks and gloves, resulting in widespread environmental pollution (Prata et al., 2020), an increase in organic and inorganic waste and a reduction in its sustainable management (Zambrano-Monserrate et al., 2020). Moreover, the use of disinfectants used to exterminate SARS-CoV-2 in public areas could also affect other organisms and species, creating an ecological imbalance (Rume and Islam, 2020). Climate change and the public's perception of this problem is not only based on scientific evidence, but also on moral and civic beliefs. It is therefore important to understand the public perception of environmental changes, since to ensure a better environment, decisions and public policies must incorporate the perspective of citizens (Bickerstaff and Walker, 2001). In this way, measures to curb climate change will be better accepted by the population. Correspondingly, this study has been able to verify that respondents associate a decrease in economic and social activity with an improvement in environmental values. In addition, participants express their concerns about their local environment, either directly by referring to households or indirectly through effects on the ecosystem such as deforestation, river pollution or waste pollution (Sennes et al., 2012). The crisis caused by the COVID-19 pandemic has effected a positive change in the public awareness of nature-related issues (Rousseau and Deschacht, 2020).

We have measured this perception of change with our study, based on people's experiences and views. However, this way of looking at change in nature is corroborated by the fact that these adjustments have been real. In effect, recent data released by NASA (National Aeronautics and Space Administration) and the ESA (European Space Agency) indicate that pollution in some of the epicentres of COVID-19 such as Wuhan (China), Italy, Spain and the USA had reduced by up to 30 % in the early stages of the pandemic (Muhammad et al., 2020). Although different studies have evaluated the impact of lockdown on reducing environmental noise and traffic, and improving air quality (Kroll et al., 2020; Singh and Chauhan, 2020; Verma and Prakash, 2020; Zambrano-Monserrate et al., 2020), how the population has perceived these changes in the natural environment has been subject to less evaluation.

Perceptions of improvements in the state of biodiversity are consistent with empirical studies that have measured a reduction in the emissions of polluting gases into the atmosphere, motorised means of transport, or noise (Fu et al., 2020; Kroll et al., 2020; Saadat et al., 2020; Singh and Chauhan, 2020; Verma and Prakash, 2020). Thus, the present study confirms that the environmental improvements brought about by the pandemic, and identified in various studies, have indeed been positively perceived by the population, with differences between countries and degrees of urbanisation.

The Tbilisi Declaration expressly mentions that "human beings must be educated environmentally through knowledge, critical thinking, analysis and problem solving skills, the possession of attitudes and values and active participation in order to obtain an environmental citizenship education that improves the ecosystem" (UNESCO and UNEP, 1978). Being aware of the imperative need to maintain well-functioning ecosystems for human wellbeing means reconciling with the environment. It is difficult to move forward as a sustainable society while turning our backs on nature (Parra et al., 2020). Therefore, policy makers should be aware that changes towards a greener economy that lead to reduced pollution and greater sustainability will be well appreciated by society. Therefore, the results of this study should serve to legitimise action towards decarbonisation, as the population requires urgent responses to today's serious environmental problems.

One of the strengths of our study is the sample size, including a large number of unselected adults from three European countries during the first wave of the COVID-19 pandemic. This study provides direct feedback on the population's perception of changes in nature at a time of shifting contact patterns with nature and increased time availability.

One of the limitations of the study was that the data were mainly collected in Spain (n = 2,464, 79.3 %), compared to the UK (n = 402,

12.9 %) and Ireland (n = 243, 7.8 %), so the results cannot be generalised. That this is a cross-sectional study from which we cannot establish cause-effect relationships is another limitation, and therefore the results should be interpreted with caution.

5. Conclusion

Although, scientific societies and scientists have been warning for decades of the looming environmental catastrophe resulting from global warming, this has not led us to change our energy supply, mobility, lifestyle or consumption patterns. However, the lockdown measures adopted as a result of the first wave of the COVID-19 pandemic brought about unprecedented changes in human behaviour and activity, showing us that smog, noise pollution, and traffic levels were not mandatory for the functioning of society. In fact, it only took a few weeks of lockdown for pollution levels to stabilise and a sense of nature-connectedness to return, even in cities. Positive consequences for the natural environment, including significant reductions in pollution levels on our planet, improved air quality with clearer skies, a greater presence of wildlife, and a reduction in noise leading to an improvement in soundscapes. Our study has demonstrated that changes in the natural environment, due to lockdown during the first wave of the pandemic, were positively perceived by the population of the three European countries assessed. Once the pandemic will be under control, it will be our responsibility to continue reducing harmful human activities in order to maintain harmony with our natural environment. If the goal is to reduce natural degradation and pollution levels, some of the decreases forced by the pandemic in terms of commercial, industrial, and transportation activities need to be replicated. We are now facing a unique window of opportunity to protect our natural environment, which we must embrace. After all, our health, wellbeing, and even our very existence depend on it.

Author statement

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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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