

Changes in use of natural outdoor environments and health of women in the context of the COVID-19 pandemic

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ABSTRACT

Natural outdoor environments (NOE) provide health benefits; meanwhile, gentrification and touristification can be detrimental to health equity by modifying who benefits from NOE. The COVID-19 pandemic has exacerbated gender-based health inequities and changed the use of NOE, while it also affected the course of neighborhood gentrification and touristification. We carried out a cross-sectional study in Barcelona to test whether changes in the use of NOE were related to women's health and if perceived gentrification/touristification modified these associations. We found that maintained or increased use of NOE (particularly those closest to one's residence) was significantly associated with lower odds of reporting poor general and mental health. Perceived gentrification and touristification were not effect modifiers of the associations. Our results indicate that contact with NOE should be promoted during pandemics like COVID-19.

1. Introduction

1.1. NOE and health

Natural outdoor environments (NOE) – understood as green spaces such as parks or gardens and blue spaces, such as the sea and lakes – have been found to have a beneficial effect on general physical and mental health (Hartig et al., 2014; Kaplan, 1995; Yang et al., 2021) such as lower mortality (Nieuwenhuijsen et al., 2018; Rojas-Rueda et al., 2019), less cardiovascular diseases (Tamosiunas et al., 2014), better self-perceived general health (Dadvand et al., 2016) and better mental health (Gascon et al., 2015; Kaplan and Kaplan, 2011; van den Berg et al., 2016). The benefits of NOE on human health, together with their contribution to climate change adaptation and mitigation, have led to an increased interest in implementing and improving access to NOE in cities (Kabisch et al., 2017).

NOE can mitigate health inequities, as underprivileged populations (e.g. those with low socioeconomic status, or minority racial/ethnic background) may benefit from these spaces more than privileged social

groups (e.g. high-socioeconomic status, or white population) (Mitchell and Popham, 2008; Rigolon et al., 2021). This disparity may be dependent on the characteristics of NOE, such as safety, biodiversity, and the perception of residents, all factors that may modify residents' use of NOE (Cohen et al., 2019; Dadvand et al., 2016; Reyes-Riveros et al., 2021).

Increased contact with NOE during the COVID-19 lockdown has been associated with better mental health outcomes, subjective wellbeing, and sleep quality (Labib et al., 2022). This protective effect could have changed throughout the pandemic (Honey-Rosés et al., 2020; Low and Smart, 2020), along with mobility restrictions imposed to control the virus (Spanish Government, 2021a, 2020a, 2020b). As a result, studies show that the use of NOE closer to residents' homes increased during the pandemic (Korpilo et al., 2021), and that residents give more importance to access to and time spent in green spaces than before the pandemic (Tansil et al., 2022).

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1.2. Gentrification, touristification, and health

Gentrification is a socio-environmental process in which a neighborhood's social, economic, cultural, and physical transformations reveal a transition towards more privileged populations able to afford new or renovated, higher-priced residences and fostering novel cultural and consumption patterns (Marcuse, 2015; Shaw and Hagemans, 2015). On the other hand, touristification is a process by which changes are promoted in the cultural, economic, and spatial fabric of a neighborhood to satisfy the needs of tourists, against the needs of neighbors (Sequera and Nofre, 2018). The results of both processes is a social, cultural, and even physical displacement of long-term residents who cannot afford the costs of living and housing, have less access to services, and lose their community ties (Anguelovski et al., 2021).

The health impacts of gentrification and touristification differ by social group, with underprivileged residents (Cocola-Gant, 2023; Cole et al., 2021) consistently harmed (Gibbons and Barton, 2016; Huynh and Maroko, 2014; Izenberg et al., 2018; Smith et al., 2018). The mechanisms by which these processes may impact health include financial insecurity, social displacement, and poor housing conditions, which can lead to physical illnesses, such as asthma, obesity, or cardiovascular diseases; mental distress, and sleep disruptions (Anguelovski et al., 2020; Cole et al., 2021; Izenberg et al., 2018). These health effects on underprivileged populations can enhance health inequalities in gentrifying neighborhoods (Cole et al., 2023).

Among different drivers (Cole et al., 2021), the implementation of urban NOE projects has been shown to contribute to neighborhood gentrification (Anguelovski et al., 2022; Stuhlmacher et al., 2022; Weber et al., 2017). NOE may become GreenLULUs (Green Locally Unwanted Land Uses), segregated spaces and disruptive green landscapes (Anguelovski, 2016; Harris et al., 2021; Triguero-Mas et al., 2021), that underprivileged residents dread due to the potential socio-cultural and physical displacement effects associated with their implementation. As a consequence, in gentrifying contexts, NOE may not be linked to health benefits for underprivileged residents (Cole et al., 2019; Triguero-Mas et al., 2021).

The mobility restrictions related to COVID-19 disease control limited the arrival of young and wealthy international populations to gentrifying neighborhoods (Ding and Hwang, 2022) and travelers to tourist destinations (Abellan et al., 2021). Moreover, privileged residents moved from their city houses to second homes in rural areas (Ding and Hwang, 2022; González-Leonardo et al., 2022). These changes could have been an opportunity for lifelong neighbors to increase their use of the neighborhood's public spaces, including NOE (Honey-Rosés et al., 2020).

1.3. Impact of COVID-19 pandemic on health equity

The COVID-19 pandemic has worsened health inequalities in terms of gender in general and mental health, with women having worse health outcomes than men (Ausín et al., 2021; Hossain, 2021; Parenteau et al., 2022). This growth in inequalities may be related to the expansion of caring tasks and feminized jobs (Alon et al., 2021) and domestic violence (Bettinger-Lopez and Bro, 2020) during the lockdown. In Spain, some studies have reported that women had worse mental health during the lockdown (Jacques-Aviñó et al., 2020).

In this context, exposure to NOE could help reduce health inequity, as they had benefitted the health of the female population previously (Sillman et al., 2022), but the usage and perceptions of these environments may be different among the female population which may result in less health protection (Berdejo-Espinola et al., 2022; Richardson and Mitchell, 2010). On the other hand, the effects of gentrification impact women severely due to the reduction of access to amenities and loss of community ties linked to gentrification (Abellan et al., 2021; Ortiz-Guitart et al., 2021), aspects that are of vital importance for women's health and which can also reduce the benefits women obtain

from NOE.

After the lockdown and the different changes in mobility restrictions that the Spanish population had experienced (Ministry of Health, Spanish Government, 2020; Spanish Government, 2020a, 2020b, 2021a), the relationships between women and their social and physical environment could have changed in the long term. We investigated the association between changes in use of NOE related to the COVID-19 pandemic and subjective women's health and assessed the roles of gentrification and touristification perceptions.

2. Methodology

2.1. Study setting and data source

This cross-sectional study was based on self-reported survey data obtained from a sample of adult women residing in two neighborhoods of Barcelona city: Sant Antoni and La Barceloneta. Barcelona is on the coast of Catalonia, in North-eastern Spain, and its population in 2021 was 1.66 million people (Ajuntament de Barcelona, 2021). Our study focuses on Sant Antoni and La Barceloneta (see Fig. 1), which encompass a rich diversity of NOE typologies, and are experiencing different types of gentrification and touristification processes. For example, a "super-block" was implemented in Sant Antoni in 2018, to pedestrianize several streets and increase the green space coverage (Ajuntament de Barcelona, 2019). In contrast, La Barceloneta is characterized by its beach, which has historically been an important part of the neighborhood economically, socially, and culturally (Nofre et al., 2018). Both neighborhoods have been experiencing gentrification processes, but in La Barceloneta, this process is strongly influenced by tourism (Crespi-Vallbona and Mascarilla-Miró, 2018).

To collect our data, we developed a survey with two community advisory boards (CABs), one per neighborhood. CABs were fundamental to adapting the survey to the context of each neighborhood. Participants were recruited by trained researchers through street intercepts in neighborhood anchoring places, which were defined as public spaces (streets, plazas, parks, markets) well-used by female neighbors. The surveys were administered face-to-face to 910 women, during both weekdays and weekends, at different times of the day. Participants had to be over 18 years old, have lived in the neighborhood for over 2 years, and be able to speak Spanish, Catalan, or English to participate in the study. These surveys were carried out between June 2021 and January 2022. Accordingly, our data was collected after the lockdown period, during a time of increased vaccination rates, intermittent closing of non-essential businesses, curfew, social distancing, and mask-wearing (Spanish Government, 2021a, 2021b), when daily life was still strongly impacted by COVID-19 pandemic. The study was approved by the ethics committee of the Autonomous University of Barcelona (approval reference CEEAH 5465M3).

2.2. Health data

We collected information on three different health outcomes referring to the participant's health over the four weeks immediately before participating in the survey.

- General health status: Self-reported general health status was assessed with the question "In general, would you say that your health was/is..." from the Short-Form health survey (SF-36) (Ware and Sherbourne, 1992), adapted to specify the mentioned time frame. We dichotomized the results into (i) good, including "Excellent", "Very Good" and "Good" responses, and (ii) poor general health, aggregating "Regular" and "Poor" responses.
- Mental health status: Self-reported mental health was estimated with the 12-item version of the General Health Questionnaire (GHQ-12), which has been validated for the Spanish population (Sánchez-López et al., 2008). We adapted it to specify our period of interest. The

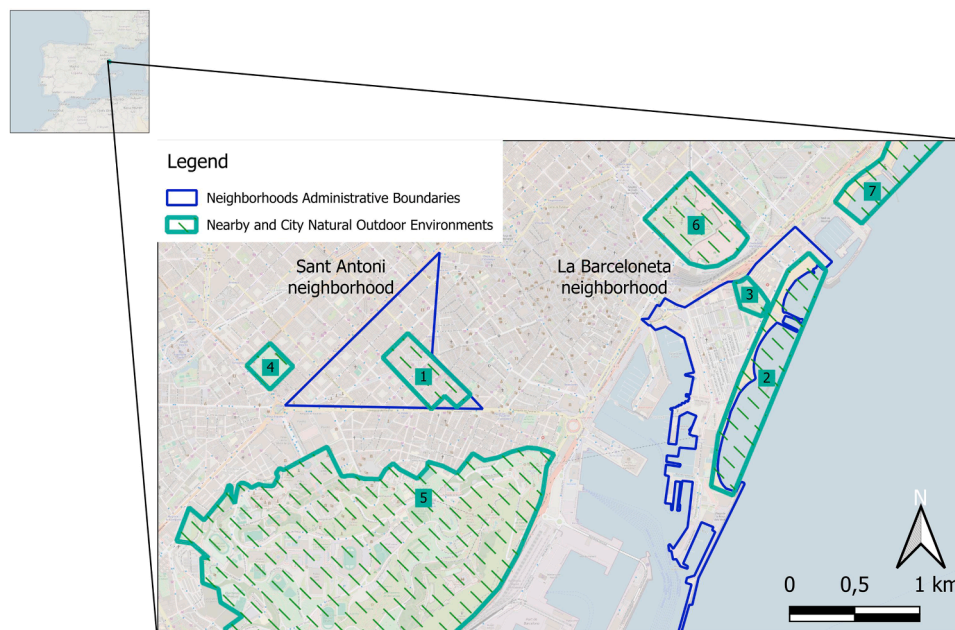


Fig. 1. Map representing both neighborhoods of study (Sant Antoni and La Barceloneta) and the Nearby and City Natural Outdoor Environments: Superblock (1), Barceloneta beach (2), Barceloneta park (3), Joan Miró park (4), Mont Juic park (5), Ciutadella park (6) and Icaria beach (7). Source: created by authors using QGIS 3.36.2 software.

responses to the 12 items were added to build a scale from 0 to 12, following Goldberg's original scoring method (Goldberg and Blackwell, 1970). The score was split into (i) good (< 3) and (ii) poor mental health (≥ 3).

- Sleep Quality: Self-reported sleep quality was assessed with the Sleep Quality-Numeric Rating Scale (SQ-NRS) (Climent-Sanz et al., 2020). The question was adapted by the CABs for the study to go from 0 (Terrible) to 10 (Excellent) and specified the time. This scale rating was inverted to follow the original method (Tang and Sanborn, 2014) and used as a continuous variable with higher levels indicating poor sleep quality.

2.3. Change in NOE use

We asked about self-reported changes in use of green and blue spaces in the participants' environment: closest spaces to their homes (i.e. Sant Antoni's superblock, Barceloneta's beach), spaces less than 15 minutes away from their homes, spaces more than 15 minutes away and spaces close to the city (i.e. Besòs Park, Badalona beach). The questions inquired about the changes in frequency and duration of visits to each space, adapted from questions previously used in other studies (van den Berg et al., 2016), and asked for a comparison between the four weeks before the COVID-19 lockdown of March 2020 and the four weeks prior to participating in the survey. The responses were summarized in three variables:

- Nearby NOE: included superblock or beach and the spaces less than 15 minutes away from the respondent's residence.
- City NOE: included the spaces more than 15 minutes away from the respondent's residence and the "Nearby NOE" spaces.
- All NOE: included the spaces close to the city and the "City NOE" spaces.

The responses were categorized into (i) decreased use, if the respondent reported a decrease in frequency or duration of visits, and (ii) increased/maintained use, if the respondent reported an increase or no change in frequency and duration of visits.

2.4. Change in gentrification/touristification perceptions

The survey included questionnaires about the perceptions of gentrification and touristification, asking participants to think about the two years before the March 2020 lockdown (i.e. pre-COVID-19 outbreak) and the period between the March 2020 lockdown until the survey was answered (i.e. post-COVID-19 outbreak):

- Perceived change in neighborhood gentrification measured with the Neighborhood Change and Gentrification Scale (DeVylder et al., 2019). Participants responded to the questions thinking about their neighborhood pre-COVID-19 and post-COVID-19 outbreak. The answers ranged from 1 to 10, with higher numbers indicating more perceived gentrification. The change in gentrification perception was created as the difference between the post-outbreak and the pre-outbreak values. The obtained scores ranged from -9 – 9 and were dichotomized into (i) decreased perception (< 0), and (ii) increased/maintained perception (≥ 0).
- Perceived change in neighborhood touristification: it was assessed using two questions, which researchers and CABs developed together, about the perceived quantities of tourists and tourist apartments/hotels/hostels, during pre-COVID-19 and post-COVID-19, using a 5-item Likert scale. Answers were added up, obtaining a score from 2 to 10 for each period, with higher numbers indicating more perceived touristification (see [Supplementary Material](#)). The change in touristification perception was calculated the same way as the change in gentrification perception, and then dichotomized into the categories (i) decreased perception (< 0), and (ii) increased/maintained perception (≥ 0).

2.5. Covariates

The survey included questions about age, education, country of origin, employment status, and perceived household income at the moment of responding to the survey. Age was measured using a continuous scale. Education levels were dichotomized into university studies, which included graduated and post-graduated university studies, and no university studies, which included no studies, and

primary, secondary, and vocational studies. Country of origin was dichotomized into Global North and Global South, following the categories used in past studies (Anguelovski et al., 2018b, 2018a). Employment status was dichotomized separating those who had a job and those who did not. Perceived household income was dichotomized into those who reported a comfortable situation and those who reported to struggle to or could not make ends meet.

2.6. Statistical analysis

Participants with missing health data were excluded from the analyses ($n = 3$). Firstly, we performed descriptive analyses between independent variables (changes in use of NOE, changes in gentrification/touristification perceptions, and covariates) and health outcomes (general health, mental health, and sleep quality).

Then, we developed multivariate analysis to explore the association between changes in use of NOE and health. To explore the potential effect modification of perceived changes in gentrification/touristification, we: (i) evaluated interaction terms between gentrification/touristification and NOE use variables, and (ii) stratified the association between changes in the use of NOE and health by changes in gentrification/touristification perception. We only performed steps (i) and (ii) for those health-NOE use combinations where we had found statistically significant associations in the main analysis.

Each of our models included either (a) change in use of nearby NOE; (b) change in use of city NOE; or (c) change in use of all NOE. For self-reported general and mental health, logistic regression models were fitted and adjusted by covariates. For sleep quality, linear regression models were used, with the covariates. All models were adjusted by three sociodemographic variables (age, education, and country of origin) and any other variables that had significant results in the bivariate analysis (Supplementary material) were included in the corresponding models and selected depending on the results of Wald tests and likelihood-ratio tests, for the logistic models, and ANOVA tests, for the linear models. The potential collinearity between predictor variables was tested on the final models. We used R Studio, version 2023.06.0 + 421, and set statistical significance at p -value < 0.05 .

3. Results

Of the 907 participants, 422 were from La Barceloneta and 485 from Sant Antoni. Their mean age was 46 years ($SD=16.5$), and most were from the Global North (80.8 %) but their characteristics in terms of education, employment, and household income were equitably distributed among the categories. The perception of gentrification and touristification decreased for most of the sample, but the share of participants declaring a decrease was higher for touristification (88 % vs. 66 %). The nearby NOE were the places with the highest increased/maintained reported use (65.1 %), meanwhile for all NOE the proportion of increase/maintained reported use was the lowest (49.3 %). The reported change of use of each NOE can be seen in the Supplementary material. In terms of health, most women had a good general and mental health status, and the median sleep quality score was 3 ($IQR=3$ (Table 1)).

3.1. Changes in use of NOE and health

The increased/maintained use of nearby NOE was associated with a 33 % ($OR = 0.67$, 95 % IC : 0.50, 0.92) lower probability of reporting poor general health compared to the reduction of use. The increase/maintained use of all the NOE considered in our study were significantly associated with lower odds of poor mental health. Nearby NOE use had the largest association, with a likelihood reduction of more than 50 % ($OR=0.46$, $IC95\%$: 0.34, 0.63) of poor mental health for those who increased/maintained the use of these NOE. However, none of the indicators of change in use of NOE showed a statistically significant

Table 1

Descriptive statistics for sociodemographic characteristics, touristification/gentrification variables, use of NOE, and health outcomes.

Variables	Total	Barceloneta	Sant Antoni
Subjects [n(%)]	907	422 (46.53)	485 (53.47)
Sociodemographic characteristics			
Age [years: mean (sd)]	46.32 (16.54)	46.52 (16.55)	46.16 (16.55)
Education [n(%)]*			
University studies	385 (42.59)	134 (31.90)	251 (51.86)
No university studies	519 (57.41)	286 (68.10)	233 (48.14)
Origin [n(%)]			
Global North	731 (80.77)	332 (78.67)	399 (82.61)
Global South	174 (19.23)	90 (21.23)	84 (17.39)
Employment status [n(%)]			
Full or part-time job	477 (53.06)	207 (49.64)	270 (56.02)
No job	422 (46.94)	210 (50.36)	212 (43.98)
Household income status [n (%)]*			
Comfortable status	403 (44.78)	168 (40.19)	235 (48.76)
Struggle or not making ends meet	497 (55.22)	250 (59.81)	247 (51.24)
Gentrification and Touristification Perception			
Change in Gentrification Perception [n(%)]*			
Decreased perception	595 (65.96)	270 (64.13)	325 (67.57)
Increased/Maintained perception	307 (34.04)	151 (35.87)	156 (32.43)
Change in Touristification Perception [n(%)]*			
Decreased perception	794 (87.54)	366 (86.73)	428 (88.25)
Increased/Maintained perception	113 (12.46)	56 (13.27)	57 (11.75)
Change in Use of Natural Outdoor Environments			
Nearby NOE [n(%)]*			
Decreased use	317 (34.95)	197 (46.68)	120 (24.74)
Increased/Maintained use	590 (65.05)	225 (53.32)	365 (75.26)
City NOE [n(%)]*			
Decreased use	413 (45.53)	243 (57.58)	170 (35.05)
Increased/Maintained use	494 (54.47)	179 (42.42)	315 (64.95)
All NOE [n(%)]*			
Decreased use	460 (50.72)	259 (61.37)	201 (41.44)
Increased/Maintained use	447 (49.28)	163 (38.63)	284 (58.56)
Outcome variables			
General health [n(%)]*			
Good	619 (68.40)	271 (64.22)	348 (72.05)
Poor	286 (31.60)	151 (35.78)	135 (27.95)
Mental Health [n(%)]			
Good ($GHQ-12 < 3$)	560 (64.81)	248 (61.85)	312 (67.39)
Poor ($GHQ-12 \geq 3$)	304 (35.19)	153 (38.15)	151 (32.61)
Sleep Quality [median (IQR)]*	3 (3)	4 (3)	3 (2)

* Variables statistically different between neighborhoods, according to Chi-square, t-student, and Wilcoxon-Mann Whitney tests.

association with sleep quality. (Table 2)

3.2. Modification of effect by changes in gentrification and touristification perceptions

3.2.1. Interaction between changes in use of NOE and changes in gentrification/touristification perceptions

We tested interactions between perceived changes in gentrification or touristification and the use of NOE variables. None of the interactions we tested were statistically significant (Table 3).

3.2.2. Stratification by changes in gentrification/touristification perceptions

To further explore the potential effect modifying role gentrification and touristification, we performed stratified analyses of those models where we found statistically significant associations between use of NOE and health outcomes (Table 2). For general health, increased/maintained use of nearby NOE was statistically significantly associated with reduced odds of poor general health among the residents who reported reduced gentrification ($OR=0.63$, $IC95\%$: 0.43, 0.93) and touristification ($OR=0.70$, $IC95\%$: 0.50, 0.98). The associations were not statistically significant for residents who reported increased/maintained perceptions of gentrification or touristification, but the direction of the association was the same. (Table 4)

Table 2

Logistic and linear models testing the relationship between use of NOE, and self-reported health.

	Poor General Health Status		Poor Mental Health		Poor Sleep Quality	
	OR (CI 95 %)	p-value	OR (CI 95 %)	p-value	Coef (CI 95 %)	p-value
Change in use of nearby NOE						
Increased/maintained use (ref: decreased use)	0.67 (0.50, 0.92)*	0.012	0.46 (0.34, 0.63)*	< 0.001	0.01 (−0.31, 0.33)	0.947
Change in use of city NOE						
Increased/maintained use (ref: decreased use)	0.79 (0.59, 1.07)	0.124	0.53 (0.39, 0.72)*	< 0.001	0.00 (−0.30, 0.31)	0.977
Change in use of all NOE						
Increased/maintained use (ref: decreased use)	0.80 (0.60, 1.08)	0.144	0.60 (0.45, 0.81)*	< 0.001	0.04 (−0.26, 0.34)	0.797

* bold = significant association (p-value < 0.05). The models are adjusted by age, origin, education, employment, and household income as covariates.

The increase/maintenance of use of the different NOE indicators was significantly associated with the reduction of poor mental health: nearby NOE, 61 % (OR=0.39, CI95 %: 0.26, 0.57); city NOE, 54 % (OR= 0.46, CI95 %: 0.32, 0.66), and all NOE, 45 % (OR= 0.55, CI95 %: 0.38, 0.79) odds reduction in the case of decreased gentrification, and 55 % (OR=0.45, CI95 %: 0.32, 0.63), 48 % (OR=0.52, CI95 %: 0.38, 0.72) and 40 % (OR=0.60, CI95 %: 0.44, 0.83) respectively in the case of decreased touristification. For women who reported increased/maintained perceptions of gentrification or touristification, the associations were not statistically significant. (Table 5)

4. Discussion

Our results indicate that most of our participants maintained/increased their contact with city NOE during the COVID-19 pandemic. We found that the increase/maintenance of NOE use were associated with a lower likelihood of self-reported poor general and mental health, but not with sleep quality. Most of our participants had lower perceptions of gentrification and touristification after the lockdown. Our results are inconclusive about the potential role of changes in gentrification or touristification perceptions as effect modifiers of the associations between use of NOE on health.

4.1. Change in use of NOE and health

Most of the participants reported maintaining/increasing their use of nearby and city NOE during the pandemic, in line with previous results in other locations (Bakir and Attia, 2021; Berdejo-Espinola et al., 2022; Doughty et al., 2022; Reid et al., 2022; Uchiyama and Kohsaka, 2020). However, our results were heterogeneous between the different types of NOE, with nearby NOE having the highest share of increase/maintenance of use, which is in line with the results from other studies (Korpilo et al., 2021). These findings could be a direct consequence of the Spanish mobility restriction policies, which prevented residents from leaving the one-kilometer radius around their homes (Ministry of Health, Spanish Government, 2020). These restrictions could have increased the use of nearby NOE (Berdejo-Espinola et al., 2022; Tansil et al., 2022). Other characteristics of NOE could be relevant to the difference in use across different types of NOE, such as the level of vegetation in green spaces (Heo et al., 2021) or the size of the natural area (Korpilo et al., 2021).

Table 3

Logistic regression models testing the interaction between change in perceived gentrification/touristification and use of NOE, and self-reported general and mental health.

	Poor General Health Status		Poor Mental Health	
	OR (CI 95 %)	p-value	OR (CI 95 %)	p-value
Change in use of nearby NOE and Change in Gentrification perception (ref: decreased use and decreased perception)				
Increased/maintained use	0.62 (0.43, 0.91)*	0.015	0.37 (0.25, 0.55)*	< 0.001
Increased/maintained perception	0.97 (0.59, 1.60)	0.910	0.66 (0.39, 1.10)	0.110
Increased/maintained use x Increased/maintained perception	1.26 (0.66, 2.39)	0.483	1.72 (0.90, 3.33)	0.104
Change in use of city NOE and Change in Gentrification perception (ref: decreased use and decreased perception)				
Increased/maintained use	—	—	0.44 (0.31, 0.64)*	< 0.001
Increased/maintained perception	—	—	0.71 (0.45, 1.12)	0.144
Increased/maintained use x Increased/maintained perception	—	—	1.67 (0.89, 3.14)	0.113
Change in use of all NOE and Change in Gentrification perception (ref: decreased use and decreased perception)				
Increased/maintained use	—	—	0.53 (0.37, 0.77)*	< 0.001
Increased/maintained perception	—	—	0.79 (0.52, 1.22)	0.290
Increased/maintained use x Increased/maintained perception	—	—	1.39 (0.74, 2.61)	0.308
Change in use of nearby NOE and Change in Touristification perception (ref: decreased use and decreased perception)				
Increased/maintained use	0.70 (0.50, 0.97)*	0.033	0.45 (0.32, 0.63)*	< 0.001
Increased/maintained perception	1.66 (0.84, 3.26)	0.142	1.00 (0.50, 2.03)	0.994
Increased/maintained use x Increased/maintained perception	0.86 (0.36, 2.08)	0.747	1.16 (0.46, 2.90)	0.744
Change in use of city NOE and Change in Touristification perception (ref: decreased use and decreased perception)				
Increased/maintained use	—	—	0.53 (0.38, 0.72)*	< 0.001
Increased/maintained perception	—	—	1.09 (0.57, 2.08)	0.788
Increased/maintained use x Increased/maintained perception	—	—	1.10 (0.45, 2.69)	0.829

(continued on next page)

Table 3 (continued)

	Poor General Health Status	Poor Mental Health
Change in use of all NOE and Change in Touristification perception (ref: decreased use and decreased perception)		
Increased/maintained use	—	0.61 (0.44, 0.83)*
Increased/maintained perception	—	1.19 (0.64, 2.21)
Increased/maintained use x Increased/maintained perception	—	0.96 (0.39, 2.34)

* bold = significant association (p-value < 0.05). ^a = approaching significance (0.05 ≤ p-value < 0.1). The models are adjusted by age, origin, education, employment, and household income as covariates.

Nevertheless, the considered nearby NOE in our study, with the largest report of increased/maintained use, include large natural green and blue environments (i.e. Montjuic park, Barcelona's beaches) and small areas (i.e. Superblock, gardens, and small parks, many with relatively low levels of vegetation), meaning that level vegetation and size would not affect the use of NOE in our study.

Our results show the increased/maintained use of NOE as protective factors for poor general and mental health. These associations are in line with previous studies focusing on the first stages of the pandemic, with lockdowns around the globe (Labib et al., 2022), and a broader body of research looking at the benefits of NOE for human health (Dadvand et al., 2016; Gascon et al., 2015; Heo et al., 2021; Triguero-Mas et al., 2015; van den Berg et al., 2016). The reduced odds of reporting poor general health associated with increased use of nearby NOE were consistent with the results found by Edwards et al. (2023) in Philadelphia residents after lockdown. On the other hand, increased/maintained use of all NOE reduced the odds of poor mental health, which is in line with the results found by Heo et al. (2021) and Reid et al. (2022) about the relationship between green spaces and depression and anxiety

symptoms in Korea and Denver after lockdowns were lifted but mobility restrictions remained. In addition, our results are more consistent, as we found stronger and more statistically significant relationships for both general and mental health.

The lack of associations we found between changes in use of green-spaces and sleep quality is in line with a study carried out before the pandemic (Feng et al., 2020). However, different reviews focusing on sleep disturbance and green space exposure, before and during the pandemic, have shown that contact with nature is a protective factor for sleep disturbances (Corley et al., 2021; Labib et al., 2022; Spano et al., 2021). The differences in methods limit comparability, showing a need for more research on this relationship.

4.2. Role of changes in gentrification and touristification

Our results indicate that, after the COVID-19 outbreak, there was a decrease in the perceptions of neighborhood gentrification and touristification. These results coincide with data showing that privileged newcomers ceased to arrive in gentrifying neighborhoods during the COVID-19 pandemic (Ding and Hwang, 2022), and the tourism activity (Abellan et al., 2021) and tourist rentals reduced drastically (Sequera et al., 2022). These could explain the reductions in perceived gentrification/touristification identified in our study.

Our results on the potential role of gentrification or touristification as effect modifiers of the NOE-health associations are inconsistent. Despite that we did not find any statistically significant interaction between NOE use and gentrification/touristification, our stratified analyses showed that the beneficial relationship between increased/maintained NOE use and health was only statistically significant for those perceiving a decrease in gentrification/touristification after the pandemic outbreak. We believe the differences we find in our stratified analyses could be due to low statistical power. Nevertheless, we cannot discard that the perceptions of gentrification/touristification have an impact on the relationship between use of NOE and self-perceived health, so only the health of those whose gentrification/touristification perceptions reduced might have benefitted from an increase in the use of NOE. The role of gentrification/touristification modifying the relationships between NOE and health has been previously illustrated, showing that privileged neighbors benefit more from NOE in gentrifying

Table 4

Stratified logistic regression models testing the relationship between use of NOE and self-reported general health.

	Effect by change in gentrification perception				Effect by change in touristification perception			
	Decreased perception		Increased/maintained perception		Decreased perception		Increased/maintained perception	
Change in use of nearby NOE (ref:decreased use)	OR	p-value	OR	p-value	OR	p-value	OR	p-value
	(CI 95 %)		(CI 95 %)		(CI 95 %)		(CI 95 %)	
Increased/maintained use	0.63 (0.43, 0.93)*	0.018	0.82 (0.48, 1.39)	0.450	0.70 (0.50, 0.98)*	0.035	0.61 (0.26, 1.43)	0.255

* , bold = significant association (p-value < 0.05). ^a = approaching significance (0.05 ≤ p-value < 0.1). The models are adjusted by age, origin, education, employment, and household income as covariates.

Table 5

Stratified logistic regression models testing the relationship between use of NOE and self-reported mental health.

	Effect by change in gentrification perception				Effect by change in touristification perception			
	Decreased perception		Increased/maintained perception		Decreased perception		Increased/maintained perception	
Change in use of nearby NOE (ref:decreased use)	OR	p-value	OR	p-value	OR	p-value	OR	p-value
	(CI 95 %)		(CI 95 %)		(CI 95 %)		(CI 95 %)	
Increased/maintained use	0.39 (0.26, 0.57)*	< 0.001	0.60 (0.34, 1.05) ^a	0.072	0.45 (0.32, 0.63)*	< 0.001	0.37 (0.13, 1.01) ^a	0.056
Change in use of city NOE (ref:decreased use)								
Increased/maintained use	0.46 (0.32, 0.66)*	< 0.001	0.70 (0.41, 1.20)	0.197	0.52 (0.38, 0.72)*	< 0.001	0.47 (0.18, 1.22)	0.123
Change in use of all NOE (ref:decreased use)								
Increased/maintained use	0.55 (0.38, 0.79)*	0.001	0.69 (0.40, 1.19)	0.184	0.60 (0.44, 0.83)*	0.002	0.44 (0.17, 1.13) ^a	0.093

* bold = significant association (p-value < 0.05). ^a = approaching significance (0.05 ≤ p-value < 0.1). The models are adjusted by age, origin, education, employment, and household income as covariates.

neighborhoods (Cole et al., 2019) and that exposure to green spaces can be a protective health factor only in non-gentrifying neighborhoods (Zayas-Costa et al., 2021).

4.3. Limitations and future research

This study has the limitations of a cross-sectional study, so we cannot test causal inference. We had a low statistical power due to the limitation of collecting face-to-face data during the pandemic. Our sample may be biased towards those who were less afraid of the COVID-19 virus and may not include those who suffered prolonged lockdowns at home and had reduced severely their use of public spaces (e.g. older, with chronic health conditions), as it has been found in other contexts (Boni et al., 2024; Chiesa et al., 2021), limiting the external validity of our study. Our data may also be impacted by recall bias, as our survey included questions about the period before the pandemic, which is approximately a two-year gap. However, our study has also some strengths. Assessing the change in behavior from 2 years ago to the present gives a retrospective overview of the associations and helps to understand the long-term consequences of the COVID-19 pandemic. Even if the period is very long, the first two years of the pandemic were such a deep and disturbing experience that most people had a very clear picture of the comparison (before vs. after the COVID-19 outbreak). The data collection via street intercept and carried out in both neighborhoods at different hours, days, and anchoring points, which included main spots for basic services (e.g. marketplaces, medical centers), may have helped increase sample representativeness. Face-to-face surveys administered by highly trained researchers and the CABs collaboration increased our ability to ensure that respondents understood the questions and that we got accurate information, resulting in a pool of substantial data that has been used. The inclusion of validated tests and questions reduces the potential measurement error. In addition, the fact that all measurements were taken at the individual level reduces the potential misclassification error.

Future studies could also identify other factors that play important roles in the relationship between NOE use and health in the context of the COVID-19 pandemic from an equity perspective in Barcelona, as other authors have found in several cities for age (Van Eeden et al., 2023), socioeconomic status (Fernandez et al., 2024; Haensch et al., 2024), and race (Lopez et al., 2021). In addition, the relationships between NOE, gentrification/touristification, and health outcomes must be explored in other contexts. Qualitative studies during emergency health events will provide further insight into how gender, migration background, socioeconomic status, and other axes of inequality influence the perception of NOE, gentrification, and touristification and how they may affect the health of underprivileged populations.

5. Conclusions

This study provides insight into women's health and its determinants during the COVID-19 pandemic in Barcelona. Most women declared an increase or maintenance of use of city NOE and good self-reported health outcomes. The increase and maintenance of use of NOE during the first months after the COVID-19 outbreak was associated with better self-reported general and mental health. We cannot discard the effect modification by gentrification and touristification perceptions on the relationship between use of NOE and general and mental health. Considering these results, the impact of future pandemics on health inequalities could be reduced if the implemented policies ensure residents can remain in contact with green and blue spaces, facilitating safe social interactions.

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CRediT authorship contribution statement

Valeria-Carolin Cuenca: Conceptualization, Data collection, Data curation, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Helen Cole:** Conceptualization, Methodology, Investigation, Supervision, Project administration, Funding acquisition, Writing – review & editing. **Margarita Tiguero-Mas:** Conceptualization, Methodology, Investigation, Supervision, Project administration, Funding acquisition, 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.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.ufug.2025.128668](https://doi.org/10.1016/j.ufug.2025.128668).

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