Psychiatry Research 329 (2023) 115494

Contents lists available at ScienceDirect

Psychiatry Research

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

Understanding the relationship between time spent outdoors, mental well-being and health-related behaviours in a Spanish sample: A real time smartphone-based study

Ana Catalan [a,b,c,d,e,*], Stefania Tognin [e,f], Ryan Hammoud [e], Claudia Aymerich [a,b,d], Borja Pedruzo [b], Amaia Bilbao-Gonzalez [g,h,i,j,k], Gonzalo Salazar de Pablo [l,m,n], Malein Pacho [b], Paolo Fusar-Poli [e,m,o,p], Miguel Ángel Gonzalez-Torres [a,b,c,d]

[a] Biobizkaia Health Research Institute, Barakaldo, Spain
[b] OSI Bilbao-Basurto, Basurto University Hospital, Bilbao, Spain
[c] Neuroscience Department, University of the Basque Country UPV/EHU, Leioa, Spain
[d] Centro de Investigación en Red de Salud Mental (CIBERSAM), Instituto de Salud Carlos III, Madrid, Spain
[e] Department of Psychosis Studies, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, UK
[f] Outreach and Support in South London (OASIS) Service, South London and Maudsley NHS Foundation Trust, London, UK
[g] Osakidetza Basque Health Service, Basurto University Hospital, Research and Innovation Unit, Bilbao, Spain
[h] Network for Research on Chronicity, Primary Care, and Health Promotion (RICAPPS), Bilbao, Spain
[i] Kronikgune Institute for Health Services Research, Barakaldo, Spain
[j] Department of Medicine, Faculty of Health Sciences, University of Deusto, Bilbao, Spain
[k] Health Services Research on Chronic Patients Network (REDISSEC), Spain
[l] Department of Child and Adolescent Psychiatry, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK
[m] Department of Brain and Behavioral Sciences, University of Pavia, Italy
[n] Child and Adolescent Mental Health Services (CAMHS), South London and Maudsley NHS Foundation Trust, London, UK
[o] Outreach and Support in South-London (OASIS) service, South London and Maudlsey (SLaM) NHS Foundation Trust, UK
[p] Department of Psychiatry and Psychotherapy, Ludwig-Maximilian-University, Munich, Germany

ARTICLE INFO

Keywords:
Mental well-being
Anxiety
Depression
Outdoors
COVID-19

ABSTRACT

Introduction: COVID-19 pandemic has affected our lifestyle and physical and mental well-being. We aimed to study the effect of being outdoors and mental well-being after the COVID-19 pandemic.

Material and methods: We used smartphone based ecological momentary assessments (EMA) (Urban Mind app) to study the mental well-being of the Spanish general population. We collected socio-demographic data, past and current physical and mental health, and social and physical environment. Participants were recruited during 5 months (February to June 2021). Longitudinal associations between EMA and anxiety, depression, loneliness, tiredness, and happiness during the assessments were investigated using random intercept ordinal logistic regression models.

Results: 274 subjects downloaded the app and completed the baseline assessment. 66 participants completed at least 50 % of the assessments. Being outdoors was related to a lower likelihood of anxiety (OR: 0.48, 95 %CI 0.34–0.66), depression (OR: 0.40, 95 %CI 0.28–0.56), tiredness (OR: 0.47, 95 %CI 0.35–0.63), and loneliness (OR: 0.59, 95 %CI 0.42–0.84), and a higher likelihood of happiness (OR: 2.14, 95 %CI 1.57–2.93).

Conclusions: Being outdoors is related to better mental health in the general population independently of other factors (baseline mental well-being or socio-demographic characteristics). Public policies should include measurements to promote outdoor spaces in urban settings.

* Corresponding author at: Psychiatry Department, Biobizkaia Health Research Institute, Spain.
E-mail address: ana.catalanalcantara@osakidetza.eus (A. Catalan).

https://doi.org/10.1016/j.psychres.2023.115494
Received 6 May 2023; Received in revised form 21 September 2023; Accepted 22 September 2023
Available online 25 September 2023

1. Introduction

COVID-19 has been the major pandemic in the last 100 years, and its global effects are unprecedented. The COVID-19 outbreak has rapidly changed how we interact with each other and our environment, resulting in an exceptional situation of unknown duration. The outbreaks impact and physical distancing measures on people's mental well-being and behaviour are still the focus of several studies to better understand the consequences on mental health after the pandemic (Holmes et al., 2020). Previous studies have employed population-based surveys or questionnaires to investigate the psychological effect of self-isolation/quarantine among public members (Wang et al., 2020) or healthcare workers (Pal et al., 2020; Salazar de Pablo et al., 2020). Moderate-to-severe stress, anxiety and depression were described in 8.1 %, 28.8 % and 16.5 % of the general population in China during the outbreak (Wang et al., 2020). The epidemic led to a global atmosphere of anxiety and depression due to disrupted travel plans, social isolation, media information overload and panic buying of necessity goods (Ho et al., 2020). Longitudinal studies have indicated a progressive increase in depressive symptoms throughout the pandemic (Ettman et al., 2022), revealing a marked deterioration in the mental health of the general population compared to the pre-COVID-19 era (O'Connor et al., 2021; Pierce et al., 2020).

Research has consistently shown the positive impact of outdoor activities on mental health (Coventry et al., 2021). Nature exposure has been linked to improved cognitive function, brain activity, blood pressure, and overall mental well-being (Jimenez et al., 2021). In the aftermath of the pandemic, the significance of outdoor activities in promoting mental health has been underscored.

However, most existing mental health studies related to COVID-19 have been cross-sectional and often focused on specific demographics or risk populations, limiting their generalizability (Ahmed et al., 2020; Aymerich et al., 2022; Gao et al., 2020; Gonzalez-Sanguino et al., 2020; Jones et al., 2021; Moccia et al., 2020; Pedruzo et al., 2023; Salazar de Pablo et al., 2020).

The main issues with traditional methods to analyse the mental health of the general population are that they do not routinely collect data, are subject to recall and social desirability biases and require extensive human resources, especially in the case of longitudinal data collection. In order to overcome these challenges, we employed the readily available smartphone app, Urban Mind (UM, https://www.urbanmind.info) (Bakolis et al., 2018), to investigate the psychological and behavioural responses to the situation one year after the COVID-19 outbreak in members of the Spanish public. The UM app employs the Ecological Momentary Assessments (EMA) (Raugh et al., 2019) methodology and is a flexible, modular tool that was developed and validated to collect ecologically valid measures in "real time". The EMA technology has proven to be an especially valuable tool in pandemic situations where face-to-face assessments are not recommended (Mitra and Dutta, 2021). It is, therefore, ideally suited to study the direct and indirect effects of COVID-19 on mental well-being and behaviour.

We hypothesised that pandemic-related restrictions could lead to heightened rates of anxiety and depression within the general population. Furthermore, we postulated that spending time outdoors might significantly impact mental well-being. Our objective is to examine the mental well-being of the general population a year after the onset of the COVID-19 outbreak and to analyse the correlation between being outdoors and mental well-being.

2. Material and methods

2.1. Urban mind app

The Urban Mind app is a smartphone-based ecological momentary assessment tool available for smartphones. The current study received institutional review board (IRB) approval from the King's College London Psychiatry, Nursing and Midwifery Research Ethics Subcommittees (LRS-17/18-6905) and The Basque Country Ethics Committee (PI2021022). The present study was performed in accordance with relevant guidelines and regulations. All participants confirmed they had read the study information and privacy policy and provided informed consent.

We used a quasi-experimental design for this study. Firstly, we employed an adapted version of the UM app to assess the direct and indirect impact of COVID-19 on members of the general population over 30 weeks (from February to June 2021). All participants were recruited from Spain. They were asked to complete one EMA per day during one month (average completion time = 2 min) at a random time between wake-up and bedtime. Following a prompt, participants had 1 h to complete the EMA.

2.2. Assessments

At baseline, participants were asked the following information: socio-demographic data (e.g. age, gender, employment, living conditions), past and current mental and physical health issues, and if they were self-isolating. A daily EMA assessment was focused on: mental well-being (e.g. positive and negative affect), social environment (e.g. quantity and quality of social contacts), behavioural responses (e.g. physical activity, sleep) and physical environment (e.g. exposure to nature). We also collected the mobility data over the day through passive monitoring. This included time spent moving, distance walking and time spent at home. A final assessment focused on overall mental and physical well-being, sleep, and effects of the outbreak on major activities (e.g. employment, study). We also asked if participants had to self-isolate and if they went through bereavement during their participation.

Participants were recruited in Spain over 5 months (February 2021–June 2021) using various social media platforms, the project-related website, and by word of mouth. Participation in the study was self-selected and anonymous. Once an individual downloaded and installed the app, they were presented with information about the study and were asked to provide informed consent. After consent was provided, participants were requested to complete a baseline assessment.

2.3. Measures

Participants were asked if they were outdoors or indoors (yes/no) at the moment of the assessment and, in a second question, where they were exactly (a. outdoors: home; someone else's home; workplace; school/university; public place e.g., shop/restaurant/cinema; public transport; garden/park; street/square; by sea/lake/river; other; or b. indoors: home; someone else's home; workplace; school/university; public place e.g., shop/restaurant/cinema; public transport; other).

Feelings of momentary loneliness, anxiety, depression, tiredness, and happiness were assessed using a single, 5-point Likert-scale item regarding an individual's feelings during the momentary assessment: "Right now, I am feeling lonely/anxious/sad/tired/happy". The participant would select a response ranging from "Strongly disagree" (1) to "Strongly agree" (5).

2.4. Statistical analyses

The description of the variables was carried out using frequency tables, means and standard deviations (SD). The main statistical analysis was focused on individuals who had completed at least 50 % of the assessments. However, we also performed sensitivity analyses running two additional analyses, including individuals who had completed at least 33 % of the assessments and those who completed the 66 %.

Longitudinal associations between momentary self-reported environmental features or mental well-being with momentary anxiety, depression, loneliness, tiredness and happiness were investigated using random intercept ordinal logistic regression models. All dependent variables (anxiety, depression, loneliness, tiredness and happiness) were considered in three categories: “Strongly disagree or Desagree”, “Neutral”, and “Agree or Stronly agree”, with a higher score indicating more agreement. The principal independent variables were the environmental feature regarding whether the participant was indoors or outdoors and the variable regarding mental well-being, considered Fair+Poor vs. Good. All models were adjusted for the following characteristics: age, gender, ethnicity, education level, and physical and mental baseline status. The statistical analysis performed was a longitudinal data analysis so that each participant’s outdoor/indoor or mental well-being was related to the different outcome variables in each assessment. Therefore, instead of working with participants, we worked with assessments in this analysis. In this way, the variability between the measures of each subject would be lower than the variability between the different subjects, as they were not independent observations. Therefore, we used a multilevel model hierarchical data analysis structure. In this case, we had two levels: level 1 is the observations or assessment of each subject, and in level 2, we had the subjects to control which group of assessments belong to the same subject. Results were expressed as odds ratios (OR) and 95 % confidence intervals (CI). Further, the interaction effect between contact with nature (outdoors vs. indoors) and mental well-being on outcome variables was assessed by including the interaction term between these two variables in the model. The results of the interaction were expressed as the ratio of the OR (ROR) and the 95 % CI.

Further, in order to address missing data, we repeated our statistical analyses after applying the Multiple Imputation with Chained Equations (MICE) procedure (Sterne et al., 2009). We compared these results with the original analyses under the missing at random (MAR) assumption (White and Royston, 2009).

We also studied the baseline relationship between pshysical or mental status and the concern about becoming infected, considered as “Agree or Strongly agree”, “Neither agree nor disagree” and “Disagree or Strongly disagree”, with a higher score indicating disagreement, using the ordinal logistic regression models. All models were adjusted for age, gender, ethnicity, and education level. Results were expressed as odds ratio (OR) and 95 % confidence intervals (CI).

A result was considered statistically significant at $p < 0.05$. All statistical analyses were performed with SAS for Windows statistical software, version 9.4 (SAS Institute, Inc., Cary, NC) and R© version 4.0.4.

3. Results

During the 2-month recruitment period, 274 participants downloaded the Urban Mind app and completed the baseline assessment. The app included a total of 30 assessments (one assessment per day) during one month. 55 participants completed just the baseline assessment, 84 (30.66 %) participants completed at least 33 % of the assessments, 66 (24.09 %) participants completed at least 50 % of the assessments, and 34 (12.41 %) participants completed at least 66 % of the assessments. Participants’ age ranged between 18 and 77 years (mean age = 41.35 years and SD = 13.65) with a median age of 41. 69.34 % were female. The socio-demographic characteristics of the sample are detailed in Table 1. 12.04 % ($n = 33$) of the sample reported a psychiatric diagnosis (87 % anxiety and/or depression).

The answers related to the COVID-19 pandemic among individuals who had completed at least 50 % of the assessments are detailed in Table 2. In this pandemic stage, most participants tested negative for COVID-19 and had not been infected (Vitiello et al., 2022) (i.e., before the omicron variant).

In the whole sample ($N = 274$), most of the sample perceived their physical health as good or very good ($n = 175$; 63.87 %) vs. poor or very poor ($n = 15$; 5.47 %), and fair ($n = 82$; 29.93 %). Regarding mental health, 139 participants reported good or very good health (50.73 %) vs. poor or very poor ($N = 30$; 10.94 %), and fair ($N = 97$; 35.40 %).

Being outdoors was related to a lower likelihood of anxiety, depression, loneliness, and tiredness, and with a higher likelihood of happiness in all response groups at follow-up (Fig. 1 and Table 3). An OR below 1 meant a lower likelihood of feeling anxious, depressed, alone, tired or unhappy being outdoors compared with being indoors, while an OR above 1 meant a higher likelihood of feeling anxious, depressed, alone, tired or unhappy being outdoors with respect indoors. In the case of mental well-being, fair/poor mental well-being was linked to a higher likelihood of feeling anxious, depressed, alone, tired or unhappy when the OR was above 1, and the opposite if the OR was below 1. As expected, fair or poor mental well-being was associated with a higher likelihood of anxiety, depression, loneliness, and tiredness, and a lower likelihood of happiness in all response groups at follow-up (Fig. 2 and Table 3). The interaction between the two independent variables (being outdoor vs. indoor and mental well-being fair/poor vs. good) did not affect these results. There were no differences between the groups of answer (33 % response rate, 50 % response rate and 66 % response rate) (Table 1).

The worry about the possibility of COVID-19 infection was independent of the baseline physical or mental health (Table 4).

Table 1
Socio-demographic characteristics of the total sample at baseline ($n = 274$).

Characteristics		n (%)
Age, mean (SD)		**41.35 (13.65)**
Sex	Female	190 (69.34)
	Male	84 (30.66)
Ethnicity	Asian - Other	2 (0.73)
	Latino or Hispanic	90 (32.85)
	Mixed	2 (0.73)
	None of the above	16 (5.84)
	Rather not say	11 (4.01)
	White	153 (55.84)
Level of education	Apprenticeship / Technical training	54 (19.71)
	High school	14 (5.11)
	Less than high school	2 (0.73)
	University	204 (74.45)
Employment	Employed	200 (72.99)
	Retired	13 (4.74)
	Student	42 (15.33)
	Unemployed	19 (6.93)
Residence	Shared flat	21 (7.66)
	Alone	25 (9.12)
	Family	221 (80.65)
	Pets	6 (2.19)
	Others	1 (0.36)

SD: Standard deviation.

Table 2
Situation regarding Covid 19 among individuals who had completed at least 50 % of the assessments ($n = 66$).

	Likely/very likely n (%)	No likely/Very unlikely n (%)	Not sure n (%)
I think I have been infected	9 (15.79)	38 (66.67)	10 (17.54)
	Yes n (%)	**No n (%)**	
Self-isolated more than one week	25 (37.88)	41 (62.11)	
Close friend or family member infected	57 (86.36)	9 (13.64)	
	Agree/ Strongly agree n (%)	**Disagree/ Strongly disagree n (%)**	**Neither agree nor disagree n (%)**
I think I will be infected	12 (21.05)	23 (40.35)	22 (38.6)
I think my friends or family will be infected	19 (28.79)	15 (22.73)	32 (48.48)
I worry I will be infected	31 (54.38)	12 (21.05)	14 (24.56)
I worry my close friends or family will be infected	56 (84.85)	6 (9.1)	4 (6.06)

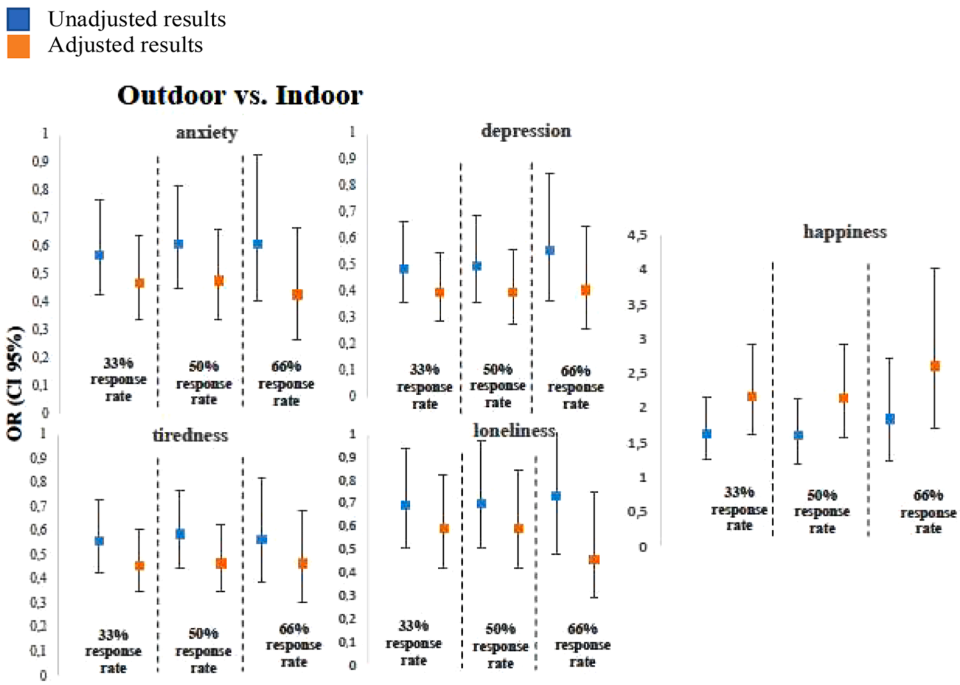

Fig. 1. Relationship between being outdoor vs. indoor and mental health good vs. fair/poor with anxiety, depression, tiredness, loneliness and happiness among individuals who had completed at least 50 % of the assessments.

4. Discussion

We used a longitudinal EMA methodology to assess mental well-being during the coronavirus pandemic. People reported higher rates of depression, anxiety, loneliness, tiredness, and lower happiness indoors than outdoors. A good perceived mental well-being was associated with lower depression, anxiety, loneliness, tiredness, and a higher likelihood of happiness. Some previous reports did not find clear evidence that depression differed during the COVID-19 pandemic from pre-pandemic assessments (Wang et al., 2021). However, there was strong observational evidence that anxiety was higher and well-being was lower during the pandemic compared to pre-pandemic levels (Bueno--Notivol et al., 2021; Kwong et al., 2021). Irrespective of the overall population differences in depression and anxiety, several sociodemographic, psychological, physical and COVID-19-specific factors were associated with greater depression and anxiety during the COVID-19 pandemic (Kwong et al., 2021), e.g., living alone, self-isolation or lack of access to a garden. As we expected, perceived good mental health was associated with better outcomes in mental health during the study.

Our study, consistent with existing literature, demonstrates the usefulness of using EMA technology in pandemic situations (Beierle et al., 2021; Schulz et al., 2021).

In our study, concerns about being infected or self-isolation were not related to the participants' previous mental or physical well-being. This could be due to the fact that "coronaphobia", a term coined to describe fear and anxiety about being infected by coronavirus-19 (Asmundson and Taylor, 2020), has been previously linked to personal vulnerability traits such as neuroticism and reassurance-seeking behaviours rather than to pre-existent medical or psychologic conditions (Lee et al., 2020). Similar risk factors have been described for previous pandemics (Wheaton et al., 2012).

Social distancing and lockdown orders have been proven to be detrimental to mental health, as demonstrated in several studies (Amit Aharon et al., 2021; Di Giuseppe et al., 2020; Fisher et al., 2020), with increased loneliness and isolation being the main reasons for significant increases in anxiety. On the other hand, some studies concluded that anxiety levels decreased when rules were eased or when participants were exempted from participating in quarantines (Bendau et al., 2021; Canet-Juric et al., 2020; Lu et al., 2020). However, our data report high anxiety levels even after lifting strict coronavirus restrictions in Spain (from March to May 2020), reflecting the persistence of the anxiety. Relevant differences can be appreciated in anxiety prevalence depending on the geographical locations since different restrictions were set in each place to control the varying spread of COVID-19. For instance, in Australia, which was an example of a tough restriction country- a lockdown was established with few exceptions to go out, similar to those rules established in Spain during the first months of the pandemic, an anxiety prevalence of 21 % was found (Fisher et al., 2020), whereas in the Netherlands and Austria, where restrictions were known for being looser-even when the lockdown was set, people were allowed to walk or do exercise outdoors-, only a prevalence of 6 % or lower was found (Budimir et al., 2021; van der Velden et al., 2020). Similar results are found for depressive symptoms, happening to worsen as government measures are more restrictive (Batterham et al., 2021; Hassannia et al., 2021). The studies performed in the first stage of the pandemic could present less depression rates, as depression is a disorder that needs more time to establish than, for example, anxiety (Malhi and Mann, 2018).

Several studies have described that contact with wildlife (e.g., hearing and seeing birds) has been related to greater mental well-being (Hammoud et al., 2022). Indeed, there has been an increasing awareness of the benefits of exposure to natural environments on mental well-being since experimental research has demonstrated that exposure to views of nature can improve people's health and well-being by providing restoration from stress and mental fatigue (Hartig et al., 1991). Similarly, walking outdoors has been found to positively affect some aspects of mood, self-esteem and subjective vitality. In contrast, it is related to decrease in frustration, worry, tension and tiredness (Focht, 2009; Pretty et al., 2005). It has also been stated that health benefits derived from green space are not uniform for all population subgroups (Focht, 2009). A recent meta-analysis showed that activity in natural environments was associated with significant reductions in anxiety and depression compared with urban and indoor environments, noticing

Table 3
Relationship between outdoor or indoor and mental well-being with mental health.

	33 % response rate (*n* = 1572 answers)		50 % response rate (*n* = 1361 answers)		66 % response rate (*n* = 822 answers)	
	Unadjusted OR (95 % CI)	Adjusted† OR (95 % CI)	Unadjusted OR (95 % CI)	Adjusted† OR (95 % CI)	Unadjusted OR (95 % CI)	Adjusted† OR (95 % CI)
ANXIETY						
Outdoor vs. Indoor	0.57 (0.43–0.77) ***	0.47 (0.34–0.64) ***	0.61 (0.45–0.82) ***	0.48 (0.34–0.66) ***	0.61 (0.41–0.93) *	0.43 (0.27–0.67) ***
Mental well-being Fair/Poor vs. Good	10.59 (8.34–13.45) ***	10.05 (7.66–13.20) ***	11.11 (8.58–14.40) ***	9.61 (7.18–12.87) ***	15.53 (10.77–22.40) ***	13.03 (8.66–19.60) ***
Interaction, ROR (95 % CI)	1 (0.50–2.02)	1.22 (0.60–2.51)	0.89 (0.43–1.83)	1.04 (0.49–2.18)	0.91 (0.30–2.72)	1.28 (0.40–4.08)
DEPRESSION						
Outdoor vs. Indoor	0.49 (0.36–0.67) ***	0.40 (0.29–0.55) ***	0.50 (0.36–0.69) ***	0.40 (0.28–0.56) ***	0.56 (0.37–0.85) **	0.41 (0.26–0.65) ***
Mental well-being Fair/Poor vs. Good	16.63 (12.76–21.67) ***	16.13 (11.98–21.71) ***	17.40 (13.06–23.17) ***	17.06 (12.36–23.55) ***	26.53 (17.46–40.31) ***	24.36 (15.45–38.41) ***
Interaction, ROR (95 % CI)	1.55 (0.61–3.93)	1.63 (0.64–4.18)	1.34 (0.52–3.46)	1.39 (0.53–3.62)	1.62 (0.34–7.67)	1.53 (0.31–7.42)
LONELINESS						
Outdoor vs. Indoor	0.69 (0.51–0.94) *	0.59 (0.42–0.82) **	0.70 (0.51–0.97) *	0.59 (0.42–0.84) **	0.73 (0.48–1.11)	0.46 (0.29–0.75) **
Mental well-being Fair/Poor vs. Good	6.16 (4.84–7.84) ***	4.79 (3.63–6.32) ***	5.98 (4.62–7.75) ***	4.82 (3.58–6.50) ***	9.12 (6.42–12.93) ***	6.54 (4.39–9.73) ***
Interaction, ROR (95 % CI)	0.68 (0.35–1.33)	0.76 (0.38–1.52)	0.66 (0.33–1.34)	0.72 (0.35–1.50)	0.47 (0.19–1.19)	0.57 (0.21–1.58)
TIREDNESS						
Outdoor vs. Indoor	0.56 (0.43–0.73) ***	0.46 (0.35–0.61) ***	0.59 (0.45–0.77) ***	0.47 (0.35–0.63) ***	0.57 (0.39–0.82) **	0.47 (0.31–0.69) ***
Mental well-being Fair/Poor vs. Good	4.47 (3.67–5.44) ***	5.29 (4.15–6.73) ***	4.44 (3.59–5.48) ***	4.78 (3.69–6.18) ***	3.87 (2.96–5.07) ***	4.40 (3.16–6.11) ***
Interaction, ROR (95 % CI)	0.63 (0.37–1.06)	0.72 (0.41–1.26)	0.65 (0.37–1.14)	0.67 (0.37–1.21)	1.16 (0.54–2.49)	0.97 (0.43–2.21)
HAPPINESS						
Outdoor vs. Indoor	1.63 (1.25–2.15) ***	2.17 (1.62–2.92) ***	1.60 (1.20–2.13) **	2.14 (1.57–2.93) ***	1.84 (1.24–2.72) **	2.61 (1.70–4.02) ***
Mental well-being Fair/Poor vs. Good	0.05 (0.04–0.07) ***	0.06 (0.05–0.08) ***	0.05 (0.04–0.07) ***	0.06 (0.05–0.09) ***	0.03 (0.02–0.05) ***	0.04 (0.02–0.05) ***
Interaction, ROR (95 % CI)	1.36 (0.72–2.55)	1.43 (0.74–2.74)	1.48 (0.77–2.87)	1.57 (0.79–3.11)	1.87 (0.70–4.99)	2.12 (0.77–5.82)

OR, Odds ratio; CI, Confidence interval; ROR, Ratio of Odds ratios.
† Adjusted by age, sex, ethnicity, level of education and physical and mental status at baseline.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

that the effect size obtained for anxiety was very large (Wicks et al., 2022). In contrast, the effect size for depression was small. It has been postulated that depression may require longer or repeated exposure to generate the same effect sizes as anxiety [28]. On the other hand, other studies state that outdoor connectedness may be related to a greater sense of eudaimonic well-being (Pritchard et al., 2020), which is also associated with personal growth and purposeful behaviour (Coventry et al., 2021) and, therefore, to a greater sense of well-being and lower levels of depression.

Previous studies have described loneliness as associated with a higher possibility of feeling depressed or anxious (Kwong et al., 2021). The manifestation of depression rather than anxiety for those living alone may relate to loneliness, which is amplified by physical contact restricted to within households, again reflecting depression being related to absence and loss rather than threat, whereas self-isolation (which in this context is related to COVID-19 exposure) may be linked to anxiety through the associated threat of the virus. Nevertheless, the relationship found in this study between being outdoors and worse mental health cannot be considered causal. People who feel better could spend more time outdoors, while depressed people tend to be more at home.

Our study has several strengths. The EMA methodology reduces recall biases resulting from retrospective recall because these questions are asked amid everyday activities (Shiffman, 2000; Shiffman et al., 2008). EMA can provide a more temporally-dense profile of the participant than retrospective recall because the questions are asked repeatedly (Stone et al., 2007). EMA technology can prevent back- or forward-dated responses by timestamping data entry (Stone and Shiffman, 1994). Besides, UM offers at least three major advantages compared to traditional data-collection methods or new activities: compared to traditional population-based surveys/questionnaires addressing similar questions, our app employs the EMA [15] methodology, which offers the possibility of gathering a large amount of data in "real-time" (reducing recall and social desirability bias) quickly and with little human resources. It also allows the collection of active and passive (mobility) data, compared to other smartphone apps. The UM app has already been tested with general and psychiatric populations [14]. The app has been deemed safe, minimising the risk of negative collateral effects; compared to new data collection approaches, the UM app provides the opportunity to employ a powerful quasi-experimental design where mental health and physical health outcomes collected during the COVID-19 outbreak could be compared with data collected routinely from the app since 2016.

As limitations, we cannot compare data from pre- and post-pandemic situations, so that we can show just a snapshot of the situation during study time. Even though smartphones are pervasive, they are often not

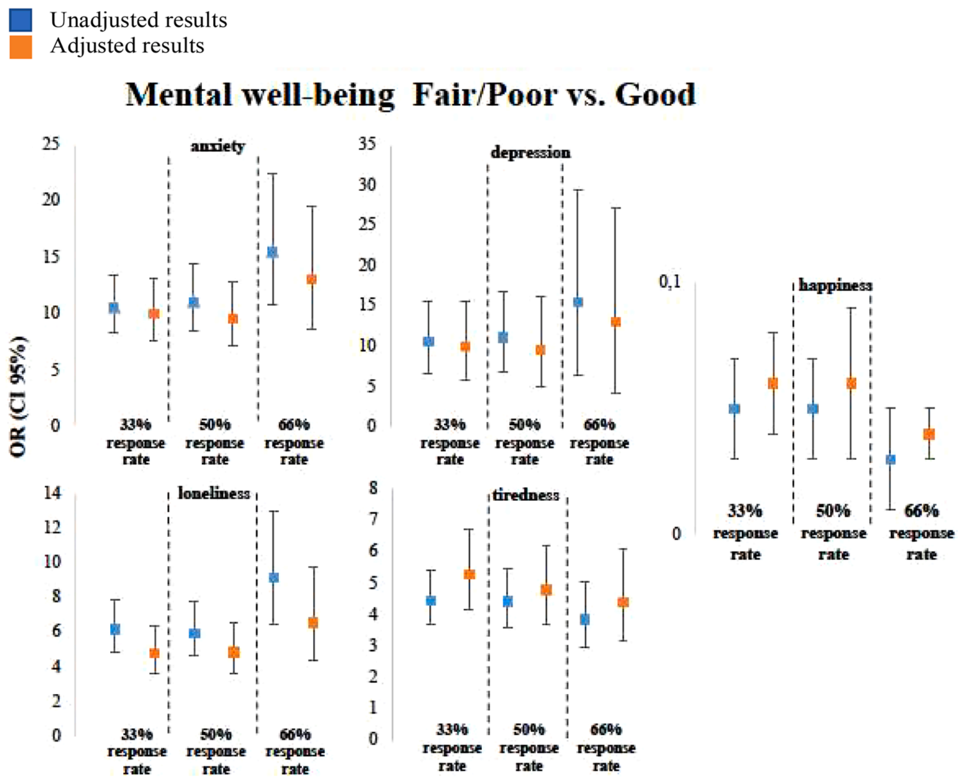

Fig. 2. Relationship between mental well-being fair/poor vs. good with anxiety, depression, tiredness, loneliness and happiness among individuals who had completed at least 50 % of the assessments.

within a hand's reach (Dey et al., 2011), and the difficulty in accessing the smartphone could contribute to the difficulty in answering questions. The barrier to obtaining/reaching out to the phone and unlocking it to read the question(s) may make participants more hesitant to initiate responses to EMA prompts. The further the phone is from the body, the less likely a person may notice the prompts. This could result in lower study compliance. One way to address such a burden could be to use a device that is easier to access and harder to ignore, such as a smartwatch. Smartwatches are worn on the wrist, permitting reliable delivery of tactile prompts. Thus, they are substantially faster to access than a phone in a pocket or the bottom of a cluttered bag (Ashbrook et al., 2008). Smartwatches also contain advanced sensors that permit real-time wrist motion and heart rate monitoring, which could be used for context-sensitive EMA (Stone et al., 2007). Some technical problems (especially with some Android devices) appeared during the study, with mistakes in the app functioning. Although we tried to solve them, this could influence compliance. Unfortunately, the low number of subjects who complete 66 % ($N = 334$) of the assessments makes the data less reliable for this group since statistical power is lost.

Table 4
Relationship between worriedness about COVID-19 infection and physical/mental health at baseline ($n = 55$).

	Infection worriedness			
	Unadjusted		Adjusted†	
	OR (95 % CI)	*p*-value	OR (95 % CI)	*p*-value
Physical				
Fair vs. Good	2.32 (0.61–8.86)	0.2198	2.21 (0.57–8.63)	0.2550
Poor vs. Good	0.40 (0.07–2.45)	0.3238	0.53 (0.08–3.43)	0.5039
Mental				
Fair vs. Good	1.35 (0.44–4.13)	0.6011	1.73 (0.51–5.88)	0.3807
Poor vs. Good	2.71 (0.28–26.38)	0.3909	3.86 (0.35–43.24)	0.2726

† Adjusted by age, sex, ethnicity, and level of education.

Furthermore, selection bias (because of mental health influencing those who respond to surveys) and reporting bias (from those who perceive depression and anxiety as higher or are more likely to report symptoms when they feel there is a 'valid' reason) (Boutron et al., 2023) could threaten the validity of results, especially from cross-sectional surveys. Although the intense campaign to promote participation in our study, we got a low rate of responses. This limits the generalizability of our results. However, other studies with similar characteristics reported similar response rates (Jones et al., 2019). On the other hand, we fully acknowledge that our sample is unlikely to be representative of the general population (e.g., individuals with above-average levels of education will likely be over-represented based on our existing UM data). Our strategy to further tackle this beyond the efforts mentioned above on recruitment is to collect demographic and socioeconomic information as part of the baseline assessment and include probability weights for variables such as age, gender and socioeconomics within our statistical models [15]. Finally, we have not analyzed the various activities associated with spending time outdoors, primarily due to the limited statistical power. Nevertheless, the relationship between outdoor activities and well-being remains substantial. Being outdoors could serve as a proxy for well-being or potentially contribute to enhanced well-being.

Our study demonstrates a possible relationship between being outdoors and a lower likelihood of depression and anxiety. These findings have potential implications for environmental protection and mental healthcare policies. Although these results should be replicated in a larger sample, we think that specific measures should be implemented to promote and increase everyday encounters with nature in urban areas.

During the preparation of this work, the author(s) used ChatGPT in order to improve the language and readability of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Funding

This research received funding from the OSI Bilbao Basurto Research Commission.

CRediT authorship contribution statement

Ana Catalan: Conceptualization, Project administration, Methodology, Validation, Data curation, Writing – original draft, Writing – review & editing. **Stefania Tognin:** Conceptualization, Project administration, Methodology, Validation, Data curation, Writing – original draft. **Ryan Hammoud:** Conceptualization, Project administration, Methodology, Validation, Data curation, Writing – original draft. **Claudia Aymerich:** Methodology, Validation, Data curation, Writing – original draft. **Borja Pedruzo:** Methodology, Validation, Data curation, Writing – original draft. **Amaia Bilbao-Gonzalez:** Methodology, Formal analysis. **Gonzalo Salazar de Pablo:** Validation, Data curation, Supervision, Methodology, Writing – original draft, Writing – review & editing. **Malein Pacho:** Validation, Data curation, Writing – review & editing. **Paolo Fusar-Poli:** Validation, Data curation, Supervision, Investigation, Methodology, Writing – review & editing. **Miguel Ángel Gonzalez-Torres:** Validation, Data curation, Supervision, Writing – review & editing.

Declaration of Competing Interest

None.

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