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People and Nature

RESEARCH ARTICLE

Roots of resilience: Assessing child and adolescent nature connectivity in the Mediterranean Region of Murcia (Spain)

Juan Antonio Ortega-García[1,2,3] | Francisco Díaz-Martínez[1,2] | Laura Teresa Cabrera-Rivera[4] | Carmen Alicia Cánovas-Conesa[5] | Elena Codina[6] | Rebeca Ramis[7] | Luz Claudio[8]

[1]Pediatric Environmental Health Specialty Unit, Department of Paediatrics, Clinical University Hospital Virgen de la Arrixaca, Murcia, Spain; [2]Environment and Human Health Lab (EH-2 Lab), Institute of Biomedical Research, IMIB-"Pascual Parrilla", Murcia, Spain; [3]Department of Paediatrics, School of Medicine, University of Murcia, Murcia, Spain; [4]Department of Environmental Health, University of Puerto Rico, Medical Sciences Campus, San Juan, Puerto Rico, USA; [5]Isaac Peral Secondary School, Ministry of Education of the Region of Murcia, Cartagena, Spain; [6]Pediatric Environmental Health Unit, Department of Paediatrics, Hospital Sant Joan de Déu, Barcelona, Spain; [7]Cancer and Environmental Epidemiology Unit, National Epidemiology Centre, Carlos III Health Institute and Centre for Biomedical Research in Epidemiology and Public Health (CIBER Epidemiología y Salud Pública – CIBERESP), Madrid, Spain and [8]Division of International Health, Icahn School of Medicine at Mount Sinai, One Gustave L. Levy Place, New York, New York, USA

Correspondence
Juan Antonio Ortega-García
Email: ortega@pehsu.org

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Abstract

1. Children today spend less time outdoors than previous generations, with potential consequences for health, learning and pro-environmental attitudes. We assessed children's connection with and exposure to nature in a Mediterranean setting using the Nature Connection and Experience Index (NCEI), a composite measure that integrates an affective–cognitive connection-to-nature module with indicators of everyday nature experiences.
2. A school-based cross-sectional survey (4 March–4 April 2022) was conducted in 50 randomly selected public schools in the Region of Murcia (Spain). The questionnaire (26 items) was completed by 3395 pupils aged 7–17 years (overall response 67.2%). Psychometric checks supported the CN block.
3. Only about one in four pupils reported daily or near-daily contact with nature across the year; approximately three in four met criteria for Nature Experience Deficit (<1 h/day, annual measure). NCEI scores declined with age and were higher in girls than boys. Lower scores were observed in more urban and socioeconomically unequal municipalities, whereas participation in outdoor lessons was positively associated with NCEI.
4. These findings point to a substantial nature-experience gap in childhood and adolescence. Embedding regular outdoor learning into timetables and improving access to nearby green and blue spaces—particularly in urban and disadvantaged areas—could strengthen children's everyday relationship with nature, with

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co-benefits for health, learning and sustainability. The NCEI offers a practical tool for monitoring and programme design in schools.

KEYWORDS
adolescence, childhood, environmental education, gender, nature connection, nature experiences, outdoor learning, urbanicity

1 | INTRODUCTION

1.1 | Disconnection from nature: A critical concern

The increasing disconnection between humans and nature has raised significant concerns due to its impact on health and well-being. This phenomenon is driven by urbanization, industrialization and the increasing prevalence of digital environments in daily life. These factors, in combination with sociocultural changes, have altered how children and adolescents engage with natural spaces (Barrable & Booth, 2022; Beery et al., 2023). Rather than a direct causal relationship, this reflects a complex interplay of environmental, technological and behavioural dynamics that shape human–nature interactions.

Children, in particular, have reduced daily interaction with natural environments compared to previous generations (Kellert, 2005). This shift is driven by factors such as the increased use of digital technologies, the expansion of urban areas with limited green spaces, and the growing demands of academic responsibilities, all of which contribute to a decrease in outdoor playtime (Díaz-Martínez, Sánchez-Sauco, Cabrera-Rivera, et al., 2023; Holland et al., 2021). This distancing is also relational, reflecting a weakening of children's affective ties to the natural world (Ortega-García, 2021).

Epidemiological and experimental studies indicate that reduced contact with everyday nature is associated with higher stress, anxiety and depressive symptoms, attention and behavioural difficulties and greater sedentary time and excess weight in childhood. By contrast, routine exposure to nearby green–blue spaces relates to better cognitive development and sleep, richer social and prosocial functioning, higher health-related quality of life and healthier cardiometabolic and immune profiles (see Table 1; Cho et al., 2017; Díaz-Martínez, Sánchez-Sauco, Cabrera-Rivera, et al., 2023; Martin et al., 2020; Sandifer et al., 2015). These patterns align with pathways involving stress regulation, attention restoration, physical activity and the social affordances of outdoor play and learning—mechanisms that schools can deliver equitably through regular contact in lessons and schoolyards.

1.2 | Nature experiences (NE): Definition and benefits

NE refers to both direct and indirect interactions with natural environments, including green spaces (e.g. forests, urban parks, gardens) and blue spaces (e.g. rivers, lakes, coastal areas). These interactions range from unstructured play in natural settings to structured educational activities outdoors. Empirical work has linked NE with benefits for children's physical and mental health, improvements in cognitive development, emotional regulation and social well-being, reduced stress, better concentration and greater physical activity (Table 1; Cho et al., 2017; Díaz-Martínez, Sánchez-Sauco, Cabrera-Rivera, et al., 2023; Díaz-Martínez, Sánchez-Sauco, Orenes-Piñero, et al., 2023; Martin et al., 2020; Sandifer et al., 2015).

TABLE 1 Main health effects associated with contact with nature in the studies.

Effects
Increases happiness and sense of well-being
Reduces aggressive behaviours, hyperactivity and increase attention and sociability
Reduces anxiety, depression, stress and improve sleep
Improves motor (coordination/balance) and cognitive neurodevelopment
Improves school performance
Prevent obesity and reduces the risk of diabetes
Improves motor, social and connectivity skills in patients with disorders of neurodevelopment (FASD, ASD…)
Improves health-related quality of life in childhood and adolescent cancer survivors
Decreases risk and increases overall survival for some types of cancer improves the immune system (increases NK activity, expression of anticancer proteins and mucosal immunoglobulin A)
Increases lung function and improves asthma and reduces cardiovascular risk (lowers blood pressure, obesity, increases physical activity, risk of heart failure…)
Improves control of acute and chronic pain

We operationalize these ideas in the Nature Connection and Experience Index (NCEI), which combines a CNI-based connection-to-nature (CN) module (Cheng & Monroe, 2012; conceptual anchor: Mayer & Frantz, 2004) with a nature-experiences (NE) module; full details are provided in Methods and the Supplement.

In this study we use the terms NE and Nature Experience Deficit (NED) within a unified conceptual and operational framework. While children's contact with nature is well established in the literature, our operationalisation clarifies NE as observable exposure patterns (frequency, duration and, where relevant, diversity) and introduces NED as a pragmatic exposure label for low-contact profiles. Guided by expert consensus and prior evidence (Ortega-García et al., 2015, 2024), we implement NED as <1 h/day

of typical contact and test robustness with alternative cut-offs and a simple composite indicator that integrates monthly and annual items. NED is used solely as an exposure indicator to support monitoring and programme design; it is not a clinical classification and does not imply causation.

1.3 | Connection with nature (CN): Definition and benefits

Beyond the physical experience of nature, CN refers to an individual's emotional, cognitive, and experiential bond with the natural world. CN is a multidimensional construct encompassing a sense of belonging, empathy towards nature and personal responsibility for environmental stewardship (Cheng & Monroe, 2012). Studies indicate that children who develop a strong CN exhibit higher levels of pro-environmental behaviours, such as resource conservation and sustainable lifestyle choices (Rosa et al., 2018). Additionally, CN has been associated with greater psychological well-being, fostering resilience and a greater appreciation for biodiversity (Richardson et al., 2016).

1.4 | Study aim: Assessing CN and NE using the NCEI

Despite the growing evidence highlighting the benefits of NE and CN for children's physical, emotional and cognitive well-being, recent studies indicate a significant decline in children's engagement with natural environments (Diputación Foral de Gipuzkoa, 2019; Richardson et al., 2016).

This study aims to quantify and analyse nature connectedness among children and adolescents aged 7–17 in the Mediterranean Region of Murcia (Spain), considering both the frequency of nature experiences (NE) and the affective–cognitive bond with the natural world (connection to nature, CN). To assess these dimensions, we introduce the NCEI, a composite measure of engagement with nature. The CN component adapts items from the Children's Connection to Nature Index (CNI) to our Spanish, school-based context (Cheng & Monroe, 2012), with the adult Connectedness to Nature Scale (CNS) used as a conceptual anchor (Mayer & Frantz, 2004). The NE component captures reported exposure patterns (frequency and, where relevant, duration/diversity) in everyday settings. This index provides a structured way to examine how school environments (including outdoor lessons) and contextual factors (urban–rural setting, family background) shape children's connection with nature. The specific objectives of this study are as follows:

1. To adapt and validate the NCEI to the Spanish, school-based context (ages 7–17), ensuring cultural and environmental relevance.
2. To analyse the NE and CN profiles by age and sex, among children and adolescents in the Region of Murcia, identifying sociodemographic, educational and contextual factors influencing their levels of nature connectedness.
3. To explore the relationship between NCEI scores, outdoor learning opportunities and well-being outcomes, providing insights for educational and policy interventions.

By identifying patterns of nature connectedness and potential barriers to engagement, this study seeks to inform evidence-based strategies to enhance equitable access to nature. The findings will support the integration of outdoor education and nature-based interventions in school curricula and urban planning, ultimately fostering healthier, more environmentally conscious generations.

2 | METHODS

2.1 | Study location

The Region of Murcia is a Mediterranean region located in the southeast of Spain, in southwestern Europe (Figure 1). It has a population of approximately 1.5 million inhabitants spread over 45 municipalities, of which the cities of Murcia, Cartagena, Lorca and Molina de Segura concentrate more than 55% of the total population. There are currently 208,997 children under the age of 18 in the territory, distributed in more than 700 primary and secondary public educational centres (Centro Regional de Estadística de la Región de Murcia, 2020).

2.2 | Sample selection

Children from 320 public educational centres (PECs) attended the 2022 School Environmental Health programme 'Aire Limpio' (Clean Air), promoted by the Regional Minister of Health and Education and led by the Pediatric Environmental Health Specialty Unit (PEHSU) of Murcia. The Aire Limpio programme was an initiative launched in the Region of Murcia to promote healthier and more resilient educational environments in response to the SARS-CoV-2 pandemic. It aimed to integrate nature-based and sustainable health and environmental measures in schools. The programme focused on fostering positive coping strategies, improving school infrastructure and enhancing environmental health education. A key component was the creation of a collaborative network among schools, local governments and parent associations to share best practices, implementing innovative approaches to improve air quality, outdoor learning and environmental awareness in the education system.

Priority was given to schools that integrated outdoor learning programmes, as these environments offer more opportunities for nature-based experiences (NE), which may influence the development of CN. By including these schools, we aimed to examine the role of environmental education in fostering CN. This programme provides each educational centre with resources, facilitating self-management linked to a school environmental health project and training about CN from 2020 to 2024 (Consejeria de Educación y Cultura, 2020). Within this programme frame, 50 public educational

FIGURE 1 Study area. Location of the Region of Murcia (Spain), a Mediterranean region in south-western Europe.

centres were randomly selected at the programme's starting point to form the school sample. The optimal sample size was calculated based on a 95% confidence level, 1.5% precision and a 30% anticipated dropout rate, resulting in 5900 participants.

Inclusion criteria required participants to be between 7 and 17 years old. Students from Aire Limpio schools were invited to participate within the programme frame to facilitate data collection.

The Ethics Committee approved the protocol (CEIC code 2021-6-10-HCUVA) and granted a waiver of written parental consent for this anonymous, minimal-risk school survey. Schools distributed an information sheet with opt-out; students provided in-class assent. No personal identifiers were collected, and procedures complied with GDPR and the Declaration of Helsinki.

2.3 | Nature Connection and Experience Index (NCEI) in child-adolescent population

We developed the NCEI as a composite with two modules: (i) a connection-to-nature (CN) module adapted to our Spanish, school-based context from the Children's Connection to Nature Index (CNI) (Cheng & Monroe, 2012), using the adult Connectedness to Nature Scale (CNS) as a conceptual anchor (Mayer & Frantz, 2004); and (ii) a nature-experiences (NE) module that captures the frequency, duration and type of everyday contact with nearby nature (e.g. schoolyard, streetscapes, parks), including outdoor lessons. CN items were rated on a 5-point Likert scale.

Prior use and rationale for adaptation. The CNI was originally developed to assess children's affective–cognitive connection to nature (domains: enjoyment, empathy towards nature, sense of belonging, responsibility) and has been applied in school-age populations in multiple settings. However, it does not include quantitative indicators of exposure to nature. We therefore adapted the CN items linguistically and contextually for Spanish schools and added a dedicated NE block, enabling us to analyse CN and NE jointly within the NCEI.

Adaptation process. The initial linguistic and contextual adaptation of the CN items was undertaken in Gipuzkoa (Basque Country, Spain) (Diputación Foral de Gipuzkoa, 2019) with teachers and bilingual reviewers; the adapted version was then implemented in the Region of Murcia with minor lexical adjustments.

Pilot and psychometric checks. A brief pilot with ≈300 students from three schools in Murcia, Cartagena and the Mar Menor (June 2021; response ≈90%) assessed comprehension, item distributions and completion time; minor wording tweaks followed. To ensure comprehension among children, the questionnaire used age-appropriate language and considered school activities, educational programmes and a holistic approach to outdoor experiences. Responses were collected via an online questionnaire administered to students from three representative schools in different areas of the study region. A descriptive study of response frequencies was performed, and the validity and internal consistency of the questionnaire was evaluated using Cronbach's Alpha (Cronbach, 1951). The pilot study was well received, with a high acceptance rate among participants. These results confirmed the tool's validity, allowing its application to a large sample.

Preliminary findings, based on the distribution and frequency analysis, were presented at the XLVII Annual Meeting of the Pediatric Society of Southeast Spain (SPSE) (Díaz-Martínez et al., 2021).

The final 26-item questionnaire was divided into three sections assessing both NE and CN.

The first section evaluates CN using 16 statements grouped into four thematic categories: enjoyment of nature, empathy towards animals, sense of belonging and responsibility towards nature (Cheng & Monroe, 2012). They are answered based on a 5-point Likert scale, choosing between five ranges (strongly agree (5), agree (4), neither agree nor disagree (3), disagree (2), strongly disagree (1)), and that allows a distinction to be made by block regarding the enjoyment of nature, empathy and relationship with animals, the sense of belonging and identity with nature and the degree of personal incorporation of responsibility with nature.

- Enjoyment with nature: Questions 1, 2, 3, 4, 5, 6 and 13*
- Empathy towards animals: Questions 7, 8, 9 and 10
- The sense of identity with nature: Questions 11, 12 and 13*
- The sense of responsibility with nature: Questions 14, 15 and 16.

*It's only asked once in the questionnaire

The second section measures NE, capturing the frequency and type of outdoor activities, pet ownership and participation in environmental programmes. It includes questions to define the individual characteristics and activity trends in the nature of the participants on:

- Pet ownership at home and tree planting activities.
- Frequency of outdoor classes during academic hours.
- Frequency of outdoor activities outside of academic hours.
- Frequency of activities in CN throughout the year.

The third section collects sociodemographic data, including sex, age, city/town of residence, educational centre and city/town where the educational centre is located.

Each CN-related question was graded from −2 to 2 points. The NE section awarded 2 points for pet ownership and -2 for non-ownership; planting a tree awarded 2 points, while not planting a tree earned −2. The frequency of outdoor activities in the past month ranged from −10 to 2 points, while annual activity frequency ranged from −2 to 2.

The NCEI assigned a final score ranging from −48 to 40 points, grouped into five categories: excellent connection (≥35), very good connection (28–34), emerging connection (20–27), latent connection (1–19) and dormant connection (≤0). The questionnaire took approximately 5 min to complete. After submission, the website provided personalized recommendations to enhance CN and NE, along with access to a nature and health asset map, detailing natural areas within the study region and the activities available there (see Appendix S1).

Full details of the item set, scoring weights, and algorithm used to compute the NCEI are provided in the Appendix S2 ('Supplement_NCEI_items'). Internal consistency and a brief structure check for the CN block are reported in Results; formal multi-group invariance testing was not undertaken. We defined NED as <1 h/day using the annual-frequency item (Q23) as the main measure and repeated analyses with a stricter annual cut-off (only 'daily or almost every day' as non-NED), the last-month item (Q22) and a composite definition (annual or monthly <1 h/day).

2.4 | Data collection

Data were collected using a cross-sectional online survey (Link: https://www.ecologiaysalud.org/?p=378) from 4 March to 4 April 2022. Participation was anonymous and voluntary. Students accessed the survey individually via the provided link, using mobile phones, tablets or computers, either during school hours or at home (children <12 years old participated under parental supervision).

Additional socio-demographic variables included: rural populations were defined as those with equal to or fewer than 5000 inhabitants, Gini Index (income inequality); population of residence zone; percentage of individuals under 18 and over 65 years in the municipality; municipality of residence (household size and household income median). Regarding to education, the level of education were defined by the system in Spain with the following six stages: primary education (first cycle, second cycle and third cycle), obligatory secondary education (first cycle and second cycle) and university preparation. Finally, the ownership of the educational centres (public, subsidized or private) was also taken into account.

2.5 | Data analysis

The questionnaire's internal consistency and reliability were calculated using Cronbach's Alpha (Cronbach, 1951) with values above 0.70 considered acceptable (Tavakol & Dennick, 2011). Construct validity was assessed using the Kaiser–Meyer–Olkin (KMO) test (Kaiser, 1974) and Bartlett's test of sphericity (Bartlett, 1950). The KMO score was 0.905, indicating strong sampling adequacy, while Cronbach's Alpha was 0.813, confirming high internal reliability.

A correlation analysis was performed between the CN and NE variables. Additionally, the T-test and ANOVA examined associations between NCEI scores (−48 to 40) and sociodemographic characteristics, with $p < 0.01$ considered statistically significant. For the Gini Index, a Pearson correlation was performed. Further linear regression analyses were performed to quantify the influence of independent variables on NCEI scores.

A chi-square or Spearman correlation was also performed to compare the difference between the Group Score (excellent connection, very good connection, emerging connection, latent connection and dormant connection) and the previously mentioned characteristics. Lastly, an ANOVA analysis was performed between the deficit with CN and the sociodemographic and economic variables.

We used OLS (ordinary least squares) regression models to examine predictors of the NCEI. To account for the clustered data structure, we computed cluster-robust standard errors clustered at the municipality level, as several contextual predictors (e.g. Gini

Index, household income, household size, % under 18) were defined at this level. This approach provides conservative inference while maintaining valid estimates of associations. Each independent variable was evaluated to see its impact on the NCEI score, controlling for the other variables in the model. The significance of the coefficients was determined at the $p < 0.01$ level.

A descriptive univariate study of the main predictors that may influence the frequency of outdoor activities during school hours was carried out, and those results that were statistically significant were included in an ordinal regression analysis model.

The data analysis procedures were carried out using R version 4.1.3 and Statistical Software for Social Sciences (SPSS) version 16 (IBM Corp, 2016).

3 | RESULTS

3.1 | Characteristics of the sample

Within the Aire Limpio programme frame, 50 schools were randomly selected at the programme's starting point. We invited 5719 students; 3844 completed the questionnaire (overall response 67.2%). After applying the age eligibility criterion (7–17 years), the analytic sample comprised 3395 students (participant flow in Figure 2). School-level response rates were broadly similar across centres, and no single school contributed a disproportionate share of the final sample. Data collection took place from 4 March to 4 April 2022. After applying the age inclusion criteria (7–17 years), the final sample comprised 3395 participants. The sample distributed by gender was similar, with 49.4% males and 50.6% females. The mean age of the participants was 11.1 years (SD: 2.53). Most participants (30.3%) were studying the third cycle of primary, followed by the second cycle of primary and the first secondary cycle with 25.3% and 17.5%, respectively. Residence: 87.1% lived in urban areas; the majority were from municipalities with over 10,000 inhabitants.

Regarding NCEI, only 13.2% of the participants have an excellent connection with nature, compared to 27.6% who are in the two lowest categories of the level of connection with nature. Characteristics of the participants are summarized in Table 2.

3.2 | Nature Connection and Experience Index (NCEI)

The CN items showed good internal consistency (KMO = 0.905; Cronbach's $\alpha = 0.813$). A brief structure check supported treating the CN block as sufficiently unidimensional; summaries by sex and age did not suggest instability.

The mean NCEI score was 24.3 (SD: 10.1), with significant differences by gender ($p < 0.01$): males 23.3 (SD: 10.4) and females 25.1 (SD: 9.5). There was also a declining trend in NCEI scores with age, with primary school students having the highest scores (Figure 3).

Based on NCEI categories, 42% of students had a high NCEI score (excellent or very good), and 57.1% were in the lower three categories (emerging, latent or dormant connection), suggesting room for improvement.

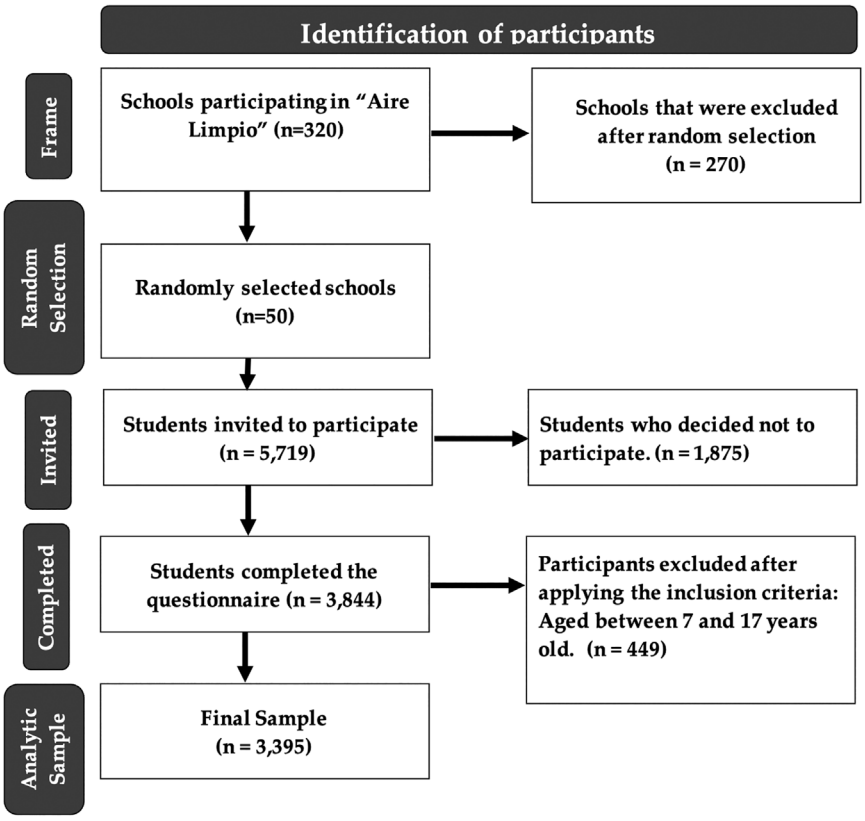

FIGURE 2 Participant-flow (STROBE) diagram. The STROBE flow diagram illustrates the participant selection process. Of the 320 schools in the 'Aire Limpio' programme, 50 were randomly selected. A total of 5719 students were invited to participate, and 3844 completed the questionnaire. After applying the inclusion criteria (aged between 7 and 17 years), the final analytic sample consisted of 3395 participants.

TABLE 2 Characteristics of the schoolchildren that participated in the survey.

Characteristics	*n* (%)
Gender	
Male	1677 (49.4%)
Female	1718 (50.6%)
Age group (years)	
7–10	1409 (41.5%)
11–13	1376 (40.5%)
14–17	610 (17.9%)
Education[a]	
Primary first cycle	553 (16.2%)
Primary second cycle	856 (25.2%)
Primary third cycle	1030 (30.3%)
Secondary first cycle	596 (17.5%)
Secondary second cycle	278 (8.1%)
University preparation	82 (2.4%)
Residence zone	
Rural	397 (13.1%)
Urban	2637 (86.9%)
Pet	
Yes	2107 (62.4%)
No	1267 (37.5%)
Plant a tree	
Yes	1039 (30.5%)
No	2359 (69.4%)
Connection to nature (NCEI)	
Excellent connection	455 (13.2%)
Very good connection	1025 (29.7%)
Emerging connection	1017 (29.5%)
Latent connection	876 (25.3%)
Dormant connection	80 (2.3%)

[a]Education were defined by the system in Spain.

For clarity of presentation, the five original NCEI categories were collapsed into three broader groups ('disconnected or weak connection' (latent and dormant), 'slightly weak connection' (emerging) and the category 'good or excellent connection' (very good and excellent) in the main analysis). The full five-category results are available in the Supporting Information (Appendix S3). Subsequent T-test and ANOVA showed significant relationships between NCEI scores and several sociodemographic and individual factors (Table 3): Females had significantly higher NCEI scores than males ($p < 0.01$). Participants from smaller municipalities (≤10,000 inhabitants) had higher scores than those from larger ones ($p < 0.01$). Students from rural schools had significantly higher NCEI scores than those in urban schools ($p < 0.05$). Children who owned pets ($p < 0.01$) or had planted a tree ($p < 0.01$) had significantly higher NCEI scores. Younger participants (7–10 years) had significantly higher scores than older participants (14–17 years) ($p < 0.01$).

The Spearman correlation analysis showed a significant positive association between all NE variables and the NCEI, even after controlling for CN. Conversely, when controlling for NE, the relationship between CN and NCEI remained significant, suggesting that both exposure to nature and emotional connection to it contribute to the overall level of nature connectedness (Appendix S4).

3.3 | Factors influencing NCEI scores

Table 4 presents regression estimates of predictors of NCEI with municipality-clustered robust standard errors. Coefficients are consistent with conventional OLS, with wider confidence intervals as expected. Female sex, age, proportion under 18, pet ownership, tree planting and weekly or more outdoor classes were all positively associated with NCEI scores. Gender played a key role, with females scoring significantly higher than males ($B = 1.65$, $p < 0.01$). Age showed an inverse relationship, as each additional year was associated with a decline in NCEI scores ($B = -0.89$, $p < 0.01$). Pet ownership ($B = 5.6$, $p < 0.01$) and tree planting ($B = 7.4$, $p < 0.01$) were both strongly associated with higher NCEI values, reinforcing the idea that direct interaction with nature fosters a stronger connection. Additionally, participation in outdoor classes was positively correlated with NCEI, with students attending three or more outdoor classes per week showing the highest increase in scores ($B = 4.27$, $p < 0.01$). In contrast, economic inequality (measured by the Gini Index) was linked to lower NCEI scores ($B = -0.17$, $p < 0.05$), and larger household sizes were also associated with a decline in NCEI ($B = -6.23$, $p < 0.01$), possibly reflecting limited access to nature due to space or resource constraints. A Chi-square analysis confirmed that females, younger participants, and those with pets or tree-planting experience had significantly higher NCEI scores ($p < 0.01$). Although the Pearson correlation analysis did not establish a statistically significant association between the Gini Index and NCEI, a linear regression plot (Figure 4) suggested a slight negative trend, indicating that higher economic inequality might be linked to lower NCEI scores, even if the relationship did not reach statistical significance.

3.4 | Nature experiences (NE) and outdoor learning

Table 5 provides a comprehensive overview of the schoolchildren's outdoor activity habits. Outdoor learning opportunities varied among students. A significant proportion (38.5%) rarely or never had outdoor lessons, while only 13.4% participated in three or more outdoor classes per week. Regarding extracurricular nature activities in the past month, the most common frequency was once or twice a week (29.2%). When considering annual nature exposure, 31.8% of students engaged with nature weekly, whereas 6.6% rarely or never did, indicating a potential gap in regular interaction with natural environments.

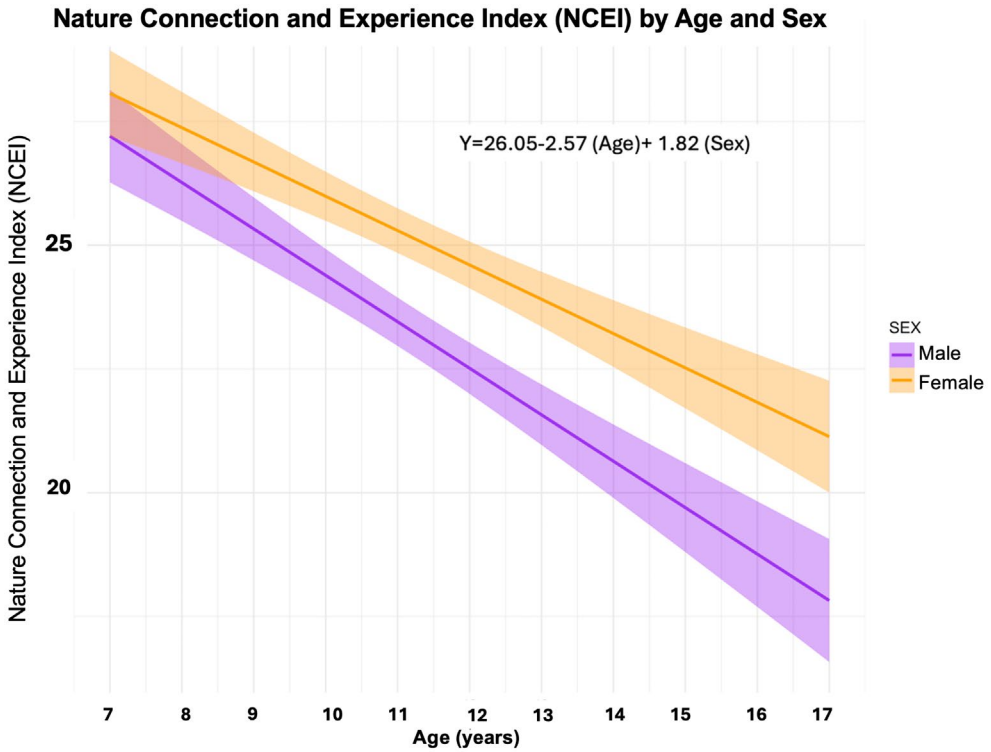

FIGURE 3 Nature Connection and Experience Index (NCEI) by age and gender. Lines represent predicted NCEI values from linear regression models for males and females, with shaded areas indicating 95% confidence intervals.

TABLE 3 Nature Connection and Experience Index (NCEI) and sociodemographic and individual factors.

		Score NCEI		Group score			
Characteristics		Mean [95% CI]	*p*-value[a]	Disconnected or weak connection	Slightly weak connection	Good or excellent connection	*p*-value[a]
Gender	Male (*n* = 1677)	23.3 [22.8, 23.8]	<0.01	527 (31.4%)	498 (29.7%)	652 (38.8%)	<0.01
	Female (*n* = 1718)	25.1 [24.7, 25.6]		406 (23.6%)	498 (28.9%)	814 (47.3%)	
Age	7–10 years (*n* = 1409)	26.1 [25.6, 26.6]	<0.01	304 (21.1%)	389 (27.0%)	744 (51.1%)	<0.01
	11–13 years (*n* = 1376)	23.6 [23.1, 24.2]		402 (28.8%)	446 (31.9%)	547 (39.2%)	
	14–17 years (*n* = 610)	20.9 [20.1, 21.8]		250 (40.2%)	182 (29.3%)	189 (30.4%)	
Population	0–10000 (*n* = 786)	25.1 [24.5, 25.8]	<0.01	200 (25.4%)	224 (28.5%)	362 (46.0%)	0.19
	>10,000 (*n* = 2300)	24.1 [23.7, 24.5]		636 (27.6%)	689 (29.9%)	975 (42.3%)	
Residence zone	Urban (*n* = 2637)	24.2 [23.8, 24.6]	<0.01	730 (27.7%)	772 (29.3%)	1135 (43.0%)	0.03
	Rural (*n* = 397)	26.0 [24.9, 26.8]		86 (21.7%)	122 (30.7%)	189 (47.6%)	
Pets	Yes (*n* = 2107)	26.6 [26.2, 27.0]	<0.01	420 (19.9%)	564 (26.7%)	1123 (53.3%)	<0.01
	No (*n* = 1267)	20.3 [19.7, 20.9]		500 (39.4%)	430 (33.9%)	337 (26.6%)	
Plant a tree	Yes (*n* = 2359)	26.7 [26.3, 27.0]	<0.01	454 (19.2%)	649 (27.5%)	1256 (53.2%)	<0.01
	No (*n* = 1039)	18.5 [17.8, 19.2]		475 (45.7%)	359 (34.5%)	205 (19.7%)	

[a]Chi-square was performed to compare the difference between the group score (disconnected or weak connection, slightly weak connection and good or excellent connection) and participant characteristics. Finally, ANOVA and *T*-test were done to determine if there was a statistical difference between the scores (−48 to 40) and participant characteristics. Significant differences were considered for all tests if the *p*-value was <0.01.

Regarding the NE deficit, 75% of participants met the criteria for NED. Results were similar under the stricter annual, last-month and composite NED definitions, indicating that the core patterns do not depend on a single definition. ANOVA analysis showed a significant relationship between NED and the Gini Index ($F = 7.378$, $p < 0.05$).

Table 6 presents the main descriptive characteristics and trends in relation to the frequency of outdoor activities during school hours.

TABLE 4 Regression analysis summary for variables predicting NCEI (with municipality-clustered robust standard errors).

	B	Std. error (cluster)	*t* value	*p*-value
(Intercept)	23.806	4.876	7.357	<0.01
Gender (female)	1.655	0.415	3.992	<0.01
Age	−0.891	0.046	−12.185	<0.01
Residence zone (rural)	0.538	0.956	0.563	0.573
Gini Index	−0.175	0.021	−0.458	0.05
Median household income[a]	0.0	0.0	0.553	0.58
Median household size[b]	−6.235	3.431	−3.142	<0.01
% of individuals under 18 years old	0.030	0.001	2.486	0.013
Pet ownership	5.625	0.321	17.521	<0.01
Tree planting	7.454	0.292	25.547	<0.01
Outdoor classes (1–3 times/month)	0.966	0.560	1.723	0.085
Outdoor classes (1–2 times/week)	2.567	0.463	5.549	<0.01
Outdoor classes (>3 days/week)	4.266	0.485	8.798	<0.01

Note: Standard errors are robust to clustering at the municipality level. Reference categories are gender (female), residence zone (rural) and outdoor classes (>3 days/week). The reference categories are sex (male), urban/rural (urban) and outdoor classes (never or almost never). OLS estimates with municipality-clustered robust standard errors. Reference categories: sex (male), residence (urban), outdoor classes (never/almost never).

[a]Median household income of the municipality of residence of the participant.

[b]Median household size of the municipality of residence of the participant.

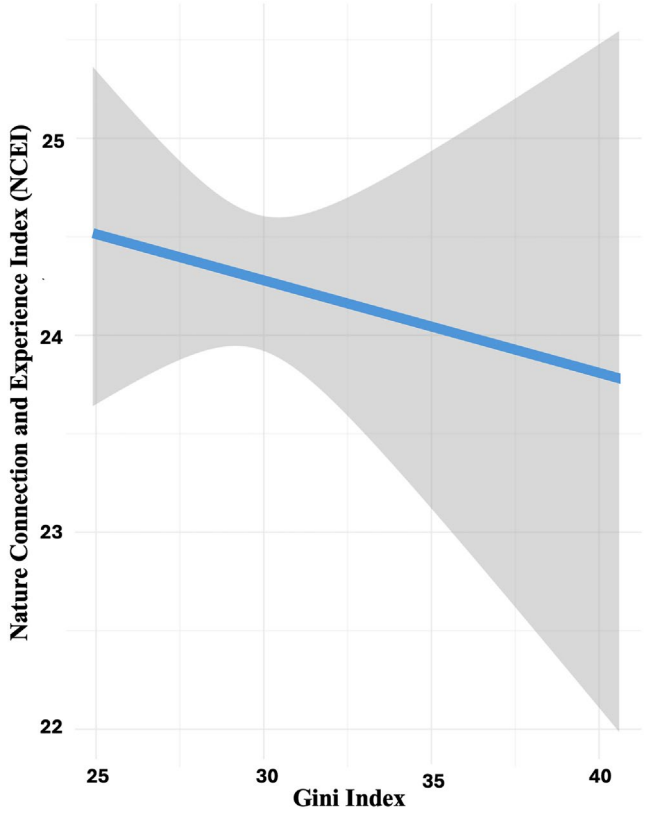

FIGURE 4 Nature Connection and Experience Index (NCEI) in relation to municipal income inequality (Gini Index). The solid line shows predicted values from linear regression, with the shaded area indicating the 95% confidence interval.

Outdoor classes refer to teaching academic subjects other than physical education. The ordinal regression analysis found that frequent outdoor learning was positively associated with higher NCEI scores, pet ownership and students in rural schools. Conversely, a negative relationship was observed with age and the Gini Index (Table 7).

4 | DISCUSSION

This study assessed the NCEI among children and adolescents (7–17 years) in a Mediterranean region, examining the influence of gender, age, academic level, socio-economic status, outdoor education and social inequalities. Our findings reveal a significant nature deficit, with 75% of children experiencing insufficient nature engagement annually. This aligns with research from the University of Essex in the UK, where weak correlations were found between CN, health and life satisfaction (Richardson et al., 2016), and a survey from Sydney, Australia, where only 28% of students reported strong CN (Keith et al., 2021).

A key finding is the decline in NCEI with age, with younger children showing stronger connections. This trend is consistent with previous studies (Keith et al., 2021) and may be attributed to increased social and academic pressures, cognitive changes and the transition from primary to secondary education, which often reduces structured engagement (Keith et al., 2021; Rudner & Malone, 2011; Van Truong et al., 2022). Furthermore, lower exposure to digital distractions, such as smartphones and social media, may contribute to greater nature sensitivity among younger children (Andrade et al., 2021).

TABLE 5 Time spent in outdoor activities and engagement with nature of the schoolchildren that participated in the survey.

Activities	*n* (%)
Frequency of outdoor classes during the academic year[a]	
Never or almost never	1256 (38.5%)
1–3 times a month	723 (22.1%)
1–2 times a week	840 (25.7%)
3 or more days a week	438 (13.44%)
Frequency of outdoor activities outside school hours in the last month[b]	
Almost never	315 (9.5%)
Sometime a month	402 (12.1%)
Sometime a week	969 (29.2%)
Daily or almost daily (1 h)	815 (24.6%)
Daily or almost daily (2 or more hours)	807 (24.3%)
Frequency of activities in contact with nature throughout the year[c]	
Never or almost never	221 (6.6%)
Only on vacations	635 (19.2%)
Sometime a month	564 (17.0%)
Sometime a week	1051 (31.8%)
Daily or almost every day	832 (25.1%)

[a]This refers to classes held outdoors that are NOT physical activity classes.

[b]This includes activities in the street, in gardens or parks, on outdoor sports tracks or any other outdoor activities, regardless of whether they are in urban, rural or natural settings.

[c]Refers to walks or activities of at least 1 h in the neighbourhood park, wooded area, beach, mountain, orchard, field.

In our study, females scored higher than males on the NCEI. This pattern is consistent with previous research reporting greater nature connectedness and environmental concern among girls and women (Hampel et al., 1996; Keith et al., 2021; Xiao & McCright, 2015). Our survey did not include direct measures of specific sustainability behaviours such as recycling, energy saving or sustainable consumption; therefore, our findings speak to gender differences in connection to nature and environmental attitudes rather than observed sustainable practices in this sample. Nonetheless, our results align with studies in Spain and elsewhere showing that women tend to report higher engagement in pro-environmental and sustainable behaviours, such as reducing and reusing materials (Escario et al., 2020). At a broader societal level, this greater environmental engagement contrasts with the persistent underrepresentation of women in environmental decision-making, as illustrated by the low proportion of female-led delegations at international climate negotiations (De Paula et al., 2021), underscoring the need for more gender-inclusive environmental policies. Gender differences in nature connectedness may also stem from distinct rates of brain development and social experiences. Studies suggest that females exhibit greater environmental responsibility and attachment to nature than males (Hampel et al., 1996; Xiao & McCright, 2015). While some of these differences may be linked to brain function (Zaidi, 2010), socialization and cultural norms likely play a significant role (Beltz et al., 2020; Hyde & Mezulis, 2020).

Our findings indicate that NCEI decreases in larger towns, where children have fewer opportunities to interact with nature. In our sample, 78% of students lived in urban areas, reflecting

TABLE 6 Frequency of outdoor classes and sociodemographic factors.

Characteristics		Frequency of outdoor classes, during the academic year				
		Never or almost never (*N* (%)/mean [95% CI])	1–3 times a month (*N* (%)/mean [95% CI])	1–2 times a week (*N* (%)/mean [95% CI])	3 or more days a week (*N* (%)/mean [95% CI])	*p*-value[a]
Gender	Male (*n* = 1600)	614 (38.4%)	364 (22.8%)	388 (24.3%)	234 (14.6%)	0.15
	Female (*n* = 1657)	642 (38.7%)	359 (21.7%)	452 (27.3%)	204 (12.3%)	
Age	7–10 year (*n* = 1360)	447 (32.9%)	301 (22.1%)	410 (30.1%)	202 (14.9%)	<0.01
	11–13 year (*n* = 1355)	536 (39.6%)	289 (21.3%)	337 (24.9%)	193 (14.2%)	
	14–17 year (*n* = 590)	291 (49.3%)	145 (24.6%)	102 (17.3%)	52 (8.8%)	
Residence zone	Urban (*n* = 2512)	1018 (41%)	541 (21.8%)	601 (24,2%)	352 (13,1%)	<0.01
	Rural (*n* = 358)	81 (22.6%)	106 (29.6%)	113 (31.6%)	58 (16.2%)	
Pets	Yes (*n* = 2022)	779 (38.5%)	448 (22.2%)	523 (25.9%)	272 (13.5%)	<0.01
	No (*n* = 1216)	469 (38.6%)	274 (22.5%)	312 (25.7%)	161 (13.2%)	
Plant a tree	Yes (*n* = 2264)	816 (36%)	506 (22.3%)	616 (27.2%)	326 (14.4%)	0.06
	No (*n* = 1212)	444 (44.5%)	220 (22.1%)	222 (22.3%)	326 (14.4%)	
Gini Index (*n* = 2978)		30.1 [29.9, 30.2]	29.5 [29.3, 29.7]	29.9 [29.7, 30.1]	29.7 [29.5, 29.9]	<0.01
Score NCEI (*n* = 3453)		22.2 [21.6, 22.8]	23.8 [23.1, 24.5]	26.1 [25.5, 26.7]	27.5 [26.6, 28.3]	<0.01
Score CN (*n* = 2907)		22.9 [22.4, 23.3]	23.4 [22.9. 23.9]	24.8 [24.4, 25.2]	25,9 [25.3, 26.5]	<0.01
Score NE (*n* = 3178)		−0.1 [−0.4, 0.2]	0.9 [0.5, 1.3]	1.9 [1.6, 2.2]	2,5 [2.1, 3.1]	<0.01

[a]Chi-square was performed to compare the difference between the Group (3 or more days a week, 1–2 times a week, 1–3 times a month, never or almost never) and participant characteristics. Finally, ANOVA and *T*-test were done to determine if there was a statistical difference between the scores, Gini Index and frequency of outdoor classes. Significant differences were considered for all tests if the *p*-value was <0.01.

TABLE 7 Ordinal regression results for the dependent variable: frequency of outdoor classes* during the school year.

Predictor variable	Estimate (β)	Std. error	CI (%95)	Wald	*p*-value
(Threshold 1)	1.869	0.515	[0.860, 2.877]	13.188	<0.01
(Threshold 2)	0.834	0.426	[0.122, 1.791]	2.923	<0.01
(Threshold 3)	0.582	0.297	[0.375, 1.538]	1.421	<0.01
Age	−0.058	0.014	[−0.086, −0.030]	16.201	<0.01
GINI Index	−0.068	0.035	[−0.099, 0.037]	18.555	<0.01
Score NCEI	0.034	0.004	[0.027–0.042]	75.710	<0.01
Having a pet	0.236	0.076	[0.088–0.385]	9.686	<0.01
School location (rural area)	0.502	0.256	[0.711, −0.292]	22.001	<0.01

Note: Significant differences were considered for all tests if the *p*-value was <0.01. Outdoor classes* refer to teaching academic subjects other than physical education.

broader demographic trends and the depopulation of rural areas. Similar patterns have been observed in Spain (Diputación Foral de Gipuzkoa, 2019) and Israel (Bashan et al., 2021), where urban children report lower CN levels than their rural counterparts. However, municipalities with a higher percentage of young residents (under 18 years) tend to provide better access to outdoor recreational spaces, fostering stronger NCEI scores.

Our findings suggest that socio-economic factors and structural inequalities substantially shape children's exposure to nature. Specifically, children in low-income neighbourhoods exhibit lower NE, aligning with previous research demonstrating that income inequality constrains outdoor play and access to green spaces (Schoeppe et al., 2015; Wüstemann et al., 2017). Additionally, high-crime areas correlated with lower CN and NE, as parental safety concerns may limit children's outdoor activities (Antonaccio & Tittle, 2008). These findings reinforce the idea that poverty and social inequalities create barriers to community cohesion and outdoor engagement, exacerbating nature disconnection.

Encouragingly, our findings show that students who spent more time in outdoor classes had higher NCEI scores, reinforcing the benefits of experiential learning in fostering emotional attachment and environmental responsibility (Pirchio et al., 2021). However, despite 49% of students engaging with nature daily, a significant proportion participated only once a week or less, which may be insufficient to develop a strong nature connection.

Additionally, owning a pet or planting a tree was strongly associated with higher NCEI scores, supporting previous research suggesting that hands-on nature experiences enhance environmental awareness (Selly, 2014; Tipper, 2011). A systematic review further highlights that nature-based outdoor learning—including adventure education, school gardens and residential camps—improves socio-emotional skills, well-being and academic performance (Díaz-Martínez, Sánchez-Sauco, Cabrera-Rivera, et al., 2023). Outdoor learning fosters self-confidence, resilience and mental health benefits, further emphasizing its importance (Wüstemann et al., 2017).

A key contribution of this study is the development and validation of the NCEI, a comprehensive instrument designed to evaluate both nature experiences (NE) and connection to nature (CN) among children and adolescents. In contrast to measures that primarily emphasize time spent outdoors, the NCEI integrates indicators of outdoor exposure, emotional attachment and behavioural engagement, offering a more holistic assessment of human–nature interactions. Conceptually, the NCEI builds upon and complements established measures: it overlaps with the Child Nature Connectedness Index (CNI) (Hughes et al., 2018), which emphasizes affective and identity-related aspects in younger populations; the Connectedness to Nature Scale (CNS) (Mayer & Frantz, 2004), which captures emotional and cognitive dimensions in adults; and the Nature Relatedness-6 (NR-6) (Nisbet & Zelenski, 2013), a concise tool addressing affective and cognitive facets of nature connectedness. The distinct contribution of the NCEI lies in its incorporation of experiential and behavioural indicators such as pet ownership, tree planting and frequency of outdoor activities, thereby broadening ecological validity and enhancing relevance for educational and policy applications. Psychometric checks supported use of a composite CN score; summaries by sex and age did not suggest instability, although a formal multi-group invariance analysis was beyond the scope of this study. For reproducibility, the Supplement provides the complete item set, scoring weights and the algorithm used to compute the NCEI.

Despite its strengths, our study has limitations. First, self-reported responses may introduce recall and social desirability bias. Second, parental CN and NE were not considered, despite their likely influence on children's nature connectedness (Lee et al., 2021). Third, the study focuses on a Mediterranean region, which may limit the generalizability of findings to different cultural and environmental contexts. Fourth, while some socio-economic variables were included, additional factors such as parental education, occupation and family structure were not fully accounted for. Fifth, because participation in *Aire Limpio* was open to all schools, the programme frame included centres with and without prior outdoor learning or green infrastructure. Our analyses refer to the 50 randomly selected schools within this frame at the programme's starting point. Accordingly, levels of NE/CN should be interpreted within this frame—likely as upper bounds for the region—whereas associations by age, sex, inequality and urbanicity (estimated with clustered inference) appear internally valid and should be generalized with care beyond programme schools.

Framing generalization in this way matters because programme schools receive resources and training to promote outdoor learning; contexts without such support may display lower absolute levels even if the directional associations are similar.

Lastly, data collection occurred in spring (4 March–4 April 2022), a period that may encourage more outdoor activity and inflate absolute NE levels. Seasonality is a known correlate of children's outdoor time, with higher levels typically observed in warmer months than in winter (Lee et al., 2021). This concern is partly mitigated by our NED operationalisation using an annual frequency item and by the similar inferences obtained with the monthly item and our composite definition; even so, seasonal influence cannot be fully excluded and should be considered when generalizing absolute levels (see Table 5 for monthly vs. annual patterns).

To mitigate seasonal bias, the questionnaire included questions about nature engagement over the past month and year. Additionally, while self-reported measures are subject to overestimation, teacher-assisted responses helped improve accuracy. Future research should expand on these findings using longitudinal studies, diverse regional samples and objective CN and NE measures, such as wearable tracking devices, behavioural observations or physiological biomarkers of nature exposure.

Despite these limitations, the NCEI represents an important methodological advancement, providing quantifiable data to support educational and policy interventions aimed at enhancing children's connection with nature. The tool is particularly valuable for monitoring trends in youth nature engagement, identifying at-risk groups and guiding strategies to integrate outdoor learning experiences into school curricula.

Our findings indicate that a significant proportion of children and adolescents lack adequate CN and NE levels, underscoring the need for further research in school environmental health. Studies consistently show that spending time in green and blue spaces enhances well-being, sociability and academic performance (Díaz-Martínez, Sánchez-Sauco, Cabrera-Rivera, et al., 2023; Ortega-García, 2021).

However, modern lifestyles pose significant challenges to nature connectedness, including increased screen time, shrinking green spaces and heavier academic workloads (De Paula et al., 2021). To counteract this trend, schools should integrate outdoor activities into daily routines, expand green spaces and adapt to climate change to foster sustainable, nature-connected learning environments.

Beyond individual benefits, equitable access to natural spaces is a matter of social justice. CN and NE are unevenly distributed across socio-economic groups, emphasizing the need for urban planning and promoting inclusive environmental policies. Addressing these disparities will contribute to healthier, more cohesive communities.

5 | CONCLUSION

Key factors influencing NCEI include age, gender and socio-economic status. Younger children exhibit stronger nature connectedness, which declines with increasing academic and social pressures. Females consistently scored higher than males, reinforcing existing research on gender differences in environmental engagement. Additionally, urbanization and economic inequalities limit access to nature-based experiences, disproportionately affecting children in low-income communities.

Addressing this issue requires integrating nature engagement into educational frameworks, urban planning and public health policies. Schools should prioritize outdoor learning, governments should expand equitable access to green spaces, and urban planning should incorporate nature-connected design. Promoting early exposure to nature and fostering pro-environmental behaviours are essential steps towards sustainability, resilience and environmental stewardship in future generations.

Policymakers, educators and urban planners must collaborate to ensure that nature becomes a fundamental part of daily life, enhancing physical, mental and social well-being. The NCEI provides a valuable tool for monitoring trends, identifying at-risk populations, and guiding interventions to strengthen children's and adolescents' relationship with nature, ultimately shaping healthier and more environmentally conscious societies.

AUTHOR CONTRIBUTIONS

Conceptualization: Juan Antonio Ortega-García; data revision: Francisco Díaz-Martínez, Juan Antonio Ortega-García, Carmen Alicia Cánovas-Conesa and Laura Teresa Cabrera-Rivera; software: Juan Antonio Ortega-García; validation, Francisco Díaz-Martínez, Laura Teresa Cabrera-Rivera and Juan Antonio Ortega-García; formal analysis: Francisco Díaz-Martínez, Juan Antonio Ortega-García and Laura Teresa Cabrera-Rivera; investigation: Francisco Díaz-Martínez and Juan Antonio Ortega-García; resources: Juan Antonio Ortega-García; data curation: Francisco Díaz-Martínez; writing—original draft preparation: Francisco Díaz-Martínez, Juan Antonio Ortega-García and Laura Teresa Cabrera-Rivera; writing—review and editing: Francisco Díaz-Martínez, Carmen Alicia Cánovas-Conesa, Laura Teresa Cabrera-Rivera, Elena Codina, Rebeca Ramis, Luz Claudio and Juan Antonio Ortega-García; visualization: Francisco Díaz-Martínez, Juan Antonio Ortega-García; supervision: Juan Antonio Ortega-García; project administration: Juan Antonio Ortega-García and Luz Claudio; funding acquisition: Juan Antonio Ortega-García and Luz Claudio. All authors have read and agreed to the published version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

An anonymized dataset, analysis code and a data dictionary for this study are openly available in a DOI-backed repository (Zenodo: https://doi.org/10.5281/zenodo.17843507). All files contain no personal identifiers and comply with GDPR.

ETHICAL APPROVAL AND INFORMED CONSENT STATEMENTS

The study protocol was approved by the Ethics Committee of Hospital Clínico Universitario 'Virgen de la Arrixaca' on 29 June 2021 (CEIC code 2021-6-10-HCUVA). Given the anonymous, minimal risk nature of the school survey, the committee granted a waiver of written parental consent. Schools sent information letters with an opt-out option for parents/guardians, and students provided in-class assent. No personal identifiers were collected, and all procedures complied with GDPR and the Declaration of Helsinki.

ORCID

Juan Antonio Ortega-García https://orcid.org/0000-0001-8577-4168

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. Spanish version of the Nature Contact Questionnaire used in the study, including item content, scoring system, classification of levels of connection with nature, and recommendations provided to participants.

Appendix S2. Full item set and scoring procedure of the Nature Connection and Experience Index (NCEI), including Connection to Nature (CN), Nature Experiences (NE), and sociodemographic items, as well as score ranges and category definitions.

Appendix S3. Nature Connection and Experience Index (NCEI) in relation to sociodemographic and individual factors.

Appendix S4. Spearman correlation matrices showing relationships among Connection to Nature (CN) items, Nature Experience (NE) items, and composite scores (NCEI, CN, and NE).

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