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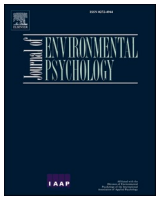

What types of nature exposure are associated with hedonic, eudaimonic and evaluative wellbeing? An 18-country study

Craig W. McDougall [a,b,*], Lewis R. Elliott [a], Mathew P. White [c], James Grellier [a,d], Simon Bell [e,f], Gregory N. Bratman [g], Mark Nieuwenhuijsen [h,i,j], Maria L. Lima [k], Ann Ojala [l], Marta Cirach [h], Anne Roiko [m], Matilda van den Bosch [h,i,j,n,o,p], Lora E. Fleming [a]

[a] European Centre for Environment and Human Health, University of Exeter, UK
[b] Scottish Collaboration for Public Health Research and Policy, University of Edinburgh, UK
[c] Vienna Cognitive Science Hub, University of Vienna, Austria
[d] Institute of Psychology, Jagiellonian University, Poland
[e] Estonian University of life Sciences, Tartu, Estonia
[f] Edinburgh School of Architecture and Landscape Architecture, Edinburgh College of Art, University of Edinburgh, UK
[g] School of Environmental and Forest Sciences, University of Washington, USA
[h] ISGlobal, Barcelona, Spain
[i] Universitat Pompeu Fabra (UPF), Barcelona, Spain
[j] CIBER Epidemiología y Salud Pública (CIBERESP), Madrid, Spain
[k] Department of Social and Organizational Psychology, University Institute of Lisbon, Portugal
[l] Natural Resources Institute Finland (Luke), Finland
[m] School of Medicine, Griffith University, Australia
[n] School of Population and Public Health, University of British Columbia, Canada
[o] Department of Forest and Conservation Sciences, University of British Columbia, Canada
[p] Biocities Facility, European Forest Institute, Rome, Italy

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ABSTRACT

Although spending time in nature can improve subjective wellbeing (SWB), little is known about how different types of nature exposure are associated with different dimensions of SWB or the consistency of associations across national/cultural contexts. Using data from 18 countries, associations between green, coastal and freshwater blue space exposures (including residential availability, visits 'yesterday' and visits in the previous four weeks) and hedonic, eudaimonic, and evaluative wellbeing were estimated. Overall, residential nature availability showed little association with any wellbeing outcome, whereas visiting green and coastal locations 'yesterday' was associated with better hedonic wellbeing. Although frequently visiting green, coastal and freshwater spaces were all associated with greater evaluative wellbeing, greater eudaimonic wellbeing was only associated with frequent visits to green and freshwater spaces. Variations existed across countries. Results suggest that different types of nature exposure vary in their association with different dimensions of SWB. Understanding these differences may help us maximise the potential of natural environments as SWB-promoting resources.

1. Introduction

Societal wellbeing is often measured by gross domestic product (GDP) and GDP per capita, although these metrics have a range of limitations (Giannetti et al., 2015). GDP has been criticised for failing to account for individuals' perceptions of their own wellbeing (Voukelatou et al., 2021) and relying solely on GDP as an indicator of societal wellbeing can lead to ill-advised national policies (Diener et al., 2018). A range of metrics have been suggested as more appropriate, or at least complementary, alternatives, better suited to measuring wellbeing (Cavalletti & Corsi, 2018). It is now recognised that subjective wellbeing (SWB) is an important indicator of societal performance (Das et al., 2020) and monitoring and promoting SWB has become an established practice in many countries (Austin, 2016; Diener, 2013).

* Corresponding author. European Centre for Environment and Human Health, University of Exeter, UK.
E-mail address: cmcdoug3@ed.ac.uk (C.W. McDougall).

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SWB is broadly defined as how people experience and evaluate their lives (Diener, 2000). Despite much debate, there is some agreement on what constitutes SWB. It is generally accepted that SWB is a multi-faceted and multi-dimensional construct that includes aspects of both the hedonic, and eudaimonic conceptions of wellbeing (Ryan and Deci, 2001) and there is now growing consensus that there are four key components of SWB that should be measured: a) positive and b) negative *hedonic* wellbeing, i.e. the emotions of pleasure (e.g. happiness) and pain (e.g. anxiety) individuals regularly experience; (c) *eudaimonic* wellbeing, i.e. how meaningful/worthwhile individuals think their behaviours/activities are; and (d) *evaluative* wellbeing, i.e. how well individuals think their life is going overall (ONS, 2011; OECD, 2013).

SWB can be influenced by a range of factors which typically fall under the remit of national or local governments including: crime (Krulichová, 2021), social capital (e.g., community cohesion) (Maass et al., 2016), housing quality (Badland et al., 2017), transport (Bokhari & Sharifi, 2022), public service provision (Isaacs et al., 2022), and urban planning (Mouratidis, 2021). Policy and decision-makers, globally, have attempted a range of strategies to improve SWB among populations. In recent years, provision of accessible urban nature has been proposed as a tool for increasing human health and wellbeing, including by the World Health Organisation (WHO) and the United Nations (UN) (Douglas et al., 2017).

A variety of studies have demonstrated the potential of natural environments to provide benefits for SWB (Huerta & Utomo, 2021; Mavoa et al., 2019; White et al., 2017; McDougall et al., 2022; Wood et al., 2017). For example, greater levels of green space surrounding a person's residence are associated with greater likelihood of reporting feelings of happiness (hedonic wellbeing) compared to lower levels/amounts (Patino et al., 2023). Measures of hedonic wellbeing often focus on the feelings of yesterday as asking about momentary wellbeing is impractical in most survey scenarios and as recalled wellbeing after a longer duration than 24 h may lead to memory accuracy fading (Kahneman et al., 2004; White & Dolan, 2009). For instance, Fisher et al. (2021) found individuals were more likely to report feelings of happiness yesterday if they had visited a green space for more than 25 min in the week prior to surveying. Living in greener areas (Mavoa et al., 2019) and visiting green space (Jiang & Huang, 2022) have also been associated with higher self-reported life satisfaction (evaluative wellbeing) relative to living in less green areas and not visiting green space, respectively.

Despite growing evidence suggesting exposure to natural environments can promote SWB, there are opportunities to progress this evidence as most studies overlook (a) actual exposure (e.g. visitation): to natural environments in favour of proxies for exposure; (b) distinctions between different types of natural environment; (c) distinctions between different components of SWB (e.g. hedonic, eudaimonic and evaluative); and (d) how each of the above is impacted by differing national and cultural contexts.

These limitations are important for several reasons. Firstly, epidemiological nature-wellbeing studies often utilise residential availability or proximity as a proxy to measure contact with natural environments (Gascon et al., 2017). Such metrics may represent reasonable proxies given that usage of natural environments is likely to decrease with increasing distance from the residence (Coombes et al., 2010; Elliott et al., 2020) and reduced accessibility (Ekkel & de Vries, 2017). However, it has also been argued that access metrics and contact with nature are weakly correlated (Jarvis et al., 2020) and a range of other factors also influence the likelihood of visiting nature such as home and work commitments and long-term illness (Boyd et al., 2018). Furthermore, access metrics are limited in their capability to quantify contact (Helbich, 2018) or to establish varying levels of contact with different natural environment types.

Self-reported accounts of nature exposure, such as recalled visit frequency, offer an opportunity to quantify an individual's exposure to different types of nature in a way that captures the heterogeneity of individual exposure. It should also be noted that nature can provide indirect benefits to SWB, which do not require visitation such as benefits related to reduction of air pollution, noise and heat (White et al., 2020). Despite progress in understanding the SWB-promoting potential of natural environments, untangling the unique SWB impacts of different types and levels of nature exposure remains a key research gap (McDougall et al., 2022).

Most studies on nature contact and SWB focus on only one of the dimensions of SWB (e.g., evaluative wellbeing (e.g. Knight et al., 2022; Patino et al., 2023), hedonic wellbeing (e.g. de Vries et al., 2021; MacKerron & Mourato, 2013) or eudaimonic wellbeing (see Lima & Mariano, 2022 for a review); and relatively few studies explore multiple dimensions in parallel (Fisher et al., 2021; Richardson et al., 2021; White et al., 2017). In one study, White et al. (2017) found that visiting nature yesterday (the day prior to surveying) was associated with greater happiness (positive hedonic wellbeing) and lower anxiety (negative hedonic wellbeing) yesterday; and visiting nature frequently in the last 12 months was associated with greater eudaimonic wellbeing. However, this study could not distinguish between different types of nature (e.g. green vs. blue), and thus was unable to investigate whether different settings might impact different dimensions of SWB.

Most research on natural environments and SWB has focused on green space (e.g. parks, woodlands and other vegetated areas) (Hong et al., 2021; Patino et al., 2023; Fisher et al., 2021; Jiminez et al., 2021). There is also growing interest in the wellbeing-promoting potential of other elements of the natural environment, such as water bodies or 'blue spaces'. Blue spaces are defined as 'outdoor environments – either natural or manmade – that prominently feature water and are accessible to humans' (Grellier et al., 2017).

Understanding the relative wellbeing-promoting potential from different natural environments can assist evidence-based policymaking and is particularly important given that blue and green space may have differing associations with SWB (McDougall et al., 2022). For example, higher neighbourhood greenness and more frequent green space visitation, but not coastal proximity or freshwater blue space availability, were associated with greater SWB in Melbourne, Australia (Mavoa et al., 2019). Contrastingly, McDougall et al. (2022) found frequently visiting coastal and freshwater blue space, but not public green space, was associated with higher SWB. Indeed, it has been hypothesised that blue spaces offer a range of unique therapeutic and health-promoting properties (Foley & Kistemann, 2015; Völker & Kistemann, 2011), and may be more suited to wellbeing-promotion than green space (McDougall et al., 2022)

The majority of blue space and SWB research has focused on the wellbeing benefits of visiting or living in close proximity to the sea (coastal blue space), with freshwater blue space often overlooked (Gascon et al., 2017). These two environments substantially differ in their physical and hydrological properties and the ecosystem services and amenity values they provide (McDougall et al., 2020). Furthermore, experiences at freshwater blue space are likely to consist of different scenery, smells, sounds, and recreation opportunities than experiences in coastal environments (Mavoa et al., 2019).

Emerging research suggests that spending time in and around freshwater blue space is associated with higher reports of happiness (de Vries et al., 2021). Visiting freshwater blue space has been associated with greater SWB (McDougall et al., 2022), lower perceived stress (Poulsen et al., 2022) and psychological benefits (de Bell et al., 2017). Although interest in the wellbeing-promoting potential of freshwater blue space is growing, empirical studies of the topic remain sparse; and there is a need for a clearer distinction between freshwater and coastal blue space and greater exploration of causation in future research (McDougall et al., 2020).

Lastly, a further criticism of nature-wellbeing research has been a lack of geographic and cultural diversity in study sites and populations (Gallegos-Riofrío et al., 2022); and it has been suggested that climatic and cultural differences may impact the influence of natural environments on SWB (Benita et al., 2019). Nature and SWB studies have been

primarily limited to single cities or countries (Gascon et al., 2017). Broadening the nature-wellbeing evidence-base to consider a wider variety of cultures, geographies, and climates is a key step in advancing current understanding, particularly as SWB (Diener, 2021), the role of nature in culture (Wheaton et al., 2020) and access to nature (Kabisch et al., 2016) vary across countries. Although comparisons of single-location studies and meta-analyses offer some value, ideally multi-location single studies are preferred to ensure comparability of wellbeing, exposure, and covariate variables.

The aim of the present study was thus to quantify the relationship between proximity and visits to green space, coastal and freshwater blue space, and multiple dimensions of SWB across 18 countries using harmonised survey data from the Horizon 2020 BlueHealth project (Grellier et al., 2017; Elliott & White, 2020). Our specific objectives were to investigate: (a) associations between residential availability of green, freshwater, and coastal space together with visits to these spaces in the *previous day* and positive hedonic wellbeing; (b) the same exposures' associations with negative hedonic wellbeing; (c) associations between residential availability of green, freshwater, and coastal space together with visits to these spaces in the *previous four weeks* and eudaimonic wellbeing; (d) the same exposures' associations with evaluative wellbeing; and (e) objectives a-d across 18 countries individually.

2. Methods

2.1. Overview

Data were obtained from the BlueHealth International Survey (BIS) (Elliott & White, 2020). BIS is an 18-country survey of health, wellbeing, and natural environment engagement carried out within the BlueHealth project (Grellier et al., 2017). BIS data have been used in studies focusing on different types of nature exposure including: childhood (Vitale et al., 2022), visit (Garrett et al., 2023) and neighbourhood exposures (Pasanen et al., 2023); for different mental health outcomes (White et al., 2021), including sub-samples with common mental health disorders (Tester-Jones et al., 2020); and more generic health outcomes (Elliott et al., 2023). However, to date, the BIS data have not been used to explore relations with different dimensions of SWB across different exposure types. Ethical approval for this research was granted by the University of Exeter's College of Medicine and Health Research Ethics Committee (Ref: Aug16/B/099).

2.2. Survey instrument and sampling

The BIS consisted of seven modules which focused on the following domains; (1) SWB; (2) natural environment visits; (3) perceptions of natural environments; (4) specific blue space visits; (5) economic valuation; (6) physical and mental health; and (7) demographics. The BIS was distributed in 18 countries/regions: Bulgaria, California (USA), Canada, Czechia, Estonia, Finland, France, Germany, Greece, Hong Kong (China), Ireland, Italy, Netherlands, Portugal, Queensland (Australia), Spain, Sweden, and the United Kingdom (UK). The BIS was distributed and administered via YouGov, an online panel provider who develop and maintain (or subcontract) a panel of participants in each of the countries/regions listed. In 14 countries, samples were recruited to reflect representative samples of the adult population based on region of residence and combined age/sex composition. In Estonia, Queensland (AU), and Hong Kong (CN), only combined age/sex composition was used, while in California (US), only age and sex (separately) were used. These decisions were based on the feasibility of recruiting such samples using the online panels. More specific information is provided in the technical report (Elliott & White, 2020).Sampling took place between June 2017 and April 2018 in four seasonal waves of data collection. Full details of the survey instrument and sampling process are available in the BlueHealth International Survey Methodology and Technical Report (Elliott & White, 2020).

2.3. Subjective wellbeing

SWB was measured using four questions developed and extensively tested by the UK's Office for National Statistics (ONS, 2011) and subsequently adopted by the Organisation of Economic Cooperation and Development (OECD, 2013). These SWB questions encompass hedonic, eudaimonic, and evaluative dimensions of SWB; and are, therefore, well-suited to distinguishing any unique variance applicable to each dimension of SWB and green/blue space proximity and visit metrics.

The four questions were: (1) 'Overall, how happy did you feel yesterday?' (Positive hedonic); (2) 'Overall, how anxious did you feel yesterday?' (Negative hedonic); (3) 'Overall, to what extent do you feel that the things you do in your life are worthwhile?' (Eudaimonic); and (4) 'Overall how satisfied are you with life nowadays?' (Evaluative). Responses were reported on an 11-point scale ranging from 0 (not at all) to 10 (completely).

Hedonic wellbeing questions asked participants about their feelings yesterday (the day prior to surveying) as recollections of wellbeing after a longer duration than 24 h may lead to memory accuracy fading (Kahneman et al., 2004; White & Dolan, 2009). Each SWB question has shown predictive validity for a range of outcomes of policy relevance (Hicks et al., 2013), as well as showing consistent patterns in previous nature-wellbeing research (de Bell et al., 2020; White et al., 2017).

2.4. Proximity and exposure to green and blue space

Three metrics of exposure to green space, coastal blue space and freshwater blue space were adopted; (1) objective residential availability of each; (2) self-reported visits to each in the day prior to survey completion (yesterday); and (3) self-reported visit frequency in the last 4-weeks.

2.4.1. Residential availability

The availability of green space, coastal and freshwater blue space within 1,000m of each participant's residence was quantified (Hogendorf et al., 2020; Klompmaker et al., 2018). Participants provided the location of their residence using a Google Maps application programming interface, with coordinates rounded to three decimal degrees to preserve anonymity, resulting in 55m error on average. Natural environment coverage was captured via the GlobeLand30 land cover map (Chen et al., 2015), derived from globally consistent 30m resolution imagery, containing ten different land cover classes in the baseline year of 2010.

Green space was defined as land cover classes classified as "forests", "grassland", "shrub land" and "cultivated land" with a Minimum Mapping Unit (MMU) between 8 and 10 square pixels each, meaning that the smallest feature represented in a map is 240–300 m^2. Freshwater blue space was defined as land classified as "water bodies" representing lakes and rivers or "wetlands" with an MMU of around 270 m^2. The presence of coastal blue space was captured via the Global Self-consistent Hierarchical High-resolution Geography shoreline database from the National Oceanic and Atmospheric Administration (Wessel & Smith, 1996).

Buffer zones of 1,000m around participant residences were chosen to represent a 10–15 min walk (Hogendorf et al., 2020; Klompmaker et al., 2018; Smith et al., 2017). The percentage of residential green space coverage within the buffer zone was calculated and divided into quartiles. Freshwater and coastal availability were operationalised as the presence or absence of each within a 1,000m buffer surrounding a participant's home (White et al., 2021). Spatial analyses were performed using Python and PostGIS extension (PostgreSQL).

2.4.2. Visits yesterday

Participants were asked whether they had visited a series of green, coastal, and freshwater environments in the day prior to surveying (Garrett et al., 2023). Responses to 12 greenspace types, six freshwater

blue space types and, eight coastal blue space types were collapsed into green, coastal, and freshwater variables. The resulting three variables were operationalised as whether a participant did or did not (reference category) visit any of the natural environment types yesterday. Focusing on specific visits yesterday minimised recall bias, memory fading and aligned with the recall period of the positive and negative hedonic wellbeing questions adopted in this study.

2.4.3. Visit frequency

Visit frequency to the same series of natural environment types was self-reported for the previous four weeks (McDougall et al., 2022; White et al., 2021). Visit frequency was operationalised as four categories: zero visits (reference category); visiting less than weekly (<4 visits); visiting weekly (4 visits); and more than weekly (>4 visits). The groupings of natural environment types were collapsed as above.

2.5. Covariates

A number of demographic and socioeconomic covariates which have been shown to influence SWB and/or nature visits were captured in the survey and utilised in the analysis including: age (Steptoe et al., 2015), sex (Graham & Chattopadhyay, 2013), disability or long-term limiting illness (Boyd et al., 2018; van Campen and van Santvoort, 2013), the number of days participants completed more than 30 min of physical activity (Román et al., 2023), education level, perceived household income status, employment status, relationship status and the number of adults and children in the household (Andrade et al., 2022; Das et al., 2020; Diener et al., 2018; Lamu & Olsen, 2016), dog ownership (White et al., 2021; Barcelos et al., 2020) and car ownership (Gan et al., 2018), Whether the day prior to surveying was during the week or weekend was also included as a covariate to account for potential day-of-the week related variations in SWB reporting (Csikszentmihalyi & Hunter, 2003). Following White et al. (2017), the analysis also controlled for different dimensions of SWB, which were not the dependent variable, to fully capture the unique variance attributable to hedonic, eudaimonic and evaluative wellbeing respectively (see section 2.6 for full details).

The covariate variables were operationalised as follows: sex (female = ref; male); age (16–29 years = ref; 30–39 years; 40–49 years; 50–59 years; ≥60 years); longstanding illness or disability (no = ref, yes); educational level (no higher education = ref; completed higher education); perceived income (struggling = ref; coping; comfortable); employment status (employed; unemployed = ref); relationship status (single = ref; married or cohabiting); number of children in household (zero = ref; 1; ≥2); number of adults in household (1 = ref; 2; >2); dog ownership (no = ref; yes); car ownership (no = ref; yes); weekly days of physical activity ≥30 min (0 = ref; 1–4, ≥5); and day of surveying (weekday = ref; weekend).

2.6. Statistical analysis

A total of 16,309 participants across eighteen countries/regions were used in the current analysis. The original sample consisted of 18,484 participants and 2175 were removed as one or more variables (primarily home locations using the mapping tool) were missing. Statistical analyses were carried out in Stata version 17.0 (StataCorp LLC, College Station, TX) and visualisation in R v4.1.3 (R Core Team, 2022). A series of linear mixed effects models were developed to quantify the relationship between proximity and exposure to green space, coastal and freshwater blue space and each dimension of SWB. All models included participant country/region of residence as a random intercept term to account for possible measurement invariance with regards to SWB outcomes (White et al., 2021).

Associations between each dimension of SWB and covariates were reported as model coefficients with 95% confidence intervals. Examination of variance inflation factors (VIFs) suggested multicollinearity was not present in the data and covariates were sufficiently independent of each other. Four models were developed for each dimension of SWB (positive and negative hedonic, eudaimonic and evaluative) to determine the unique variance applicable to each wellbeing dimension and exposure metric. A summary of each model is provided in Table 1.

The models for positive and negative hedonic wellbeing included: (Model 1/Model 5) residential availability of each natural environment type; (Model 2/Model 6) residential availability and visits yesterday to each natural environment type; (Model 3/Model 7) residential availability and visits yesterday to each natural environment type, controlling for all listed covariates; and (Model 4/Model 8) residential availability and visits yesterday to each natural environment type, controlling for all listed covariates and the alternative SWB dimension (e.g. negative hedonic in the positive hedonic model and positive hedonic in the negative hedonic model).

The models for eudaimonic and evaluative wellbeing included: (Model 9/Model 13) residential availability of each natural environment type; (Model 10/Model 14) residential availability and visit frequency to each natural environment type; (Model 11/Model 15) residential availability and visit frequency to each natural environment type, controlling for all listed covariates; and (Model 12/Model 16) residential availability and visit frequency to each natural environment type, controlling for all listed covariates and the alternative wellbeing dimension (e.g. eudaimonic in the evaluative model and evaluative in the eudaimonic model).

Table 1
Summary of variables included in each model. (–) indicates variables not included.

Model Name	Wellbeing Outcome	Residential Availability	Visits Type	Covariates	Wellbeing Adjustment
M1	Positive Hedonic	Yes	–	–	–
M2	Positive Hedonic	Yes	Visit Yesterday	–	–
M3	Positive Hedonic	Yes	Visit Yesterday	Yes	–
M4	Positive Hedonic	Yes	Visit Yesterday	Yes	Negative Hedonic
M5	Negative Hedonic	Yes	–	–	–
M6	Negative Hedonic	Yes	Visit Yesterday	–	–
M7	Negative Hedonic	Yes	Visit Yesterday	Yes	–
M8	Negative Hedonic	Yes	Visit Yesterday	Yes	Positive Hedonic
M9	Eudaimonic	Yes	–	–	–
M10	Eudaimonic	Yes	Visits in Previous Week	–	–
M11	Eudaimonic	Yes	Visits in Previous Week	Yes	–
M12	Eudaimonic	Yes	Visits in Previous Week	Yes	Evaluative
M13	Evaluative	Yes	–	–	–
M14	Evaluative	Yes	Visits in Previous Week	–	–
M15	Evaluative	Yes	Visits in Previous Week	Yes	–
M16	Evaluative	Yes	Visits in Previous Week	Yes	Eudaimonic

Fully-adjusted models were then stratified by country so that the relationships could be examined for each of the 18 countries/regions separately. Due to substantial reductions in sample size in these models, the four-week visit frequency categories used in the eudaimonic and evaluative wellbeing models were collapsed into two groups: (1) zero visits or visiting less than weekly (reference category); and (2) visiting weekly or more than weekly. Of note, visiting nature weekly has been used as a key threshold for health benefits in previous work (Shanahan et al., 2016).

Table 2
Summary statistics of subjective wellbeing (SWB), residential availability, visitation and covariates.

Variable	mean	SD	Variable	n	%
SWB			**Sex**		
Positive hedonic	6.85	2.18	Female	8303	50.91
Negative hedonic	3.97	3.97	Male	8006	49.09
Eudaimonic wellbeing	7.37	1.87	**Disability status**		
Evaluative wellbeing	7.01	1.82	No	10,344	63.43
			Yes (to some extent)	5965	36.57
	n	**%**	**Physical activity**		
Residential availability			Zero PA	4195	25.72
Green space [Q1]	4079	25.01	0-4 PA days	8846	54.24
Green space [Q2]	4077	25	≥5 PA days	3268	20.04
Green space [Q3]	4075	24.99	**Perceived income status**		
Green space [Q4]	4078	25	Struggling	4091	25.08
Coastal blue space [No]	14,513	88.99	Coping	7648	46.89
Coastal blue space [Yes]	1796	11.01	Comfortable	4570	28.02
Freshwater blue space [No]	10,148	62.22	**Education status**		
Freshwater blue space [Yes]	6161	37.78	No higher education	7934	48.65
Visit yesterday			Yes higher education	8375	51.35
Green space [No]	8114	49.75	**Unemployment status**		
Green space [Yes]	8195	50.25	Unemployed	1025	6.28
Coastal [No]	14,095	86.42	Not unemployed	15,284	93.72
Coastal [Yes]	2214	13.58	**Relationship status**		
Freshwater [No]	12,740	78.12	Single	6634	40.68
Freshwater [Yes]	3569	21.88	Married or cohabiting	9675	59.32
Visits in last four weeks			**Children in household**		
Green space [zero]	1913	11.73	0	11,704	72
Green space [less than weekly]	4673	28.65	1	2496	15
Green space [weekly]	4127	25.31	≥2	2109	12.93
Green space [more than weekly]	5596	34.31	**Adults in household**		
Coastal [zero]	7851	48.14	1	3262	20
Coastal [less than weekly]	4757	29.17	2	5577	34.2
Coastal [weekly]	1834	11.25	>2	7470	45.8
Coastal [more than weekly]	1867	11.45	**Dog ownership**		
Freshwater [zero]	4423	27.12	No	11,310	69.35
Freshwater [less than weekly]	5749	35.25	Yes	4999	30.65
Freshwater [weekly]	3168	19.42	**Car ownership**		
Freshwater [more than weekly]	2969	18.2	No	2846	17.45
Age			Yes	13,463	82.55
18–29	3088	18.93	**Day prior to surveying**		
30–39	2997	18.38	Weekday	13,252	81.26
40–49	3045	18.67	Weekend	3057	18.74
50–59	2959	18.14			
60+	4220	25.88			

3. Results

3.1. Descriptive statistics

Table 2 summarises the SWB responses and socioeconomic and demographic characteristics of the sample. The analytical sample was composed of 8303 females (51%) and 8006 males (49%) and was spread consistently across the five collected age categories (suggesting the loss of participants to missing data was not systematic). Mean positive hedonic wellbeing and negative hedonic wellbeing were 6.85 (SD: 2.18) and 3.97 (SD: 2.81), respectively. Mean eudaimonic wellbeing was 7.37 (SD: 1.87) and mean evaluative wellbeing was 7.01 (SD: 1.82).

Fig. 1 shows the mean wellbeing values for each of the countries and regions included in the analysis. Canada (7.27) exhibited the highest mean value of positive hedonic wellbeing and Greece (5.56) exhibited the highest mean value of negative hedonic wellbeing. The lowest mean positive hedonic wellbeing was reported in Hong Kong (6.23) and the lowest mean negative hedonic wellbeing was reported in the Netherlands (2.68). The Netherlands (7.44) exhibited the highest mean evaluative wellbeing and Portugal exhibited the highest mean eudaimonic wellbeing (7.72). The lowest mean evaluative wellbeing was reported in Greece (6.15) and the lowest mean eudaimonic wellbeing was reported in Hong Kong (6.70).

Table 2 also summarises residential availability, visits in the last four weeks and visits in the day prior to surveying for green space and coastal and freshwater blue space. Approximately 11% and 38% of the sample resided within 1,000m of coastal and freshwater blue space respectively. Green space was the most visited natural environment category. In the last four weeks, only 12% of the sample did not visit a green space. Contrastingly, 48% of the sample did not visit coastal blue space in the last four weeks and 27% did not visit freshwater blue space.

Green spaces were also visited more frequently (more than weekly) than both types of blue space in the last four weeks. Approximately 34% of the sample visited green spaces frequently, while coastal and freshwater blue space were visited frequently by 11% and 18% of the sample, respectively. A similar trend was present for visits taken yesterday. Around half of participants (50.25%) reported visiting a green space yesterday compared to only 14% for coastal blue space and 22% for freshwater blue space.

3.2. Inferential statistics

Fig. 2 displays the fully adjusted relationships between all four dimensions of SWB and proximity (residential availability) and exposure (visits yesterday and in the last four weeks) to green space, coastal blue space and freshwater blue space. Unadjusted and adjusted model results (without results for each covariate) are displayed for positive hedonic wellbeing (Table 3), negative hedonic wellbeing (Table 4), eudaimonic wellbeing (Table 5) and evaluative wellbeing (Table 6). Supplementary Tables 1–16 show the same models including results for all covariates in full.

3.2.1. Positive hedonic wellbeing

3.2.1.1. Residential availability. Positive hedonic wellbeing models are displayed in Table 3. No significant associations were observed between residing in areas with higher coverage of green space or near coastal or freshwater blue space and positive hedonic wellbeing (self-reported feelings of happiness in the day prior to surveying) in any of the final adjusted models.

3.2.1.2. Visits (yesterday). Mixed associations were observed between visiting each natural environment type in the day prior to surveying and positive hedonic wellbeing. Visiting green space in the day prior to completing the survey was significantly associated with higher reports

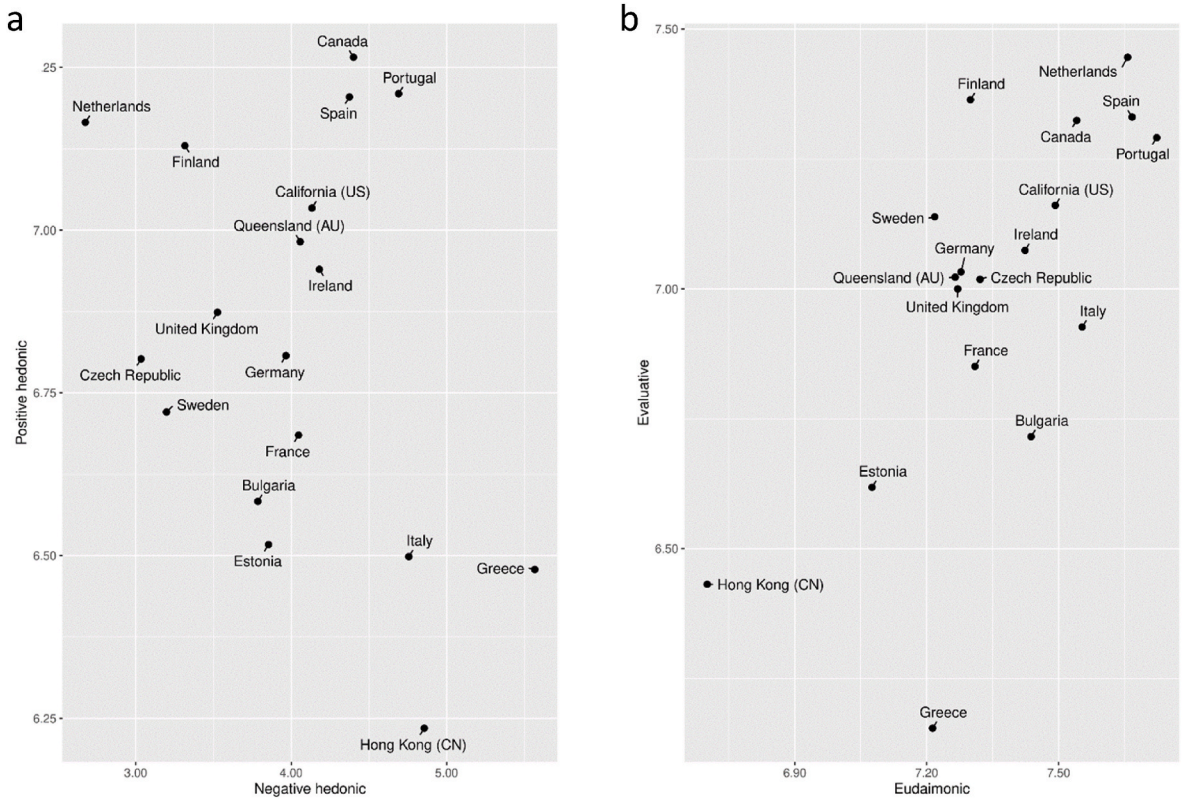

Fig. 1. Mean values of each SWB dimension for each country/region included in the analysis.

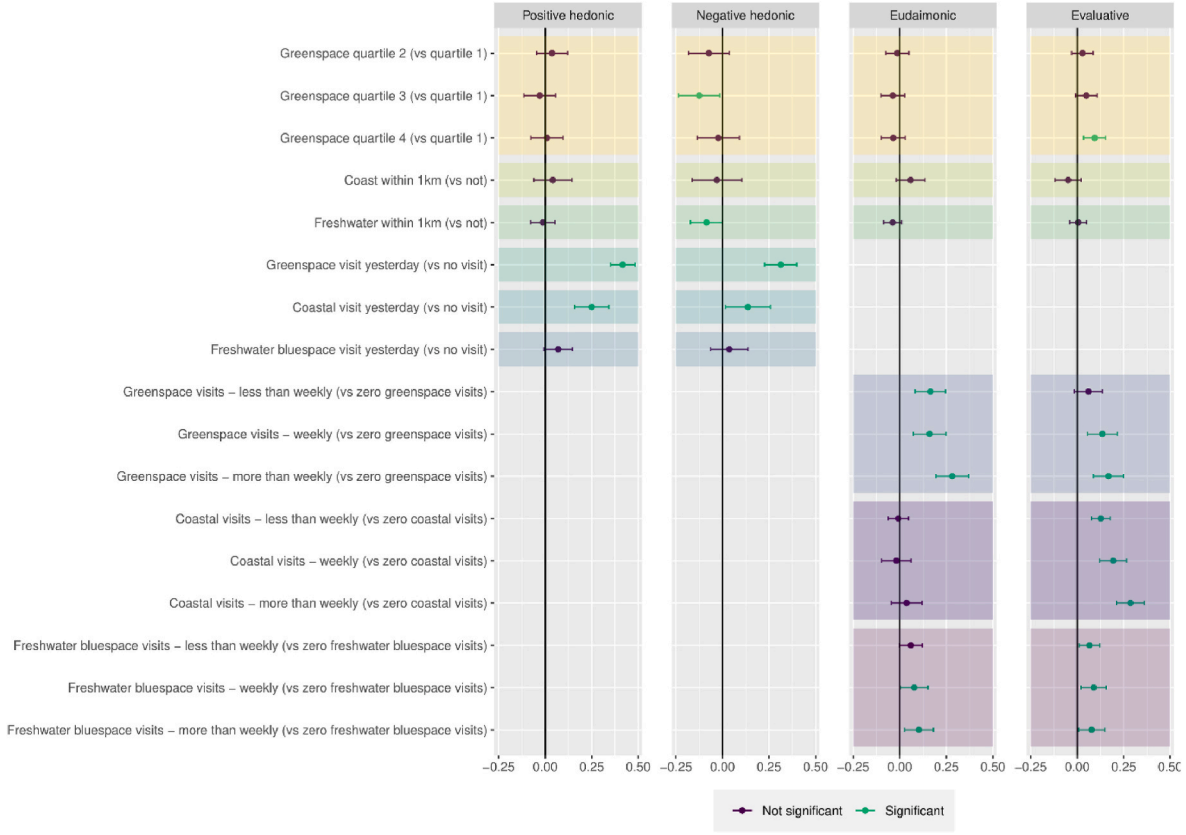

Fig. 2. Summary of fully adjusted models of all dimensions of SWB and residential availability and visits to green space, coastal blue space and freshwater blue space. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 3
Models of residential availability and visits 'yesterday' to green space, coastal and freshwater blue space and positive hedonic wellbeing displayed as regression coefficients (β) with Upper (U) and Lower (L) 95% Confidence Intervals (CI) and Intraclass Correlation Coefficient (ICC). ***p < 0.001, **p.0.01, *p < 0.05.

Positive hedonic wellbeing (happiness yesterday)	M1			M2			M3			M4		
	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI	B	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI
Green space within 1000m												
Q1	REF			REF			REF			REF		
Q2	0.07	−0.02	0.17	0.07	−0.03	0.16	0.06	−0.03	0.15	0.04	−0.05	0.12
Q3	0.07	−0.03	0.16	0.03	−0.07	0.12	0.00	−0.09	0.09	−0.03	−0.11	0.06
Q4	**0.14*** **	0.04	0.24	0.07	−0.02	0.17	0.02	−0.07	0.11	0.01	−0.08	0.10
Coast within 1000m												
No	REF			REF			REF			REF		
Yes	**0.15****	0.03	0.26	0.09	−0.02	0.21	0.05	−0.06	0.16	0.04	−0.06	0.14
Freshwater within 1000m												
No	REF			REF			REF			REF		
Some	0.00	−0.08	0.07	−0.02	−0.09	0.06	0.01	−0.06	0.08	−0.01	−0.08	0.05
Green space yesterday												
No	REF			REF			REF			REF		
Yes	NA			**0.53*** **	0.46	0.61	**0.38*** **	0.31	0.45	**0.42*** **	0.35	0.48
Coastal yesterday												
No	REF			REF			REF			REF		
Yes	NA			**0.32*** **	0.22	0.43	**0.24*** **	0.14	0.33	**0.25*** **	0.16	0.34
Freshwater yesterday												
No	REF			REF			REF			REF		
Yes	NA			**0.09***	0.00	0.17	0.07	−0.01	0.15	**0.07***	−0.01	0.15
Covariates	NA			NA			Yes			Yes		
Negative hedonic wellbeing (anxiety yesterday)	NA			NA			NA			**−0.22*** **	−0.24	−0.21
Constant	**6.76*** **	6.60	6.91	**6.46*** **	6.29	6.63	**5.00*** **	4.73	5.12	**6.06*** **	5.84	6.28
R^2	0.0006			0.0166			0.1547			0.2262		
ICC	0.01			0.04			0.02			0.02		

of positive hedonic wellbeing (β = 0.42, 95% CI = 0.35–0.48), relative to not visiting green space in the day prior. Visiting coastal blue space yesterday was also associated with reporting higher positive hedonic wellbeing yesterday, compared to not visiting (β = 0.25, 95% CI = 0.16–0.34). Visiting freshwater blue space in the day prior was not significantly associated with positive hedonic wellbeing.

3.2.2. Negative hedonic wellbeing

3.2.2.1. Residential availability. Negative hedonic wellbeing models are displayed in Table 4. Residing in areas with more green space (Quartile 3 β = −0.13, 95% CI = −0.24 to −0.01) was significantly associated with lower self-reported negative hedonic wellbeing (feelings of anxiety) in the day prior to surveying compared to areas with lower levels of green space (Quartile 1). Residing in close proximity to freshwater blue space was also significantly associated with lower self-reported feelings of anxiety in the day prior to surveying (β −0.09, 95% CI = −0.17 - 0.00).

3.2.2.2. Visits (yesterday). Visiting green space (β = 0.31, 95% CI = 0.23 0.40) and coastal blue space (β = 0.14, 95% CI = 0.02–0.26) in the day prior to completing the survey were both significantly associated with reporting greater feelings of anxiety (negative hedonic wellbeing). Visiting freshwater blue space in the day prior to surveying was not significantly associated with negative hedonic wellbeing.

3.2.3. Eudaimonic wellbeing

3.2.3.1. Residential availability. Eudamonic wellbeing models are displayed in Table 5. No significant associations were identified between living in areas with high green space or living in close proximity to coastal or freshwater blue space and eudaimonic wellbeing.

3.2.3.2. Visits (last four weeks). Each category of green space visits in the last four weeks was significantly associated with higher reports of eudaimonic wellbeing relative to zero visits. Visiting green spaces more than weekly (β = 0.28, 95% CI = 0.19–0.37) had a larger coefficient value than visiting weekly (β = 0.16, 95% CI = 0.07–0.25) and less than weekly (β = 0.16, 95% CI = 0.08–0.25). Although visiting coastal blue space in the last four weeks was significantly associated with higher reports of eudaimonic wellbeing in unadjusted models (M10 and M11), no significant association was observed for any frequency of coastal blue space visits in the last four weeks and eudaimonic wellbeing once controls for evaluative wellbeing were included (M4). Visiting freshwater blue space weekly (β = 0.08, 95% CI = 0.00–0.15) and more than

Table 4
Models of residential availability and visits 'yesterday' to green space, coastal and freshwater blue space and negative hedonic wellbeing displayed as regression coefficients (β) with Upper (U) and Lower (L) 95% Confidence Intervals (CI) and Intraclass Correlation Coefficient (ICC). ***p < 0.001, **p.01, *p < 0.05.

Negative hedonic wellbeing (anxiety yesterday)	M5			M6			M7			M8		
	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI
Green space within 1000m												
Q1	REF			REF			REF			REF		
Q2	−0.11	−0.23	0.01	−0.11	−0.23	0.01	−0.10	−0.21	0.02	−0.07	−0.18	0.04
Q3	**−0.15***	−0.27	−0.03	**−0.16****	−0.28	−0.04	**−0.13***	−0.24	−0.01	**−0.13***	−0.24	−0.01
Q4	−0.12	−0.24	0.00	**−0.13***	−0.26	−0.01	−0.03	−0.15	0.09	−0.02	−0.14	0.09
Coast within 1000m												
No	REF			REF			REF			REF		
Yes	−0.13	−0.28	0.01	−0.12	−0.27	0.02	−0.05	−0.19	0.09	−0.03	−0.16	0.10
Freshwater within 1000m												
No	REF			REF			REF			REF		
Some	−0.06	−0.16	0.03	−0.07	−0.16	0.03	**−0.09***	−0.18	0.00	**−0.09***	−0.17	0.00
Green space yesterday												
No	REF			REF			REF			REF		
Yes	NA			**0.16*****	0.07	0.25	**0.16*****	0.07	0.25	**0.31*****	0.23	0.40
Coastal yesterday												
No	REF			REF			REF			REF		
Yes	NA			−0.03	−0.17	0.10	0.04	−0.08	0.17	**0.14***	0.02	0.26
Freshwater yesterday												
No	REF			REF			REF			REF		
Yes	NA			−0.01	−0.12	0.09	0.01	−0.09	0.11	0.04	−0.06	0.14
Covariates	NA			NA			Yes			Yes		
Positive hedonic wellbeing (happiness yesterday)	NA			NA			NA			**−0.39*****	−0.41	−0.37
Constant	**4.16*****	3.83	4.49	**4.09*****	3.76	4.42	4.92***	4.53	5.31	**6.84*****	6.45	7.24
R^2	0.0061			0.0081			0.0899			0.1668		
ICC	0.06			0.06			0.06			0.06		

weekly (β = 0.10, 95% CI = 0.02–0.18) were both significantly associated with reports of higher eudaimonic wellbeing.

3.2.4. Evaluative wellbeing

3.2.4.1. Residential availability. Evaluative wellbeing models are displayed in Table 6. Residing in areas with high green space coverage (Quartile 4) was significantly associated with higher reports of evaluative wellbeing (β = 0.09, 95% CI = 0.03–0.15), relative to residing in areas with low green space coverage (Quartile 1). No significant differences in evaluative wellbeing were observed between areas of low (Quartile 1) and moderate (Quartile 2 and Quartile 3) green space coverage. Similarly, no significant associations were observed between residing in close proximity to coastal nor freshwater blue space and evaluative wellbeing.

3.2.4.2. Visits (last four weeks). Visiting any type of natural environment in the last four weeks was associated with reporting higher evaluative wellbeing. For each natural environment type, larger coefficient values were apparent for higher visit frequencies. Frequently visiting green space (β = 0.17, 95% CI = 0.09–0.25), coastal blue space (β = 0.29, 95% CI = 0.21–0.36) and freshwater blue space (β = 0.08, 95% CI = 0.01–0.15) were all significantly associated with higher reports of evaluative wellbeing compared to not visiting at all in the last four weeks.

A reduction in coefficient values was observed in the fully adjusted model, which included controls for eudaimonic wellbeing (M16). For example, the association between evaluative wellbeing and frequent coastal blue space visits was greater without a eudaimonic control (β = 0.44, 95% CI = 0.36–0.54) (M15), relative to the final model which included a eudaimonic control (β = 0.29, 95% CI = 0.21–0.36) (M16).

3.3. Country stratification

Fig. 3 displays the fully adjusted relationships between all four dimensions of SWB and exposure (visits yesterday for hedonic wellbeing and in the last four weeks for evaluative and eudaimonic wellbeing) to green space, coastal blue space and freshwater blue space for each of the 18 countries/regions included in the analysis.

A significant positive association (minimum p < 0.05) was observed between visiting green space yesterday and positive hedonic wellbeing in 13/18 countries. Only Italy and France reported a significant positive association between positive hedonic wellbeing and visiting the coast yesterday. Italy was the only country where a significant association was reported for visiting freshwater in the day prior to surveying and positive hedonic wellbeing.

Significant positive associations (minimum p < 0.05) were observed

Table 5
Models of residential availability and visit frequency to green space, coastal and freshwater blue space and eudaimonic wellbeing displayed as regression coefficients (β) with Upper (U) and Lower (L) 95% Confidence Intervals (CI) and Intraclass Correlation Coefficient (ICC). ***p < 0.001, **p.0.01, *p < 0.05.

Eudaimonic wellbeing	M9			M10			M11			M12		
	B	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI
GS within 1000m												
Q1	REF			REF			REF			REF		
Q2	0.03	−0.05	0.11	0.01	−0.07	0.09	0.01	−0.07	0.08	−0.01	−0.08	0.05
Q3	0.07	−0.01	0.15	0.03	−0.05	0.11	−0.01	−0.09	0.07	−0.04	−0.10	0.03
Q4	**0.17***	0.09	0.26	0.10	**0.02***	0.19	0.03	−0.04	0.11	−0.04	−0.10	0.03
Coast within 1000m												
No	**REF**			**REF**			**REF**			**REF**		
Yes	**0.16***	0.06	0.26	0.05	−0.05	0.15	0.04	−0.05	0.13	0.06	−0.02	0.14
Freshwater within 1000m												
No	**REF**			**REF**			**REF**			**REF**		
Some	−0.06	−0.12	0.01	**−0.07***	−0.14	−0.01	−0.05	−0.10	0.01	−0.04	−0.09	0.01
Green space visits												
Zero visits	**REF**			**REF**			**REF**			**REF**		
Less than weekly	NA			**0.41***	0.30	0.51	**0.30***	0.20	0.40	**0.16***	0.08	0.25
Weekly	NA			**0.55***	0.44	0.66	**0.36***	0.25	0.46	**0.16***	0.07	0.25
More than weekly	NA			**0.80***	0.69	0.91	**0.57***	0.46	0.67	**0.28***	0.19	0.37
Coastal visits												
Zero visits	**REF**			**REF**			**REF**			**REF**		
Less than weekly	NA			**0.17***	0.10	0.24	**0.10***	0.04	0.17	−0.01	−0.06	0.05
Weekly	NA			**0.16***	0.06	0.26	**0.15***	0.05	0.24	−0.02	−0.10	0.06
More than weekly	NA			**0.42***	0.31	0.52	**0.31***	0.21	0.41	0.04	−0.05	0.12
Freshwater visits												
Zero visits	**REF**			**REF**			**REF**			**REF**		
Less than weekly	NA			**0.23***	0.15	0.30	**0.15***	0.07	0.22	0.06	0.00	0.12
Weekly	NA			**0.25***	0.16	0.34	**0.19***	0.10	0.28	**0.08***	0.00	0.15
More than weekly	NA			**0.27***	0.17	0.37	**0.22***	0.13	0.32	**0.10****	0.02	0.18
Covariates	NA			NA			Yes			Yes	NA	
Evaluative wellbeing	NA			NA			NA			**0.62***	0.61	0.63
Constant	**7.29***	7.17	7.42	**6.52***	6.37	6.67	**5.30***	5.11	5.49	**2.31***	2.14	2.48
R^2	0.0007			0.0379			0.1494			0.4236		
ICC	0.02			0.02			0.01			0.01		

between visiting green space and negative hedonic wellbeing (greater feelings of anxiety) in half (9/18) of the studied countries. Queensland, Australia was the only location where coastal visitation yesterday was significantly negatively associated with negative hedonic wellbeing (reduced feelings of anxiety). Significant associations were reported between visiting the coast yesterday and greater feelings of anxiety (negative hedonic wellbeing) in Canada and France. California was the only location where significant association was reported for visiting freshwater in the day prior to surveying and negative hedonic wellbeing.

Significant associations between at least weekly visits to green space in the last four weeks and eudaimonic wellbeing were observed in three countries (Bulgaria, Germany and Hong Kong) and between at least weekly visits to freshwater blue space and eudaimonic wellbeing in three countries (Czechia, Italy, and Portugal). No significant associations were found between visiting the coast in the last four weeks and eudaimonic wellbeing in any country.

Half (9/18) countries/regions showed significant positive associations between evaluative wellbeing and visits to at least one type of natural environment in the last four weeks. Significant positive associations were observed between evaluative wellbeing and at least weekly visits to green space (Italy, California, Portugal, Queensland), coastal blue space (France, Ireland, Italy, the Netherlands, Queensland and Spain) and freshwater blue space (Canada and Italy).

4. Discussion

This study aimed to quantify the relationship between proximity and exposure to green space, coastal and freshwater blue space and hedonic, eudaimonic, and evaluative dimensions of SWB across 18 countries. Collectively, our findings align with previous suggestions of a positive and multidimensional relationship between spending time in and around natural environments and SWB (Fisher et al., 2021; Huerta & Utomo, 2021; Mavoa et al., 2019; McDougall et al., 2022; Sharifi et al., 2021; White et al., 2017; Wood et al., 2017). However, our results also indicate that these relationships can differ by: (1) natural environment type; (2) dimension of SWB; and (3) country/region.

Table 6
Models of residential availability and visit frequency to green space, coastal and freshwater blue space and evaluative wellbeing displayed as regression coefficients (β) with Upper (U) and Lower (L) 95% Confidence Intervals (CI) and Intraclass Correlation Coefficient (ICC). ***p < 0.001, **p.0.01, *p < 0.05.

	M13			M14			M15			M16		
	B	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI	β	U. 95% CI	L. 95% CI
GS within 1000m												
Q1	REF			REF			REF			REF		
Q2	0.04	−0.04	0.12	0.03	−0.05	0.10	0.03	−0.04	0.10	0.03	−0.03	0.09
Q3	**0.10***	0.02	0.18	0.05	−0.02	0.13	0.04	−0.03	0.12	0.05	−0.01	0.11
Q4	**0.21*****	0.13	0.29	**0.14*****	0.06	0.22	**0.11*****	0.04	0.18	**0.09*****	0.03	0.15
Coast within 1000m												
No	**REF**			**REF**			**REF**			**REF**		
Yes	**0.13****	0.04	0.23	−0.02	−0.12	0.07	−0.02	−0.11	0.06	−0.05	−0.12	0.02
Freshwater within 1000m												
No	**REF**			**REF**			**REF**			**REF**		
Some	−0.03	−0.09	0.03	−0.05	−0.11	0.01	−0.02	−0.07	0.04	0.01	−0.04	0.05
Green space visits												
Zero visits	**REF**			**REF**			**REF**			**REF**		
Less than weekly	NA			**0.35*****	0.25	0.45	**0.21*****	0.12	0.31	0.06	−0.01	0.13
Weekly	NA			**0.55*****	0.44	0.65	**0.32*****	0.23	0.42	**0.14*****	0.06	0.22
More than weekly	NA			**0.72*****	0.61	0.82	**0.46*****	0.37	0.56	**0.17*****	0.09	0.25
Coastal visits												
Zero visits	**REF**			**REF**			**REF**			**REF**		
Less than weekly	NA			**0.27*****	0.21	0.34	**0.18*****	0.12	0.24	**0.13*****	0.08	0.18
Weekly	NA			**0.32*****	0.23	0.42	**0.27*****	0.18	0.36	**0.19*****	0.12	0.27
More than weekly	NA			**0.60*****	0.49	0.70	**0.45*****	0.36	0.54	**0.29*****	0.21	0.36
Freshwater visits												
Zero visits	**REF**			**REF**			**REF**			**REF**		
Less than weekly	NA			**0.26*****	0.19	0.34	**0.14*****	0.07	0.21	**0.07***	0.01	0.12
Weekly	NA			**0.30*****	0.21	0.39	**0.19*****	0.11	0.27	**0.09****	0.02	0.16
More than weekly	NA			**0.28*****	0.19	0.38	**0.19*****	0.11	0.28	**0.08***	0.01	0.15
Covariates	NA			NA			Yes			Yes		
Eudaimonic wellbeing	NA			NA			NA			**0.52*****	0.51	0.53
Constant	**6.90*****	6.74	7.07	**6.08*****	5.89	6.28	**4.83*****	4.63	5.03	**2.08*****	1.91	2.25
R^2	0.0021			0.0423			0.2371			0.4830		
ICC	0.03			0.04			0.03			0.03		

4.1. Residential availability and SWB

Residing in close proximity to natural environments had limited associations with hedonic and eudaimonic wellbeing; and a significant association with evaluative wellbeing, in the case of individuals living in the greenest areas. Our findings, support the notion that simply residing in close proximity to natural environments is less important than contact with or visits to natural environments when considering pathways between nature and hedonic, eudaimonic, and evaluative wellbeing. These findings were somewhat anticipated as both proximity and access to blue and green space are important determinants of visits (Ekkel & de Vries, 2017) and because usage decreases with increasing distance (Coombes et al., 2010). Previous studies have also shown visits to green space, coastal and freshwater blue space to be more associated with SWB than other metrics such as accessibility or residential availability (Elliott et al., 2023; Geiger et al., 2023; McDougall et al., 2022).

In our data, eudaimonic wellbeing was unrelated to green space quantities around the residence and proximity to coastal or freshwater blue space. This largely replicates White et al. (2017) who only found an association for the highest (vs. lowest) quantities of green space and also found no association between proximity to coastal blue space and eudaimonic wellbeing. The mere availability of nature is unlikely to stimulate a eudaimonic response given the eudaimonic survey question concerns 'activities' of daily life, and should therefore theoretically be better determined by behaviours and actions, rather than one's surroundings.

Residing in highly green areas (Quartile 4) was positively associated with evaluative wellbeing, even when a control for visits was included. Residing in areas with higher coverage of green space surrounding the residence has been associated with greater evaluative wellbeing in both cross-sectional (Houlden et al., 2019) and longitudinal studies (White et al., 2013). Residential green space availability may be more important for evaluative wellbeing compared to hedonic and eudaimonic wellbeing, because the presence of neighbourhood green space can influence neighbourhood satisfaction and overall life satisfaction (Houlden et al., 2019). Residing in highly green areas may also increase the likelihood of indirect (e.g. via household views) or incidental (passing by) exposure to green space (Garrett et al., 2019) and these exposures may not be

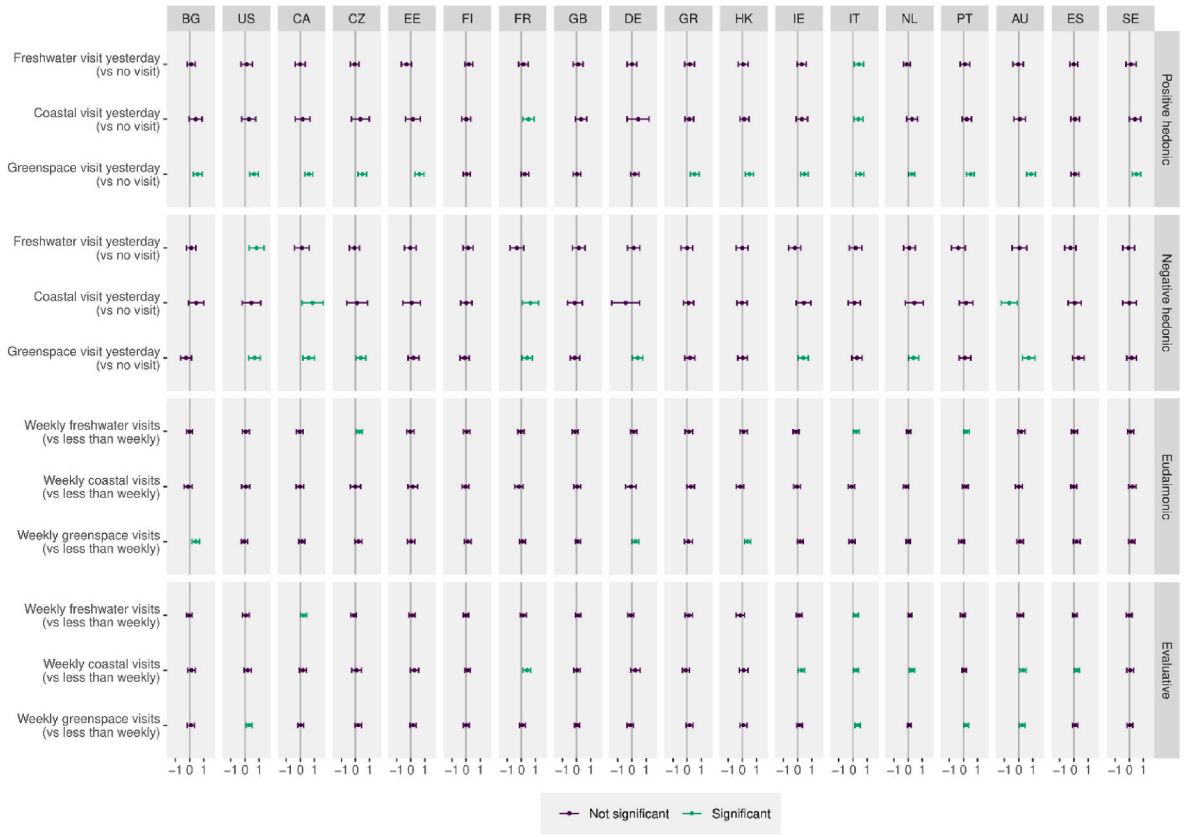

Fig. 3. Summary of fully adjusted models of all dimensions of SWB and visits to green space, coastal blue space and freshwater blue space stratified for each of the 18 countries/regions included in the analysis. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

captured in our visit metrics. Furthermore, high quantities of green space can provide wellbeing benefits by improving environmental conditions which do not require visits e.g. urban noise masking (Axelsson et al., 2014), improved thermal comfort (Sun et al., 2017) and air quality (Moradpour & Hosseini, 2020), which have been associated with SWB ().

When a control for visit frequency was added to our models, residing in close proximity to freshwater or coastal blue space was not associated with greater evaluative wellbeing. It should be noted that our blue space measures only accounted for the presence or absence of freshwater or coastal blue space within 1,000m of a participant's household; and were unable to capture the quality or quantity of nearby blue space in the area, which may be more strongly associated with wellbeing than the presence or absence of blue space alone (McDougall et al., 2022).

4.2. Visits and hedonic wellbeing

Visits to natural environments were associated with improved SWB, although these associations varied depending on the dimension of SWB considered. Visiting green space and coastal blue space yesterday were significantly associated with improved positive hedonic wellbeing yesterday. These relationships remained once negative hedonic wellbeing was controlled for, suggesting the observed hedonic benefits were independent of any negative hedonic effects. This finding supports key theoretical debates surrounding the connection between positive and negative hedonic wellbeing by demonstrating that hedonic dimensions of wellbeing are not merely two ends of a spectrum as sometimes assumed (McMahan & Estes, 2015).

Our findings align with various studies that show people are happier when visiting green and blue spaces (de Vries et al., 2021; MacKerron & Mourato, 2013) and recall being happier even a day after visiting these environments (Garrett et al., 2023). Research conducted by de Vries et al. (2021) found people were happier when in or around freshwater blue space, relative to other environment types. However, our results extend these findings as visits to freshwater blue space specifically, were not significantly associated with positive hedonic wellbeing in our multi-country models; and a significant positive association was only observed in 1/18 countries (Italy) in our country-stratified analysis. Momentary evaluations of happiness, as adopted by de Vries et al. (2021), are likely to be more sensitive to changes in happiness than the recalled happiness in the previous day approach adopted in our study and this may partly explain differences in our findings.

Interestingly, our findings also show an association between visiting green space and coastal blue space and *greater* feelings of anxiety (negative hedonic wellbeing). Although our data do not allow detailed analysis explaining this association, a number of possibilities exist. Firstly, the association between visiting green and coastal blue space and negative hedonic wellbeing may represent causal direction ambiguity and reflect a 'self-medicating' effect whereby individuals choose, or are recommended to, visit these environments to improve their wellbeing (Tester-Jones et al., 2020). Prescribed or self-prescribed visits are likely to increase as nature-based prescriptions become more popular (Kondo et al., 2020) and awareness of the health benefits of spending time in and around nature increases. Qualitative research often depicts nature visits for self-medicating purposes whereby individuals suffering from stress, physical discomfort, or mental ill-health are drawn to the restorative benefits of nature or particular green and blue spaces associated with healing (Bell et al., 2015; Korpela et al., 2010).

Secondly, these findings may be indicative of negative experiences of blue and green space within the study population. Large scale epidemiological studies often focus primarily on the net population health impact of exposure to nature; however, this may oversimplify the relationship between nature and SWB and fail to account for nuances of the individual experience. Consequently, negative experiences in nature,

which have been demonstrated in poor quality environments and for particular minority groups, may be overlooked (Phoenix et al., 2021; Milligan & Bingley, 2007). By controlling for positive hedonic wellbeing, our analysis may be more suited to capturing negative hedonic effects, which could be overlooked in study designs which do not include these controls.

Thirdly, it is plausible that the relationship between visits to nature and hedonic wellbeing is complex and can induce both positive and negative hedonic experiences within a single visit. Such complexity is often described in the experiences of adventurous engagement with nature such as surfing and open water swimming, whereby the activity provides both happiness and anxiety from risk (Costello et al., 2019).

Despite only being able to speculate as to why visitation to natural environments can be associated with negative hedonic wellbeing, researchers and policymakers should be aware of these potentially negative impacts. This issue is particularly important in the development of nature-based wellbeing interventions or nature-based prescriptions aimed at improving wellbeing among groups who may be particularly vulnerable to negative hedonic experiences. Indeed, our findings reinforce the value of considering positive and negative hedonic wellbeing independently rather than merely as two ends of a single spectrum in nature-wellbeing research (McMahan & Estes, 2015).

4.3. Visits and eudaimonic and evaluative wellbeing

Visiting both green space and freshwater blue space in the last four weeks was associated with greater eudaimonic wellbeing, even after controlling for evaluative wellbeing. Previous studies of green space and wellbeing often fail to consider eudaimonic dimensions of wellbeing (Houlden et al., 2018); and the eudaimonic wellbeing potential of blue space has also been largely ignored in previous research. Qualitative research suggests eudaimonic wellbeing is promoted in natural environments, more generally, by increasing connections to one's self (e.g. cultivating a sense of belonging and developing self-discovery), or increasing connections to others, which can stimulate feelings of purpose (Saint-Onge et al., 2022). A recent meta-analysis suggests greater feelings of nature connection could partly explain improved eudaimonic wellbeing as a result of visiting nature (Pritchard et al., 2020).

Visiting the coast was not associated with improved eudaimonic wellbeing in the overall or any of the stratified country-specific models, unlike other natural environments. Vert et al. (2020) did not find any significant differences in eudaimonic wellbeing after undertaking 20 min of walking along a coastal blue space route, on 4 days each week, for 3 weeks. Garrett et al. (2023) also found visits to a range of coastal blue space categories (e.g. open seas, harbours or marinas) were not associated with eudaimonic wellbeing.

People are often willing to travel further to visit coastal blue spaces than other natural environment types (Wilczyńska et al., 2023). Literature on coastal engagement and interactions often depict a deep and unique relationship between humans and coastal environments (Bell et al., 2015; Severin et al., 2022). Coastal visits are often passive and motivated by relaxation, whereas evidence from the UK suggests freshwater blue space visits are more likely to be purposeful, i.e. to attain health benefits (Elliott et al., 2018). This may partly explain why only associations between costal visits and evaluative wellbeing (and not eudaimonic wellbeing) were observed in our data. Indeed, people tend to report being happier, in and around coastal rather than freshwater blue space (MacKerron and Mourato, 2013) and passive activities or soft leisure in blue space may be less likely to produce eudaimonic wellbeing benefits than other activities (Próchniak & Próchniak, 2023).

Although, our data only allow speculation on the relationship between coastal blue space and eudaimonic wellbeing, a unique relationship is apparent relative to other natural environments and this may be at least partly due to the types of visits that occur at the coast (e.g. Garrett et al., 2023; Wilczyńska et al., 2023). Understanding these differing wellbeing impacts is important, particularly as nature-based health interventions often rely on eudaimonic wellbeing-promotion (e.g. by promoting feelings of purpose or promoting vitality) as mechanisms for wider health and wellbeing benefits (Coventry et al., 2021; Ryan et al., 2010).

Visiting all types of natural environment in the last four weeks was associated with greater evaluative wellbeing (or life satisfaction) as has been demonstrated in a range of other studies (Jiang & Huang, 2022; Mavoa et al., 2019). Advancing previous research, our findings additionally show that such an association is not driven by an overlap (or shared variance) with eudaimonic wellbeing. Generally, associations with evaluative wellbeing were larger with higher visit frequency, suggesting spending more time in nature can provide greater wellbeing benefits (White et al., 2019; McDougall et al., 2022).

Evaluative wellbeing benefits were somewhat expected given the hedonic benefits associated with individual visits, which are likely to cumulative contribute to a wider life satisfaction over a several week period (White et al., 2017), particularly if visitation occurs frequently. Indeed, Foley (2017) suggests an accretive process whereby visits to natural environments can progressively provide benefits and contribute to a growing wellbeing over time.

4.4. Country stratification

The random intercept in our non-stratified model and country-stratification indicate heterogeneity between countries when considering associations between visiting natural environments and different dimensions of wellbeing. Our data may not be particularly well suited for identifying particular country trends as stratification by country, natural environment type and wellbeing dimension reduced statistical power considerably. However, some tentative conclusions can be drawn.

When all wellbeing dimensions were considered, at least one significant positive association between one type of natural environment visit frequency and one dimension of wellbeing was identified for 15/18 countries, despite the substantively reduced power. Generally, associations between improved wellbeing and coastal visit frequency appear greater in countries and regions with warmer climates and strong cultures of coastal engagement, such as Queensland, Italy, and Spain. This was also suggested in a previous study, which indicated that Mediterranean countries may benefit particularly from coastal blue space (White et al., 2021).

Only Queensland, Australia, was associated with reductions in feelings of anxiety (negative hedonic wellbeing) as a result of visiting coastal blue space. This is somewhat surprising given the wide publicity and public health warnings on the risks of beach visits in Australia – e.g. sunburn, shark attacks, and riptides (Costello et al., 2019). Perhaps it is due to the fact that the marine environment is a much more familiar feature of Australian life, not least because much of the population live relatively close to the coast (Maguire et al., 2011).

The wellbeing benefits of visiting green space appeared to be more homogenous than those of freshwater and coastal blue space. These findings may point to climate and cultural differences playing a greater role in the facilitation of wellbeing benefits via blue space than green space, potentially as climate and weather conditions can have major impacts on the suitability of freshwater and coastal environments for recreation and the ecosystem services these environments provide (Elliott et al., 2019). Our study, therefore, reinforces the need for wider considerations of climates and cultures in future blue space and health research.

4.5. Strengths, limitations, and future research

Our study design and data offer a number of strengths allowing it to overcome common limitations of nature-wellbeing research and address a number of key gaps in the current literature. Our sample (>16,000 individuals across 18 countries) provided a number of benefits including

cultural/geographic diversity (Gascon et al., 2017). A key strength of the multi-country approach adopted in our study was the capability to establish which patterns generalise across countries and which patterns do not, something that can help inform efforts to promote nature contact more broadly.

By considering green space and freshwater and coastal blue space independently, our findings deepen our understanding of how different elements of nature may contribute to wellbeing (Frumkin et al., 2017). By considering hedonic, eudaimonic, and evaluative wellbeing, our approaches allowed key theoretical debates regarding different dimensions of SWB to be considered and accounted for in our statistical analysis. Our findings, therefore, allowed us to distinguish the unique variance applicable to each wellbeing concept and exposure metric, which has been deemed an important step for policy and research (White and Dolan, 2009; Fisher et al., 2021). The adoption of the ONS/OECD wellbeing indicators means our results are highly comparable and aligned with a key set of global policy tools.

Our study also has a number of limitations, offering valuable opportunities to build upon the research outlined here. The study design was cross sectional and our ability to determine causation or understand temporal effects of nature visits on wellbeing is therefore limited. Longitudinal studies offer an opportunity to draw causal inference more comprehensively and funding to conduct these kinds of more resource demanding studies should be encouraged (Geary et al., 2023).

Our analysis was also unable to account for variation in green and blue space quality, which is likely to play an important role in for health and wellbeing benefits (Nguyen et al., 2021). Although a range of green and blue space quality indicators exist, there is a dearth of suitable indicators to apply at national (or multi-national) scale as necessary for this research (McDougall et al., 2020).

Although our study was able to advance current understanding of the impact of green and blue space visits on different dimensions of wellbeing, our analysis was unable to explore the mechanisms by which contact with nature could come to impact SWB as such analysis would require a more thorough understanding of the motivations behind such visits and their characteristics, which exceeded the scope of this study. Mediation analysis, including for example variables related to motivation or characteristics, seeking to understand the relationship between hedonic, eudaimonic and evaluative wellbeing in the context of blue and green space exposure offers opportunities to advance current understanding considerably.

Our data may also be subject to a range of reporting and memory biases. For example, following global practice for over a decade (OECD, 2013; www.oecdbetterlifeindex.org) our four measures of SWB were single items and thus potentially subject to mono-operation bias. Given the size of the survey this was required to enable sufficient topics to be included, but future studies could use more complex multi-item measures of each SWB sub-dimension. Further, self-reported visit frequency may be subject to recall biases or errors, and responses to wellbeing or covariates may be subject to social desirability bias. Realistically collecting more objective data from such large samples across multiple countries will remain a challenge. Although modern tracking technologies may begin to be able to overcome some of these issues, whether or not this is acceptable to participants, and is feasible for large samples in multiple locations, remains an open question.

5. Conclusion

This study estimated the relationships between proximity and visit-related exposure to green space, coastal and freshwater blue space and hedonic, eudaimonic and evaluative dimensions of SWB across 18 countries, whilst controlling for a range of socioeconomic and demographic variables. The findings suggest visiting green space and coastal blue space was associated with both positive and negative hedonic wellbeing outcomes. Frequently visiting green space and freshwater blue space, but not coastal, was associated with greater eudaimonic wellbeing and frequently visiting green space, coastal and freshwater blue space was associated with greater evaluative wellbeing.

Though likely underpowered due to stratification, our results allow us to begin to understand the generalisability of some of these associations across countries. Our results contribute to a growing body of literature that suggests spending time in and around nature can provide SWB benefits. Importantly, our data suggest that different types of natural environment may – but not always – vary in their associations with different dimensions of SWB. Understanding these potential differences and potentially negative wellbeing outcomes is an important consideration for future research; and is a prerequisite for evidence-based public health and environmental policy making to maximise the wellbeing-promoting potential of different natural environments.

CRediT authorship contribution statement

Craig W. McDougall: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Lewis R. Elliott:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Investigation, Formal analysis, Conceptualization. **Mathew P. White:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **James Grellier:** Writing – review & editing, Funding acquisition, Data curation, Conceptualization. **Simon Bell:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Gregory N. Bratman:** Writing – review & editing, Validation, Supervision, Investigation, Funding acquisition, Data curation, Conceptualization. **Mark Nieuwenhuijsen:** Writing – review & editing, Validation, Supervision, Funding acquisition, Conceptualization. **Maria L. Lima:** Writing – review & editing, Validation, Supervision, Funding acquisition, Data curation, Conceptualization. **Ann Ojala:** Writing – review & editing, Validation, Supervision, Funding acquisition. **Marta Cirach:** Writing – review & editing, Validation, Supervision, Funding acquisition. **Anne Roiko:** Writing – review & editing, Validation, Supervision, Funding acquisition. **Matilda van den Bosch:** Writing – review & editing, Validation, Supervision, Funding acquisition. **Lora E. Fleming:** Writing – review & editing, Validation, Supervision, Funding acquisition.

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Appendix A. Supplementary data

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