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Health and well-being in nature: Analysis of 18,054 visit reports and implications for nature-based biopsychosocial resilience theory (NBRT)

Valentina Hampejs [a,b,*], Addi Wala [a], Ulrich S. Tran [c], Sabine Pahl [c,d], Julia A.M. Egger [a], Martin Voracek [c], Mathew P. White [d,e]

[a] Vienna Cognitive Science Hub, University of Vienna, Vienna, Austria
[b] Vienna Doctoral School in Cognition, Behavior, and Neuroscience (VDS CoBeNe), University of Vienna, Austria
[c] Department of Cognition, Emotion, and Methods in Psychology, Faculty of Psychology, University of Vienna, Vienna, Austria
[d] Environment and Climate Research Hub, Faculty of Psychology, University of Vienna, Vienna, Austria
[e] Department of Clinical and Health Psychology, Faculty of Psychology, University of Vienna, Vienna, Austria

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ABSTRACT

Nature-based biopsychosocial resilience theory (NBRT) proposes that visiting nature helps build and maintain 'stocks' of adaptive biological, psychological, and social resilience resources that can later be used to prevent, respond to, or recover from stressors. Using 2020-24 data from a representative sample of adults across England, we examined how recent nature visits (n = 18,054) contribute to self-reported biopsychosocial health and well-being (foundational components of resilience stocks), as a function of natural setting (e.g., urban/rural green, coastal), natural elements (e.g., safety, biodiversity), and nature contact components (i.e., activity, duration, companionship, nature connectedness). Coastal visits were more positively associated with biological and psychological (but not social) health and well-being than the average across all setting types. Visit settings rated as peaceful, safe, clean, accessible, and biodiverse, as well as longer visits and those undertaken by people higher in nature connectedness, were positively related to all three types of health and well-being. Further scrutiny of walking as the most common visit type (n = 9,065) showed that duration was more important for self-reported biological and psychological health and well-being when alone than when with others. Additionally, duration and companionship were less important for social well-being among those with higher nature connectedness. Findings are in line with the notion that nature visits can enhance multiple dimensions of health and well-being, thus contributing to biopsychosocial resilience stocks. Further research is needed to explore how such visit-related benefits may support individuals to be more adaptively resilient to diverse stressors.

1. Introduction

Contact with the natural world plays an important role in supporting biological, psychological, and social processes that promote health and well-being (van den Berg et al., 2010; Wells, 2021; Yang et al., 2021). Biologically, nature contact is linked to better immune function (Rook, 2013; Soininen et al., 2022), greater parasympathetic activation that lowers cortisol levels (Verheyen et al., 2021), blood pressure (Wang et al., 2019), and heart rate (Bonham-Corcoran et al., 2022), and to improved metabolic health with a reduced risk of cardiovascular disease and type 2 diabetes (Seo et al., 2019). At the psychological level, nature contact is associated with lower stress (Høj et al., 2021), greater subjective well-being (McDougall et al., 2024), fewer symptoms of psychological disorders such as depression (Sarkar et al., 2018) and anxiety (Callaghan et al., 2021), and better overall mental health (Nguyen et al., 2021). At the social level, time in nature is associated with a greater sense of belonging (Leavell et al., 2019) and reduced loneliness (Astell-Burt et al., 2024), which are both beneficial for health.

Various pathway frameworks (e.g., Hartig et al., 2014; Markevych et al., 2017; Marselle et al., 2021; White et al., 2020) outline mechanisms linking nature with health. For instance, nature can promote biological health by mitigating environmental stressors such as noise (Hemmat et al., 2023), air pollution (Twohig-Bennett & Jones, 2018), or the effects of extreme weather (Jay et al., 2021), and by promoting physical activity (Pasanen et al., 2019). Nature contact can promote psychological health by regulating emotions (Bratman et al., 2024;

* Corresponding author. Vienna Cognitive Science Hub, University of Vienna, Vienna, Austria.
E-mail address: valentina.hampejs@univie.ac.at (V. Hampejs).

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Johnsen & Rydstedt, 2013), improving mindfulness (Schutte & Malouff, 2018), boosting self-esteem and self-efficacy (Mygind et al., 2019), and restoring depleted emotional and cognitive resources (Ohly et al., 2016; Stevenson et al., 2018). Finally, nature contact can promote social health and well-being by encouraging social contact and interaction (Elliott et al., 2023; Yang et al., 2025), supporting social cohesion (Jennings & Bamkole, 2019), encouraging prosocial behaviours (Goldy & Piff, 2020), and helping to maintain healthy personal relationships (Pasanen et al., 2023).

While these dimensions and pathways are often studied in isolation, biological, psychological, and social health and well-being – and their determinants – are deeply interconnected and mutually reinforcing (Dzhambov et al., 2019; Elliott et al., 2023). For example, stress negatively affects psychological health, which can strain social relationships (Kansky & Diener, 2017) and trigger biological responses, such as heightened arousal via an activated sympathetic nervous system (Chrousos, 2009). These biological responses can generate psychological and social challenges, creating a negative feedback loop affecting overall health and well-being. A holistic perspective is therefore crucial to fully understand nature's impact on human health and well-being, as highlighted by nature-based biopsychosocial resilience theory (White et al., 2023).

1.1. Nature-based biopsychosocial resilience theory (NBRT)

Nature-based biopsychosocial resilience theory (NBRT; White et al., 2023; see Fig. 1 for visualisation) provides a framework for understanding how different forms of nature interaction can buffer individuals against stressors that affect biological, psychological, and social health and well-being. NBRT posits that nature contact can enhance resilience (Dzhambov et al., 2019; van den Berg et al., 2010; Wells, 2021). At the individual level, resilience is conceptualised both as a set of adaptive resources (the 'stocks' of resilience) and the processes through which they are utilised (their 'flows'; White et al., 2023). These stocks of resilience integrate three different (yet deeply intertwined) facets, namely, biological, psychological, and social resilience, thereby providing a comprehensive understanding of biopsychosocial resilience beyond traditional perspectives (Cosco et al., 2016; Davydov et al., 2010; Fletcher & Sarkar, 2013). NBRT argues that nature builds stocks of biological, psychological, and social resilience gradually over time, with single visits making modest (but nonetheless cumulatively significant) contributions. Identifying which features of single visits support momentary biological, psychological, and social health and well-being is thus key to explaining how repeated nature contact builds biopsychosocial resilience resources over time.

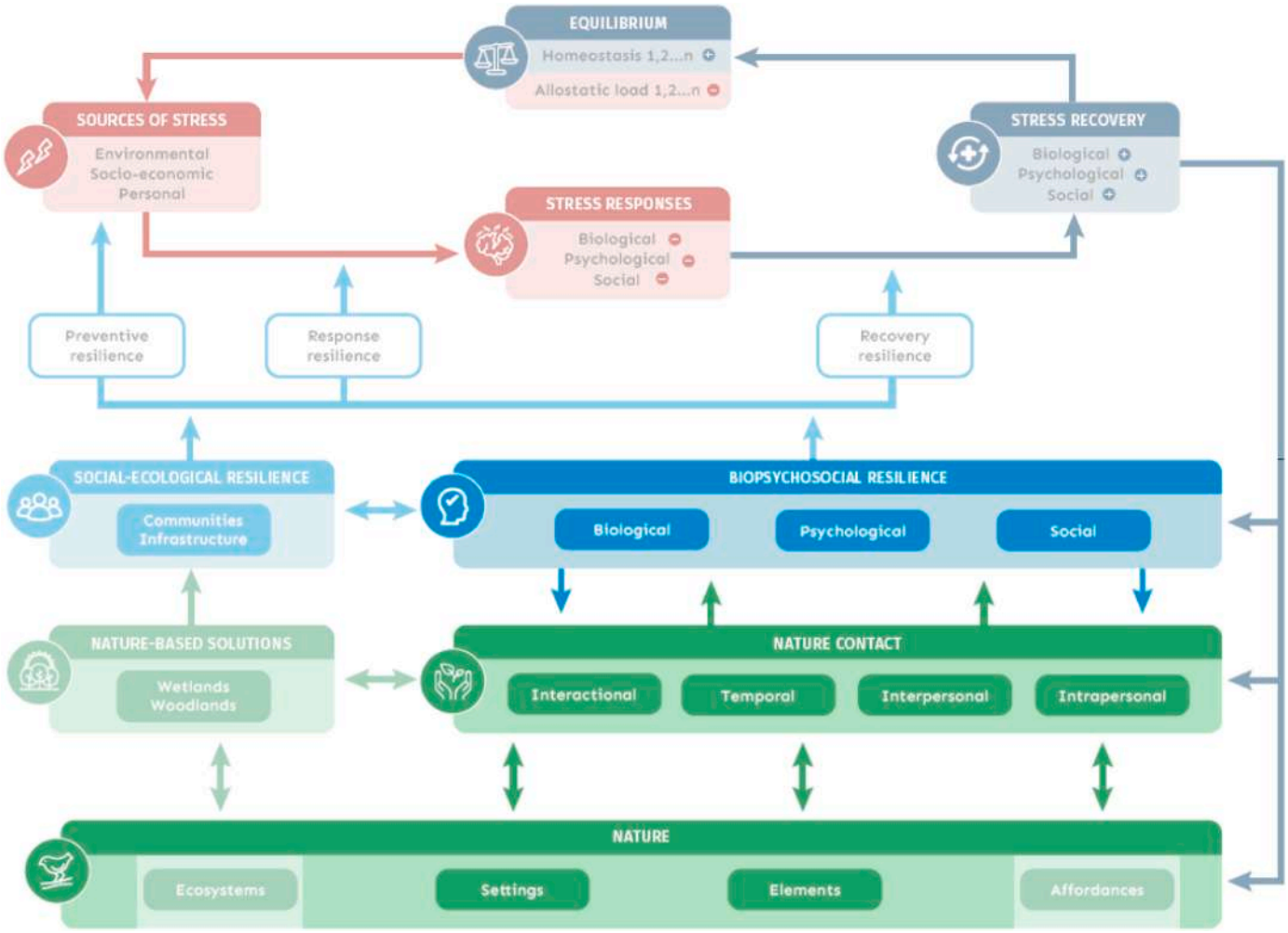

Fig. 1. Investigated aspects of nature-based biopsychosocial resilience theory (NBRT) in full schematic context.
Note. For the sake of clarity, the aspects analysed in this study are highlighted, while the remaining components of NBRT are presented in a shaded form. The figure is adapted from „*Nature-based biopsychosocial resilience: An integrative theoretical framework for research on nature and health*" by White et al., 2023, *Environmental International, 181* (https://doi.org/10.1016/j.envint.2023.108234). Licenced under CC by 4.0.

1.1.1. NBRT's nature typology

NBRT posits that individual experiences of nature are influenced by various components, including types of nature and nature contact (see Fig. 1). To operationalise nature, a three-level typology is proposed, with ecosystems located at the broadest taxonomic level (e.g., rainforest). It then narrows to geographically bounded natural *settings* (e.g., parks, beaches), which exist within ecosystems and are often compared in research. Finally, within these settings, there are specific *elements*, such as the presence of animals, plants and/or pollution, as well as more subjective perceptions of, for instance, safety and accessibility. Within this framework, the present study focuses on associations between key indicators (i.e., biopsychosocial health and well-being) and visits to specific natural settings and their constituent elements (Bratman et al., 2021; Garrett et al., 2023), rather than on whole ecosystems.

1.1.2. NBRT's nature contact components

While cumulative nature contact is pivotal for supporting longer-term health, well-being, and resilience (Foley, 2017; White et al., 2021), each contact experience serves as an essential building block for these more substantive resources. NBRT identifies four main components of these experiences: interactional, temporal, and interpersonal factors (i.e., what people do, for how long, and with whom), alongside more intrapersonal aspects (e.g., values, expectations). Nature-based interactions can be direct (e.g., hearing/smelling nature), indirect (e.g., watching documentaries), incidental (e.g., passing by nature), and/or intentional (e.g., gardening), each potentially associated with different dimensions of subjective well-being (Garrett et al., 2023). Contact duration can vary considerably, ranging from minutes to hours. Interpersonal aspects include visits alone, with one or more adults, children, or animals. While group visits often yield higher visit satisfaction (Garrett et al., 2023), their effects on biopsychosocial health, well-being, and resilience are unknown. Finally, intrapersonal aspects, such as trait nature connectedness, shape nature experiences (Martin et al., 2020), meaning the same setting can have different effects across individuals. This study examines how nature visits and their varying components relate to levels of self-reported biological (physical), psychological (mental), and social well-being, outcomes that may cumulatively contribute to biopsychosocial resilience resources.

1.2. Testing elements of NBRT in the present study

The study uses secondary data on recreational nature visits from the People and Nature Survey (PaNS) in England (Natural England, 2024, p. 9093). The primary objective was to investigate whether (and, if so, how) nature enhances self-reported biopsychosocial health and well-being. Specifically, we examined recent nature visits (within the last two weeks), including their settings, elements, and nature contact components (interactional, temporal, interpersonal, intrapersonal), vis-à-vis their associations with self-reported biological, psychological, and social health and well-being. We controlled for sociodemographic and person-specific factors (generic health, well-being, loneliness) that might influence the choice of visit location or interactions and thus confound the core associations.

Our first four research questions (RQs) were:

- **RQ1**: To what extent is self-reported visit-related biopsychosocial health and well-being associated with setting type (e.g., urban green spaces; **RQ1.1**) and setting elements (e.g., perceived safety; **RQ1.2**)?
- **RQ2**: To what extent is self-reported visit-related biopsychosocial health and well-being associated with different nature contact experiences, including interactional (activity type; **RQ2.1**), temporal (visit duration; **RQ2.2**), interpersonal (companionship; **RQ2.3**), and intrapersonal (nature connectedness; **RQ2.4**) components?
- **RQ3**: To what extent is self-reported visit-related biopsychosocial health and well-being associated with sociodemographics and general levels of biopsychosocial health and well-being?
- **RQ4**: To what extent are the different visit-related biopsychosocial health and well-being measures interrelated (after controlling for other variables)?

Our second objective was to examine how nature contact components (temporal, interpersonal, intrapersonal) interact in predicting biopsychosocial health and well-being. For example, while longer visits may be positively associated with psychological well-being (Garrett et al., 2023), this might depend on companionship (e.g., longer visits may be more beneficial with others). By examining such interactions, we aimed to gain a more nuanced understanding of the conditions under which nature visits are particularly beneficial. For these analyses, we focused on walking visits as the most common activity. Given the complexity of these interactions and the absence of prior evidence, analysis was exploratory for this research question:

- **RQ5**: Do temporal, interpersonal, and intrapersonal components of walking visits interact in predicting visit-related biopsychosocial health and well-being?

2. Methods

This preregistered study (Sep 30, 2024; at Open Science Framework: https://osf.io/dnpgu/?view_only=62fc382ab87a403b8e20a464e55d7f11) analysed secondary, public data (hence, no ethical approval was required) from Natural England (2024, p. 9093) to examine associations between visits to natural environments and self-reported visit-related health and well-being. To test NBRT, we fitted hierarchical (blockwise) linear regressions and conducted structural equation modeling (SEM) to assess interactions among nature contact components.

2.1. PaNS survey overview

Participants were drawn from the People and Nature Survey (PaNS), an ongoing online self-report survey conducted by Natural England (2024, p. 9093) that began in April 2020, replacing the Monitor of Engagement with the Natural Environment (Natural England, 2019). Data collection began amidst the COVID-19 pandemic and its various restrictions. PaNS uses quota sampling to collect nationally representative monthly data from individuals aged 16+ years, enabling observations across the general adult population of England over time. The survey gathers evidence on how people interact with and benefit from nature, including attitudes towards the natural environment, frequency and types of nature contact, and perceived physical, mental, and social health and well-being benefits. With up to 25,000 respondents annually, PaNS is one of the largest surveys on nature-human interaction. This study focused on approximately 4,500 respondents per year who had visited a natural space in the previous 14 days and completed relevant items (PaNS modules 2A and 2A_Sub).

PaNS data access is tiered: 'open access', 'safeguarded', and 'secure' (Natural England, 2024, p. 9093). As our team is based outside the UK, we accessed the 'safeguarded' dataset (via a project registered with the UK Data Archive). This included some demographic variables (e.g., age, income), but excluded others (e.g., ethnicity), and provided some restricted categorisation (e.g., income). While this may limit nuance in the results, it does not impact key outcomes.

2.2. Survey respondents

We analysed April 2020 to March 2024 data. Of 99,929 survey respondents, 60,030 (60.1 %) reported visiting nature in the past 14 days. Among these, 18,054 (30.1 %) completed modules 2A and M2A_Sub and provided responses to relevant variables. This subsample was largely comparable to the overall sample in age and gender but slightly skewed towards higher income brackets (Table S1). After excluding missing data, analysis sample size ranged from n = 13,664 to 16,257

(Tables S2–S4). Respondents had a mean age of 46.8 years ($SD = 17.0$), a balanced gender distribution (50.1 % women, 49.7 % men, 0.2 % diverse; Table 1), and an average approximated household income of £34,424 (SD = £16,449; Mdn = £35,000).

2.3. Measures

Following the NBRT framework, we describe outcome variables, predictors, and covariates. Key survey items (item number, wording, and original and recoded response options) are detailed in Table 2. Some response options were collapsed for data manageability.

2.3.1. Outcome variables

Biological, psychological, and social health and well-being were reported using three statements about the most recent nature visit. Respondents rated their agreement with "It was good for my physical health" (biological), "It was good for my mental health" (psychological) and "It was a good opportunity to spend time with friends and family" (social) on scales from 1 (*strongly agree*) to 5 (*strongly disagree*).

2.3.2. Predictors

2.3.2.1. Nature. Natural settings were identified based on respondents' self-reported main destination for their most recent visit. Following prior research (McDougall et al., 2024), destinations were grouped into five categories: 'urban green space', 'rural green space', 'inland blue space', 'coastal blue space', and 'other' (see Table 2).

Within-setting elements were operationalised using various characteristics of the natural environment. Participants rated the extent to which they agreed that the setting had positive attributes, such as 'biodiversity', 'facilities', 'accessibility', 'cleanliness', 'safety', and 'peace/tranquillity' (from *strongly agree* [1] to *strongly disagree* [5]; see Table 2). Although a 'positive element index' was preregistered, this was omitted from main analysis, as preliminary data inspection revealed this would obscure important information about specific elements. Instead, individual elements were analysed separately, with the preregistered index-based analyses reported in the Supplementary Materials for full transparency.

2.3.2.2. Nature contact. The interactional component was operationalised as the primary activity engaged in during the visit, selected from a list of 15 activities (e.g., 'walking', 'picnicking'; see Table 2).

The temporal aspect of nature contact was quantified by reported activity duration, ranging from under 30 min to over 5 h. Categorical responses were recoded into a continuous variable using midpoints, with duration squared included to test for possible quadratic effects (e.g., White et al., 2019).

Interpersonal nature contact was assessed based on whom respondents visited the natural environment with, categorised as 'alone', 'accompanied by a dog', or 'with others'.

The intrapersonal aspect of nature contact was measured using trait nature connectedness as the only available relevant metric. Due to survey modifications, different measures were used. From April 2020 to April 2023 (PaNS waves 2–37), respondents rated how much they 'feel part of nature' (Nature Connectedness Index, NCI; Richardson et al., 2019), which represents our preregistered variable. Subsequent survey waves used the Illustrated Inclusion of Nature in Self Scale (IINS; Kleespies et al., 2021). Both variables, measured on 7-point scales, were treated as functionally equivalent for present purposes due to their similarity ($M_{NCI} = 4.93$, $SD_{NCI} = 1.26$ vs. $M_{IINS} = 4.72$, $SD_{IINS} = 1.64$). Sensitivity analyses conducted on the NCI subsample (as preregistered) supported this analytic decision (see Tables S5–S7).

2.3.3. Covariates

2.3.3.1. Sociodemographics. The safeguarded PaNS dataset included limited sociodemographic variables but provided age, gender, and income. Age and income categories were converted to continuous variables using midpoints. Survey waves were recoded as years to account for potential cross-temporal trends, especially since the early waves occurred during COVID-19 lockdowns in England.

2.3.3.2. Generic health and well-being. To account for differences in baseline (generic) health and well-being that might influence location choices or engagement (e.g., activities, duration), we included metrics of overall (non-visit-related) biopsychosocial health and well-being, specifically self-reported physical health (biological), life satisfaction (psychological), and loneliness (reversed to reflect social well-being; see Table 2 for details).

2.4. Analysis

All analyses were conducted in RStudio (version 2024.09.0 + 375; Posit Team, 2024) using R (version 4.4.1, R Core Team, 2024). Variables were recoded into respective categories (see Table 2), with agreement levels ranging from −2 (*strongly disagree*) via 0 (*neutral*) to +2 (*strongly agree*). For the intrapersonal measure (nature connectedness) and generic psychological health and well-being, scales ranged from −3 to +3 and −5 to +5, respectively. Responses like 'don't know' or 'prefer not to say' were recorded as 'other' for variables encompassing such categories (setting, activity) or treated as missing data where appropriate (e.g., visit-related health and well-being).

Categorical variables (setting, activity, interpersonal, gender, wave) were modelled using deviation coding, i.e., comparing each value of a variable to the grand mean of the respective variable (e.g., 'urban green space' compared to all settings combined; Garrett et al., 2023). This facilitates cross-category comparisons but might understate the actual magnitude of between-level differences. For instance, quantifying the absolute difference between urban green and coastal blue settings requires adding their regression coefficients. Regression analyses included only cases with non-missing data, resulting in slightly varying sample sizes.

In the first analysis part, three four-step regressions (one per outcome) were conducted to test NBRT components. Consistent with the tenets of NBRT, variables were added sequentially in the model (White et al., 2023). First, natural settings and elements were included to examine simple associations between nature and visit-related outcomes (**RQ1**). Step 2 added nature contact variables (**RQ2**). Step 3 included sociodemographic factors, generic health and well-being, and survey year to account for person-specific differences (**RQ3**). Step 4 controlled for other visit-related health and well-being measures (**RQ4**). R^2 was calculated at each step to quantify attributable variance.

In the second analysis part, a structural equation model (SEM) focusing on walking (the most common activity) was fitted to explore potential interactions between nature contact components and outcomes (**RQ5**). Unlike regression analyses, SEM allowed simultaneous analysis of all three outcomes, thereby offering a more fine-grained understanding of how visit characteristics predict each of the individual health and well-being outcomes by controlling for their shared variance. As the SEM investigated only moderation (interactions between predictors) but not mediation, the model contained only direct effects of predictors on outcomes (i.e., no indirect effects via intervening variables). In reporting, we denote these direct effects of each predictor on its own as the main effects. Deviating from preregistration, all settings were included, as regression models for walking-only visits (see Table S8) revealed no associations between settings and visit-related health and well-being after controlling for person-specific factors. Model fit was assessed using the χ^2 test value, the comparative fit index

Table 1
Characteristics of nature visits and analysis sample sizes for visit-related biological, psychological, and social health and well-being.

Variable	Category	*N*	%	Biological Resilience Resources		Psychological Resilience Resources		Social Resilience Resources	
				M	*SD*	*M*	*SD*	*M*	*SD*
			100	1.29	0.69	1.29	0.71	0.93	1.04
Setting									
	Urban green	6567	36.4	1.25	0.67	1.25	0.68	0.85	1.07
	Rural green	7353	40.7	1.31	0.72	1.30	0.72	0.96	1.03
	Inland blue	2061	11.4	1.32	0.67	1.31	0.71	0.96	1.02
	Coastal blue	1734	9.6	1.31	0.69	1.32	0.72	1.06	0.99
	Other	339	1.9	1.24	0.68	1.23	0.68	0.80	1.01
Elements									
	Accessibility	17976	99.6	.	.	.	.	.	.
	Adequate facilities	17416	96.5	.	.	.	.	.	.
	Biodiversity	17956	99.5	.	.	.	.	.	.
	Cleanliness	17001	94.2	.	.	.	.	.	.
	Peace and tranquillity	18006	99.7	.	.	.	.	.	.
	Safety	17998	99.7	.	.	.	.	.	.
Interactional									
	Appreciating scenery from a car	475	2.6	1.25	0.66	1.31	0.69	0.81	1.15
	Boating, water sports, swimming outdoors	248	1.4	0.92	0.93	1.11	0.86	1.01	0.94
	Cycling or running	182	1.0	0.99	1.07	1.12	0.92	1.01	1.12
	Fishing	945	5.2	1.37	0.78	1.29	0.79	0.73	1.15
	Horse-riding	183	1.0	1.06	0.98	1.15	0.98	0.98	1.10
	Picnicking	115	0.6	1.23	0.96	1.21	0.94	1.16	0.98
	Playing with children	1078	6.0	1.14	0.79	1.22	0.77	1.17	0.91
	Shooting/hunting	1470	8.1	1.27	0.70	1.29	0.70	1.41	0.70
	Sports and games	82	0.5	0.95	1.10	0.96	1.05	0.91	1.02
	Visiting an attraction	430	2.4	1.21	0.82	1.17	0.87	1.13	0.91
	Walking	534	3.0	1.11	0.85	1.16	0.85	1.24	0.87
	Wildlife watching	11179	61.9	1.33	0.62	1.30	0.65	0.81	1.07
	Other	1133	6.3	1.31	0.71	1.37	0.72	0.96	1.03
Temporal									
	Up to 30min	3155	17.5	1.21	0.69	1.20	0.71	0.77	1.09
	Over 30min and up to 1h	6287	34.8	1.27	0.68	1.27	0.69	0.81	1.06
	Over 1h and up to 2h	5884	32.6	1.32	0.69	1.31	0.71	1.01	1.01
	Over 2h and up to 3h	1869	10.4	1.36	0.70	1.35	0.70	1.13	0.94
	Over 3h and up to 5h	639	3.5	1.38	0.71	1.38	0.72	1.28	0.88
	Over 5h	219	1.2	1.35	0.77	1.45	0.67	1.34	0.93
	Prefer not to say	1	0.0	1.00	NA	1.00	NA	0.00	NA
Interpersonal									
	Alone	5076	28.1	1.29	0.67	1.27	0.69	0.14	1.17
	Alone with dog	2215	12.3	1.24	0.75	1.24	0.76	0.21	1.16
	With others	10761	59.6	1.30	0.69	1.30	0.70	1.27	0.76
	Not stated	2	0.0	1.50	0.71	1.50	0.71	1.50	0.71
Intrapersonal (nature connectedness)		17754	98.3	.	.	.	.	.	.
Age									
	16–24	2228	12.3	1.13	0.84	1.16	0.85	0.93	1.06
	25–39	4624	25.6	1.25	0.76	1.29	0.76	1.09	0.96
	40–45	4441	24.6	1.34	0.65	1.36	0.65	0.95	1.03
	55–64	2813	15.6	1.34	0.60	1.32	0.64	0.79	1.11
	65+	3948	21.9	1.32	0.60	1.24	0.64	0.78	1.06
Gender									
	Female	9044	50.1	1.33	0.65	1.34	0.66	1.00	1.01
	Male	8981	49.7	1.25	0.73	1.23	0.74	0.86	1.07
	Diverse	29	0.2	1.10	0.86	1.24	0.69	1.05	1.03
Income									
	£0–14,999	2314	12.8	1.25	0.71	1.27	0.70	0.75	1.11
	£15,000–19,999	1846	10.2	1.30	0.69	1.30	0.72	0.87	1.05
	£20,000–29,999	3593	19.9	1.28	0.67	1.28	0.68	0.91	1.03
	£30,000–39,999	3012	16.7	1.27	0.69	1.24	0.71	0.96	1.01
	£40,000–49,999	2305	12.8	1.30	0.70	1.31	0.70	0.96	1.04
	£50,000–59,999+	4923	27.3	1.31	0.70	1.30	0.72	1.00	1.03
	Prefer not to say	48	0.3	1.23	0.52	1.27	0.54	1.03	0.90
	Don't know	13	0.1	1.15	0.90	1.23	0.73	1.00	0.74
Wave									
	2020	3170	17.6	1.30	0.67	1.29	0.68	0.84	1.09
	2021	4323	23.9	1.30	0.68	1.29	0.70	0.91	1.05
	2022	4376	24.2	1.28	0.68	1.27	0.71	0.97	1.03
	2023	5005	27.7	1.27	0.72	1.28	0.73	0.96	1.01
	2024	1180	6.5	1.33	0.70	1.33	0.69	0.93	1.04

Note. Response ranges for biological, psychological, and social outcomes were from −2 ('strongly disagree') to +2 ('strongly agree'). Mean values exceeding zero indicate a positive effect of nature visits on the respective outcome. The table reports average well-being for categorical variables (e.g., setting), with means shown within each category (e.g., urban green). Means cannot be computed for continuous variables (indicated by ".").

Table 2
Variable names, survey items, response options, and concrete recoding scheme.

Variables	Survey Item	Item Wording	Original Response Options	Recoded Response Options
Outcomes				
Visit-related biological health and well-being	M2A_Q9_a	To what extent do you agree or disagree with the following statements about this time spent outdoors: It was good for my physical health	−3 Not applicable −2 Prefer not to say −1 Don't know 1 Strongly agree 2 Agree 3 Neither agree nor disagree 4 Disagree 5 Strongly disagree	−2 Strongly disagree −1 Disagree 0 Neither agree nor disagree 1 Agree 2 Strongly agree NA Not applicable, prefer not to say, don't know
Visit-related psychological health and well-being	M2A_Q9_b	To what extent do you agree or disagree with the following statements about this time spent outdoors: It was good for my mental health		
Visit-related social health and well-being	M2A_Q9_c	To what extent do you agree or disagree with the following statements about this time spent outdoors: It was a good opportunity to spend time with friends or family		
Predictors				
Setting	M2A_Q2	Which of these, best describes the main destination of your visit? (i.e. the place you spent most time in)	−2 Prefer not to say −1 Don't know 1 Urban green space (such as a park, field or playground) 2 Grounds of a historic property or country park 3 Allotment or community garden 4 Woodland or forest 5 River, lake or canal 6 Hill, mountain or moorland 7 Beach/other coastline/sea 8 Nature/wildlife reserve 9 Fields/farmland/ countryside 10 Other specify	1 Urban green space (1, 3) 2 Rural green space (2, 4, 6, 8, 9) 3 Inland blue space (5) 4 Coastal blue space (7) 5 Other (10, −2, −1)
Elements				
Biodiversity	M2A_SUB_Q7_a	Thinking about the place you visited: There was a variety of plants and wildlife	−2 Prefer not to say −1 Don't know 1 Strongly agree 2 Agree 3 Neither agree nor disagree 4 Disagree 5 Strongly disagree	−2 Strongly disagree −1 Disagree 0 Neither agree nor disagree 1 Agree 2 Strongly agree
Facilities	M2A_SUB_Q7_b	Thinking about the place you visited: There were adequate facilities		*See Biodiversity*
Accessibility	M2A_SUB_Q7_c	Thinking about the place you visited: The place was accessible and well maintained.		*See Biodiversity*
Cleanness	M2A_SUB_Q7_d	Thinking about the place you visited: There was lots of litter/dog mess/graffiti		−2 Strongly agree −1 Agree 0 Neither agree nor disagree 1 Disagree 2 Strongly disagree
Safety	M2A_SUB_Q7_e	Thinking about the place you visited: The place felt welcoming/ safe		*See Biodiversity*
Peace	M2A_SUB_Q7_f	Thinking about the place you visited: It was a good place to get fresh air/peace and tranquillity		*See Biodiversity*
Interactional Nature Contact				
If only 1 activity per visit		Which of these activities, if any, did you do on this specific visit?		
Picnicking	M2A_Q8A_1	Eating or drinking out/picnicking	1 No 2 Yes	1 Eating or drinking out/ picnicking
Playing with children	M2A_Q8A_2	Playing with children		2 Playing with children
Walking	M2A_Q8A_3	Walking (including taking a dog for a walk)		3 Walking (including taking a dog for a walk)
Cycling or running	M2A_Q8A_4	Cycling or running		4 Cycling or running (4, 15, 16)
Fishing	M2A_Q8A_5	Fishing		5 Fishing
Appreciating scenery from a car	M2A_Q8A_6	Appreciating scenery from a car		6 Appreciating scenery from a car
Horse-riding	M2A_Q8A_7	Horse-riding		7 Horse-riding
Shooting/hunting	M2A_Q8A_8	Shooting/hunting		8 Shooting/hunting
Sports and games	M2A_Q8A_9	Sports and games		9 Sports and games
Visiting an attraction	M2A_Q8A_10	Visiting an attraction		10 Visiting an attraction
Boating, water sports or swimming outdoors	M2A_Q8A_11	Boating, water sports or swimming outdoors		11 Boating, water sports or swimming outdoors
Wildlife watching	M2A_Q8A_12	Wildlife watching		12 Wildlife watching
Don't know	M2A_Q8A_13	Don't know		13 Other (13, 14, Other)
Prefer not to say	M2A_Q8A_14	Prefer not to say		
Cycling	M2A_Q8A_15	Cycling		
Running	M2A_Q8A_16	Running		
Other	M2A_Q8A_Other	Any other outdoor activities		
If > 1 activity per visit	M2A_Q8B	And which would you say was the main activity you did on this specific visit?	1 Eating or drinking out/ picnicking 2 Playing with children 3 Walking (including taking a	*See above*

(*continued on next page*)

Table 2 (*continued*)

Variables	Survey Item	Item Wording	Original Response Options	Recoded Response Options
			dog for a walk) 4 Cycling or running 5 Fishing 6 Appreciating scenery from a car 7 Horse-riding 8 Shooting/hunting 9 Sports and games 10 Visiting an attraction 11 Boating, water sports or swimming outdoors 12 Wildlife watching 13 Other 14 Cycling 15 Running	
Temporal Nature Contact	M2A_Q8C	During this visit, how long did you spend doing the activity?	−2 Prefer not to say −1 Don't know 1 Up to 30 min 2 Over 30 min and up to an hour 3 Over 1 h and up to 2 h 4 Over 2 h and up to 3 h 5 Over 3 h and up to 5 h 6 Over 5 h	Midpoints (in hours): 0.25 0.75 1.5 2.5 4 5.5
Interpersonal Nature Contact				
With Children	M2A_SUB_Q2_1	Did you go on this visit: With children	0 No 1 Yes	If 1, 2, or 4 = 1 With others If 3 = 1 Alone with dog If 5 = 1 Alone
With friends/family	M2A_SUB_Q2_2	Did you go on this visit: With friends/other members of the family		
With dog	M2A_SUB_Q2_3	Did you go on this visit: With a dog		
With group	M2A_SUB_Q2_4	Did you go on this visit: With an organised group		
Alone	M2A_SUB_Q2_5	Did you go on this visit: By yourself		
Don't know	M2A_SUB_Q2_6	Did you go on this visit: Don't know		
Prefer not to say	M2A_SUB_Q2_7	Did you go on this visit: Prefer not to say		
Intrapersonal Nature Contact (Nature Connectedness)				
Before Survey Changes (Wave 2–37)	M1_Q6_a	How much do you agree or disagree with the following: I feel part of nature	−2 Prefer not to say −1 Don't know 1 Completely disagree 2 Strongly disagree 3 Disagree 4 Neither agree nor disagree 5 Agree 6 Strongly agree 7 Completely agree	−3 Completely disagree −2 Strongly disagree −1 Disagree 0 Neither agree nor disagree 1 Agree 2 Strongly agree 3 Completely agree
After Survey Changes (Wave 38–46)	M1_Connect	How connected do you feel to nature? Please choose the picture that best describes your relationship to nature	−2 Prefer not to say −1 Don't know 1 1Picture A 2 Picture B 3 Picture C 4 Picture D 5 Picture E 6 Picture F 7 Picture G	−3 Completely disagree −2 Strongly disagree −1 Disagree 0 Neither agree nor disagree 1 Agree 2 Strongly agree 3 Completely agree
Covariates				
Sociodemographics				
Age	Age_Band	What was your age last birthday? (banded)	−2 Prefer not to say −1 Don't know 1 16-24 2 25-39 3 40-54 4 55-64 5 65+	Midpoints (in years): 20 32 47 59.5 70
Gender	Gender	What gender do you identify as?	−2 Prefer not to say −1 Don't know 1 Male 2 Female 3 In another way (specify)	Male Female Diverse
Income	Income	Which of the following best describes your total annual household income before tax?	−2 Prefer not to say −1 Don't know 1 £0–14,999 2 £15,000–19,999 3 £20,000–29,999 4 £30,000–39,999 5 £40,000–49,999 6 £50,000+	Midpoints (in £) 7500 17500 25000 35000 45000 55000
Generic health and well-being				

(*continued on next page*)

Table 2 (*continued*)

Variables	Survey Item	Item Wording	Original Response Options	Recoded Response Options
Biological health and well-being	General_Health	Would you say that, in general, your health is:	−2 Prefer not to say −1 Don't know 1 Very good 2 Good 3 Fair 4 Bad 5 Very bad	−2 Very bad −1 Bad 0 Fair 1 Good 2 Very good
Psychological health and well-being	Wellbeing_satisfied	Overall, how satisfied are you with your life nowadays?	−2 Prefer not to say 0 Not at all 1 2 3 4 5 6 7 8 9 10 Completely	−5 not at all to 5 completely
Social health and well-being	Wellbeing_lonely	How often do you feel lonely?	−2 Prefer not to say −1 Don't know 1 Often/always 2 Sometimes 3 Occasionally 4 Hardly ever 5 Never	−2 Often/always −1 Sometimes 0 Occasionally 1 Hardly ever 2 Never
Years	Wave	Month of interview	Wave 2 – April 2020 To Wave 49 – March 2024	2 to 10 2020 11 to 22 2021 23 to 34 2022 35 to 46 2023 47 to 49 2024

Note. As a consequence of survey modifications concerning the most recent data (PaNS waves 38 to 49), certain variables diverge from our preregistered values (namely, activity, age, income, and nature connectedness). The latest dataset now requires PaNS respondents to indicate whether they engage in either running or cycling, rather than providing a single response category combining both. Some age and income categories were already combined by Natural England, resulting in less precise category midpoints than originally expected.

(CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR), with the good-fit thresholds being CFI >0.95, RMSEA <0.06, and SRMR <0.08 (Hu & Bentler, 1999).

We report both unstandardised (*b*) and standardised (β) coefficients. We use *b* to report the absolute extent to which predictors are associated with outcomes (**RQs1-4**), and β to indicate the relative importance of specific predictors and for the SEM results (**RQ5**).

Little's (1988) MCAR (missing completely at random) test assessed whether data missingness was related to other values in the dataset (see Supplements). Sensitivity analyses included models using the preregistered intrapersonal variable only (NCI; Tables S5–S7) and regressions with the preregistered positive element index (Tables S9–S11). The significance level was set to $\alpha = .05$ (two-tailed).

3. Results

Unless stated otherwise, effect sizes from Block 3 of the regression models are presented, as they included most of the relevant variables. Block 4 results, which were fairly analogous to the SEM results are discussed in greater detail in Section 3.5.

3.1. Descriptive statistics

Rural green spaces ($n = 7{,}353$; 40.7 %) were the most prevalent setting, followed by urban green spaces ($n = 6{,}567$; 36.4 %). On scales from −2 to +2, respondents rated visited environments as peaceful/tranquil ($M = 1.30$, $SD = 0.70$), safe ($M = 1.05$, $SD = 0.76$), accessible ($M = 1.04$, $SD = 0.82$), biodiverse ($M = 0.84$, $SD = 0.90$), and with good facilities ($M = 0.61$, $SD = 1.07$). However, cleanliness was rated poorly ($M = -1.45$, $SD = 0.71$). Walking was the most common activity ($n = 11{,}179$; 61.9 %), followed by playing with children ($n = 1{,}470$; 8.1 %), and wildlife watching ($n = 1{,}133$; 6.3 %). Visits lasted an average of 1.26 h ($SD = 0.96$). Most respondents ($n = 10{,}761$; 59.6 %) visited nature with others, either with friends or family, children, or an organised group. Respondents' mean nature connectedness was 0.87 ($SD = 1.37$).

3.2. *RQ1: Associations between nature and visit-related biopsychosocial health and well-being*

Linear regression models examined associations between self-reported visit-related biological, psychological, and social 'health and well-being' (from now on referred to as simply 'well-being') and natural settings (**RQ1.1**) as well as natural elements (**RQ1.2**).

Natural settings were generally not significantly associated with outcomes, particularly when including variables from subsequent blocks (Tables S2–S4). However, coastal blue spaces showed consistent positive associations with psychological well-being ($b_{Block3} = 0.05$, 95 % CI [0.02, 0.08], $p = .001$) across all blocks, and with biological well-being in Blocks 2 and 3 ($b_{Block3} = 0.03$ [0.00, 0.06], $p = .045$). Coastal blue spaces were positively associated with social well-being only in Block 1 ($b_{Block1} = 0.10$ [0.05, 0.14], $p = .001$). Urban green spaces were positively associated with psychological well-being in Blocks 1, 2, and 4 ($b_{Block4} = 0.02$ [0.00, 0.04], $p = .035$).

Natural elements were stronger predictors of all three outcomes than settings (see Fig. 2). For biological and psychological well-being, peace/tranquillity (biological: $\beta_{Block3} = 0.16$ [0.15, 0.17], $p < .001$; psychological: $\beta_{Block3} = 0.17$ [0.16, 0.18], $p < .001$) and accessibility (biological: $\beta_{Block3} = 0.10$ [0.09, 0.12], $p < .001$; psychological: $\beta_{Block3} = 0.08$ [0.06, 0.09], $p < .001$) were the natural elements with the strongest associations across all blocks. Also, safety emerged as a strong predictor of psychological well-being ($\beta_{Block3} = 0.08$ [0.07, 0.09], $p < .001$). For

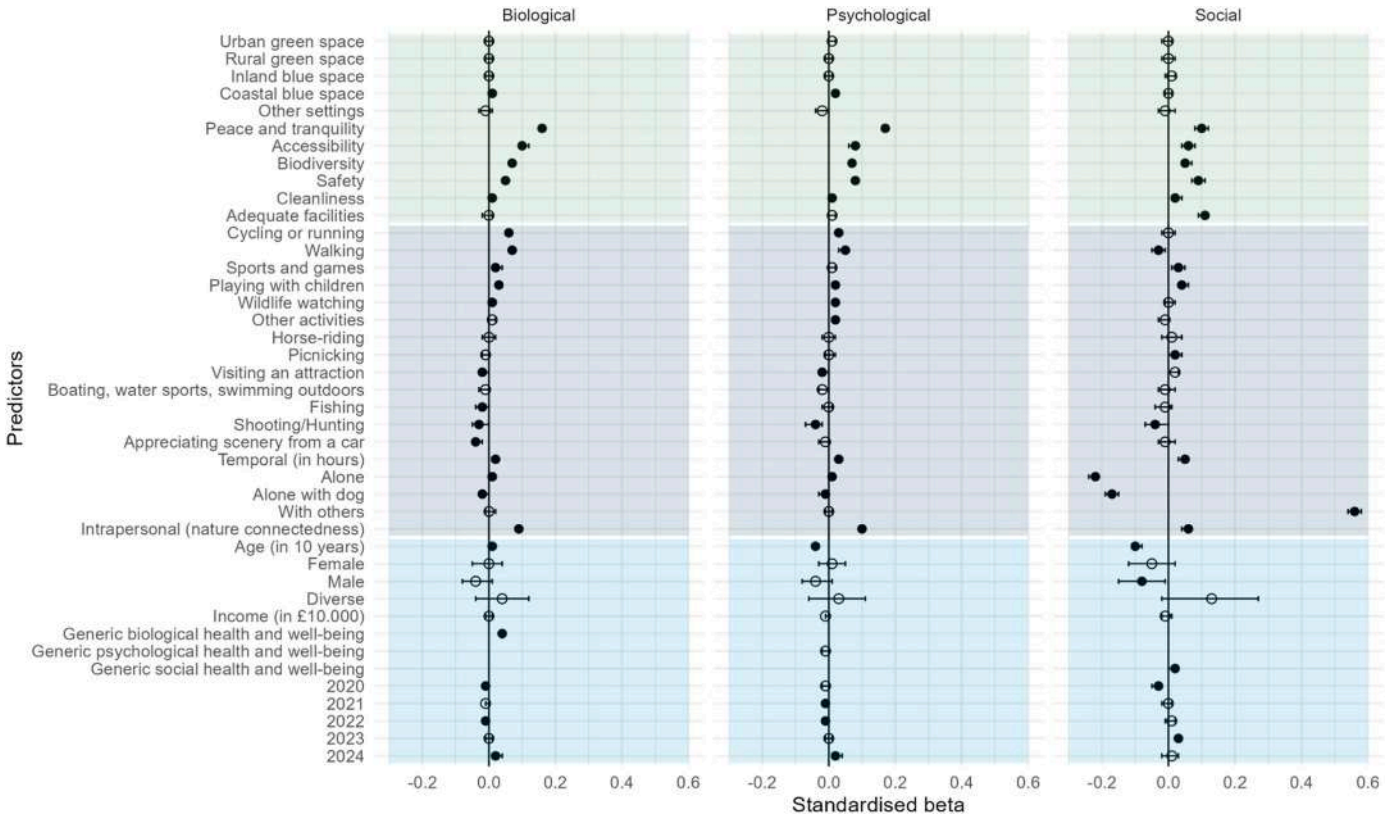

Fig. 2. Forest plot displaying the standardised regression coefficient (β) for each outcome from Block 3 of the hierarchical linear regression models.
Note. The colour coding system applied indicates the respective parts of NBRT (green = nature, grey = nature contact, blue = covariates). Full circles represent nominally significant effects ($p < .05$), while open circles represent non-significant ones.

social well-being, the strongest predictors were adequate facilities ($\beta_{Block3} = 0.11$ [0.09, 0.12], $p < .001$), peace/tranquillity ($\beta_{Block3} = 0.10$ [0.08, 0.12], $p < .001$), and safety ($\beta_{Block3} = 0.09$ [0.07, 0.11], $p < .001$).

3.3. *RQ2: Associations between nature contact and visit-related biopsychosocial health and well-being*

The regression models were expanded from Block 2 onwards to include interactional, temporal, interpersonal, and intrapersonal nature contact components, examining their relationships with visit-related health and well-being outcomes.

3.3.1. *RQ2.1: Interactional aspects (activities)*

For self-reported biological well-being, engaging and dynamic activities like cycling/running ($b_{Block3} = 0.21$ [0.17, 0.25], $p < .001$), walking ($b_{Block3} = 0.13$ [0.10, 0.15], $p < .001$), and sports/games ($b_{Block3} = 0.11$ [0.05, 0.17], $p < .001$), were positively associated compared to visit averages (Fig. 3). Sedentary activities, such as appreciating a scenery from a car ($b_{Block3} = -0.18$ [−0.26, −0.10], $p < .001$), as well as shooting/hunting ($b_{Block3} = -0.16$ [−0.29, −0.03], $p = .017$), and fishing ($b_{Block3} = -0.10$ [−0.19, −0.02], $p = .017$), displayed negative associations.

For psychological well-being, similar patterns emerged. Positive associations were found for cycling/running ($b_{Block3} = 0.10$ [0.06, 0.14], $p < .001$), walking ($b_{Block3} = 0.09$ [0.06, 0.11], $p < .001$), and playing with children ($b_{Block3} = 0.07$ [0.03, 0.11], $p < .001$). Negative associations were observed for shooting/hunting ($b_{Block3} = -0.25$ [−0.38, −0.12], $p < .001$) and visits to attractions ($b_{Block3} = -0.07$ [−0.12, −0.02], $p = .008$).

In terms of social well-being, inherently social activities, like sports/games ($b_{Block3} = 0.14$ [0.06, 0.23], $p < .001$), playing with children ($b_{Block3} = 0.13$ [0.08, 0.18], $p < .001$), and picnicking ($b_{Block3} = 0.07$ [0.01, 0.12], $p = .02$), were consistently positively associated compared to visit averages, whereas shooting/hunting ($b_{Block3} = -0.21$ [−0.40, −0.02], $p = .028$) was negatively associated. Walking was associated with lower social well-being ($b_{Block3} = -0.05$ [−0.09, −0.02], $p = .004$) compared to visit averages.

3.3.2. *RQ2.2: Temporal aspects (duration)*

Visit duration was positively associated with both psychological and social well-being across all blocks, being slightly higher for social ($b_{Block3} = 0.05$ [0.03, 0.06], $p < .001$) than for psychological well-being ($b_{Block3} = 0.03$ [0.02, 0.04], $p < .001$). Positive associations with biological well-being were observed in Blocks 2 and 3 (both $b = 0.02$ [0.01, 0.03], $p < .001$). Quadratic effects of visit duration were never significant and thus excluded from further analysis (Tables S12–14). Relationships between visit duration and outcomes were broadly linear, with, for example, each additional hour linked to a 0.03-point increase in self-reported psychological well-being.

3.3.3. *RQ2.3: Interpersonal aspects (companionship)*

Visits with others were positively associated with social well-being ($b_{Block3} = 0.64$ [0.61, 0.66], $p < .001$), while visiting alone ($b_{Block3} = -0.36$ [−0.39, −0.34], $p < .001$) or with a dog ($b_{Block3} = -0.27$ [−0.30, −0.24], $p < .001$) were negatively associated. In contrast, biological and psychological well-being were positively associated with visiting alone (biological: $b_{Block3} = 0.03$ [0.01, 0.05], $p < .01$, psychological: $b_{Block3} = 0.05$ [0.03, 0.07], $p < .001$) and negatively associated when accompanied by a dog (biological: $b_{Block3} = -0.03$ [−0.05, −0.01], $p = .006$; psychological: $b_{Block3} = -0.02$ [−0.04, 0.00], $p = .022$). Visiting with others showed no significant association with these two outcomes (both $b_{Block3} < 0.01$ [−0.01, 0.02], $ps > 0.05$).

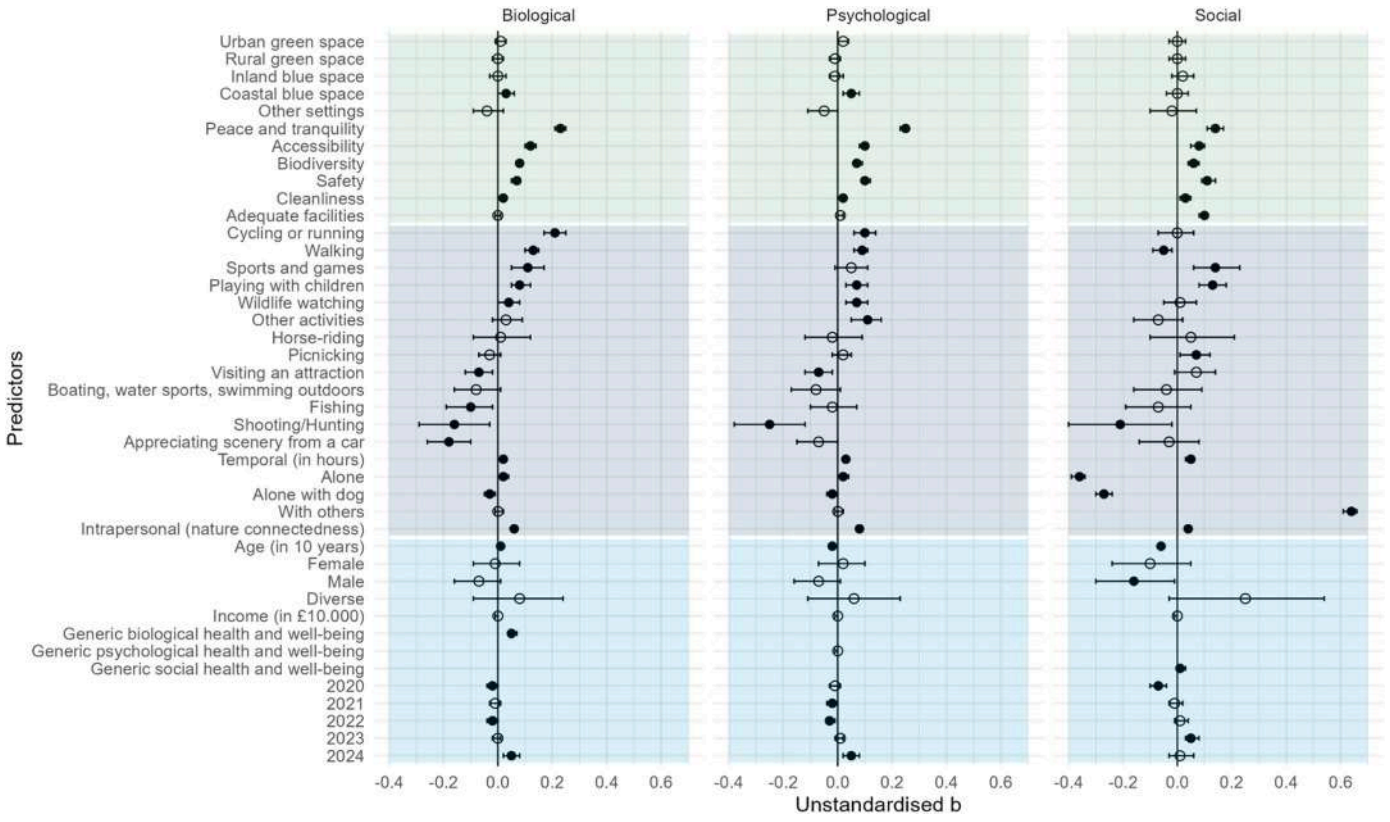

Fig. 3. *Forest plot displaying the unstandardised regression coefficient (*b*) for each outcome from Block 3 of the hierarchical linear regression models.*
Note. The colour coding system applied indicates the respective parts of NBRT (green = nature, grey = nature contact, blue = covariates). Full circles represent nominally significant effects ($p < .05$), while open circles represent non-significant ones.

3.3.4. ***RQ2.4**: Intrapersonal aspects (nature connectedness)*

Nature connectedness was positively associated with visit-related biological ($b_{Block3} = 0.06$ [0.06, 0.07], $p < .001$), psychological ($b_{Block3} = 0.075$ [0.068, 0.082], $p < .001$), and social ($b_{Block3} = 0.04$ [0.03, 0.05], $p < .001$) well-being across all blocks.

In summary, among all nature contact components, the intrapersonal component showed the strongest association with biological ($\beta_{Block3} = 0.09$ [0.08, 0.10]) and psychological ($\beta_{Block3} = 0.10$ [0.09, 0.11]) well-being compared to other predictors. For social well-being, the interpersonal component demonstrated by far the strongest association ($\beta_{Block3/Others} = 0.56$ [0.54, 0.58]; $\beta_{Block3/Dog} = -0.17$ [-0.19, −0.15]; $\beta_{Block3/Alone} = -0.22$ [-0.24, −0.21]).

3.4. ***RQ3**: Associations between person-specific covariates and biopsychosocial health and well-being*

From Block 3 onwards, analyses controlled for sociodemographic covariates, generic biopsychosocial well-being levels and survey year. Age was positively associated with biological well-being ($b_{Block3} = 0.008$ [0.002, 0.014], $p = .007$) but negatively associated with psychological ($b_{Block3} = -0.02$ [−0.027, −0.015], $p < .001$) and social ($b_{Block3} = -0.06$ [−0.07, −0.05], $p < .001$) outcomes. Gender and income did not predict any aspect of visit-related biopsychosocial well-being. In contrast, all three elements of visit-related biopsychosocial well-being were lower during earlier survey years (2020 and 2021; Fig. 3), possibly due to COVID-19 restrictions.

Both generic biological (general health) and social (reversed loneliness) well-being positively predicted their respective visit-related outcomes (biological: $b_{Block3} = 0.05$ [0.04, 0.07], $p < .001$, social: $b_{Block3} = 0.01$ [0.002, 0.026], $p = .02$). However, generic psychological well-being (life satisfaction) was negatively associated with visit-related psychological well-being in Block 4 ($b_{Block4} = -0.01$ [−0.013, −0.005], $p < .001$).

3.5. ***RQs4-5**: Exploring interrelations and interactions*

To expand on the linear regression insights, a SEM analysed all outcomes simultaneously for the most prevalent activity (walking, $n = 11{,}179$). Respondents from all settings were combined due to minimal setting differences. Those walking alone with a dog ($n = 1{,}861$), identifying as neither male nor female ($n = 17$), or with missing data ($n = 236$) were omitted to simplify analyses, resulting in a final sample of $n = 9{,}065$.

Overall model fit was good (see graphical model representation, Fig. 4), with CFI = 0.99, RMSEA = 0.05 (90 % CI [0.04, 0.06]), SRMR = 0.008, and $\chi^2(6) = 133.19$ ($p < .001$). Given the large sample size, model complexity, and the satisfactory further model-fit indices, the nominally significant χ^2 test was deemed negligible.

3.5.1. ***RQ4**: Associations between visit-related biopsychosocial metrics of health and well-being*

Visit-related well-being metrics were significantly interrelated (Tables S2–S4). SEM results corroborated and expanded these findings, revealing stronger associations between biological and psychological outcomes ($r = 0.56$, $p < .001$) than between the social outcome and either biological or psychological outcomes ($r = 0.28$ and 0.32, $ps < 0.001$).

3.5.2. ***RQ5**: Interaction effects between nature contact components*

The SEM also explored interaction effects between temporal, interpersonal, and intrapersonal nature contact components during walking visits. Besides all main effects, pairwise interactions and one three-way interaction were calculated. Main effects were mostly consistent with regression findings and thus are not discussed further (Fig. 4).

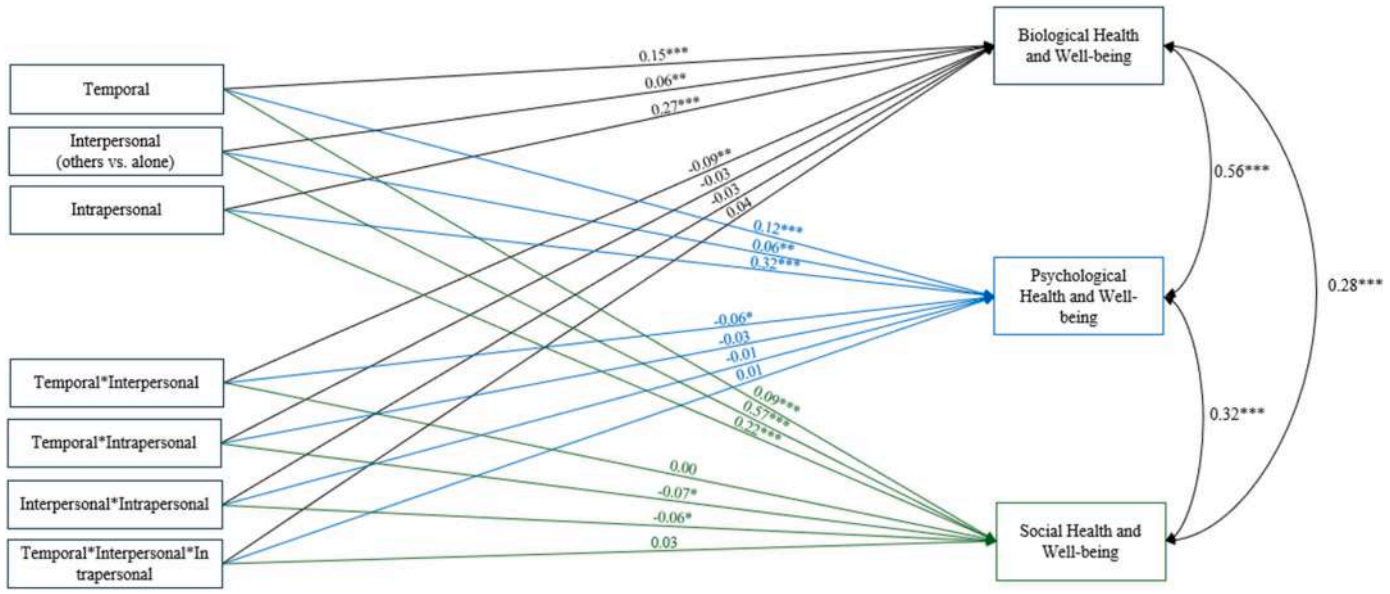

Fig. 4. Structural equation model investigating the interaction effects of temporal, interpersonal, and intrapersonal nature-visit components and visit-related biological, psychological and social health and well-being (for walking visits only [n = 9065], collapsing across all settings).
Note. The interpersonal variable was dummy-coded, with 'alone' serving as the reference category (those with dogs were excluded from the analysis). The SEM also accounted for sociodemographic covariates, the respective generic (i.e. trait) health and well-being, and survey year. For the sake of clarity, these variables are not shown in the figure. The figure presents standardised estimates across all variables, thus allowing for comparisons of the strength of the relations between predictors and outcomes. Numerical values are standardised coefficients, representing the change in the respective outcome when the predictor increases by one standard deviation.
*$p < .05$, **$p < .01$, ***$p < .001$.

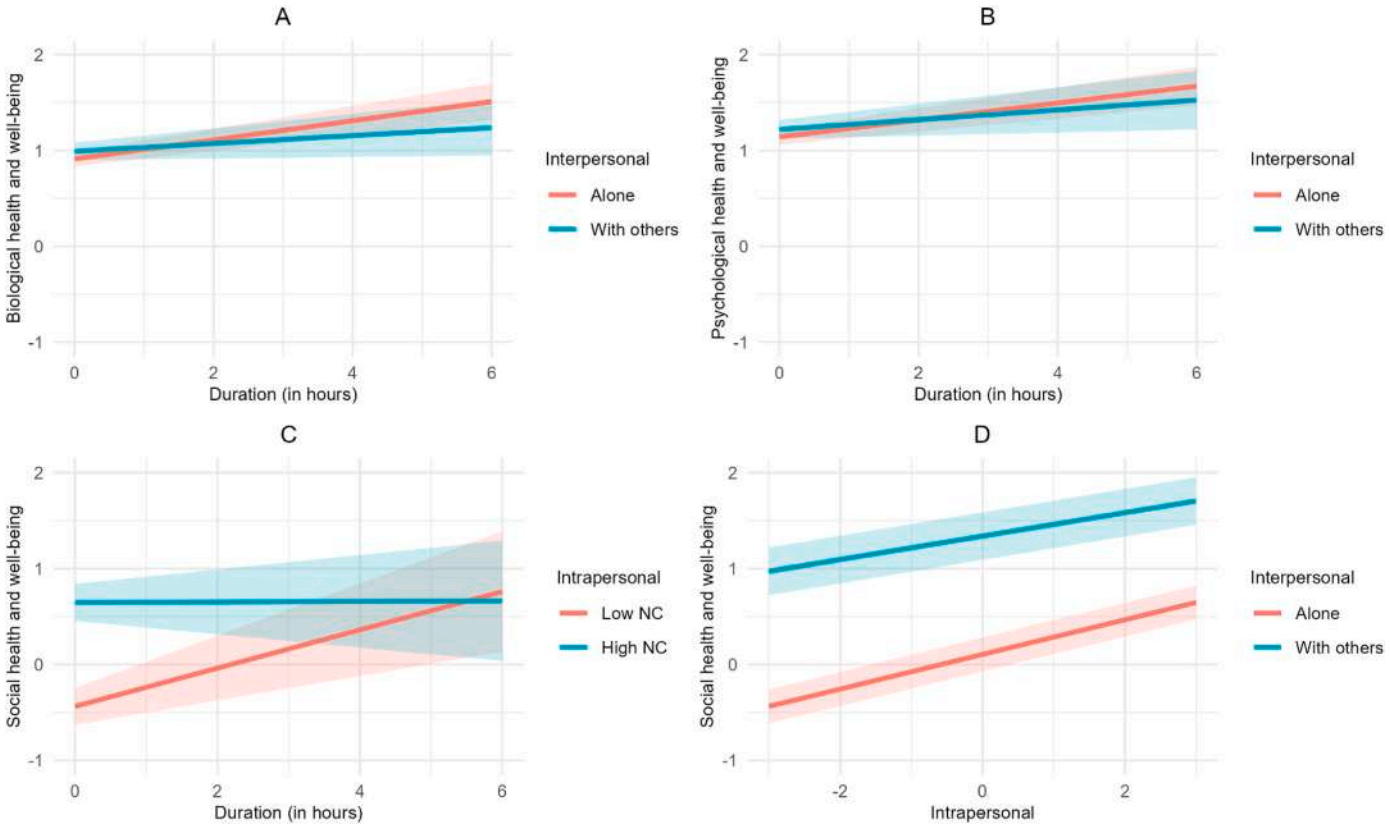

Fig. 5. Visualisation of significant interaction effects between nature-contact components for visit-related biological, psychological, and social health and well-being.
Notes. For each significant interaction effect, the legend is displayed on the right. (A) Interaction between interpersonal and temporal nature-contact components for biological health and well-being. (B) Interaction between interpersonal and temporal nature-contact components for psychological health and well-being (C) Interaction between temporal and intrapersonal (i.e., nature connectedness). nature-contact components for social health and well-being. (D) Interaction between interpersonal and intrapersonal nature-contact components for social health and well-being.

The only notable change was the direction of the interpersonal variable's main effect on biological and psychological well-being, indicating that walking with others was more beneficial than walking alone. This shift was due to a significant interaction between companionship and visit duration (biological: $\beta = -0.09$ [-0.15, −0.04], $p = .001$; psychological: $\beta = -0.06$ [-0.11, 0.00], $p = .049$), indicating that companionship moderated the impact of visit duration on these two outcomes (Fig. 5A and B). Companionship was coded as 'alone' (0) vs. 'with others' (1); hence, these negative interaction coefficients indicate that the positive effect of visit duration (biological: $\beta = 0.15$ [0.10, 0.19], $p < .001$; psychological: $\beta = 0.12$ [0.08, 0.17], $p < .001$) was weaker for those visiting with others compared to those visiting alone.

For visit-related social well-being, a negative interaction was found between temporal and intrapersonal variables ($\beta = -0.07$ [-0.13, −0.01], $p = .031$), indicating that visit duration was positively associated with social well-being for individuals with low nature connectedness, but slightly negatively related for those with high nature connectedness (Fig. 5C). Furthermore, a negative interaction between interpersonal and intrapersonal variables ($\beta = -0.06$ [-0.12, −0.01], $p = .025$) showed that the relationship between nature connectedness and social well-being was less pronounced when visiting with others compared to visiting alone (Fig. 5D).

No three-way interaction effects between temporal, interpersonal, and intrapersonal components emerged ($\beta = 0.01$ to 0.04, all $ps > 0.23$).

4. Discussion

This study used data from the People and Nature Survey (Natural England, 2024, p. 9093) to examine how aspects of specific nature visits relate to components of biopsychosocial health and well-being, important building blocks of biopsychosocial resilience (White et al., 2023). Several predictors (settings, elements, temporal, intrapersonal, wave) showed broadly similar associations across biological, psychological, and social domains, whereas others (interactional, interpersonal, age, generic health and well-being) showed differing associations. We also tested interactions among duration, companionship, and nature connectedness.

4.1. Biopsychosocial health and well-being as building blocks of adaptive resilience resources

Self-reported visit-related biological, psychological, and social well-being were significantly intercorrelated (**RQ4**). Although not traditional resilience measures, these outcomes plausibly serve as building blocks of resilience resources, reflecting how visiting nature strengthens the foundational components of adaptive resilience. Recognising health and well-being as resilience-enabling attributes that both protect against and support recovery from stressors (Egan et al., 2024), our findings suggest that nature contact may foster overall biopsychosocial resilience by holistically building resilience resources ('stocks') rather than targeting specific subcomponents.

4.1.1. *RQ1: Nature*

Most visits occurred in green (77 %) or blue spaces (21 %), with coastal blue spaces associated with higher self-reported biological and psychological well-being than the average visit (**RQ1.1**). While this aligns with evidence linking coastal environments to greater visit satisfaction, happiness, and reduced anxiety compared to other blue spaces (Garrett et al., 2023), caution is warranted as these accounted for <10 % of all visits and may be associated with particularly important times (foremost, vacations). Generally, within-setting elements were more important than the setting itself. Perceived peacefulness/tranquillity, safety, maintenance, and biodiversity were the strongest predictors of visit-related well-being, with higher quality linked to greater reported benefits (**RQ1.2**). This aligns with a substantial body of previous work examining similar metrics of actual and perceived green/blue space quality and various health and well-being outcomes (Ekkel & de Vries, 2017; Nguyen et al., 2021; Stoltz & Grahn, 2021; Ward Thompson, 2011). Notably, the qualities examined here were not necessarily indicators of ecological quality (e.g., biodiversity, special ecological status; Wyles et al., 2019), nor the kinds of elements typically prioritised in nature-based solutions or community-level socio-ecological resilience (Lafortezza et al., 2018). Instead, our quality metrics included elements such as tranquillity and perceived safety, alongside facilities (e.g., benches) and aspects related to accessibility (e.g., car parking, well-maintained paths). Park and garden designers have long recognised that carefully managed nature, making human contact safe and welcoming, is particularly beneficial for biopsychosocial well-being (Stigsdotter et al., 2017; Ward Thompson, 2011). More broadly, these findings question the utility of comparing benefits of different settings (green vs. blue spaces) and instead highlight the importance of examining specific elements within such settings.

4.1.2. *RQ2: Nature contact*

Visit duration was positively linearly associated with biopsychosocial health and well-being (**RQ2.2**), consistent with prior research (Garrett et al., 2023; Shanahan et al., 2016). As well, individuals with higher nature connectedness reported greater benefits from nature visits (**RQ2.4**; Martin et al., 2020; Pritchard et al., 2020), likely due to their ability to notice, appreciate, and connect with nature, themselves, and others (Darcy et al., 2022). Within the NBRT framework, this could be interpreted as nature connectedness supporting stocks of biopsychosocial resilience directly by fostering health and well-being, and indirectly by encouraging the preservation and provision of high-quality natural environments, as nature connectedness is also positively linked to pro-environmental behaviours (Liu et al., 2022; Martin et al., 2020; Whitburn et al., 2020).

4.1.3. *RQ3: Covariates*

Gender and income showed no significant associations with self-reported biopsychosocial outcomes, suggesting that nature visits may equally benefit individuals across genders and income groups. Respondents from earlier waves (2020, 2021) reported lower perceived benefits, likely reflecting uncertainties and restrictions during the COVID-19 pandemic in England (Benke et al., 2020; Berdejo-Espinola et al., 2021; Pierce et al., 2020). However, an English study (Stock et al., 2022) and two meta-analyses of longitudinal cohort studies (Robinson et al., 2022; Sun et al., 2023) point to short-lived impacts of the pandemic on health and well-being. Findings show either no significant change in general mental health (Sun et al., 2023) or small, immediate declines that returned quickly to pre-pandemic levels (Robinson et al., 2022; Stock et al., 2022). Accordingly, restricted nature access during the pandemic does not appear to have had a lasting impact.

4.2. Nature contact and biological health and well-being

Most visits (~78 %) involved moderate- to high-intensity activities (e.g., walking, cycling/running), which are associated with higher physical health benefits relative to passive/sedentary activities (**RQ2.1**; e.g., appreciating scenery from a car). Physical activity contributes to overall health and cardiovascular fitness, which, in turn, reduces risks of developing high blood pressure, obesity, cardiovascular diseases, and cancer (Dhuli et al., 2022). Within NBRT, enhancing physical health and reducing disease risk are understood to contribute to biological resilience, but such long-term benefits typically accrue through repeated visits over several years, not a single experience (Grellier et al., 2024).

In general, respondents with good perceived generic health reported greater physical health benefits from nature visits (**RQ3**). This may reflect a positive feedback loop, where individuals with positive health-related self-perception are more likely to engage in physical activity, perceive greater benefits from it, and require less recovery time from potentially tiring visits (Denche-Zamorano et al., 2022). Additionally,

expectations of health benefits following nature visits may heighten awareness of their impact, though this interpretation remains speculative as actual physical health was not assessed.

Solitary nature visits appeared to be more advantageous for self-reported physical health than visits with others or dogs (**RQ2.3**). This contrasts with evidence showing that dog owners are more likely to meet physical activity guidelines and engage in frequent physical activity through dog walking (White et al., 2018; Zijlema et al., 2019). However, these studies examined associations over time, whereas the PaNS focused on single visits. One possible explanation is that paying attention to the dog during a visit may detract from other benefits.

Additionally, associations between physical health and companionship were context-sensitive for walking visits without a dog (**RQ5**). While a significant positive main effect of companionship suggests that walking with others is more beneficial for physical health than walking alone, SEM results indicated this was only true for relatively short visits. The main effect of duration indicated a positive link between self-reported physical health and visit duration for solitary visits, while the negative interaction effect reflected a reduced duration effect for those visiting with others. Thus, walking with others is more beneficial for short visits, but as duration increases, this effect diminishes and eventually reverses, making walking alone more associated with perceived biological well-being. The same negative interaction was found for psychological well-being (**RQ5**). These findings highlight the importance of considering the interplay between visit duration and social context when designing interventions to promote physical and mental health through nature contact.

4.3. Nature contact and psychological health and well-being

The results for psychological well-being were broadly similar to those for biological well-being, albeit with some variation (**RQ2.1**). This underscores the interconnectedness between biological and psychological well-being, suggesting that physical activity enhances health and well-being, potentially through neurochemical and neurophysiological changes in the brain (Martín-Rodríguez et al., 2024).

Visiting nature alone was found to be associated more positively with self-reported psychological well-being compared to visiting with others or with a dog (**RQ2.3**). Previous research has highlighted the benefits of intentional solitude in nature, which fosters positive emotions, engagement, meaning, and overcoming challenges (Petersen et al., 2021). Additionally, our 'others' category included children, and prior work indicates that visits with children (particularly when multiple children accompany a single adult) are associated with fewer psychological benefits than visiting alone (White et al., 2013).

The negative association between generic life satisfaction and visit-related psychological well-being (**RQ3**) suggests that individuals with lower life satisfaction perceive greater benefits from single visits compared to those with higher life satisfaction.

4.4. Nature contact and social health and well-being

Despite our findings that visits alone were associated with greater psychological well-being, most nature visits (~60 %) were nonetheless undertaken in the company of others. Unsurprisingly, companionship emerged as the strongest predictor of perceived social well-being (**RQ2.3**), as visiting with others constituted opportunities to spend time with friends or family. In contrast, visiting alone or with a dog was negatively associated with the social outcome, though the negative link of visiting with a dog was less pronounced, suggesting that while dogs cannot substitute for human contact and interaction, their presence still provides some social benefits.

The negative interaction between companionship and nature connectedness, however, suggests that high nature connectedness contributes less to social well-being when walking with others (**RQ5**). While both groups benefit from higher nature connectedness, individuals with low nature connectedness may compensate through companionship. Similarly, the negative interaction between visit duration and nature connectedness indicates that respondents with low nature connectedness gain more from longer visits, as extended durations may offset their lower nature connectedness. Conversely, respondents with high nature connectedness appear to require less time to achieve similar social outcomes as those with lower levels. These findings highlight nature connectedness as a key moderator and suggest that individual nature connectedness levels should be considered when designing interventions.

Activities facilitating social interaction (e.g., picnicking) were positively associated with social well-being (**RQ2.1**), whereas activities requiring silence (e.g., hunting/shooting) or physically demanding activities (e.g., cycling/running) were less conducive. Perhaps surprisingly, walking was linked to lower social well-being than the average visit. Group-based nature walks are among the most common nature-based interventions (Ma et al., 2024) and have been investigated for their potential to build psychological resilience, albeit with mixed findings (Marselle et al., 2019). Perhaps the most obvious difference is that in many intervention settings, walking is embedded within either professional (van den Berg & Beute, 2021) or peer (Hubbard et al., 2020) support structures, whereas here the item focused on 'friends or family'. Further research is needed to clarify the mechanisms underlying this observation.

Finally, individuals with higher generic loneliness reported fewer social benefits from nature visits (**RQ3**), potentially challenging the notion that spending time in nature might be particularly effective at alleviating loneliness (Astell-Burt et al., 2024). Notably, the survey item targets 'friends or family' rather than regular incidental contact with familiar (but not necessarily close) others (Kaźmierczak, 2013), which is often emphasised in loneliness research (Veitch et al., 2022). This underscores the importance of precise item wording and the need to test alternative operationalisations before drawing firmer conclusions.

5. Limitations and future research

Although the large and representative sample enabled us to explore several elements of NBRT simultaneously, we also recognise a number of limitations. For instance, the study's cross-sectional design limits causal conclusions, and the reliance on self-reports of perceived (rather than more objective) benefits implies that biases (perception, recall) cannot be ruled out. Evidence of positive associations between subjective assessments of health and well-being and both professional assessments (Diener et al., 1999) and objective outcomes (e.g., mortality rates: Kyffin et al., 2004) suggests the observations still have value. Nonetheless, we recognise that nature visit studies exploring more objective outcomes in real time (e.g., Beute & de Kort, 2018) would definitely strengthen the evidence base and offer more direct tests of NBRT.

We also acknowledge that our focus on single visits meant we could not examine the importance of cumulative exposures over extended periods, which are likely needed to build and maintain adaptive bio-psychosocial resilience-related resources. Accordingly, our conclusions are tentative, and longitudinal designs that track recreational nature contact over time are needed to test whether visit-related gains in self-reported well-being translate into more durable resilience resources. Nevertheless, although effect sizes were generally small, the finding that even a single nature visit in the past 14 days was significantly associated with perceived health and well-being is promising.

We also recognise that secondary analysis of a dataset with limited variables forced us to use single-item measures for perceived general and visit-related health and well-being, and that these did not perfectly serve our purposes. For instance, the item gauging social health and well-being, along with its 'not applicable' response option, appeared ambiguous. A total of 2,667 respondents (14.8 %) selected 'not applicable', with this response option being particularly frequent among individuals who visited nature alone (69.9 %) or with a dog (22.4 %). This

raises questions about the precise item meaning and appropriateness of its response options. Future research may utilise more robust multi-item measures of health, well-being, and resilience if timing and resources allow. Finally, despite the large sample of visits, certain activities (e.g., shooting/hunting: $n = 82$) were rare in the PaNS dataset, which reduces the robustness of conclusions for these types of visits, and those interested in particular activities will need to engage in more purposive sampling efforts.

6. Conclusion

This study examined the associations of nature settings (location type), nature elements (qualities), and nature contact (activity type, duration, interpersonal and intrapersonal aspects) with self-reported measures of biological, psychological, and social health and well-being in a nationally representative English sample. Results replicate prior findings and extend them by framing multiple visit features within nature-based biopsychosocial resilience theory (NBRT). Given the intercorrelations among biopsychosocial domains, supporting one type of well-being is likely to replenish others, positioning nature as a resource for maintaining and fostering biopsychosocial resilience resources over time. Findings indicate that perceptions of natural elements (e.g., biodiversity, safety) within settings are stronger predictors of outcomes than the type of setting itself (e.g., urban green spaces), thus highlighting the need to focus on such within-setting elements. Several key patterns emerged: engaging and dynamic activities (e.g., cycling/running, walking) were particularly positively associated with biological health and well-being, nature connectedness was robustly linked to psychological health and well-being, and companionship during visits was related to social health and well-being. Additionally, a number of nuanced interactions were observed. Understanding such complex patterns and interactions advances theoretical thinking (in this case by testing NBRT), while large, representative datasets (here, the PaNS) allow for more complex modelling and holistic treatment of a multitude of aspects at the same time. Ultimately these insights help unravel how and why spending time in nature is linked to biopsychosocial resilience and other potential benefits of nature visits.

CRediT authorship contribution statement

Valentina Hampejs: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Addi Wala:** Writing – review & editing, Methodology, Conceptualization. **Ulrich S. Tran:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Sabine Pahl:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Julia A.M. Egger:** Writing – review & editing, Methodology. **Martin Voracek:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Mathew P. White:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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Appendix A. Supplementary data

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