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An 18-country analysis

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Abstract

Contact with natural environments is associated with good health and well-being. Although childhood nature experiences may be important in the development of an individual's relationship with nature and subsequent well-being, previous studies have tended to focus on 'nature' in general, and the mechanisms by which childhood experiences influence well-being in adulthood remain insufficiently studied. Drawing on cross-sectional survey data from an 18-country sample (N = 15,743) the current work extended previous research by examining: a) blue spaces (coasts, rivers, lakes, etc.) in particular; b) associations between adults' recalled childhood exposure to blue spaces, frequency of recent visits to green and blues spaces, and adult subjective well-being; c) the role of childhood exposure to blue spaces on intrinsic motivations to spend time in nature; and d) the consistency of these relationships across different countries. Tests of a model where childhood exposure to blue spaces was linked to adult subjective well-being serially through intrinsic motivation and then recent blue and green space visits exhibited a good fit, a pattern largely consistent across all 18 countries. However, an alternative model where recent visits predicted intrinsic motivation also demonstrated good fit, indicating that these processes may be iterative. Building familiarity with and confidence in and around blue spaces in childhood may stimulate a joy of, and greater propensity to spend recreational time in, nature in adulthood, with positive consequences for adult subjective well-being.

[229 words]

Keywords: WHO-5, intrinsic motivation, subjective well-being, blue/green space, cross-cultural analysis, childhood

1. Introduction

1.1 Overview

Despite growing body of evidence linking nature experiences to positive mental health outcomes (Frumkin et al., 2017; Hartig et al., 2011), including greater subjective well-being (i.e., how people think and feel about their own lives, White et al., 2017), people are becoming increasingly detached from the natural world (Orr, 2002; Pergams & Zaradic, 2008). For instance, in a representative study of over 16,000 people in England that do not visit natural environments regularly, 22% of respondents reported that they were 'not interested', felt that nature was 'not for people like them', or reported 'no particular reason' for not visiting nature (Boyd et al., 2018). Such lack of interest, feelings of alienation, and apathy may, in part, be due to competing demands of other daily activities and to the growth of other forms of entertainment, particularly electronic technology (Oswald et al., 2020; Pergams & Zaradic, 2006; Staempfli, 2009). Equally, less exposure to nature in childhood with each consecutive generation, the so-called 'extinction of experience' (Charles & Louv, 2009; Pyle, 1993; Soga & Gaston, 2016), may undermine familiarity, connection with, and appreciation of, the natural world (although see Novotny et al., 2021, Oh et al. 2020).

Supporting this proposition, less nature exposure during childhood has been associated with fewer recreational nature visits as an adult (Rosa et al., 2018; Taye et al., 2019; Pensini et al., 2016; Ward Thompson et al., 2008; Hosaka et al., 2018; although see also van Heezik et al., 2021). Given that adult nature visits independently predict better well-being (Capaldi et al., 2015; Cox et al., 2017; Shanahan, et al., 2016; White et al., 2017, 2019, 2021; van den Berg et al., 2016), limited childhood nature exposure may come at a cost to mental health across the lifespan. Certainly, spending time in nature as a child has been linked to better subjective well-being and a lower risk of poor mental health during both childhood and adulthood (Chawla, 2015; Li et al., 2021; Tillmann, 2018; Roberts, Hinds & Camic, 2020 Bezold et al., 2018; Engemann et al., 2019, 2020a, 2020b; Preuß et al., 2019; Snell et al., 2016; Pensini, Horn & Caltabiano, 2016). Nonetheless, the specific role of childhood exposure to blue spaces in adult subjective well-being, as well as potential

underlying mechanisms and cultural differences in the childhood nature – adult well-being relationship remain underexplored. The overarching aim of the current paper was to investigate these issues using data from a large multi-country survey that had a particular focus on blue spaces such as rivers, lakes and the coast (Grellier et al., 2017). Specifically, we examined the relationship between childhood exposure to blue spaces and adult well-being and the potential mediating role of adult intrinsic motivation to visit natural spaces and the frequency of visits to blue and green spaces. Moreover, we explore if the patterns of associations were consistent across different countries and regions.

1.2 Childhood blue space exposure and adult well-being

Despite evidence of the potential benefits of blue spaces for adult well-being (Bell et al., 2021; Völker & Kistemann, 2011, 2013; White et al., 2020), studies examining childhood nature exposure and adulthood outcomes have largely focused on green space, or natural spaces in general (e.g. Bezold et al., 2018; Preuß et al., 2019; Snell et al., 2016). Blue spaces have unique sensory qualities (e.g., light reflections, wave motion, sounds, etc., Volker & Kistemann, 2015; Ruiz-Gil et al., 2020) and facilitate a distinct range of leisure activities (e.g., swimming, fishing, water-sports; Elliott et al., 2018). They also pose a number of hazards and risks, particularly for children (e.g., drowning, infectious diseases, harmful algae blooms; WHO, 2014; Congdon et al., 2013; Lawes et al., 2021), which may increase parental concerns about children's contact with these environments (Moran, 2009; Pitt, 2019). Nevertheless, recent evidence suggests that growing up near blue spaces is associated with a lower prevalence of a variety of mental health disorders during adulthood, even after accounting for concurrent green space exposure (Engemann et al., 2020a, 2020b). These findings situate exposure to blue spaces during childhood as potentially important predictor of adult mental well-being in its own right. Moreover, even if green and blue spaces can be conceptualized as distinct and separate entities concerned with environmental characteristics and their benefits, sometimes, cannot be distinctly separated from each other (Korpela et al. 2010). For example,

terrestrial attributes around blue spaces, such as high-quality paths (Verbič et al., 2016) and easily accessible waterside spaces (De Bell et al. 2017) usually contain green vegetation and it is also common the presence of blue–green spaces, with both green vegetation and water bodies. Thus, blue- and green space experiences are frequently bound together and in line with that, childhood exposure to blue spaces is likely to play a role in predicting future frequency of green space visits as well. Yet, it remains to be established whether this pattern of associations extends to less incidental forms of blue space exposure (i.e., active engagement with blue spaces, as opposed to residential proximity; Keniger, et al. 2003) and non-clinical aspects of well-being. Thus, the first aim of the current study was to investigate whether recalled childhood exposure to blue spaces is related to better adult subjective well-being.

1.3 The role of intrinsic motivation to visit natural spaces

Several studies have now demonstrated that childhood exposure to natural environments and positive adult outcomes, are mediated, in part, through a heightened propensity to visit natural environments during adulthood (Rosa et al., 2018; Pensini et al., 2016; van Heezik et al., 2021). Proposed mechanisms underpinning adults' recreational visits to natural spaces include: landscape preferences (van Heezik et al., 2021), habit formation (Taye et al., 2019) nature connectedness (Rosa et al., 2018; Pensini et al., 2016), and crucially for the current study, intrinsic motivation (Cleary et al., 2007).

Based on Self Determination Theory (Ryan & Deci, 2000), 'intrinsic motivation' refers to the desire to do something because it is pleasurable, valuable, and inherently rewarding. Intrinsic motivation can be contrasted with 'extrinsic motivation' (doing something to please others, or because one is required to do so) and 'amotivation' (an absence of motivation to engage in an activity). Furthermore, four types of extrinsic motivation have been identified along the continuum from amotivation and intrinsic motivation, differing in terms of the extent to which the motivation is autonomous or self-determined. From the least to the most autonomous type of motivation, they

are: ‘external regulation’ (i.e., behavior controlled by external demand or incentives such as tangible rewards or punishment avoidance); ‘introjected regulation’ (i.e., doing something for a sense of pressure to avoid guilt and shame and to obtain a feeling of pride or worth); ‘identified regulation’ (i.e., acting as one feels it is personally important and congruent with one’s own goals and values); and ‘integrated regulation’ (i.e., the behavior is fully integrated into personal values and beliefs).

The distinction between intrinsic and extrinsic motivation seems to be important as they each inspire different experiences of the behaviour that is undertaken. Indeed, intrinsic motivation for a specific leisure activity, in addition to pure engagement and the individual’s opportunity to realize their leisure interests, appear to be a crucial aspect in relation to its potential effects. Previous studies suggested that intrinsic motivation in leisure activities may drive leisure engagement that could in turn enhance subjective well-being (Schulz et al., 2018). Moreover, intrinsically motivated leisure activities have a greater recovery potential, from stress and negative emotions (Brummelhuis & Trougakos, 2014). According to that, persons who are inherently intrinsically motivated experience greater freedom in performing the activity and are more absorbed in what they are doing; consequently, they derive more pleasure from doing the activity and feel free and relaxed. Contrariwise, extrinsically motivated persons experience more negative feelings such as anxiety, tension, and negative affect (Vallerand, 2007).

There is increasing recognition that intrinsic motivations to spend time in nature may underpin adult nature visits, and by implication, how these settings could potentially influence mental well-being (Tester-Jones et al, 2020). For instance, Cleary and colleagues (2017) maintain that the affective benefits of nature exposure (e.g., McMahan & Estes, 2015; Nisbet et al., 2011) are intrinsically rewarding, thus may trigger intrinsic aspirations involving the pursuit of goals concerning personal growth, intimacy, openness, and community (see also Snell et al., 2020; Weinstein et al., 2009). Prior findings also support the idea that situational experiences matter in the building process of intrinsic motivation (Løvoll et al., 2017). In this regard, autonomy-supportive

situations have been characterized as providing greater opportunity for enhancing intrinsic motivation in an activity (e.g., Deci et al., 1994; Enzle & Anderson, 1993). This could be the case of childhood exposure to blue spaces (or more generally, to nature), which can provide favourable conditions to enhance intrinsic motivation to spend time in nature later in life. Support for this contention comes from Asah et al.'s (2012) findings that childhood nature experiences are associated with greater motivation to engage in nature-based activities in later life, which in turn predicts higher levels of adult participation. However, to our knowledge, no research has examined whether this pattern of associations extends to better subjective well-being in adulthood. Building on previous theory and research, the current study examined whether the relationship between recalled childhood exposure to blue spaces and adult subjective well-being was mediated, in a serial manner, by greater intrinsic motivation to visit natural spaces and more frequent recent visits to blue and green spaces.

1.4 Potential cultural differences in childhood and adult nature experiences

Studies have largely demonstrated that people from various cultures prefer natural to built environments (Ulrich, 1993); although this may vary as a function of age (e.g., Berto, 2007; Hughes et al. 2019). Nevertheless, cultural and contextual factors may influence people's aesthetic perceptions and preferences (Kaplan & Herbert, 1987; Kaplan & Talbot, 1988; Todorova et al., 2004; Van den Berg et al., 1998; White et al., 2014), as well as their use of, and experiences in, natural spaces (Loukaitou-Sideris, 1995). The way people relate to nature has been shown to vary across diverse geographical, cultural and socio-economic contexts (Milfont & Schultz, 2016; Soga & Gaston, 2020). Social and cultural backgrounds can also trigger distinct parental perceptions of risk and different educational approaches, with varying degrees of adult guidance and restrictions and these may differentially affect children's exposure or attitudes (Prince et al., 2013). Such differences have the potential to influence the strength of any relationship between childhood nature exposure and adult outcomes. For instance, associations between blue space exposure in childhood

(and adulthood) and adult subjective well-being may be stronger in some countries than others (e.g., those with warmer climates).

Whilst making important contributions, prior research into childhood nature exposure have tended to use relatively small non-representative samples, consisting of a few hundred respondents from a single country (e.g., Pensini et al. 2016; Rosa et al., 2018; Ward Thompson et al., 2008; van Heezik et al., 2021; although see Preuß, 2019 for a four-city sample of 3,583). Heterogeneity in the operationalisation of childhood nature exposure and adult well-being outcomes between studies, further limits potentially important cross-study comparisons. Thus, an additional aim of the current research was to assess the consistency of associations between childhood exposure to blue spaces and adult subjective well-being across 18 counties/regions.

1.5 Current study

The current study extended prior theory and research by investigating the associations between childhood blue space exposure, adult intrinsic motivation to visit natural spaces, recent visits to blue and green spaces, and adult subjective well-being using representative cross-sectional samples from 18 countries/regions. The aims of the study were threefold: 1) to explore whether greater childhood exposure to blue spaces was associated with better adult subjective well-being; and if so; 2) whether this relationship was serially mediated by higher adult intrinsic motivation to visit natural spaces and a greater frequency of recent visits to blue and green spaces in adulthood; and 3) to examine the consistency of these associations between different countries/regions. Figure 1 presents our conceptual model depicting the hypothesised associations between childhood blue space exposure, intrinsic motivation to visit natural spaces, recent visits to blue and green spaces and adult subjective well-being.

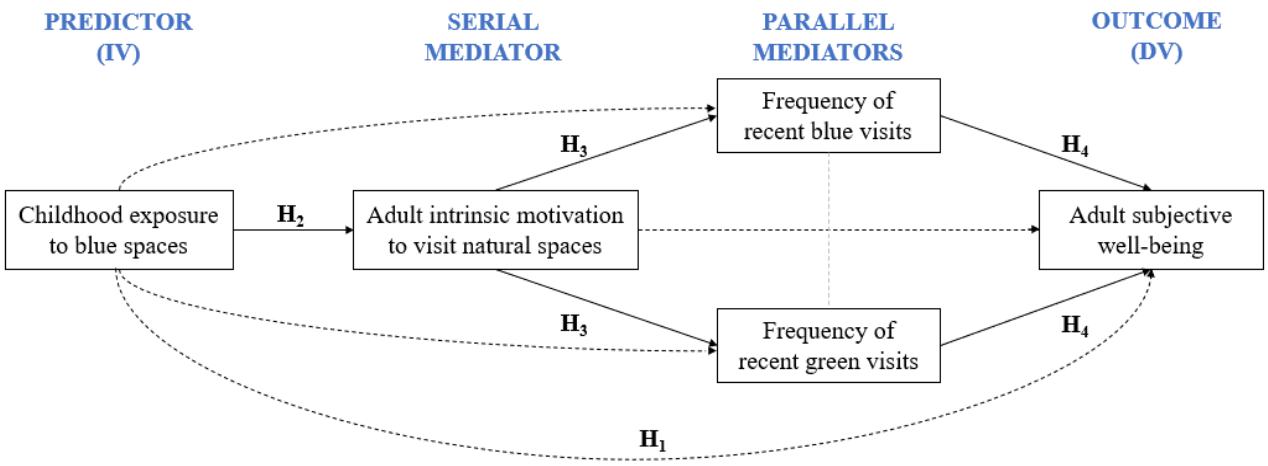

Figure 1. Conceptual model linking childhood exposure to blue spaces to adult subjective well-being with serial-parallel mediation through intrinsic motivation and recent visits to blue and green spaces (solid lines = indirect paths, dotted lines = direct paths).

Our overarching hypothesis was that there would be a positive relationship between childhood exposure to blue spaces and adult subjective well-being (H_1). Based on prior theory and research we also predicted: a) a positive association between childhood exposure to blue spaces and intrinsic motivation to visit natural spaces in adulthood (H_2); b) higher intrinsic motivation to visit natural spaces would be associated with more frequent recent visits to blue and green spaces in adulthood (H3) and c) more frequent recent blue and green space visits during adulthood would be linked to higher adult subjective well-being (H4). Put differently, we expect the relationship between childhood exposure to blue spaces to be serially mediated by intrinsic motivations and recent nature visits (blue and green). Since there has been little prior work regarding cross-cultural differences in childhood nature exposure– adult well-being associations, we made no specific hypotheses regarding the consistency of these associations across countries/regions. Nonetheless, due to the international nature of the sample, we explored the following research question: to what extent is our conceptual model supported across each of the 18 countries/regions? (RQ_1). However, although

the current paper does run the main model separately for each country, a detailed examination of the similarities and differences across country is beyond the scope of the current paper.

2. Methods

Ethical approval for the methods, content and data management of the anonymised survey was granted by [*temporarily omitted for anonymity*] (Ref: Aug16/B/099).

2.1 Sample and survey

Data were drawn from the BlueHealth International Survey (BIS), which examined recreational use of natural environments (with a particular focus on blue spaces), as well as various health and well-being outcomes. The survey formed part of the wider BlueHealth project concerning health and well-being opportunities arising from urban blue spaces in Europe (Elliott & White, 2020; Grellier et al., 2017). Representative samples were recruited in each country typically by sex, age, and NUTS1 or NUTS2 region of residence in European countries (excluding Estonia, where only sex and age were the sampling strata). In non-European countries, only sex and age were used as sampling strata, apart from Canada where provincial regions were also used. Samples were obtained by the market research international company YouGov using online survey panels. Data collection took place in four seasonal, cross-sectional waves between June 2017 to April 2018 with no plans for further data collection. The full sample consisted of 18,838 respondents, from 14 European countries (Bulgaria, the Czech Republic, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, and the United Kingdom) and four other non-European countries/regions (Hong Kong, Canada, Australia [primarily Queensland], and the USA [state of California only]). Most of the European countries were chosen because: a) they were countries represented by partners in the BlueHealth project, b) additional countries were added to ensure all major coastlines were covered; and c) at least one country had no coastline, i.e., the Czech Republic, to provide a landlocked comparator. Further countries were included based upon the wish

of colleagues in other locations to have their countries included in the overall dataset including in Finland, Ireland, Portugal, HK, Australia, USA and Canada (see Funding sources).

The survey itself consisted of seven main sections: (1) subjective well-being; (2) recreational visits to different natural environments; (3) perceptions of natural environments and other related aspects (e.g., motivations for visiting natural spaces, childhood experiences); (4) details about the most recent visit to a blue space; (5) a contingent behaviour experiment concerning water quality; (6) health and well-being outcomes; and (7) demographic information. Previous publications with this dataset have examined distance-decay effects (Elliott et al., 2020), intrinsic motivations for visiting nature (Tester-Jones et al., 2020), mental health and well-being (White et al., 2021), valuation of blue space with regards to water quality (Börger et al., 2021), correlates of nature connectedness (Richardson et al., in press), and decision and experienced utility assessments of recreational nature visits (Börger et al., in press). Full methodological details are available in the BIS technical report (Elliott & White, 2020) and an excerpt of data from 11 countries is available open access from the UK Data Service (Elliott & White, 2022).

The current study uses a sub-sample of the BIS dataset (N =15,743) for cases where there were no missing or ambiguous data (e.g., prefer not to answer) for key variables of interest which were selected to match our conceptual model (Figure 1). Missing/ambiguous data were distributed as follows: childhood exposure to blue spaces (N = 926), adult intrinsic motivation to visit natural spaces (N = 550), frequency of recent blue visits (N = 69) frequency of recent green visits (N= 48) and adult subjective well-being (N= 22). There was little variation in the proportion (<1.4%) of respondents within each socio-demographic group as a function of the reduced sample, indicating no systematic biases in the exclusion of cases (Supplementary Materials, Table S1).

2.2 Measures

2.2.1 Adult subjective well-being.

Subjective well-being was measured using the World Health Organisation 5-item well-being index (WHO-5). This is a widely used and validated measure of recent psychological well-being (e.g., Mitchell et al., 2015; Garrett et al., 2019; Sischka et al., 2020; White et al., 2021) that has been translated into over 30 languages. Respondents were asked to rate five statements about their emotional state during the past two weeks, e.g., 'I have felt cheerful and in good spirits'. Each item was rated on a 6-point scale, ranging from 'At no time' (0) to 'All of the time' (5), with higher scores indicating better well-being (α = 0.92 in the current study). Following standard scoring procedures (Topp et al., 2015), response values were summed (range: 0-25) and multiplied by four (range: 0-100) for the purpose of the bivariate analyses. Individual scale items were used to construct a latent subjective well-being variable for the Structural Equation Models (SEM).

2.2.2 Childhood exposure to blue spaces

Three items required respondents to rate recalled childhood exposure to blue spaces (aged 0 to 16 years of age): 'as a child, there was easily accessible blue space near my home(s)', 'as a child, my parents/guardians were comfortable with me playing in and around blue spaces', 'as a child, I often visited blue spaces'. No additional explanations were provided about the term blue space, but a definition was introduced early in the survey. Specifically, participants were told that: "Blue spaces include water and could be inland areas like lakes, canals, rivers, fountains and pools; urban coastal areas such as seaside resorts, harbours, ports and piers; or other coastal areas such as beaches, cliffs and headlands. However, these spaces do not include: (a) indoor locations, (b) places which you visit as part of your job, or (c) private locations such as your own garden, land, pond, or swimming pool." Thus, we assume participants drew on this definition when answering all future questions related to blue spaces. Respondents rated the extent they agreed with each statement on a seven-point scale ranging from 'strongly disagree' (-3) to 'strongly agree' (+3), with an additional 'don't know/prefer

not to answer' option coded as missing. The items demonstrated high internal consistency (α = 0.85), thus three item scores were averaged to provide an overall measure of childhood exposure to blue spaces (childhood blue space for short).

2.2.3 Proposed mediators

Adult intrinsic motivation to visit natural spaces

Adult intrinsic motivation to visit natural spaces was assessed through three items. Firstly, the proper experience of intrinsic motivation was measured using a question adapted from the physical activity domain (Behavioral Regulation in Exercise Questionnaire-2; Markland & Tobin, 2004) to the context of spending time in nature: 'I find visiting green and blue spaces enjoyable or fun' (1). Similar to exercise, visiting natural spaces is an activity that promotes health and well-being (Tester-Jones et al., 2020; Weinstein et al., 2009). The survey also included items that attempted to tap into the SDT constructs of identified regulation, 'The things I do in green and blue spaces (e.g., exercise, relaxation) are important to me' (2), and introjected regulation, 'I would feel disappointed in myself if I spent all of my time indoors' (3). Respondents rated each statement on a 7-point Likert scale, ranging from 'not at all' (0) to 'very true' (6), with an additional 'don't know/prefer not to answer' response option coded as missing. A preliminary analysis testing loading across these ideas suggested that although these did not traditionally tap to intrinsic motivation, as per SDT, they were in fact highly positively correlated and preliminary analyses suggested that collapsing them together to form a scale (α = 0.75) resulted in very similar results as using just the single 'pure' intrinsic motivation item (1). Given the superior psychometric properties of a three-item scale over a single item (if they are in practice measuring overlapping constructs, perhaps due to limitations in our single item measures), we proceeded with the three-item version. Although we refer to this as a measure of 'intrinsic motivation' for brevity, we recognise that it is perhaps more accurately a measure of a range of internalized motivations.

Frequency of recent visits to blue and green spaces.

Respondents indicated how often they had made recreational visits to 17 categories of blue spaces (e.g., seaside promenades, urban rivers) and 12 types of green spaces (e.g., local park, woodlands, meadows). Participants were presented with the lists of spaces and accompanying visual exemplars (see Appendix A and B for the full lists and images) and asked to report how often in the last four weeks they had visited each of them, using four categorical response options ('not at all in the last four weeks', 'once or twice in the last four weeks', 'once a week', 'several times a week'). These taxonomies were derived from existing reports (Bell et al., 2021; Cvejić et al., 2015). Following prior work using the same dataset (White et al., 2021), we estimated a numerical equivalent of these response options to be zero, one, four and eight visits in the last four weeks, respectively. Numerical estimates for each of the 17 blue space categories and 12 green space categories were summed to give the total number of visits to green and blue spaces within the last four weeks, respectively. With a small number of people reporting very high visit frequencies, and introducing considerable skew, the total number of visits to blue spaces were capped at 56. This would be consistent with someone, for instance, visiting blue spaces twice a day, every day, for four weeks. Caps were applied to 1.1% and 1.5% of the sample for blue and green space visits, respectively. For temporal consistency with other variables of interest (i.e., adult subjective well-being), visit totals were subsequently divided by two, to represent the number of visits to green and blue spaces over the last two weeks (i.e., possible range from 0-28). For brevity, we refer to these variables as recent blue and green visits.

2.2.4 Control variables

Models were adjusted for several socio-demographic indicators that have been found to be associated with nature visits and/or mental health in previous research (Martin et al., 2020, White et al., 2021). These included: gender (female = ref; male); age (18–29 years = ref; 30–39 years; 40–49 years; 50–59 years; ≥60 years); highest level of educational achievement (degree; below degree =

ref); employment status (in paid employment, in education, retired, housework; others [disabled, community/military service, other, don't know]; unemployed = ref); disposable household income (lowest quintile = ref); longstanding illness or disability (yes, no = ref); relationship status (married/cohabiting; single/ separated/divorced/widowed = ref); number of adults in the household (1 = ref; 2, ≥3); number of children in the household (0 = ref; 1, ≥2); dog ownership (yes, no = ref); car ownership (yes, no = ref); and survey wave (spring = ref, summer, autumn, winter). Of note, seasons were approximate since 'Spring' data were collected in June and referred to the 'last four weeks' (i.e., May–June), 'Summer' in September (i.e., August–September), 'Autumn' in December (November to December), and 'Winter' in March (i.e., February–March); seasons were reversed for Australia.

We also adjusted for residential nature exposure, by assigning respondent residential geolocations to data derived from the Global Land Cover dataset (GlobeLand30), a globally-consistent 30m resolution raster data set based on classification of remotely-sensed data. Land cover classed as forests, grassland, shrub land and cultivated land were classified as green space, and land cover classed as water bodies, or wetlands were classified as blue space. Radial buffers of 1000 meters around respondent's residential geolocations (representing a 10-15 minute walk) were established and the percentage of green space and inland blue spaces within these buffers assigned. With highly skewed distributions, inland blue space was dichotomised as no blue space (0% = reference) or some blue space (>0%) and residential green space was divided into four quartiles ranging from the lowest (1^{st} = reference, M = 1.37, SD = 1.88) to the highest (4^{th}, M = 97.01, SD = 4.04). Distance of the home coordinate from the nearest coastline, using a Euclidean distance metric, was determined using the highest resolution version of the Global Self-consistent Hierarchical High-resolution Geography shoreline database from the National Oceanic and Atmospheric Administration. With skews in the distribution distance to coast was dichotomised according to whether respondents has a coast within 1km of their home location (no = reference, yes).

2.3 Analytical approach

Analyses were conducted using STATA 16 (StataCorp, College Station, TX). Pearson's correlations were used to determine the direction of associations between our key variables. Preliminary regression analyses assessing potential evidence of mediation are reported in Supplementary Material (Table S2), due to space constraints. Specifically, a series of multi-level mixed effects ordinary least squares regressions were used to estimate the relationships between childhood exposure to blue spaces and adult subjective well-being, controlling for socio-demographics and accounting for potential country clustering. Proposed mediators were sequentially added into the models, with a reduction in the strength of the association between childhood exposure and adult well-being indicating potential mediation.

Whole sample and country-specific mediation effects were formally tested using structural equation modelling (SEM). Allowing for the estimation of all indirect and direct effects within a single model, SEM has several advantages over traditional tests of mediation (MacKinnon, 2008). Specifically, multiple mediation models are able to estimate specific indirect pathways whilst controlling for the presence of other variables, thereby reducing the likelihood of parameter bias associated with omitted variables (Preacher and Hayes, 2008). This was particularly important within the current study as there were multiple proposed mediators. The SEMs used maximum likelihood estimation with a bootstrap resample of 1000. Our whole sample SEM controlled for sociodemographic covariates, as well as country/region of residence, whereas country-specific models controlled for socio-demographic covariates only. For all models, goodness of fit indices included: the comparative fit index (*CFI*) > 0.95; Tucker-Lewis Index (*TLI*) >0.95; standardized root-mean-square residual (*SRMR*) <0.08; and the root-mean-square error of approximation (*RMSEA*) <0.06 (Schreiber, 2008). Chi-square goodness of fit values (χ^2) were not used to assess fit, because this index is less informative with larger samples (Schermelleh-Engel et al., 2003).

Whilst the temporal order of our conceptual model was informed by previous theory and research, given the cross-sectional nature of the dataset, we also tested three alternative causal models (Supplementary Materials, Figure S1, S2, S3). First, it is feasible that adults who visit nature more frequently may seek to justify their behaviour by reporting heightened intrinsic motivation (Beauvois, Joule & Brunetti, 1993), and/or that greater nature contact over the life course may enhance intrinsic motivation to continue visiting natural spaces. Thus, our first alternative model specified visits to blue and green spaces in adulthood as the first serial mediators, which in turn predicted intrinsic motivation to visit natural spaces. Second, factors other than nature experiences (e.g., social norms) may determine intrinsic motivation, and these individual differences in intrinsic motivation may turn influence the way in which people respond to the natural world. Certainly, the potential for stable individual differences to moderate relationships between nature contact and well-being have been noted elsewhere (Martin et al., 2020). Consequently, we specified two further alternative models which included intrinsic motivation as a moderator, either influencing the relationships between childhood exposure and visits, or the associations between visits and subjective well-being.

3. Results

3.1 Descriptive statistics

Descriptive statistics and correlation coefficients for key variables are presented in Table 1. The Ns and Percentages of all the covariates are reported in Supplementary Materials, Table S3. Significant positive associations were observed between each variable of interest. Notably, in line with our conceptual model, childhood blue space was positively associated with adult subjective well-being (H_1) and intrinsic motivation to visit natural spaces (H_2). Intrinsic motivation was associated with more frequent recent visits to blue and greenspaces (H_3). Recent visits to both blue and green spaces were related to better adult well-being (H_4).

Table 1. Descriptive statistics for, and correlations between, key variables of interest.

						Correlation coefficients			
	M	***Mdn***	**Percentiles**		***SD***	**1**	**2**	**3**	**4**
			25th	**75th**					
1. Childhood blue space [a]	0.87	1.00	0.00	2.00	1.62	-			
2. Intrinsic motivation [b]	4.45	4.67	3.67	5.67	1.30	0.23*	-		
3. Recent blue visits [c]	5.47	2.50	0.50	7.50	6.99	0.16*	0.19*	-	
4. Recent green visits [c]	6.21	4.00	1.50	9.00	6.43	0.14*	0.26*	0.61*	-
5. Adult subjective well-being [d]	60.48	64.00	48.00	76.00	25.55	0.16*	0.28*	0.23*	0.26*

Note. M = mean, Mdn = median, * = p <.001
[a] Childhood exposures scores ran from -3 (strongly disagree) to +3 (strongly agree); [b] scores for Intrinsic motivation ran from 0 (not at all) to 6 extremely (6); [c] number of recent visits in the last two weeks capped at a maximum of 56;
[d] World Health Organisation 5 items well-being scores run from 0-100, with higher scores indicating better well-being.

3.2 Structural equation models

3.2.1 Whole sample models

Structural Equation Modelling (SEM) was used to test the pathways outlined in our conceptual model (Figure 1). The observed variables: childhood blue space, intrinsic motivation, recent blue and green visits, plus control variables, were regressed onto the latent adult subjective well-being variable. Childhood blue space, plus control variables, were regressed onto the first proposed serial mediator: intrinsic motivation. Finally, childhood blue space, intrinsic motivation and control variables were regressed onto the remaining serial mediators: recent blue and green visits. With a strong positive association between recent blue and recent green visits (Table 1), the residual terms for these two visit frequency variables were allowed to covary.

The model exhibited an excellent fit to the data (*CFI* = 0.97, *TLI* = 0.94, *SRMR* = 0.00, *RMSEA* = 0.03) and the largest normalised residuals, 0.06 and -0.07, were within acceptable limits (Kline, 2016). Figure 2 depicts all paths between variables of interest (full models are reported in Supplementary Material, Table S4). The model accounted for 12%, 18% and 22% of the variance in intrinsic motivation, recent blue space and green space visits, respectively, as well as 26% of the variation in adult subjective well-being.

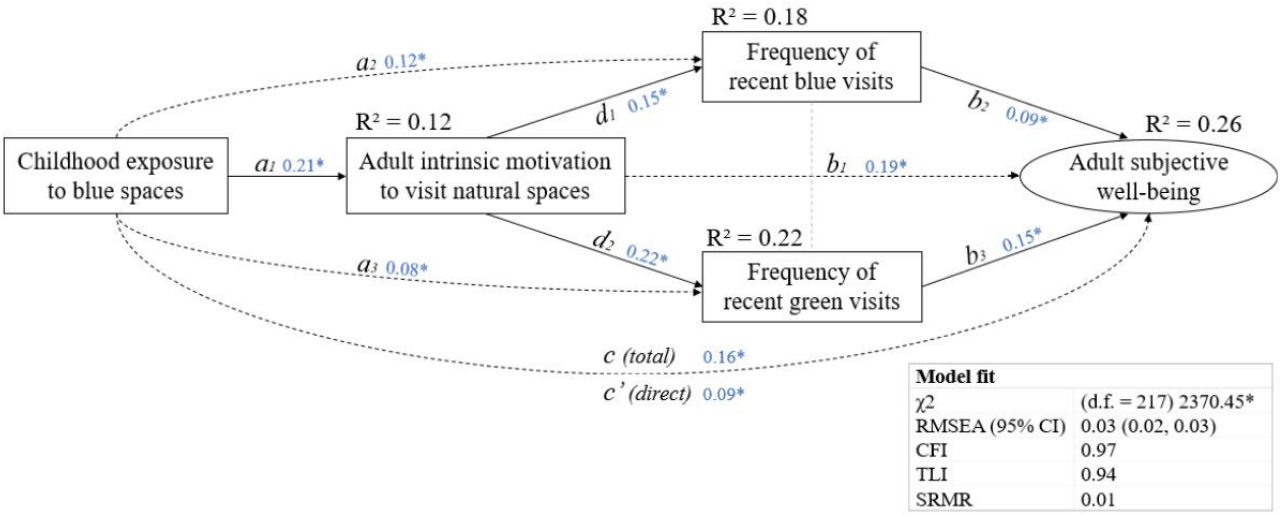

Figure 2. Path diagram depicting standardised coefficients for the associations between childhood exposure to blue spaces, intrinsic motivations, recent visits to blue and green spaces and adult subjective well-being, after adjustment for control variables.

Table 2 presents a decomposition of the standardised total, direct and indirect effects of childhood exposure to blue spaces on adult subjective well-being, as well as the specific indirect effects through each mediator (intrinsic motivation, recent blues visits and recent green visits). Supporting H_1, childhood exposure to blue spaces exhibited significant positive direct (β = 0.091; *95% CIs* = 0.189, 0.221; p <.001) and total effects (β = 0.162; *95% CIs* = 0.146, 0.179; p <.001) on adult subjective well-being. Childhood blue space had significant positive direct effects on intrinsic motivation in line with H_2 (β = 0.20; *95% CIs* = 0.189, 0.221; p <.001), and also on recent blue visits (b = 0.12; *95% CIs* = 0.11, 0.13; p <.001) and recent green visits (β = 0.08; *95% CIs* = 0.067, 0.094; p < .001). Intrinsic motivation had significant positive direct effects on recent blue visits (β = 0.154; *95% CIs* = 0.140, 0.169; p < .001), recent green visits (β = 0.223; *95% CIs* = 0.209, 0.236; p < .001) thus supporting H_3, and also on adult subjective well-being (β = 0.189; *95% CIs* = 0.173, 0.206; p <.001). Finally, consistent with H_4 recent blue visits (β = 0.088; *95% CIs* = 0.068, 0.107; p

<.001) and recent green visits (β = 0.149; *95% CIs* = 0.129, 0.169; $p < .001$) both exhibited significant positive direct paths to adult subjective well-being.

Supporting our conceptual model proposing serial-parallel mediation, the positive indirect paths from childhood blue space through both intrinsic motivation and recent blue visits (β = 0.003; *95% CIs* = 0.002, 0.003; $p < .001$), and intrinsic motivation and recent green visits (β = 0.007; *95% CIs* = 0.006, 0.008; $p < .001$) on adult well-being were all significant. Significant direct and indirect paths between childhood blue space and adult well-being suggests partial mediation of these associations. Of the total effect of childhood exposure to blue spaces on adult well-being, 56% was in the direct effect and the remaining 44% was in indirect effects through intrinsic motivation and recent blue/green visits. Approximately 6% and 17% of the total effect of intrinsic motivation on subjective well-being were mediated by recent blue visits (β = 0.014; *95% CIs* = 0.010, 0.017; $p <$ .001), and recent green visits (β = 0.033; 0.03; *95% CIs* = 0.028, 0.038, $p < .001$), respectively.

3.2.2 Country specific models

To assess the consistency of these associations across countries/regions, a series of country-specific SEM models were specified. A summary of the direction of the associations between key variables across the 18 country/regional sub-samples are presented in Tables 3a-3b (full models including coefficients are outlined in Supplementary Materials, Table S5).

Table 2. Summary of total, direct and indirect pathways between childhood exposure to blue space and adult subjective well-being.

Outcome	**Predictor**	**Pathway**	***β***	***95% CIs β***	***b***	***p***
Intrinsic motivation	Childhood blue space	Direct (a_1)	0.205	(0.189, 0.221)	0.164	<.001
Recent blue visits	Childhood blue space	Direct (a_2)	0.121	(0.107, 0.134)	0.522	<.001
		Indirect via intrinsic motivation	0.032	(0.028, 0.035)	0.137	<.001
		Total	0.152	(0.139, 0.166)	0.659	<.001
	Intrinsic motivation	Direct (d_1)	0.154	(0.140, 0.169)	0.832	<.001
Recent green visits	Childhood blue space	Direct (a_3)	0.081	(0.067, 0.094)	0.322	<.001
		Indirect via intrinsic motivation	0.046	(0.041, 0.050)	0.181	<.001
		Total	0.126	(0.113, 0.140)	0.503	<.001
	Intrinsic motivation	Direct (d_2)	0.223	(0.209, 0.236)	1.103	<.001
Adult subjective well-being	Childhood blue space	Direct (c')	0.091	(0.074, 0.108)	0.056	<.001
		Indirect via intrinsic motivation	0.039	(0.034, 0.043)	0.024	<.001
		Indirect via recent blue visits	0.011	(0.008, 0.013)	0.006	<.001
		Indirect via recent green visits	0.012	(0.009, 0.015)	0.007	<.001
		Indirect via intrinsic motivation and recent blue visits	0.003	(0.002, 0.003)	0.002	<.001
		Indirect via intrinsic motivation and recent green visits	0.007	(0.006, 0.008)	0.004	<.001
		Total indirect	0.071	(0.065, 0.077)	0.043	<.001
		Total	0.162	(0.146, 0.179)	0.099	<.001
	Intrinsic motivation	Direct (b_1)	0.189	(0.173, 0.206)	0.144	<.001
		Indirect via recent blue visits	0.014	(0.010, 0.017)	0.010	<.001
		Indirect via recent green visits	0.033	(0.028, 0.038)	0.025	<.001
		Total indirect	0.047	(0.042, 0.052)	0.036	<.001
		Total	0.236	(0.220, 0.252)	0.180	<.001
	Recent blue visits	Direct (b_2)	0.088	(0.068, 0.107)	0.012	<.001
	Recent green visits	Direct (b_3)	0.149	(0.129, 0.169)	0.023	<.001

Note. Estimates are based on fully-adjusted SEM accounting for covariates (see Section 2.4). *β* = standardised coefficients, *b* = unstandardised coefficients

Overall, model fit across countries was acceptable (except for France) and the direction of the direct pathways were largely consistent with the conceptual model. Childhood blue space had significant positive total effects on adult subjective well-being in each of the 18 countries/regions (H_1), but the strength of the positive direct paths to adult well-being varied between countries.

Findings that childhood blue space had significant positive direct effects on intrinsic motivation (H_2), which in turn predicted more frequent recent blue and green visits (H_3) were replicated across all 18 counties/regions. For each country/region, there were also significant indirect paths between childhood blue space and a) recent blue visits and b) recent green visits through intrinsic motivation. Thus, there was consistent evidence that intrinsic motivation mediated the relationship between childhood blue space and recent visits to natural spaces across countries/regions.

Support for H4, predicting that recent blue/green space visits would have significant direct effect on adult subjective well-being, was more mixed. Significant positive direct effects between recent blue visits and adult well-being were observed in eight countries/regions (Estonia, Finland, France, Germany, Italy, Portugal, Spain and Sweden). Whereas, recent green visits had significant positive direct effects in fourteen countries/regions (Australia, Bulgaria, California, the Czech Republic, Estonia, Finland, France, Greece, Hong Kong, Ireland, Italy, the Netherlands, Portugal and Sweden). There were also differences in the strength of the indirect effects of childhood blue space on adult well-being through recent blue space visits and recent green space visits. Taken together, these findings indicate a degree of country/region level heterogeneity in the links between childhood exposure to blue spaces, recent nature visits and adult subjective well-being.

3.3 Alternative models

Given the cross-sectional nature of the data, three alternative directional models were specified using SEM (see Section 2.3 and Supplementary Materials, Figures S4-6, and Table S6 for further details). Comparison of model fits indices indicated that our original conceptual model (AIC:

Table 3a. *Summary of total, direct and indirect pathways between childhood blue space and adult subjective well-being for country-specific models*

			Country/Region								
Outcome	**Predictor**	**Pathway**	**Australia** ***N*** **= 826**	**Bulgaria** ***N*** **= 912**	**California** ***N*** **= 871**	**Canada** ***N*** **= 872**	**Czechia** ***N*** **= 927**	**Estonia** ***N*** **= 836**	**Finland** ***N*** **= 916**	**France** ***N*** **= 890**	**Germany** ***N*** **= 908**
Intrinsic motivation	Childhood blue space	Direct (a_1)	+	+	+	+	+	+	+	+	+
Recent blue visits	Childhood blue space	Direct (a_2)	+	+	+	+	+	n.s.	n.s.	+	+
		Indirect via intrinsic motivation	+	+	+	+	+	+	+	+	+
	Intrinsic motivation	Direct (d_1)	+	+	+	+	+	+	+	+	+
Recent green visits	Childhood blue space	Direct (a_3)	+	+	+	+	+	n.s.	n.s.	+	+
		Indirect via intrinsic motivation	+	+	+	+	+	+	+	+	+
	Intrinsic motivation	Direct (d_2)	+	+	+	+	+	+	+	+	+
Adult subjective well-being	Childhood blue space	Direct (c')	+	+	+	n.s.	+	n.s.	+	n.s.	+
		Indirect via intrinsic motivation	+	+	+	+	+	+	+	+	+
		Indirect via recent blue visits	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+	+
		Indirect via recent green visits	+	+	+	n.s.	+	n.s.	n.s.	n.s.	n.s.
		Indirect via intrinsic motivation and recent blue visits	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+	+	+
		Indirect via intrinsic motivation and recent green visits	+	+	+	n.s.	+	+	+	+	n.s.
		Total(c)	+	+	+	+	+	+	+	+	+
	Intrinsic motivation	Direct (b_1)	+	+	+	+	+	+	+	+	+
		Indirect via recent blue visits	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+	+	+

		Indirect via recent green visits	+	+	+	n.s.	+	+	+	+	n.s.
	Recent blue visits	Direct (b_2)	n.s.	n.s.	n.s.	n.s.	n.s.	+	+	+	+
	Recent green visits	Direct (b_3)	+	+	+	n.s.	+	+	+	+	n.s.

Note. Estimates are based on fully-adjusted SEM controlling for: gender, age, highest level of educational achievement, employment status, disposable household income, longstanding illness or disability, relationship status, number of adults in the household, number of children in the household, dog ownership, car ownership, survey wave, residential greenspace, in land water and distance from coast. + indicates a significant positive association; n.s. = a non-significant association

Table 3b. Summary of total, direct and indirect pathways between childhood exposure to blue space and adult subjective well-being for the remaining country-specific models.

			Country/Region								
Outcome	**Predictor**	**Effects Pathway**	**Greece N = 800**	**HK N = 606**	**Ireland N = 915**	**Italy N = 897**	**Netherlands N = 970**	**Portugal N = 795**	**Spain N = 866**	**Sweden N = 840**	**UK N = 1,085**
Intrinsic motivation	Childhood blue space	Direct (a_1)	+	+	+	+	+	+	+	+	+
Recent blue visits	Childhood blue space	Direct (a_2)	+	n.s.	+	+	n.s.	+	+	+	+
		Indirect via intrinsic motivation	+	+	+	+	+	+	+	+	+
	Intrinsic motivation	Direct (d_1)	+	+	+	+	+	+	+	+	+
Recent green visits	Childhood blue space	Direct (a_3)	n.s.	+	+	+	n.s.	+	+	n.s.	n.s.
		Indirect via intrinsic motivation	+	+	+	+	+	+	+	+	+
	Intrinsic motivation	Direct (d_2)	+	+	+	+	+	+	+	+	+
Adult subjective well-being	Childhood blue space	Direct (c')	n.s.	+	+	n.s.	+	+	+	+	+

	Indirect via intrinsic motivation	+	+	+	+	+	+	+	n.s.	+
	Indirect via recent blue visits	n.s.	n.s.	n.s.	+	n.s.	+	+	+	n.s.
	Indirect via recent green visits	n.s.	n.s.	n.s.	+	n.s.	+	n.s.	n.s.	n.s.
	Indirect via intrinsic motivation and recent blue visits	n.s.	n.s.	n.s.	+	n.s.	+	+	+	n.s
	Indirect via intrinsic motivation and recent green visits	+	+	+	+	+	+	n.s.	+	n.s.
	Total	+	+	+	+	+	+	+	+	+
Intrinsic motivation	Direct (b_1)	+	+	+	+	+	+	+	n.s.	+
	Indirect via recent blue visits	n.s.	n.s.	n.s.	+	n.s.	+	+	+	n.s.
	Indirect via recent green visits	+	+	+	+	+	+	n.s.	+	n.s.
Recent blue visits	Direct (b_2)	n.s.	n.s.	n.s.	+	n.s.	+	+	+	n.s.
Recent green visits	Direct (b_3)	+	+	+	+	+	+	n.s.	+	n.s.

Note. Estimates are based on fully-adjusted SEM controlling for: gender, age, highest level of educational achievement, employment status, disposable household income, longstanding illness or disability, relationship status, number of adults in the household, number of children in the household, dog ownership, car ownership, survey wave, residential greenspace, in land water and distance from coast. + indicates a significant positive association; n.s. = a non-significant association. HK = Hong Kong; UK = United Kingdom.

800738.64) was a better fit than alternative model two (AIC = 1098e+06) and three (AIC = 870307.09). Fit indices for alternative model one, which specified recent visits to blue and green spaces as the first serial mediators, which in turn predicted intrinsic motivation, were similar to our original conceptual model, suggesting a potential bi-directional relationship between recent nature visits and intrinsic motivation.

4. Discussion

Growing detachment from the natural world, during childhood and adulthood, may have a negative impact on mental health (Twohig-Bennett & Jones, 2018; Lovell et al., 2018; Capaldi et al., 2014; Preuß et al., 2019).The current study investigated the associations between childhood blue space exposure, adult intrinsic motivation to visit natural spaces, recent visits to green and blue spaces, and adult subjective well-being using representative cross-sectional samples from 18 countries/regions. Our research objectives were three-fold: 1) to explore whether greater childhood exposure to blue spaces was associated with better well-being in adulthood; and if so; 2) whether this relationship was serially mediated by higher adult intrinsic motivation and recent visits to blue and green spaces; and 3) to examine consistency of these paths across different countries/regions.

4.1 Summary of Main Findings

Consistent with prior work concerning childhood nature experiences more broadly (Bezold et al., 2018; Engemann et al., 2020a, 2020b; Preuß et al., 2019; Snell et al., 2016), greater exposure to blue spaces during childhood predicted better subjective well-being in adulthood. This association remained after adjustment for other known risk factors of poor mental well-being, including population density and socioeconomic factors, suggesting that childhood blue space exposure is a robust and independent predictor of adult well-being. Moreover, despite evidence that the way people relate to nature varies across cultures (Soga & Gaston, 2020), the positive relationship between childhood exposure to blue spaces and adult subjective well-being was upheld after

accounting for country/region effects and was largely consistent across countries/regions. Notably, our country specific models indicated that childhood exposure to blue spaces had significant positive total effects on adult subjective well-being in each of the 18 countries/regions sampled. Thus, our findings highlight the potentially long-term impact of childhood blue space experiences in promoting well-being, as well as the potential protective value of this factor on adult mental health issues, internationally.

Regarding the mechanisms underlying this association, supporting our conceptual model, we found evidence of partial serial mediation through: a) higher intrinsic motivation to visit natural spaces in adulthood, and b) more frequent recent visits to blue and green spaces. Notably, childhood exposure to blue spaces was positively associated with adult intrinsic motivations to visit natural spaces, which in turn predicted more recent visits to blue and green spaces, which themselves predicted better subjective well-being in adulthood. Extending prior work concerning the motivational benefits of general nature exposure during childhood (Asah et al., 2012; Hosaka et al., 2018), we demonstrate, for the first time to our knowledge, that childhood experiences within blue spaces are associated with higher intrinsic motivation to visit natural spaces in adulthood. Also, consistent with evidence that nature-based activities during childhood enhance motivation and engagement with nature in later life (Asah et al., 2012; Hosaka et al., 2018; Rosa et al., 2018; Pensini et al., 2016; Ward Thompson et al., 2008; Sachs et al., 2020), intrinsic motivation partially mediated the relationship between childhood exposure to blue spaces and recent visits to blue and green spaces.

Building on research linking adult nature visits to better mental health outcomes (e.g., Shanahan, et al., 2016; White et al., 2017, 2019, 2021), our findings indicate that the potential benefits of childhood exposure to blue spaces may extend beyond motivational factors and recent visit frequency, to better subjective well-being in adulthood. The pattern of associations was consistent in direction across all 18 countries/regions sampled. Although perhaps due to the

relatively small effects and the reduced sample sizes at the country level (Deng et al., 2018), a number of pathways within our country specific models failed to reach statistical significance.

Further supporting our conceptual model, two of the alternative path models tested exhibited a weaker fit to the data. However, as noted previously, alternative model 1 exhibited a similar model fit to our conceptual model and we recognise that there was some evidence of a bidirectional relationship between intrinsic motivation and recent nature visits. A positive feedback loop between intrinsic motivation to visit natural spaces and nature visits themselves seems feasible. For instance, high intrinsic motivation is likely to lead people to seek out natural spaces and positive experiences in nature may further reinforce intrinsic motivation. Certainly, reciprocal and self-reinforcing relationships between intrinsic motivation and engagement in particular activities have been observed within other domains (Prabha, Punniyamoorthy & Nivethitha; 2021; Liu & Hou, 2018). Future work capable of establishing temporal order (i.e., longitudinal or experimental studies) would be informative in this respect and provided potential useful insights for social prescribing initiatives and behavioural change programmes.

The precise aspects of childhood exposure to blue spaces that may enhance adult intrinsic motivation, and thus may support more nature visits and better subjective well-being in adulthood, are beyond the scope of the current study. However, prior theory and research are potentially informative. Whilst speculative, contact with natural environments is considered to be intrinsically rewarding (Cleary et al., 2017), thus positive blue space experiences in the formative years of childhood may trigger enduring motivations to engage with natural spaces across the lifespan. Indeed, several authors have proposed that nature contact may lead to the development of aspirations and personality traits involving the pursuit of goals concerning personal growth, intimacy, openness, and community (Snell et al., 2020; Weinstein et al., 2009). Moreover, according to Self Determination Theory (Deci & Ryan, 2000) environments that support autonomy, competence and relatedness will facilitate more intrinsic motivations. Previous studies have suggested that nature contact may have beneficial effects on well-being precisely because it

provides a means through which basic psychological needs can be satisfied (e.g., Cleary et al. 2017; Howell & Passmore, 2013; Nisbet et al. 2009).

Particularly relevant to intrinsic motivation to spend time in natural spaces, greater contact with natural environments has been linked to autonomy (Barrable, 2020; Chawla & Heft, 2002; 2006) and competence building in children (Chawla et al., 2014). Natural spaces also provide children with opportunities for social contact with friends and family, which may promote a sense of belonging (Freeman et al., 2021). Since parents and other family members can support (or inhibit) children's relationships with nature (Chawla, 2007; D'Amore & Chawla, 2020), extrinsic motivations to visit natural spaces may be internalized (e.g., introjection regulation) through a process of social reinforcement. Whilst norms from parents/guardians have a known impact on the attitudes and behaviour of younger children, other social relationships, e.g., with peers, may also influence motivations to visit natural spaces during later childhood and adolescence (Shanahan et al., 2007). Future research might examine the development of motivation to visit natural spaces along the broader motivational continuum (amotivation-extrinsic-intrinsic) and examine how such motivations influence visit frequency and mental health outcomes across the life course.

Partial mediation of the relationships between childhood exposure to blue spaces and adult subjective well-being indicates that additional mechanisms contribute to the association between childhood nature exposure and mental health outcomes. Childhood exposure to blue spaces had significant direct positive effects on recent visits to blue and green spaces, suggesting that blue space experiences during childhood may facilitate more frequent nature visits in adulthood via pathways other than intrinsic motivation. For instance, childhood blue space experience may increase familiarity and sense of safety towards those environments and natural spaces in general, through repeated exposures (Bratman et al., 2021), and not necessarily reflect intrinsic motivations *per se*. Similarly, people may be extrinsically motivated to visits green and blue spaces to spend time with friends and family (Oh et al., 2021), in patterns that were established in childhood, and which continue into adulthood without any inherent enjoyment associated with where these

activities are taking place (i.e., in nature). Future conceptual and empirical work might usefully explore these potential mediating pathways further.

4.2 Limitations

Whilst providing insights into the relationships between childhood exposure to blue spaces and adult subjective well-being, we also recognize several limitations of our study. First, the cross-sectional data limit our ability to make causal inferences. Despite experimental evidence demonstrating improved mood following exposure to natural environments in both adults and children (McMahan & Estes, 2015; Browning et al., 2020), reverse causality cannot be ruled out. For instance, adults already exhibiting better subjective well-being may choose to spend more time in natural spaces and therefore recall greater intrinsic motivation and more childhood exposure to blue spaces.

Second, our results are based on self-reported data. Whilst there is good evidence that self-reported subjective well-being correlates positively with objective indices (Diener, Suh, Lucas, & Smith, 1999; Kyffin, Goldacre, & Gill, 2004), we cannot rule out possible misclassifications in subjective well-being reports due to social desirability bias. There is, however, less clarity regarding the accuracy of self-reported visit frequency, so it is somewhat unclear whether there are any biases within these measures. We further acknowledge that when responding to questions about recreational visit frequency, it is likely that a respondent may have visited several environment types on one recreational visit, which are subsequently treated as distinct numbers of 'visits' in our analytical models. Also, it is probable that participants have encountered green spaces when visiting blue spaces and vice versa, as suggested by the strong positive correlation between the two variables (r = 0.61). The implication this could have is that coefficients predicting these from intrinsic motivation, have the potential to be slightly inflated. Future studies may try to disentangle this by developing a more nuanced description of the visited location and the presence or absence of multiple features (e.g., woods, river, meadows etc). So again, we remain cautious in over-

interpreting the exact details, rather than the general patterns, of our findings. We also recognise that we know little about the duration of nature exposure, both within childhood and adulthood. With previous work suggesting that visit duration may be an important determinant of psychological restoration (Shanahan et al., 2016), future research might usefully extend the conceptual model to include the amount of time spent visiting natural spaces.

Third, the retrospective approach used to measure respondent childhood exposure to blue spaces could also be a source of measurement error (Gibson & Kim, 2010). Notably, individuals who perceived themselves to be more actively engaged with, or invested in, the natural world during adulthood might have over-represented the extent of their childhood blue space exposure (Wells & Lekies, 2006). Equally, our measure of childhood experiences focused exclusively on blue spaces, whilst providing unique insights in this area, we are aware that our measure does not capture the totality of childhood nature experiences. With prior work demonstrating that childhood experiences within green space exhibit a similar pattern of associations to adult nature visits and well-being (Ward Thompson et al., 2008), research examining the role of childhood green space in intrinsic motivations to visit natural spaces would be an interesting next step.

Fourth, we recognise that our measure of 'intrinsic motivation' also included adaptations of measures that were designed to measure other internalized regulations in the domain of physical activity (Markland & Tobin, 2004) and thus, despite the high correlations between them, we remain cautious about our interpretations of results in terms of 'intrinsic motivation' per se. Moreover, our measure of intrinsic motivation did not distinguish between motivation to visit blue and green spaces, rather related to natural spaces more broadly. Studies utilizing longitudinal designs, with more objective and comprehensive measurements of people's nature experiences are therefore needed to assess the robustness of our findings.

Fifth, we cannot exclude the possibility that other several factors may have an impact on the paths of our conceptual model. For example, dog owners appear to be more likely to visit natural outdoor environments on a regular basis, as suggested by previous studies (Colléony et al., 2019;

White et al., 2018; Zijlema et al., 2019) and future work may want to stratify on dog ownership in particular, though motivations for dog-related visits may be complex, ranging from the intrinsic enjoyment of spending time with a companion animals to more extrinsic motivations of feeling compelled to walk the children's dog on a dark and rainy night. Also, adult intrinsic motivation is unlikely be the only mediator in the relationship from childhood exposure to recent visits. As discussed in Section 1.3., a number of mechanisms have been proposed to underpin the relationship between childhood nature exposure and adults' recreational visits to natural spaces. Indeed, the pattern of partial mediation observed here indicate that additional mediators, not captured in the current study, may also play a role in the links between childhood blue space exposure and adult mental wellbeing (e.g., nature connectedness). Further work capable of examining these issues further, and disentangling the potential inter-relationships between these mediators, is therefore needed.

4.3 Implications

Whilst recognising the methodological limitations of our research, there are a number of potential practical implications should further research confirm that the associations observed are causal. Our findings are particularly relevant to practitioners and policy makers because of the nationally representative nature of the samples. First, our findings reinforce the need to protect and invest in natural spaces in order to optimise the potential benefits to subjective well-being. Second, our findings suggest that policies and initiatives encouraging greater contact with blue spaces during childhood may support better mental health in later life by enhancing intrinsic motivations and consequently the frequency of nature-based recreational activities in adulthood. With evidence that potential risks associated with blue spaces (e.g., accidental drowning, WHO, 2014; Congdon et al., 2013; Lawes et al., 2021) may increase parental concerns about children's contact with these environments and constitute a barrier to engagement (Moran, 2009; Pitt, 2019), increased accessibility to swimming lessons, especially for children from marginalised communities (Pilgaard

et al., 2019), as well as the provision of safe and supervised blue space recreational activities for children more generally appears warranted. Third, intrinsic motivations to visit natural spaces were associated with the frequency of blue and green space visits in adulthood, which were subsequently linked to better subjective well-being. Thus, efforts to encourage key components underpinning intrinsic motivation (i.e., autonomy, competence and relatedness, Deci & Ryan, 2000) might also be embedded into existing nature-based interventions aimed at improving adult mental health, for instance nature based social prescribing initiatives (Leavell et al., 2019; Robinson et al., 2020).

4.4 Conclusion

Growing detachment from the natural world, during childhood and adulthood, may be a factor in poor mental health outcomes (Twohig-Bennett & Jones, 2018; Lovell et al., 2018; Capaldi et al., 2014; Preuß et al., 2019). The current study provides evidence that childhood exposure to blue spaces was positively associated with subjective well-being in adulthood, and that this was partially mediated through intrinsic motivation to visit natural spaces as an adult and recent recreational visits to blue and green spaces. Recognition of these associations supports the need to protect existing high quality blue spaces, provide safe and enriching blue spaces, and to encourage childhood visits to them. If further evidence can corroborate that these associations are causal, then increased exposure to blue spaces during childhood may offer a viable strategy of improving population-level well-being of future generations.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Full list of blue spaces with corresponding visual examples.

Fig. A.1. Fountains

Fig. A.2. Urban rivers or canals

Fig. A.3. Swimming pools or outdoor spas

Fig. A.4. Ponds/streams/small water bodies

Fig. A.5. Lakes

Fig. A.6. Rural rivers or canals

Fig. A.7. Waterfalls

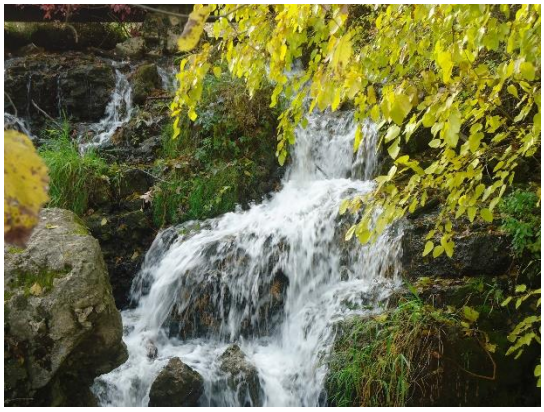

Fig. A.8. Wetlands

Fig. A.9. Outdoor ice rinks

Fig. A.10. Esplanades/promenades

Fig. A.11. Piers

Fig. A.12. Harbours or marinas

Fig. A.13. Sandy beaches

Fig. A.14. Rocky shores

Fig. A.15. Cliffs and headlands

Fig. A.16. Lagoons

Fig. A.17. Open sea

Appendix B

Full list of green spaces with corresponding visual examples.

Fig. B.1. Local parks/pocket parks

Fig. B.2. Large urban parks

Fig. B.3. Community gardens or allotments

Fig. B.4. Playgrounds or playing fields

Fig. B.5. Cemeteries or churchyards

Fig. B.6. Botanical gardens or zoo

Fig. B.7. Woodlands or forests

Fig. B.8. Farmland or arable land

Fig. B.9. Meadow or grassland

Fig. B.10. Mountains

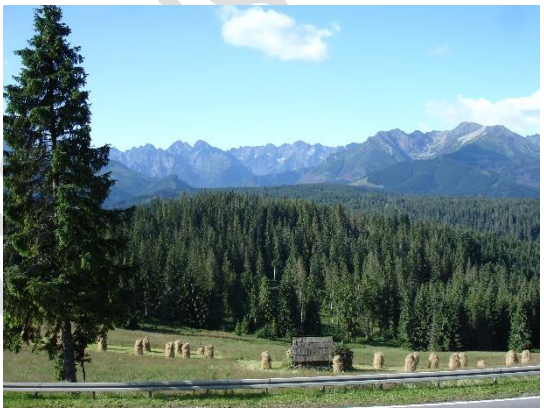

Fig. B.11. Moorland or heathland

Fig. B.12. Country parks

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