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Contact with nature, nature prescriptions, and loneliness: Evidence from an international survey of adults in Australia, India, Singapore, the United Kingdom, and the United States

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A B S T R A C T

Evidence to support nature contact and nature prescriptions to reduce loneliness is scant. A total of 2100 individuals took part in a survey conducted in Australia (n = 525, mean age = 34.1), India (n = 526, mean age = 29.5), Singapore (n = 523, mean age = 36.1), the UK (n = 526, mean age = 37.3), and the US (n = 525, mean age = 43.6) in 2022 (overall age range 18–89yrs). Multilevel logistic regressions adjusted for confounding indicated mean levels of overall loneliness tended to be higher in India (Odds Ratio [OR] 1.21, 95% Confidence Interval [95%CI] 0.90–1.62), Singapore (OR = 1.54, 95%CI = 1.15–2.07), the UK (OR = 1.26, 95%CI = 0.96–1.67) and the US (OR = 1.24, 95%CI = 0.94–1.64) compared with Australia. Notable differences were observed by loneliness type, for example, with lower odds of social loneliness (OR = 0.57, 95%CI = 0.41–0.79) and higher odds of emotional loneliness (OR = 1.57, 95%CI = 1.14–2.06) in India compared with Australia. Findings with regards to loneliness and nature contact varied between country. In general, social loneliness was lower in participants who visited natural surroundings regularly (OR = 0.81, 95%CI = 0.61–0.98) and spent two hours or more per week in nature (OR = 0.65, 95%CI = 0.49–0.81). Overall loneliness (OR = 1.98, 95%CI = 1.48–2.47) and emotional loneliness (OR = 2.84, 95%CI = 2.13–3.51) were substantially higher among those who felt having no-one to go with was a barrier to spending time in nature. Emotional loneliness was higher in those who had more time in nature (OR = 1.32, 95%CI = 0.94–1.75) or more frequent visits (OR = 1.24, 95%CI = 0.94–1.49), which may be indicative of selective processes by which some people who feel emotionally lonely seek meaningful sources of connection or solace in natural environments. In sum, these findings highlight potentially important contingencies in how people feel lonely in different countries, and the potential of contact with nature as a means to address this critical issue of modern times. Randomised trials of nature prescription interventions for loneliness co-designed with respect to contrasting cultural, economic, and climatic contexts are needed to ensure programs intended to reconnect people with nature are effective, equitable, and acceptable for everyone.

1. Introduction

On November 2023, the World Health Organization (2023) recognized loneliness as a major concern for international public health with the announcement of the Commission for Social Connection. Loneliness is a felt deprivation of connection, companionship, and camaraderie that is likely to be caused or aggravated by places and spaces that isolate, exclude, and eliminate feelings of attachment and belonging; 'lonelygenic environments' (Feng and Astell-Burt, 2022). Whether a lack of friendship (social loneliness), or an absence of an close companion (emotional loneliness), persistent loneliness increases risks of depression (Erzen and Çikrikci, 2018), self-harm (Troya et al., 2019), heart disease (Valtorta et al., 2016), dementia (Lara et al., 2019), and suicide (Gvion and Levi-Belz, 2018). Few effective interventions sustain prevention or alleviation of loneliness (Akhter-Khan and Au, 2020). A failure to identify evidence-based upstream policy options that address loneliness

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before it becomes deadly likely stem from research hitherto focussed on individuals without consideration of the lonelygenic environments to which they are exposed.

A recent systematic review (Astell-Burt et al., 2022b) as well as multiple subsequent studies from Australia, Canada, and China (Villeneuve et al., 2023; Astell-Burt et al., 2023c; Astell-Burt et al., 2024; Wang et al., 2024) indicate that contact with nature, such as parks or forests, may help to reduce loneliness (though evidence is not unequivocal e.g., Jamalishahni et al., 2023). Natural environments are attractive settings that bring individuals together who might not otherwise meet. Regular and ritualistic participation in shared activities of mutual interest facilitated by natural environments such as walking, gardening, dog walking, and outdoor social recreation imbues places with personal and collective meanings that nourish senses of attachment and belonging (Hindley, 2022; Kingsley et al., 2019). One might not necessarily require direct interaction with other humans to reap these benefits; the simple act of sharing spaces with others may be sufficient to alleviate loneliness and associated feelings of despair and hopelessness in some people (Neal et al., 2015; Schertz et al., 2023). For those who feel ostracised, disenfranchised, or distrustful of others, each of which being commonly experienced by those who are lonely, a sense of solace and solitude afforded by nature and the 'more-than-human-world' can be restorative in ways that feel dependable and non-judgemental (Birch et al., 2020). Indeed, research is increasingly demonstrating that having stronger feelings of connectedness to nature is health-promoting (Capaldi et al., 2014; Pritchard et al., 2020), highlighting that fulfilling a sense of meaningful connection need not always require contact with other humans.

While an increasing number of studies indicate the availability of nearby natural environments can reduce the risk of feeling lonely (Astell-Burt et al., 2022b), there are few studies that examine how much contact is needed e.g., in terms of time spent in those settings (Astell-Burt et al., 2024). Furthermore, there is a lingering concern that many people who are vulnerable to loneliness may also find nature contact challenging (Olcoń et al., 2023; Robinson et al., 2020). Some people may have little experience of visiting green spaces due to an absence of opportunities, while others may be held back by a range of barriers. For example, a lack of company may be especially relevant to some individuals considering to visit parks and forests that may be unfamiliar or felt unsafe (Astell-Burt et al., 2023b; Fixsen and Barrett, 2022).

Nature prescriptions, sometimes referred to as green social prescriptions or nature-based social prescriptions, may be an important part of the solution (Astell-Burt et al., 2022c; Kondo et al., 2020). These terms are increasingly used to describe a form of nature-based solution for health and wellbeing that dates back thousands of years in many countries and cultures around the world, for example to Hippocrates of Cos (460-370 BC), the Enlightenment, and the Romantic and Environmental Movements (Crnic and Kondo, 2019; Garraty and Gay, 1972; Hartig et al., 2011), Traditional and more recent theories of contact with nature indicate that these experiences permit and promote restorative processes and replenish cognitive capacities depleted from everyday demands (Kaplan and Kaplan, 1989), reduce exposure to stress (Ulrich et al., 1991), enable relational and collective capacities for restoration (Hartig, 2021) and bolster biopsychosocial resilience (White et al., 2023). These restorative processes are closely entwined and likely synergise with other domains of pathways linking nature contact and human health and wellbeing, such as capacity strengthening behaviours like physical activity and sleep, and protective mechanisms that mitigate harms of climate pollution and temperature extremes (Markevych et al., 2017). While many of these benefits may occur as a result of the availability of nearby green and blue spaces with no requirement for direct contact (e.g., cooling of urban heat islands), optimisation of their benefits may be dependent on the congruence of person-place factors that nature prescription programs could, in theory, help to establish, but without which may leave some vulnerable groups (e.g., people living with disability or mental illness) feeling unable to reap the same rewards as other groups (Astell-Burt et al., 2022b; Olcoń et al., 2023).

Nature prescriptions are adjuncts to routine medical care comprising written authoritative directives by health or social professionals to spending time in natural environments, as is currently done in some countries such as Canadian national PaRx program (Sherman et al., 2021). Recent meta-analysis of international evidence indicates that nature prescriptions received from health or social professionals may be more potent in terms of increasing daily step counts and reducing blood pressure and symptoms of anxiety and depression (Nguyen et al., 2023). The links between nature prescriptions and loneliness are, however, under-researched with prior quantitative studies limited by a range of issues including small sample sizes (Sachs et al., 2024).

Accordingly, we hypothesised that individuals with lower odds of feeling lonely have (a) more nature contact, (b) potential experience of a nature prescription, and (c) were unencumbered by a lack of company as being a barrier to visiting natural environments. Given that evidence on the links between natural environments and health has historically been focussed on high income and 'western' countries and so may lack generalisability elsewhere, we tested these hypotheses in the contrasting cultural, economic, and climatic contexts of Australia, India, Singapore, the United Kingdom (UK), and the United States (US). This aspect of our paper was more exploratory and we were agnostic with respect to differences between countries.

We examined these hypotheses in relation to overall levels of loneliness, while also examining social and emotional loneliness separately in case of important differences. These different ways of feeling lonely have been ignored in reviews of potential health impacts of loneliness (e.g., Lim et al., 2020; Wang et al., 2023) and also in studies of natural environments and loneliness so far (Astell-Burt et al., 2022b), even when those studies use measures that were developed to permit differentiation (e.g., Fu et al., 2024). These are missed opportunities to generate more nuanced understandings because research has demonstrated that different ways of feeling lonely are reported between men and women, with men generally feeling more socially lonely than women and women generally feeling more emotionally lonely than men (Barjaková et al., 2023), while emotional loneliness, but not social loneliness, is associated with depression (Peerenboom et al., 2015) and mortality (O'Súilleabháin et al., 2019) in older adults. Thus, the extent to which contact with natural environments might have similar effects, or disproportionate benefits for one type of loneliness over another, such as whether nature elicits feelings of support or of meaningful attachment, is crucial to explore with a view towards developing potential nature prescription interventions.

2. Method

2.1. Data

A cross-sectional survey was conducted via Qualtrics XM (Salt Lake City, UT, US) on a large English-speaking panel spanning all five candidate countries. Qualtrics recruits this panel for facilitating survey research using email invitations, SMS notifications, in-app notifications, and a dedicated online portal. Incentives tailored to country context are used to motivate panel member responses to surveys, including cash, airline miles, gift cards, redeemable points, charitable donations, sweepstakes entry, and vouchers. Survey invitations foreshadow the length of time to complete a survey but do not include specific information on question content to avoid self-selection bias. We sampled approximately 525 respondents from each country via Qualtrics panels, aged 18 years or older to explore nature contact, nature prescription participation, social and emotional loneliness. Our surveys were conducted 6–16 September 2022 in Australia, India, Singapore, the UK, and the US. These countries were selected to provide geographic spread across a range of contrasting cultural, economic, and climatic contexts where English is commonly spoken. Our survey took a mean respondent

time of 7 min and 35 s. The study was approved by the ethics board at the US-based academic institution partner (North Carolina State University).

2.2. Loneliness

Loneliness was measured using three indicators derived from the 6-item De Jong Gierveld scale (Gierveld and Tilburg, 2006; De Jong Gierveld and Van Tilburg, 2010): overall loneliness; social loneliness; and emotional loneliness. The 6-item De Jong Gierveld scale does not use the word "lonely" to avoid potential non-responses relating to pervading stigma. Instead, it requires participants to respond to statements such as *"Often, I feel rejected"* (emotional loneliness) and *"There are enough people that I feel close to"* (social loneliness) that pertain to different ways of feeling lonely with either "yes", "more or less", or "no". Responses to positively framed statements are inverted so that all scoring is consistently in the same direction. Affirmative responses on each item were coded as equal to one, all else zero. Social and emotional loneliness were each identified as participants scoring three points out of a possible three by summing scores on the three respective items. Overall loneliness was identified as individuals who report feeling socially and/or emotionally lonely (i.e., affirmative indications on either, or both, social and emotional loneliness scales, obtained by summing the emotional and social loneliness scores).

2.3. Nature-related variables

Nature contact was measured in terms of self-reported frequency of visitation and overall duration of visits across seven days prior to the survey. Frequency of participation was assessed with the question *"How often do you visit the park or greenspace closest to your home?"* with responses dichotomised to once a week or more versus less. Duration of nature contact was measured using responses of 2 h per week or more versus less to the question *"Approximately how many hours did you spend in greenspaces and/or blue spaces in total over the last 7 days?"*.

Participation in a nature prescription was examined using the statement *"please select your awareness of green social prescriptions (also referred to as nature or park prescriptions, or forest bathing)"*, with possible answers including *"I am a participant in such a program"*, *"Aware of idea, but unsure of what it is"*, or *"Not aware"*. We ensured that answers to this question were informed by a definition of green social prescriptions, as they can be known by different names in different contexts. This information preceding the question on awareness was as follows: *"Green Social Prescriptions are programs where a trusted health or wellness professional recommends or prescribes time or activities in green, natural spaces such as parks, forests, or gardens for human health and wellness benefits."* The survey did not specify if these programs had to be prescribed by a health or social work professional. A lack of company as a barrier to nature contact was explored with the question "How likely are the following to be barriers to your participation in green social prescriptions? - No one to go with", with answers on a 5-point Likert scale ranging from "extremely likely" to "extremely unlikely".

2.4. Confounders

Several factors potentially influencing both loneliness risk and each of the nature-related variables were accounted for. These included gender, age, geography (urban, suburban, or rural), perceived financial circumstances (comfortable, finding it difficult), highest educational qualification, and economic circumstances (e.g., employed, retired).

2.5. Statistical analysis

Summary statistics such as means and percentages were used to describe the study sample. Multilevel logistic regressions were fitted to define the odds of each type of loneliness in relation to the nature-related variables separately while adjusted for confounding variables (see above), then within multivariate models. Participants were nested within postcodes, which was fitted as a random intercept in all the multilevel models. Models were fitted initially for the full sample adjusting for country, and then stratified by country to examine within-country patterns. Models were fitted in R Studio version 4.3.1. Statistically significant associations were defined by $p < 0.05$.

3. Results

3.1. Descriptive summary

A total of 2625 responses to the survey were obtained with broadly equal numbers from each country (Table 1). Females were over-represented in general (73%) and especially in the Australia, UK, and US samples, while being under-represented in the India sample. The mean age of each country-based sample was in the mid-thirties for Australia, Singapore, and the UK, with younger respondents on average in India at 29.5 years old and older in the US at approximately 44.

Self-reported urban living was low in the Australia, UK, and US samples (suburban percentages were 62.7%, 49.9% and 40.5%, respectively) and highest in the India and Singapore samples (suburban percentages were 15.6% and 31.7%, respectively). Participants in India were more likely to report being financially comfortable (70.7%),

Table 1
Sample characteristics, by country.

	Australia	India	Singapore	UK	USA
N	525	526	523	525	526
General loneliness: n (%)	316 (60.2%)	342 (65.0%)	364 (69.6%)	351 (66.9%)	325 (61.8%)
Social loneliness: n (%)	208 (39.6%)	118 (22.4%)	224 (42.8%)	211 (40.2%)	234 (44.5%)
Emotional loneliness: n (%)	216 (41.1%)	283 (53.8%)	241 (46.1%)	245 (46.7%)	196 (37.3%)
Female: n (%)	382 (72.8%)	227 (43.2%)	240 (45.9%)	316 (60.2%)	346 (65.8%)
Age: (mean ± SD)	34.1 ± 13.2	29.5 ± 8.30	36.1 ± 11.6	37.3 ± 12.5	43.6 ± 15.3
Urban: n (%)	127 (24.2%)	372 (70.7%)	315 (60.2%)	183 (34.9%)	176 (33.5%)
Financially comfortable: n (%)	253 (48.2%)	345 (65.6%)	275 (52.6%)	196 (37.3%)	237 (45.1%)
College Degree or higher: n (%)	215 (59.0%)	51 (90.3%)	141 (73.0%)	157 (70.1%)	294 (44.1%)
Employed: n (%)	360 (72.3%)	461 (88.7%)	461 (90.2%)	412 (79.2%)	312 (62.3%)
Visit nature at least once per week: n (%)	210 (40%)	353 (67.1%)	212 (40.5%)	264 (50.3%)	166 (31.6%)
Two or more hours per week in nature: n (%)	342 (65.1%)	486 (92.4%)	409 (78.2%)	421 (80.2%)	307 (58.4%)
Participant in a nature prescription: n (%)	14 (2.7%)	40 (7.6%)	13 (2.5%)	15 (2.9%)	7 (1.3%)
No company as a barrier to visiting nature: n (%)	245 (46.7%)	297 (56.5%)	246 (47.0%)	241 (45.9%)	217 (41.3%)

SD: Standard Deviation | "Living comfortably" refers to perceived financial circumstances, with the alternative being "finding it difficult" | "Highly educated" refers to participants with a university degree or higher qualification, with the alternative being "less educated" denoting those without a degree | "Employed" includes full-time and part-time employment including self-employment, with alternatives including "retired", "seeking opportunities", "student", or "prefer not to say" | "Urban" in comparison with "Suburban", "Rural", or "Other" (self-defined) | Overall, social, and emotional loneliness are all derived from the 6-item De Jong Gierveld Loneliness Scale.

especially in comparison to those in the UK (37.3%). The India sample also reported very high levels of college degrees (90.3%) and employment (88.7%), in contrast with the US in particular (44.1% and 62.3%, respectively).

Levels of loneliness were high across the board, from just over 60% in Australia, reaching nearly 67% among respondents in the UK. Social loneliness was lowest among the Singapore sample at about 22% and highest in the US at 44.5%. The US was also where emotional loneliness happened to be lowest at about 37%, with the highest level reported by the India sample at nearly 54%.

Visitation of natural environments at least once per week was highest in the India sample (67.1%) and lowest in the US (31.6%), with a similar pattern reported for time spent in nature equal to or exceeding 2 h per week. Levels of participation in a nature prescription were low, at just 1.3% in the US sample and up to 7.6% in the Indian sample. A lack of company was felt to be a barrier to visiting natural environments for 40–60% of participants across all countries.

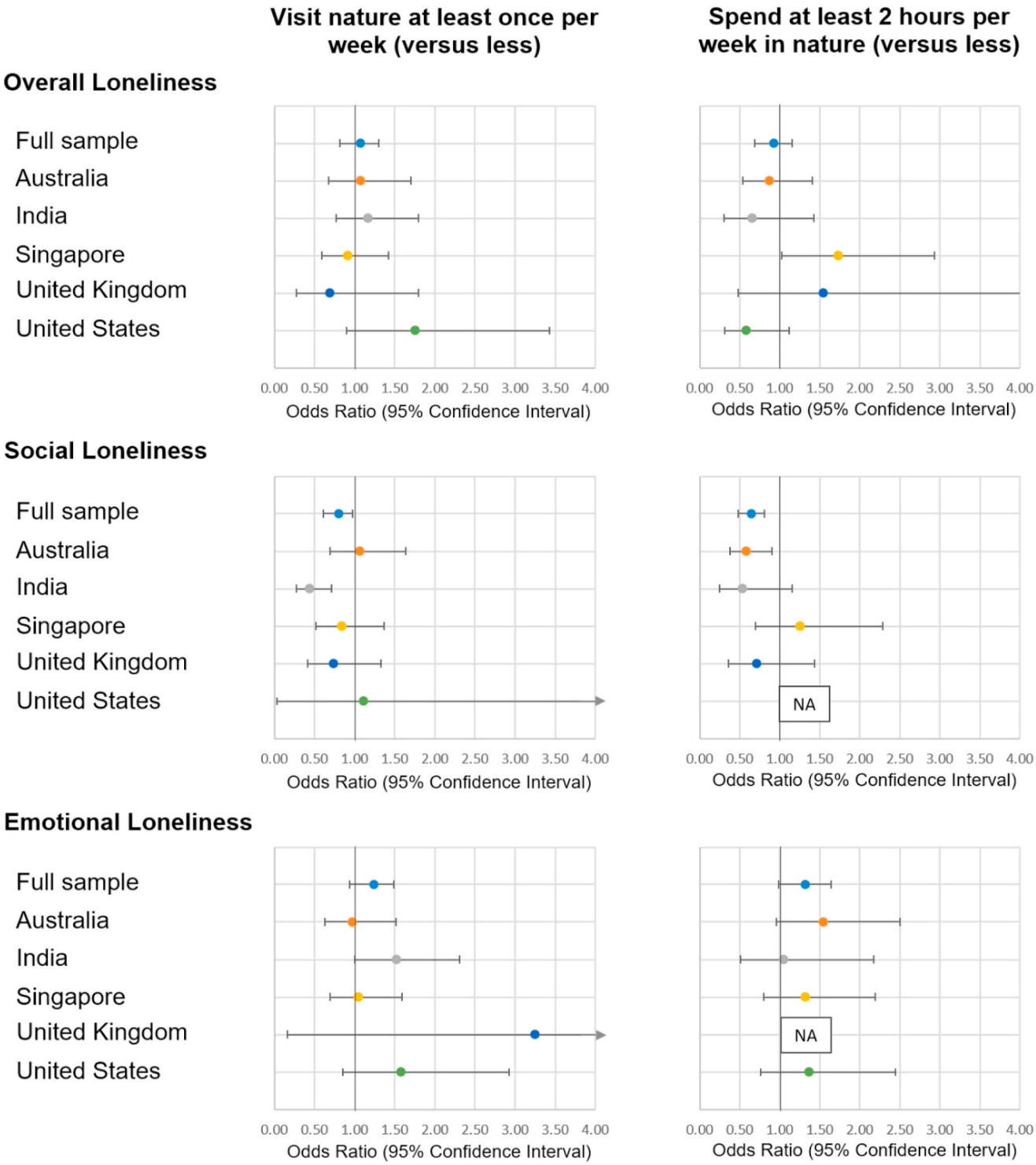

Fig. 1. Associations between loneliness and nature contact (multilevel logistic regressions adjusted for gender, age, geography, financial circumstances, highest qualification, economic circumstances, nature prescription participation, and a lack of company as a potential barrier to nature contact).

3.2. Nature contact

Adjusted odds ratios (AOR) for loneliness in relation to nature contact, nature prescriptions, and a lack of company as a barrier to visiting natural environments are presented in Figs. 1–3, respectively. Please note several odds ratios could not be calculated robustly due to small numbers, resulting in implausible values; those are marked as 'NA' in each of the figures. In Fig. 1, compared with respondents who visited natural environments infrequently, those who reported visiting them at least once a week or more did not tend to have different levels of overall loneliness in the full sample nor at the country level. Although the adjusted odds ratio (AOR) for the US sample was elevated at 1.76 in comparison with other countries, the 95% confidence interval (95%CI) spanned unity denoting a lack of statistical significance (0.90, 3.42). Notable differences in this association were found when distinguishing between social and emotional loneliness. More frequent nature contact was associated with lower odds of social loneliness (AOR 0.81 95%CI 0.61, 0.98), but also higher (albeit not statistically significant) odds of

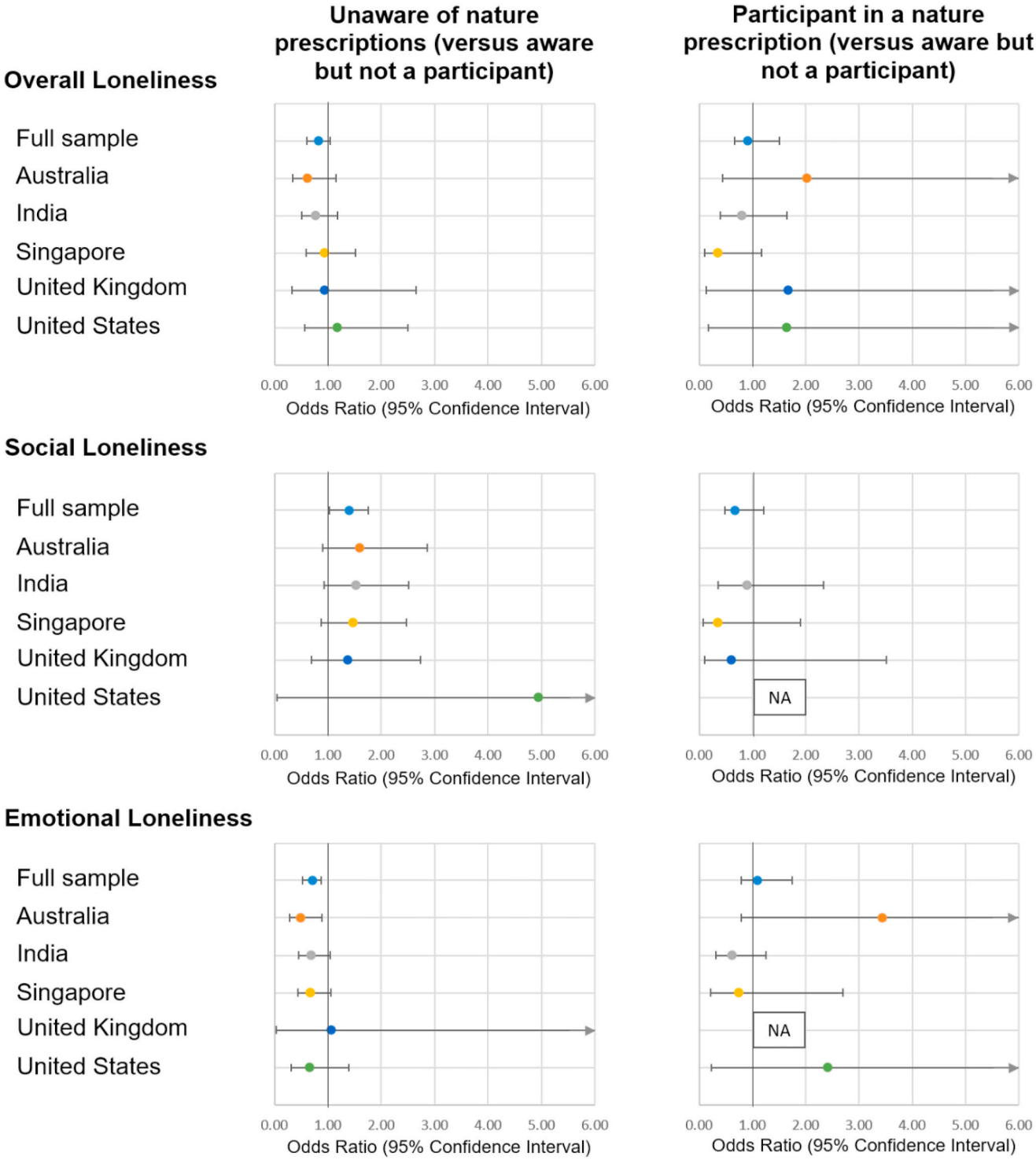

Fig. 2. Associations between loneliness and nature prescription participation (multilevel logistic regressions adjusted for gender, age, geography, financial circumstances, highest qualification, economic circumstances, nature contact, and a lack of company as a potential barrier to nature contact).

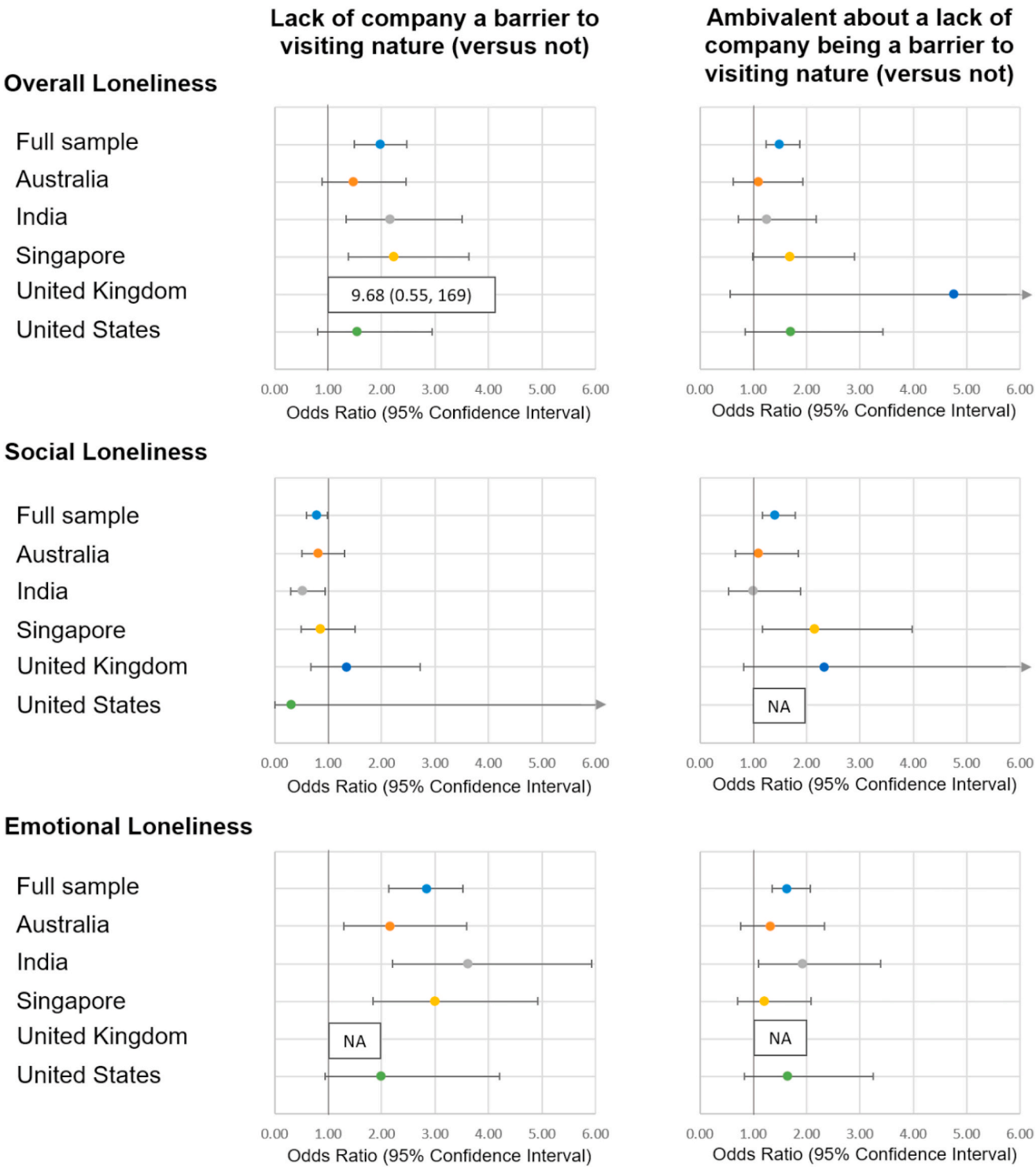

Fig. 3. Associations between loneliness and a lack of company as a barrier to nature contact (multilevel logistic regressions adjusted for gender, age, geography, financial circumstances, highest qualification, economic circumstances, nature contact, and nature prescription participation).

emotional loneliness (AOR 1.24, 95%CI 0.94, 1.49) across the entire sample. In India, the odds of social loneliness were lower (AOR 0.44, 95%CI 0.27, 0.72) and emotional loneliness were higher (AOR 1.52, 95%CI 1.00, 2.31) with more frequent nature contact. The results for time spent in natural environments were reasonably aligned with those for nature contact frequency. There was no statistically significant association for overall loneliness in the full sample, but there were lower odds of social loneliness (AOR 0.65, 95%CI 0.49, 0.81) among those spending 2 h or more per week in nature. There were also higher odds of emotional loneliness among the same individuals in the full sample, albeit with the confidence intervals just spanning unity (AOR 1.32, 95% CI 0.98, 1.64). In Singapore, the odds of overall loneliness were higher (AOR 1.74, 95%CI 1.03, 2.93) among those with increased time in nature, while respondents in Australia (AOR 0.58, 95%CI 0.38, 0.90) reported lower odds of social loneliness with increased time in nature.

3.3. Nature prescriptions and a lack of company as a barrier

In the full sample (Fig. 2), the odds of overall loneliness were somewhat lower but with confidence intervals just spanning unity among respondents who were unaware of nature prescriptions, compared to those who were aware but not participants (AOR 0.84, 95% CI 0.61, 1.04). Participation in nature prescriptions was not associated with the odds of overall loneliness. Respondents in the full sample who were unaware of nature prescribing had higher odds of feeling socially lonely (AOR 1.04, 95%CI 1.03, 1.76) in comparison with peers who were aware but not participants. None of the within-country estimates reached statistical significance for this comparison despite being consistently in the same direction. In contrast, the odds of feeling emotionally lonely were lower in the full sample (AOR 0.72, 95%CI 0.52, 0.88) and in the Australian sample (AOR 0.50, 95%CI 0.28, 0.89), but did not reach statistical significance elsewhere.

Compared with those who were aware but not participants in nature prescriptions, those who were participating had no greater or lesser odds of feeling lonely in general, or of a specific type.

A lack of company (Fig. 3) reported as a barrier to nature contact in the full sample was associated with higher odds of overall loneliness (AOR 1.98, 95%CI 1.48, 2.47) and higher odds of emotional loneliness (AOR 2.84, 95%CI 2.13, 3.51), but also lower odds of social loneliness (AOR 0.79, 95%CI 0.59, 0.99). Higher odds of overall loneliness while reporting this barrier were consistently reported in each country, with statistically significant odds ratios from the samples in India (AOR 2.16, 95%CI 1.34, 3.50) and Singapore (AOR 2.23, 95%CI 1.37, 3.63). A lack of company as a barrier to nature contact was associated with lower odds of social loneliness in the Indian sample (AOR 0.53, 95%CI 0.30, 0.95), with odds ratios in the same direction but not reaching statistical significance for samples from Australia, Singapore, and the US. The odds of emotional loneliness were higher among those reporting a lack of company as a barrier to nature contact in all countries, with those from Australia (AOR 2.15, 95%CI 1.29, 3.59), India (AOR 3.62, 95%CI 2.21, 5.93), and Singapore (AOR 3.00, 95%CI 1.83, 4.92) reaching statistical significance.

Ambivalence about the lack of company as a barrier to nature contact was associated with higher odds of overall loneliness (AOR 1.49, 95%CI 1.24, 1.87) in the full sample, with the odds ratio for the sample from Singapore just spanning unity (AOR 1.69, 95%CI 0.99, 2.89). Ambivalence was also associated with higher odds of social loneliness (AOR 1.41, 95%CI 1.17, 1.79) and emotional loneliness (AOR 1.63, 95%CI 1.36, 2.06) in the full sample. Higher odds of social loneliness in this regard were observed for the sample from Singapore (AOR 2.16, 95%CI 1.17, 3.98), whereas higher odds of emotional loneliness were observed for the sample from India (AOR 1.93, 95%CI 1.09, 3.39).

4. Discussion

Key findings from this study indicate that loneliness is common in all five countries, adding further weight to previous studies already highlighting this as a major challenge (Chawla et al., 2021; Gardiner et al., 2020). More contact with nature was associated with less social loneliness, but also more emotional loneliness. Higher levels of overall and emotional loneliness, but also less social loneliness, was experienced by those who felt the absence of company was a barrier to visiting natural environments. In contrast, ambivalence to the lack of company being a barrier was associated with higher odds of all loneliness outcomes. Finally, nature prescriptions were relatively rare but for those who were recipients, the odds of reporting any type of loneliness were not statistically different from those who were unaware or had not received one, although some of the more precisely measured odds ratios (with narrower confidence intervals) were indicative of potential benefit for overall loneliness and social loneliness. These findings varied to some extent by country, for example, with participants in India reporting substantively higher levels of nature prescribing than their peers.

Persons who spend more time in natural environments, or visit them more frequently, may have lower levels of social loneliness. This aligns with evidence noting how natural environments can be attractive settings in which people can meet, whether planned or serendipitously (Astell-Burt et al., 2022b). This finding extends previous studies that have tended to rely on measuring the quantity or quality of green space nearby in relation to self-reports of loneliness, without measuring the ways that people may interact with those Third Places, potentially leading to mixed findings (Astell-Burt et al., 2022b, 2023c; Villeneuve et al., 2023; Wang et al., 2024; Jamalishahni et al., 2023). That this was not observed for overall loneliness is a function of an opposite association with emotional loneliness, which was more evident among people with higher levels of nature contact. Although unexpected, but it is likely a case of reverse causation in this cross-sectional data, underpinned by evolutionary theory of loneliness proposed by Cacioppo and Cacioppo (2018). That is, loneliness is a biological signal to re-establish a sense of connection, companionship, and camaraderie. It is notable, then, that the lack of company as a barrier to visiting natural environments tended to be associated with lower odds of feeling socially lonely, but in contrast, was strongly associated with higher odds of emotional loneliness. Emotional loneliness may be a catalyst for visiting natural environments for coping with absent family and friends in some people, as is commonly depicted by cemetery visits in the literature (Brant et al., 2020), or visiting special places that evoke comforting memories (Rishbeth and Powell, 2013; Sobel, 1990). It is therefore a key finding and demonstration of the challenge for intervention research that the lack of close companionship which fuels emotional loneliness can also be a significant barrier to visiting Third Places where sustained relief may be found. It indicates that for some people, provision of natural environments nearby may be necessary but not sufficient to find resolution, highlighting the role for nature prescriptions and other forms of social prescribing as a social catalyst (Astell-Burt et al., 2023a).

Our findings highlight the nuanced experiences of loneliness, which was also captured in a recent study on nature walking groups within mental health services (Olcoń et al., 2023). Specifically, participants repeatedly reported having enjoyed being around other people and feeling more connected to others while participating in the group. Some participants reported enjoying simply being among others, a silent and friendly companionship. Others preferred there to be greater emphasis in the group on the social aspect, for example, by incorporating more opportunities to get to know each other while walking together in nature (Olcoń et al., 2023). Importantly, that study focussed on a nature group walking program in part because individuals with mental illness often lack company with which to visit natural environments; a barrier highlighted by our findings that is most pertinent to the challenge of addressing loneliness, but by no means the only one. For example, work from the US in non-clinical populations reported little discretionary time during the day being a correlate of loneliness (Kannan and Veazie, 2023). Thus, future interventions need to address the diversity of motivations and multitude of barriers people face for seeking time in natural environments to maximise effectiveness, equity, and sustainability (Astell-Burt et al., 2023b, 2024).

In our study sample, the lowest level of social loneliness and highest level of emotional loneliness were reported in India. In comparison with the countries in our study, India has higher levels of population density and crowding. Studies have demonstrated that emotional loneliness is often exacerbated by overcrowding. When living in densely populated areas, individuals may feel a sense of disconnectedness and a lack of personal space, leading to heightened feelings of emotional distress (Rugel et al., 2019; Yadav et al., 2022). This can contribute to a greater sense of emotional loneliness (Levine et al., 2008). There are certain cultural, social, and demographic factors that could contribute to a potentially lower prevalence of social loneliness in the Indian context. Indian society places significant importance on family and community bonds. The extended family system is still prevalent in many parts of India, where several generations often live together or in close

proximity. This provides a built-in support network and reduces the likelihood of social isolation (Mohapatra, 2001). Family members are often relied upon for emotional support, companionship, and social interaction, which can mitigate feelings of social loneliness. Festivals, religious gatherings, and celebrations are integral parts of Indian life, providing ample opportunities for social interaction. These events bring people together, foster a sense of belonging, and create a feeling of connectedness, which can help alleviate social loneliness (Hossain et al.).

High population density can lead to increased chances of social interactions and opportunities for forming connections with others (Lin and Ren, 2021). The bustling nature of Indian cities and towns often means that individuals are surrounded by people, making it easier to engage in social activities and build relationships. There is a cultural expectation of supporting and helping others, especially within the context of extended family and community. This emphasis on social connectedness can create an environment where individuals are more likely to reach out and engage with others, reducing the likelihood of social loneliness. As the global population continues to urbanise, it is increasingly important to understand the impact of density on loneliness in general and of contrasting types. This point raises considerations of the characteristics of contrasting climatic, economic, political, and cultural contexts that our international study hints at, without explicit measurement. For instance, in Australia, where single-level detached and semi-detached dwellings are the norm, recent studies indicate that mental health benefits of nearby tree canopy observed regardless of housing type (Feng et al., 2022) may not translate into increased levels of physical activity, nor reduced risks of major cardiovascular events for residents of the apartments that constitute the dominant mode of achieving compact cities (Feng et al., 2021, 2023, 2024). Future research might measure contextual variables that could be influential, from population density, housing type, walkability, and access to different types of natural environment, through to potential barriers such as inclement weather, crime, and air pollution. It is entirely plausible that similar levels of exposure to these characteristics may be internalised differently and shape subtly different behavioural responses between places. For example, a heavy snow in places where this is uncommon even where temperatures tend to be low in winter months (e.g., the UK) may be a major deterrent and cause many people to stay indoors, but in other places where this is commonplace and expected for many months of the year (e.g., in northern areas of the US), local adaptation to those conditions and the hazards they can present may generate fertile ground for rich, resonating experiences in natural environments (Wilkins and Horne, 2024; Finlay, 2018). Future mixed-methods research including qualitative studies and international surveys might usefully tease out how these intricacies manifest contextually and the extent to which they may be consequential for levels of nature contact and interventions designed to increase it.

Nature prescribing was rare, though this was not surprising given that it is a nascent option that many health professionals are yet to adopt for various reasons. An Australian study of mental health professionals (Tambyah et al., 2022), for example, reported support and willingness to prescribe nature-based interventions to patients. Many of those clinicians felt that participation in nature-based interventions would enhance consumers' mental wellbeing, social connections, mindfulness, and relaxation beyond the outcomes obtained from current mental healthcare provision. However, they listed several barriers including consumer resistance, scepticism, and unawareness of the potential benefits, as well as organisational factors that might inhibit implementation of nature prescriptions in mental health settings (Tambyah et al., 2022). Our description of nature prescribing in the survey prior to asking respondents about their awareness and participation in it was important to ensure, in so far as that is possible, that answers provided are robust. That said, we acknowledge that there may be activities aligned with nature prescribing, or other ways of defining it, that may resonate more with some respondents living in particular circumstances and so there could be opportunities for qualitative research to strengthen this part of the survey.

We acknowledge that the recruitment of participants into our study was not representative of the populations from which they were drawn. We report this for the gender, age, education, and employment distributions in these samples; Supplementary Table 1 indicates our samples tend to be younger (except in the case of India), more educated, more likely to be in employment, and more female in the cases of Australia, the UK, and the US. This may be in part due to our reliance upon a survey panel company which was tasked with recruiting a particular number of respondents in each country; information on panel members who declined to participate was not provided. It was notable that the sample skewed younger during a period of global crisis inflicted by the Covid-19 pandemic and periods of mandatory physical isolation and social distancing. This may help to explain why loneliness prevalence estimates were higher than previously reported for general populations (Chawla et al., 2021) or at a similar level to older adults in care homes (Gardiner et al., 2020). This is unsurprising given the well-documented u-shape distribution of loneliness by age, peaking among the young and old (Luhmann and Hawkley, 2016). The lack of representativeness in our data does not preclude use-value in assessing associations (Rothman et al., 2013) and this is the main strength of our study, providing to our knowledge one of the first investigations of time in nature, receipt or awareness of nature prescriptions, and multiple types of loneliness.

The present study has several other strengths, including data from five countries including two outside of the typical 'western' focus of prior studies, and the leveraging of a validated question-set to define general, social, and emotional loneliness. The data are cross-sectional and give rise to the potential reverse causation already discussed in relation to emotional loneliness. Cohort studies capable of tracking changes in loneliness status over time will provide more robust data, while experimental manipulation of exposures through randomised trials and implementation science will generate important information that could inform the definition and scale-up of nature prescribing programs tailored to achieve loneliness reduction as a primary goal (Astell-Burt et al., 2023a). The potential of nature prescriptions as a formal part of healthcare to address issues related to loneliness is exciting and needs to be addressed in properly designed clinical trials. Currently, the use of nature prescriptions appears to be low with only few countries currently offering this option to healthcare professionals as an adjunct to more traditional approaches.

In conclusion, this multi-country study documents contrasting associations between nature contact and different types of loneliness. Higher levels of nature contact are associated with less social loneliness in many contexts (e.g., Australia, India). Positive association between nature contact and emotional loneliness may be attributable to other factors including reverse causation, wherein the experience of emotional loneliness is a signal for people to seek connection in public spaces common to natural environments. Most research linking natural environments and loneliness has been cross-sectional, as revealed in a recent systematic review (Astell-Burt et al., 2022b) that found only three experimental studies (Rodríguez-Romero et al., 2021; Razani et al., 2018; Neale et al., 2021), two quasi-experiments (Brown et al., 2004; Tse, 2010), and two longitudinal studies (Astell-Burt et al., 2022a; Hammoud et al., 2021). Perhaps most crucially for future research and implementation of programs was the finding that persons who considered the lack of a companion with whom to visit natural environments as a barrier tended to have substantively higher odds of feeling emotionally lonely. This provides a useful insight on the emerging lonelygenic environments conceptual framework (Feng and Astell-Burt, 2022), wherein the setting in which one lives may have Third Places like parks nearby, but norms that influence proclivity towards spending time outdoors alone may mean those with the highest potential to benefit do not do so without a social catalyst. This indicates an important role for socially-oriented nature prescribing interventions, and also activities where the focus is instead to reconnect passively with community while

purposefully connecting with the 'more than human' world, in individuals for whom that avenue is acceptable and even preferable (Birch et al., 2020). Each of these findings provide tentative steps and a foundation for further longitudinal studies and randomised trials with the goal of generating scalable, effective, equitable, and sustainable nature-based solutions to the loneliness epidemic.

CRediT authorship contribution statement

Thomas Astell-Burt: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Michelle Kondo:** Writing – review & editing, Investigation, Funding acquisition, Data curation. **Tanya Pritchard:** Writing – review & editing, Investigation, Formal analysis. **Katarzyna Olcon:** Writing – review & editing, Investigation, Funding acquisition. **J. Aaron Hipp:** Writing – review & editing, Investigation, Funding acquisition. **Deepti Adlakha:** Writing – review & editing, Investigation, Funding acquisition. **Evangelos Pappas:** Writing – review & editing, Investigation, Funding acquisition. **Xiaoqi Feng:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2024.103331.

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