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# Inequalities in residential nature and nature-based recreation are not universal: A country-level analysis in Austria

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A B S T R A C T

Evidence suggests that residential nature, e.g., greenness around the home, and nature-based recreation, e.g., visits to specific natural locations, are beneficial for health and well-being. However, several studies report that residential access is lower among socio-economically disadvantaged communities, potentially exacerbating health inequalities. We explored this issue in Austria, a relatively rural and mountainous country that also contains several cities, including the capital Vienna with around 2 million citizens. Data were drawn from a representative survey of the adult population across all nine Austrian regions ($N = 2258$) and explored socio-demographic predictors of residential green and blue space (using satellite data on surrounding greenness and distance to rivers and lakes), and visit frequencies to 12 different urban and rural green/blue environments. In contrast to most findings elsewhere, which usually focus on relatively specific locations (e.g., cities), we found little evidence of socio-economic inequalities in residential green/blue space at the whole country level. Further, although frequent visits to specific environments were less likely among, e.g., people with lower vs. higher education, other typically disadvantaged groups, e.g., those self-identifying as belonging vs. not belonging to an ethnic minority, reported more visits to e.g., urban parks and rivers. Findings suggest that inequalities in nature exposure may not be universal when considered at a country level.

## 1. Introduction

There is growing evidence that nature around people's homes (residential nature including public and private green spaces), and spending leisure time in natural settings (recreational use) positively affects a variety of health- and well-being-related outcomes. These include reduced stress, improved general and mental health, improved cognitive functioning, better sleep, greater life satisfaction, as well as increased prosocial and pro-environmental behaviors (Alcock et al., 2020; Jimenez et al., 2021; Twohig-Bennett & Jones, 2018). Some research suggests that living near both green spaces such as urban parks and woodlands and blue spaces such as rivers and the coast may be particularly beneficial for socio-economically disadvantaged individuals (Garrett et al., 2019; Mitchell & Popham, 2008). To the extent that these benefits can reduce socio-economic inequalities in health (Rigolon et al., 2021), they have been described as having a so-called 'equigenic' effect (Pearce et al., 2015; Wang et al., 2022). Although encouraging for policy goals to increase the access to natural spaces, there is also evidence that lower socio-economic status is linked to poorer nature access (Guan et al., 2023), in part due to historical housing policies (Flournoy, 2021). This in turn can lead to an unequal distribution of nature's benefits (Moran et al., 2021; Nesbitt et al., 2019), which may hinder nature's equigenic potential.

Studies on the access of nature access do not, however, paint a totally clear picture. While reviews show that many studies do find more vulnerable groups to be disadvantaged regarding green space either in terms of amount, distance and/or quality (e.g., Rigolon, 2016; Sharifi et al., 2021), some studies also found no differences or even the opposite

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effect (Nghiem et al., 2021; Sun et al., 2022; Xu et al., 2018). Sun et al.'s (2022) review of inequity in urban green spaces, for instance, shows that around 80 % of cities across the globe demonstrated unequal access to green spaces, but major cities like New York, Sydney and Shanghai found greater access to green spaces among lower socio-economic groups. Similarly, in a comparative study of five European cities, while income was positively related to green space access in four of the cities (Brussels, Milan, Prague, Stockholm), in Birmingham access was higher in lower income communities (Buckland & Pojani, 2023).

Given the growing urban population in many countries, a focus on inequalities in urban green spaces and parks is understandable. However, an exclusive focus on cities tends to neglect the substantial number of people who still live in more rural locations, many of which may also be relatively deprived despite their high levels of green space coverage (Wen et al., 2013). In Austria, for instance, education levels tend to be lower in rural than urban areas (Statistics Austria, 2021). Since ~40 % of the population live in these rural areas, a country-wide level analysis of inequalities in nature access may produce different results opposed to merely city-level analyses. Moreover, city boundaries may be misleading in terms of nature access, use and exposure. In a country like Austria, for instance, all of its major cities border significant nature areas including mountains, lakes and woodlands (woods cover close to half the country; BFW, 2018), which are regular recreational destinations even if just beyond the city boundaries (Arnberger et al., 2018).

This last point highlights the fact that estimating neighbourhood green space access, often using satellite-based estimates of Normalised Difference Vegetation Index (NDVI) which detects green plant canopies, and/or distances to the nearest park/greenspace using Euclidean or network distance estimates (e.g., Holland et al., 2021; Mitchell et al., 2011) represent only one approach to measuring people's exposure to nature (Bratman et al., 2012). A second general approach focuses on exposure more in terms of time spent recreating in these settings, for example via self-reported visits in the last week, month or year (e.g., Shanahan et al., 2016; White et al., 2019). In a study of over 71,000 people in England, for instance, 62 % of nature visits were further than 1 mile (1.6 km) from home (Elliott et al., 2015), even though most residential exposure studies use buffers of 300 m, 500 m or 1000 m. Further, results from an 18-country survey by White et al. (2021) suggest that spending recreational time in green and blue settings may be more important for mental health than merely living near nature. Thus, if we want to get a better understanding of societal-wide inequalities in proximity to and use of green and blue spaces, and their implications for health at a country-level, we need to think beyond merely residential exposure of predominantly urban communities.

To address these issues, we used data from a representative sample of the adult population across the whole of Austria, which looked at both residential and recreational exposure to a wide range of urban and rural green and blue spaces. Our focus was on potential inequalities in access and use as a function of a diverse set of socio-demographic predictors. Such an investigation is a first step in better understanding equalities and inequalities in exposure, which can be used later to explore associated health and well-being impacts. Building on prior research into nature contact, we explored the role of factors such as sex, age, income, education, work status, longstanding limiting illnesses, ethnic minority status, car access, private outdoor space, household composition, marital status, presence of children and dog ownership (e.g., Boyd et al., 2018; Lenaerts et al., 2021; Lin et al., 2014). Moreover, we explored a much more diverse range of urban and rural nature settings than has been considered in most prior research in order to go beyond generic statements about 'greenness' and 'nature' to provide more specific evidence pertaining to a range of natural settings (Holland et al., 2021).

Given the exploratory nature of the analyses, we did not have specific hypotheses. Rather we had a broader set of research questions pertaining to whether any given socio-demographics may be related to any given residential or recreational exposure metrics. Previous work in the UK, for instance, has found that women, older adults, those with longstanding limiting illnesses and those from ethnic minorities tend to visit nature in general less often than comparable groups, potentially exacerbating inequalities in health (Boyd et al., 2018). However, this earlier study did not consider the possibility that specific types of nature may buck the overall trend. For instance, while it may be true that people from ethnic minority backgrounds visit nature overall less, it may also be the case that there are specific locations such, as urban green/-blue spaces, which they are more likely to visit (Arnberger et al. 2021), with implications for urban park design to encourage greater use among these communities as means of health promotion.

## 2. Method

### 2.1. Sample and procedure

Data collection was an extension of the BlueHealth International Survey (BIS) on green and blue spaces and health (Grellier et al., 2017). Although the original survey collected data from 18-countries during 2017–2018, data collection in Austria was only conducted later in October 2020. Data for the original BIS and the Austrian sub-sample was collected on-line by an international market research company using established internet-panels. Full methodological details of the BIS are available on the Open Science Framework website: https://doi.org/10.17605/OSF.IO/7AZU2. Data was collected in accordance with relevant guidelines and regulations, and informed consent was obtained from all participants. Ethical approval was granted by the University of Exeter Medical School's Research Ethics Committee (Ref: Aug16/B/099). The total Austrian sample of $N = 2514$ was stratified to be representative in terms of age, gender and federal state. There are nine federal states including Lower Austria, Upper Austria, Styria, Tyrol, Carinthia, Salzburg, Vorarlberg, Burgenland, and the city of Vienna, a state in its own right. Due to missing data on some variables our final analytical sample was $n = 2258$. A comparison of the original and final samples, alongside Austrian national averages, is presented in Supplementary Table S1 and it shows that the final sample continued to be broadly representative of the adult Austrian population. The geographical spread of participants, based on home location, is presented in Fig. 1.

### 2.2. Questionnaire

The full survey asked participants a range of questions but here we only describe variables that are of interest for the current study (see Supplementary Table S2 for further details).

#### 2.2.1. Residential nature

Participants indicated their home location via a Google Maps application programming interface. The exact location was only recorded to three decimal points (approx. 75 m precision) on latitude and longitude to reduce the ability to identify individual homes. Full details of collection and processing of green and blue space data surrounding these residential addresses can be found in the technical report of the main BIS study (Elliott & White, 2020).

*Greenness within 1 km.* For green spaces, the Normalised Difference Vegetation Index (NDVI) was used with data taken from MODIS Terra satellite imagery (https://modis.gsfc.nasa.gov/). From the respondent's home location, we derived the average amount of photosynthetically active vegetation in a 1000 m radial buffer, in terms of % of residential green space landcover (which does not differentiate between public and private sources). This percentage was used (as a linear outcome variable) in the model predicting green space coverage as a function of different socio-demographics. When used as a predictor, in the models estimating nature visits, this residential green space landcover was divided into quartiles in order to explore potentially non-linear relationships (lowest quartile = *ref*).

*Blue space presence within 1 km.* For blue spaces, we used data from

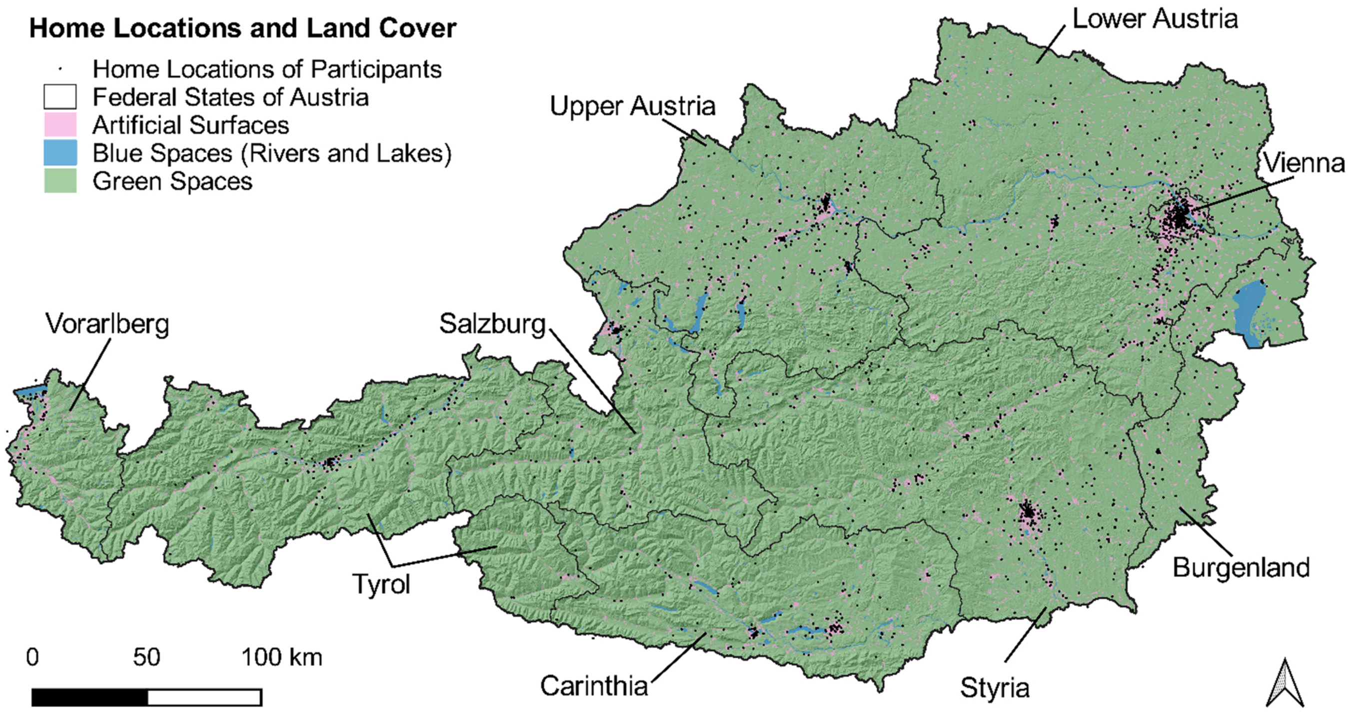


**Fig. 1.** Spatial distribution of home locations of the analytical sample. *Note.* We re-grouped a Corine Land Cover (CLC) Classification into three main categories to visualise that the homes locations of survey participants are mostly located in (larger) settlement areas. Austria is in general characterized by well distributed green and larger blue spaces areas. Whereas the CLC allows for a broader depiction of the land cover fitting for the purpose of visualisation, smaller rivers are missing from this data for instance. That is why NDVI for green spaces and distances to blue spaces (rivers, lakes) is based on ECRINS for the analysis. Map Sources: CLC 2018; Umweltbundesamt GmbH & European Union, Copernicus Land Monitoring Service 2018, European Environment Agency (EEA), with funding by the European Union; data.gv.at – for borders.

the European Catchments and Rivers Network System (ECRINS) database (European Environment Agency, 2012) to assign Euclidean distances from the home location to the nearest lake and river (or canal, waterway etc). ECRINS data are derived from CORINE Land Cover (CLC) data, the EU Water Framework Directive (WFD), and the EU Catchment Characterisation Model (CCM). Rivers are modelled within catchment areas and thus have no minimum width. Lakes have varying minimum mapping units depending on the original data source, spanning 25 $m^2$ (CCM) to 500 $m^2$ (CLC). Due to the highly skewed distributions (77 % of people lived within 1 km of a river, while only 8 % lived within 1 km of a lake), two binary categories were created: River present within 1 km Yes/No; Lake present within 1 km Yes/No.

*Perceived presence of blue space within 10–15 min walk.* In addition to this objective measure, we included a subjective measure. Respondents were asked how much blue space there was within a 10–15 min walk from their home, which approximates to 1 km (Smith et al., 2010). Answering options were “not sure”, “none”, “a little” and “a lot”, and were collapsed into a binary variable (“yes, at least some” vs. “no, none or not sure” = *ref*). In the final sample, 81 % reported to have blue space available within a 10–15 min walk. Point biserial correlations between perceived presence of blue spaces and objective proximity of rivers and lakes within 1 km were both low ($r_{pb}$ <.12) reducing the chance of multicollinearity in regression models. Perceived green space proximity was not collected as part of the survey.

### 2.2.2. *Recreational visit frequency to urban and rural green/blue natural environments*

A list of 29 green/blue urban/rural spaces with accompanying images were presented to participants (Supplementary ‘Questionnaire’ for more information). Given that eight of these were marine settings and Austria has no coastline, they were not considered further (only a handful of, presumably holiday visits, were recorded). For each of the remaining 21 settings, participants were asked how often they visited such locations in the last four weeks for recreation. Response options were 1) Not at all; 2) Once or twice; 3) Once a week and 4) Several times a week. Following earlier research (e.g. Shanahan et al., 2016), we collapsed the first two responses together and the last two responses together to create a binary variable for each location of “visited ≥ once a week” vs. “visited < once a week” in the last 4 weeks. The percentage of respondents visiting each of the locations is presented in Fig. 2 and ranged from 43 % (woodlands) to 2 % (ice rinks). Given that further analyses of rarely visited locations would be statistically unreliable, we focus here on the most frequently visited 12 environment types, i.e. those with > 15 % of respondents visiting ≥ once a week.

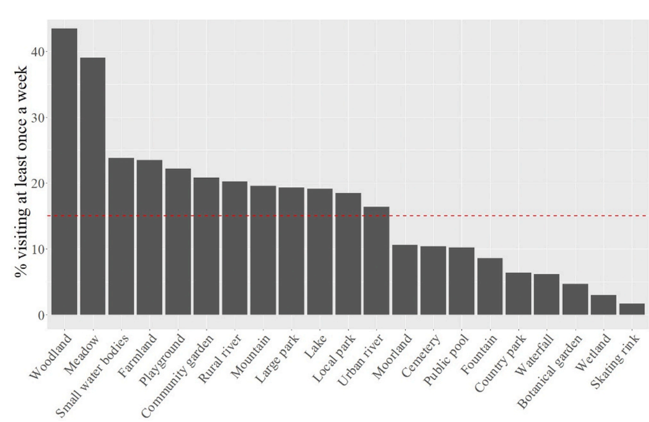


**Fig. 2.** Percentages of respondents visiting 21 different natural environments ≥ once in last four weeks. *Note:* The line represents our cut-off at > 15 % of respondents visiting ≥ once a week.

### 2.2.3. Socio-demographic predictors

Following earlier research, models explored: a) demographic factors, specifically sex and age; b) socio-economic issues, i.e., household income, education level, work status, longstanding limiting illness, and self-perceived ethnic minority status; c) access to private outdoor spaces (green private outdoor space, non-green private outdoor space, communal gardens) and car ownership; and d) household composition, i.e., marital status, number of individuals at home, presence of children, and dog ownership. Region was also added as a covariate, with Vienna as the reference category because it is by far the most urban and densely populated state allowing us to compare exposure as a function of relatively urban vs. rural locations. Detailed information on wording and collapsing of response categories to aid statistical analysis can be found in Supplementary Table S2.

## 2.3. Statistical analysis

To explore socio-demographic predictors of residential green and blue spaces, we conducted three regression models with all covariates included. The green space model predicted the % of greenspace within the 1 km buffer and, thus, we used an ordinary least squares (OLS) approach. The two blue space models predicted the odds of a river or a lake being present vs. absent within a 1 km buffer using binary logistic regressions. Binary logistic regressions were also used to predict

**Table 1**
OLS/Binary Logistic regression models predicting residential green/blue space.

| | Greenness within 1 km[1] | | River within 1 km[2] | | Lake within 1 km[2] | |
|---|---|---|---|---|---|---|
| | *b* | 95 % CIs for *b* | *OR* | 95 % CIs for *OR* | *OR* | 95 % CIs for *OR* |
| (Intercept) | 0.44 | 0.41, 0.48 | 7.65 | | 0.15 | |
| ***Demographic factors*** | | | | | | |
| Sex (ref = female; *n* = 1136) | | | | | | |
| Male (*n* = 1122) | -0.01 | -0.03, 0.00 | 1.08 | 0.87, 1.34 | 1.08 | 0.78, 1.51 |
| Age (ref = 18–29 yrs; *n* = 474) | | | | | | |
| 30–39 yrs (*n* = 403) | -0.00 | -0.03, 0.02 | 0.83 | 0.57, 1.20 | 0.99 | 0.57, 1.71 |
| 40–49 yrs (*n* = 428) | -0.01 | -0.03, 0.02 | 0.89 | 0.61, 1.29 | 1.04 | 0.60, 1.80 |
| 50–59 yrs (*n* = 492) | -0.00 | -0.02, 0.03 | 0.81 | 0.57, 1.17 | 0.77 | 0.44, 1.36 |
| 60 + yrs (*n* = 461) | 0.02 | -0.01, 0.05 | 0.62 | 0.39, 0.98 | 1.13 | 0.55, 2.27 |
| ***Socio-economic related factors*** | | | | | | |
| Income category (ref = low; *n* = 484) | | | | | | |
| Moderate (*n* = 764) | 0.02 | -0.00, 0.04 | 0.82 | 0.60, 1.11 | 0.74 | 0.48, 1.14 |
| High (*n* = 585) | 0.03 | 0.01, 0.06 | 0.81 | 0.57, 1.16 | 0.61 | 0.36, 1.03 |
| Missing (*n* = 425) | 0.02 | -0.00, 0.04 | 0.88 | 0.62, 1.25 | 0.47 | 0.27, 0.81 |
| Education (ref = Higher education; *n* = 523) | | | | | | |
| No or primary (*n* = 904) | 0.03 * | 0.01, 0.05 | 0.91 | 0.68, 1.20 | 0.71 | 0.47, 1.10 |
| Secondary or further (*n* = 831) | 0.02 | 0.00, 0.04 | 0.91 | 0.69, 1.19 | 0.84 | 0.56, 1.27 |
| Work status (ref = In paid work; *n* = 1219) | | | | | | |
| Unemployed (*n* = 199) | -0.02 | -0.05, 0.01 | 1.20 | 0.78, 1.87 | 1.10 | 0.58, 2.01 |
| In education (*n* = 136) | -0.01 | -0.05, 0.02 | 1.45 | 0.91, 2.40 | 0.75 | 0.34, 1.49 |
| Retired (*n* = 457) | 0.00 | -0.02. 0.03 | 1.39 | 0.95, 2.04 | 0.87 | 0.48, 1.60 |
| Long-term health-related absence (*n* = 103) | -0.01 | -0.05, 0.03 | 0.74 | 0.46, 1.22 | 0.96 | 0.38, 2.11 |
| Military service (*n* = 68) | -0.03 | -0.08, 0.01 | 1.90 | 0.96, 4.13 | 0.77 | 0.25, 1.90 |
| Missing (*n* = 76) | 0.02 | -0.02, 0.06 | 1.54 | 0.82, 3.11 | 1.50 | 0.63, 3.20 |
| Longstanding limiting illness (ref = No; *n* = 1296) | | | | | | |
| Yes (*n* = 952) | 0.02 | 0.00, 0.03 | 0.92 | 0.74, 1.15 | 1.10 | 0.78, 1.55 |
| Self-identified ethnicity (ref = Ethnic majority; *n* = 2046) | | | | | | |
| Ethnic minority (*n* = 137) | 0.01 | -0.02, 0.04 | 0.71 | 0.47, 1.08 | 0.74 | 0.34, 1.46 |
| Do not know (*n* = 75) | 0.03 | -0.01, 0.07 | 1.04 | 0.57, 2.05 | 0.62 | 0.18, 1.59 |
| ***Access to resources*** | | | | | | |
| Private outdoor space (ref = None; *n* = 227) | | | | | | |
| Communal garden (*n* = 213) | -0.02 | -0.05, 0.01 | 1.24 | 0.77, 2.02 | 1.09 | 0.56, 2.13 |
| Non-green private outdoor space (*n* = 524) | -0.01 | -0.03, 0.02 | 0.87 | 0.58, 1.30 | 0.80 | 0.44, 1.47 |
| Green outdoor space (*n* = 1294) | 0.02 | -0.01, 0.05 | 0.62 | 0.42, 0.91 | 1.15 | 0.66, 2.06 |
| Car access (ref = No; *n* = 381) | | | | | | |
| Yes (*n* = 1877) | 0.02 | 0.00, 0.05 | 1.02 | 0.74, 1.38 | 0.82 | 0.53, 1.30 |
| ***Household composition*** | | | | | | |
| Marital status (ref = No partner; *n* = 861) | | | | | | |
| Partner (*n* = 1230) | -0.01 | -0.03, 0.01 | 0.92 | 0.68, 1.24 | 0.95 | 0.61, 1.49 |
| Missing (*n* = 167) | 0.01 | -0.02, 0.04 | 1.20 | 0.76, 1.93 | 0.75 | 0.36, 1.44 |
| Number of individuals in household (ref = 1; *n* = 581) | | | | | | |
| 2 (*n* = 845) | 0.01 | -0.02, 0.03 | 1.07 | 0.76, 1.50 | 1.02 | 0.62, 1.69 |
| 3 + (*n* = 832) | 0.02 | -0.01, 0.04 | 0.88 | 0.60, 1.30 | 1.11 | 0.61, 2.00 |
| Children in household (ref = No; *n* = 1717) | | | | | | |
| Yes (*n* = 512) | 0.02 | -0.01, 0.04 | 1.38 | 0.99, 1.94 | 0.95 | 0.56, 1.60 |
| Dog ownership (ref = No; *n* = 1746) | | | | | | |
| Yes (*n* = 512) | 0.02 | -0.00, 0.03 | 1.15 | 0.90, 1.48 | 1.16 | 0.79, 1.68 |
| ***Home-location related predictor*** | | | | | | |
| Federal state (ref = Other regions; *n* = 1785) | | | | | | |
| Vienna (*n* = 473) | -0.20*** | -0.22, − 0.18 | 0.35*** | 0.27, 0.46 | 1.28 | 0.85, 1.90 |
| | $R^2$ | .233 | Cox & Snell $R^2$ | .044 | Cox & Snell $R^2$ | .010 |
| | Adj. $R^2$ | .223 | Nagelkerke $R^2$ | .067 | Nagelkerke $R^2$ | .024 |

*Note.* *N* = 2258. *b* = unstandardised coefficient. *OR* = Odds Ratio; CIs = confidence intervals.
* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.
[1] Calculated from NDVI within 1 km, treated as linear. [2] Calculated from the ECRINS database, treated as binary (River/Lake within 1 km: Yes/No).
Due to the application of the Benjamini-Hochberg procedure, some *p*-values are not significant, even if the CIs do not include 0 (OLS) or 1 (logistic regression).

whether or not individuals had visited the 12 specific locations ≥ once a week (in the last four weeks) as a function of our socio-demographic predictors. Covariates, which were included in all models, included the geographical and socio-demographic predictors listed above. Assumptions were tested and are presented in the Supplementary Materials. To reduce the chance of false discovery across these 15 different regressions, alpha error correction for multiple hypothesis testing was applied using the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995). Due to word limits, significance levels and 95 % Confidence Intervals are only presented in the full results tables in the Supplementary Materials (all coefficients reported in the text are significant to at least $p < .05$). Statistical analyses were performed using R statistical software (Version 4.1.1).

## 3. Results

### 3.1. Models predicting residential green/blue space

There was little evidence of socio-economic related inequalities in residential green and blue spaces in Austria (see Table 1). Of the main markers of socio-economic status, neither household income, work status, illness status, nor ethnicity, were significantly related to residential green space. Those with the lowest level of education lived in areas with significantly more greenspace within 1 km ($b = 0.03$; *ref*=Higher education). Living in Vienna was associated with significantly less residential greenspace compared to all other Austrian regions ($b = -0.20$). Living in Vienna, which lies directly on the Danube, was, however, associated with higher odds of having a river within 1 km of home ($OR = 0.35$). No other significant predictors of residential blue spaces emerged, and the amount of variance explained was small for both models (Rivers: Nagelkerke $R^2 = 6.7$ %, Lakes: Nagelkerke $R^2 = 2.4$ %). For greenspace, explained variance was substantially greater adj. $R^2 = 22.3$ %.

### 3.2. Models predicting green/blue space visits

Figs. 3–5 present the results for all 12 settings grouped into urban green spaces, rural green spaces and blue spaces. Estimates are expressed as odds ratios with "< once a week" (=*ref*) vs. "≥ once a week" in the last 4 weeks including 95 % Confidence Intervals. Full models are presented in Supplementary Tables S3, S4 and S5.

#### 3.2.1. Urban green spaces

*Local neighbourhood parks.* The two greenest quartiles were associated with lower odds of visiting local urban parks at least once a week than the 1st (least green) quartile (3rd: $OR = 0.55$; 4th: $OR = 0.50$), whereas the subjective measure of residential blue space was associated with higher odds ($OR = 1.59$). Respondents self-identifying as belonging to an ethnic minority ($OR = 1.78$), and dog owners ($OR = 1.93$) had greater odds of visiting local neighbourhood parks at least once a week.

*Large urban parks.* Subjective residential blue space was associated with higher odds of visiting large urban parks at least once a week ($OR = 1.89$). Moreover, self-reported ethnic minority status ($OR = 1.98$) was linked to higher odds.

*Community gardens.* People with access to a communal garden ($OR = 2.68$), and green private outdoor space ($OR = 6.65$), had greater odds of visiting community gardens at least once a week. Importantly, individuals with a longstanding limiting illness also had higher odds of visiting community gardens ($OR = 1.42$).

*Playgrounds.* Those living within 1 km of a lake ($OR = 1.63$), and those self-reporting residential blue space ($OR = 1.60$) had higher odds of weekly playground visits. Being 50 + yrs old was associated with lower odds of weekly visits compared to < 30 yrs (50–59 yrs: $OR = 0.36$; 60 + yrs: $OR = 0.42$). Car owners ($OR = 1.63$), people with access to a communal garden ($OR = 2.95$), and, perhaps least surprisingly, individuals with children ($OR = 2.80$), had higher odds of visiting playgrounds at least once a week.

Explained variance was significant for all models with Nagelkerke $R^2$ ranging from 8.8 % for local neighbourhood parks to 18.3 % for playgrounds.

#### 3.2.2. Rural green spaces

*Farmland.* Subjective residential blue space was associated with greater odds of weekly farmland visits ($OR = 1.60$). Odds were also greater if the person had a moderate income ($OR = 1.59$; *ref*=low), access to a communal garden ($OR = 3.13$), non-green private outdoor space ($OR = 2.45$), and green private outdoor space ($OR = 5.19$), and owned a dog ($OR = 2.60$).

*Woodland.* People living in the 4th (vs. 1st) quartile of residential greenness ($OR = 1.56$), and with self-reported residential blue space ($OR = 1.80$) had higher odds of visiting woodlands at least once a week. Living in Vienna was associated with lower odds ($OR = 0.60$) compared to the rest of Austria. The age group 30–39 yrs had lower odds, compared to adults < 30 yrs ($OR = 0.65$). In contrast, odds for weekly woodland visits were higher among car owners ($OR = 1.72$), those with (vs. without) access to green private outdoor space ($OR = 2.11$), and dog owners ($OR = 1.90$).

*Meadows.* Living in the two greenest quartiles (3rd: $OR = 1.56$; 4th: $OR = 1.63$), and having perceived blue space access ($OR = 1.69$) were both associated with greater odds of weekly meadow visits, a particularly important aspect of rural Austria. In contrast, living in Vienna was related to lower odds of visiting meadows compared to the rest of Austria ($OR = 0.49$). Visiting odds of people aged 50–59 yrs were lower compared to the < 30 yrs group ($OR = 0.65$). People with a longstanding limiting illness (vs. no illness) also had lower odds ($OR = 0.77$), while people with moderate income ($OR = 1.5$; *ref*=low), private green outdoor space ($OR = 2.39$), a car ($OR = 1.57$), and a dog ($OR = 2.72$) had greater odds of visiting meadows at least once a week, than those without.

*Mountains*. Again, the 3rd ($OR = 2.18$) and 4th quartiles ($OR = 2.97$) of residential greenness, and self-reported residential blue space ($OR = 1.87$) were associated with greater odds of weekly visits to mountains. Respondents who had no or primary education ($OR = 0.64$; *ref*=Higher) had lower odds of visiting mountains at least once a week.

Explained variance was significant for all models with Nagelkerke $R^2$ ranging from 12.2 % for mountains to 20.2 % for meadows.

#### 3.2.3. Blue spaces

*Urban rivers.* Those who reported a blue space within a 10–15 min walk of home had greater odds of weekly visits to urban rivers than those who did not ($OR = 2.01$). Car access ($OR = 0.63$) was linked to lower odds, while self-reported ethnic minority status ($OR = 2.21$) was associated with greater odds of visiting urban rivers at least once a week.

*Rural rivers.* As with urban rivers, those with self-reported blue space access within a 10–15 min walk also had substantially higher odds of weekly visits to rural rivers ($OR = 3.01$) than those who did not. Individuals with (vs. without) a dog ($OR = 1.87$) also had significantly higher odds of visiting rural rivers at least once a week.

*Lakes.* Living in the 4th quartile (vs. 1st) of residential greenspace ($OR = 1.69$), and within 1 km of a lake ($OR = 2.28$), as well as reporting blue space within a 10–15 min walk ($OR = 1.60$) was associated with higher odds of visiting a lake at least once a week. Individuals with high vs. low income also had greater odds ($OR = 1.82$).

*Small water bodies.* Those living in the greenest quartile ($OR = 1.74$; *ref*=1st quartile), and those with perceived blue space access ($OR = 2.61$) had greater odds for visiting small water bodies at least once a week. Moreover, access to a communal garden ($OR = 2.21$), non-green private outdoor space ($OR = 2.12$), green private outdoor space ($OR = 2.58$), as well as car access ($OR = 1.80$), and dog ownership ($OR = 2.03$) were associated with greater odds.

Explained variance was significant for all models with Nagelkerke $R^2$ between 7.3 % for lakes and 11.9 % for small water bodies.

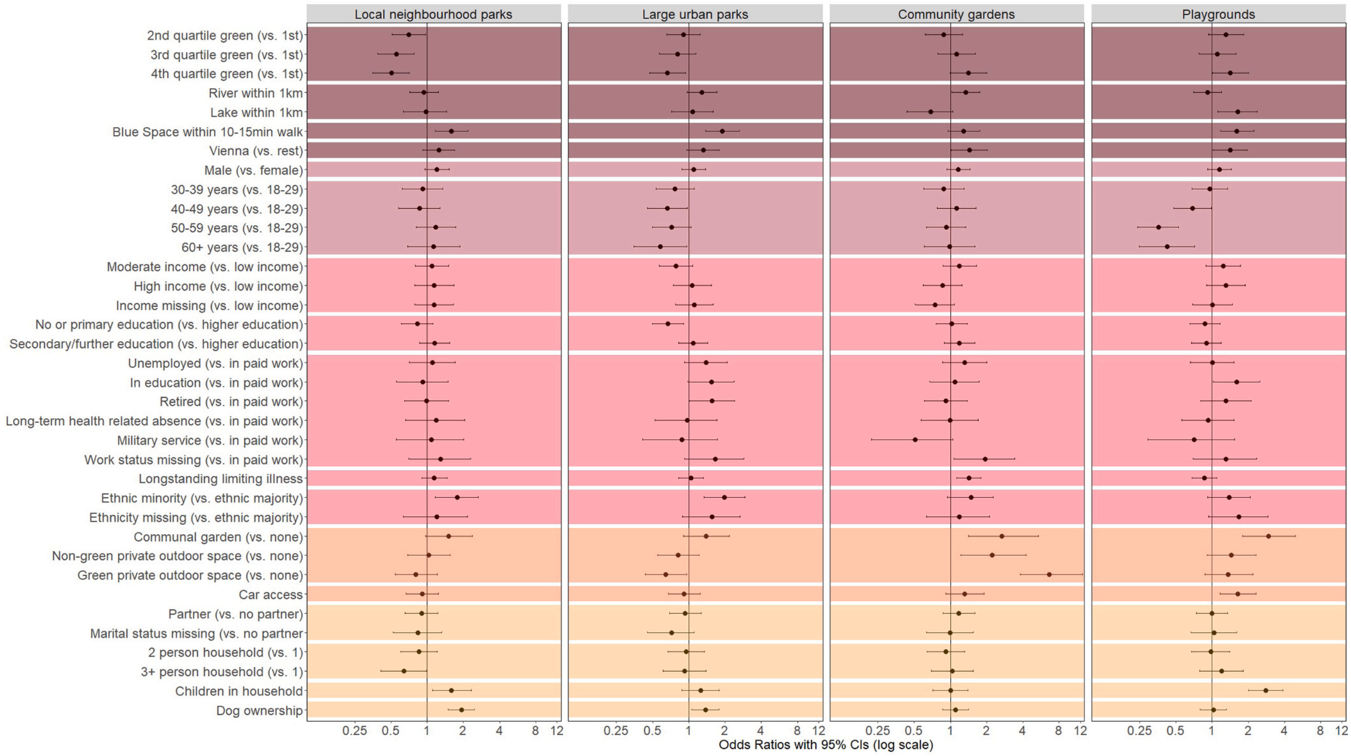


**Fig. 3.** Logistic regression models for recreational visits to four types of urban green space (≥ once in last four weeks). *Note.* $N = 2258$. Due to the application of the Benjamini-Hochberg procedure, some *p*-values are not significant, although the CIs do not include 1. *OR*s are plotted on the log scale.

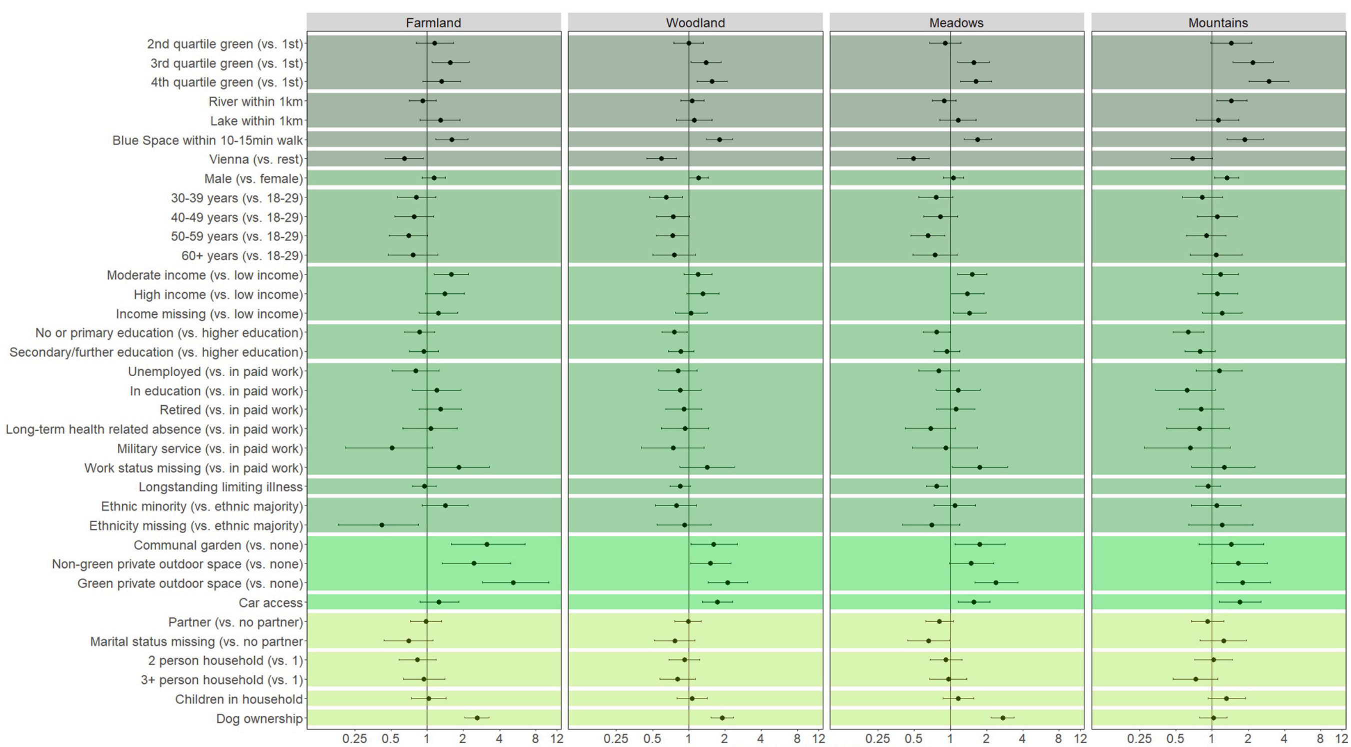


**Fig. 4.** Logistic regression models for recreational visits to four types of rural green space (≥ once in last four weeks). *Note.* $N = 2258$. Due to the application of the Benjamini-Hochberg procedure, some *p*-values are not significant, although the CIs do not include 1. *OR*s are plotted on the log scale.

## 4. Discussion

In an effort to understand whether inequalities in proximity to, and use of, green and blue spaces reported in several studies were also present in Austria, we used a nationally representative survey to explore socio-demographic predictors of both residential green and blue space as

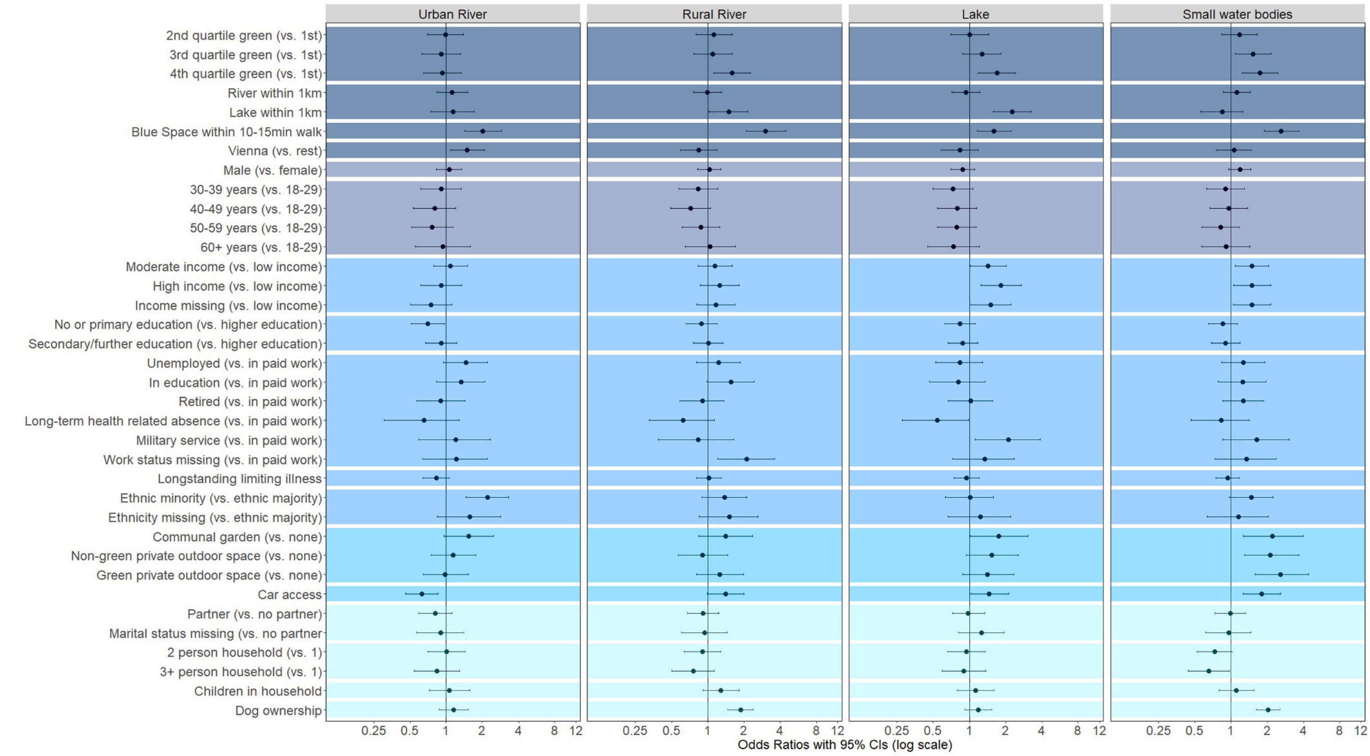


**Fig. 5.** Logistic regression models for recreational visits to four types of blue space (≥ once in last four weeks). *Note.* $N = 2258$. Due to the application of the Benjamini-Hochberg procedure, some *p*-values are not significant, although the CIs do not include 1. *ORs* are plotted on the log scale.

well as visits to 12 different urban and rural, green and blue settings. In contrast to some findings elsewhere (e.g., Guan et al., 2023; Nesbitt et al., 2019; Schüle et al., 2019; Wüstemann et al., 2017), we found very little evidence of socio-economic related inequalities in residential green space coverage or proximity to blue spaces in Austria as a whole. The amount of green space near individual's homes and proximity to both rivers and lakes was similar regardless of age, gender, income, work status, health status, nor marital status. People without (vs. with) a university degree were actually more likely to live in greener areas, probably reflecting the fact that average education levels tend to be lower in more rural areas in Austria (Statistics Austria, 2022).

The results for our second type of exposure, recreational visits, were more nuanced. Perhaps unsurprisingly, individuals living in more rural areas were more likely to regularly visit more rural locations (e.g., mountains and meadows) and those living in Austria's major city Vienna were more likely to visit urban green and blue spaces. In addition, perceived proximity of blue spaces within a 10–15 min walk of home was also associated with more visits to all four blue spaces that we explored as well as all green spaces we examined except community gardens.

In terms of gender, we found no significant differences between men and women in visitation rates. According to existing research on gender differences in outdoor recreation, women, although being more connected to nature, are less likely to engage in outdoor recreation (Rosa et al., 2023). Potential reasons might be higher barriers, for example fear of crime (Zanon et al., 2013), and gender role socialization that makes women more likely to feel limited in outdoor recreation (Godtman Kling et al., 2020). Our results do not support these findings, and potential differences in geographical and cultural influences in the Austrian context compared to those previously studied could be explored in future research.

In terms of age, distinct patterns were found. Given the tendency of less visits to some rural green space among 30–59 yr olds it may be important to facilitate the integration of more time-efficient and work-compatible nature exposure into the daily working life through, e.g., greening work commutes and offices (Haaland & Konijnendijk van den Bosch, 2015), providing workplace outdoor environments, or promoting an outdoor break culture in offices (Lottrup et al., 2012). Nevertheless, for most environments, no significant age differences were found, which is of particular relevance for older adults, especially in terms of vulnerability towards urban heat (Arnberger et al., 2017).

With regard to income, visits to lakes and small water bodies were higher for the highest income group, and for small water bodies also for moderate vs. lower income groups. Given that residential access to water showed no income gradient in this analysis, this is clearly not a proximity issue. However, it could indicate that visits to water bodies are associated with higher costs. Other potential indicators of socio-demographic inequalities showed mixed results. Individuals with low levels of formal education (no/primary), although living in greener neighbourhoods, were less likely to visit mountains than those with higher (tertiary) education, and not significantly more likely to visit any setting. This is in line with the findings of Muhar et al. (2007) that hikers in the Austrian mountains tend to have high levels of education, and the possibility that people with lower education may be in jobs where they work longer hours to obtain a living wage resulting in less time available for recreational nature visits that are relatively time-consuming like mountain visits. A similar conclusion was reached by Boyd et al. (2018) who found that the most common reason for fewer visits of natural environments in the UK was being too busy at work. The implication is that education level and job-related time pressures, rather than income per se, might be more important drivers of nature use inequalities, especially for environments with the potential for particularly high health benefits, such as mountainous areas (Arnberger et al., 2018).

In terms of work status, however, there were no significant differences across the 12 location types, reiterating that inequalities in use in Austria may be less than in other locations. Perhaps even more encouraging was the finding that people with a longstanding limiting illness, while less likely to visit meadows, were significantly more likely to visit community gardens, and no less likely to visit any of the other environments including all four blue spaces.

The findings for ethnicity are perhaps the most encouraging in terms of equality of visits. Specifically, although caution is needed because the sample was relatively small, those who self-identified as being in an ethnic minority were significantly more likely to visit local neighbourhood parks, large urban parks and urban rivers, and did not report significantly fewer visits to any other setting. Previous studies in North America, Europe, and in Vienna itself, suggest that ethnic minority groups may use outdoor spaces more for social and child-related activities, such as picnicking, ball games, and socializing in large, family-oriented groups, while hiking, jogging, and dog walking were less popular (Arnberger et al., 2021; Derose et al., 2015). Although specific activities were not considered here, the current results are broadly consistent with this picture. Natural environments have been shown to enhance social interaction, place attachment, learning of cultural customs and well-being of immigrant communities (Gentin et al., 2019), and given the increasing migrant populations in cities, creating and maintaining adequate urban natural environments is an issue of growing importance. Thus, ethnic minority community's preferences for more developed park facilities, e.g., barbeque and picnic areas, should be considered when planning urban natural spaces.

Furthermore, we observed a tendency for significantly more visits to most rural green spaces as well as small water bodies among people with access to some kind of private outdoor space. This may be because they tend to live in the less dense urban and rural areas where having a garden is more likely, or because they selectively chose to have a garden because being outdoors is important to them (de Bell et al., 2020). Importantly, having access to a car was associated with more visits to playgrounds, woodlands, meadows and small water bodies. Although whether to buy a car or not might partly be influenced by an individual's home location (e.g., less important in Vienna compared to a remote Tyrolian mountain village), it might also partially reflect a person's socio-economic situation. According to Morris et al. (2020), lack of private vehicle access is associated with 35 % less time spent on outdoor recreation activities. This indicates that limited mobility due to a lack of private car access may have the potential to amplify inequalities in health and well-being in relatively rural locations, and local policies to support better public transport links in general as well as more regular, possibly subsidized, services for specific groups (e.g., older adults who no longer have access to a car) might be a way to facilitate nature's potential to reduce such inequalities.

Broadly speaking there did not appear to be any household composition-related inequalities in visits to green/blue spaces in Austria, apart from people with children more often visiting playgrounds. Finally, and consistent with findings elsewhere (White et al., 2018), owning a dog was associated with significantly more visits to six of our twelve locations.

Although offering unique insights into (in-)equalities in access to and use of natural environments across Austria, we also recognize several issues and limitations. First, we recognise that these findings differ from most previous research investigating inequalities in nature access/exposure (e.g., Han et al., 2023) in two main respects: a) we included a country-wide sample in a context where nearly 40 % of inhabitants live in rural areas, as opposed to the majority of studies which focused on cities and urban populations; and b) we also explored recreational visits to 12 different types of urban and rural green and blue space settings, where the majority of previous studies focused only on local green space coverage and/or distance to urban parks. Our findings are thus not directly comparable with most previous studies. Nevertheless, we would argue that they perhaps give a more rounded, nuanced picture than previously described and would suggest that future inequality in access to nature studies also include populations beyond the city boundaries and carefully consider their recreational and voluntary exposures given that much of this will also be further from home than the typical buffers (e.g., 500 m, 1000 m) used in these studies (Elliott et al., 2015).

We also recognise that our models explored socio-demographic variables individually, rather than in combination. Further work could make greater efforts to explore such 'intersectionality' (Colley et al., 2022) as it may be that certain combinations of vulnerability are still relevant for inequalities in nature access and use even in the Austrian context.

Much of our data is also self-reported, which raises issues of possible recall or social desirability bias. Although our geographical exposure metrics were based on satellite data, we were still relying on respondent's ability to accurately place their home location on the mapping tool. Further, recruitment through a paid online-panel might have caused selection bias, e.g., by excluding people without internet access. In general, while being broadly representative in terms of gender, age, work status and region, the sample appears to not have been fully representative of other factors, such as, e.g., ethnicity and education. Also, in some demographic sub-groups, sample sizes were relatively small (e.g., ethnic minority status: $n = 135$), which should also be considered when interpreting the results.

Following earlier work (e.g. Shanahan et al., 2016), our measure of visit frequency was based on a relatively simple distinction between people who reported visiting the given locations at least once a week in the past four weeks. Further work might look at more precise estimates of time spent in specific settings through alternative self-report approaches, such as diaries or by tracking people's movements over time. It is possible, for instance, that more sensitive measures may be more likely to uncover inequalities than the binary outcomes used here. We also recognize that although participants were asked about recreational visits, we cannot rule out the possibility of occupational visits being included by respondents (e.g., by farmers, forestry workers, alpine guides, etc.), and if these groups have lower incomes and education levels it may be the case that they are masking inequalities in specific recreational visits. We are also sensitive to the fact that locations are rarely classifiable into distinct types and will often contain multiple elements. For instance, most lakes will be connected to rivers, thus, a visit to a lake may also be categorised as a visit to a river resulting in some element of double-counting. Further work examining the complex interplay of different environmental elements would help unpick this issue. We further recognize that our loose classification of locations into urban and rural green spaces is also open to scrutiny given, for instance, that although community gardens and playgrounds were categorised as 'urban', from the pictures the participants saw we cannot conclude for certain, whether they were interpreted as such given extensive local greenery.

We further recognize that data were collected in October 2020, and visits were related to the last four weeks. Thus, results are limited to specific seasonal and weather conditions. Furthermore, this marks a time when some COVID-19 related travel limitations were still in place. Although access to natural spaces at this time was largely unaffected, due to longer term closure of many hotels and catering facilities including hill and mountain huts (important destinations in the Austrian context), access to more remote areas presented significantly more barriers than in a normal year (BMLRT, 2021).[1] What is worth mentioning, however, is the increase in domestic overnight stays of 6.2 % during the period between June and October 2020. That is, more Austrians spent their summer holidays in Austria due to the COVID-19 pandemic (BMLRT, 2021), and further surveys in future years will be needed to see how representative our findings are of "normal" years.

## 5. Conclusions

To conclude, when looked at from a country-wide perspective we found relatively little evidence of socio-economic-related inequalities in either residential green and blue space exposure or recreational visits to urban and rural natural environments in Austria, especially once a wider

[1] During 60 of the 274 calendar days before October a strict lockdown including closure of the hotel industry was enforced.

than usual range of potential destinations was considered. While lower visit frequencies to several different locations were observed among some groups (e.g., people with lower education, longstanding limiting illnesses or without car access), for other typically disadvantaged groups like people self-identifying as belonging to an ethnic minority, we even found more visits to specific environments, such as urban parks and rivers. The few inequalities we saw in visit frequencies do not seem to be systematically linked to any inequalities in residential proximity to natural environments either. Although, given a number of limitations which means we remain cautious about over-interpreting these findings, they raise the possibility that issues of nature-based equity may be more apparent at smaller scales or within certain geographical contexts. When examined at the country-level of a relatively rural country such as Austria, evidence of such inequalities seems much less apparent. To date, most of the literature on socio-economic inequalities in nature has focused on residential nature exposure, but here we found relatively little evidence that a lack of neighbourhood nature resulted in fewer recreational visits. To the extent that such visits play an important role in reducing health and well-being related inequalities, a key question for future planners and health professionals is how to optimise the use of existing green and blue spaces in the wider vicinity to support people from all backgrounds maximise their contact with potentially health promoting natural settings.

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*Author contribution*

**LF:** Conceptualisation, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **MW:** Funding acquisition, Conceptualisation, Methodology, Writing - review & editing. **TT:** Funding acquisition, Conceptualisation, Visualisation, Writing - review & editing. **AA**: Conceptualisation, Writing - review & editing. **LE:** Methodology, Writing – reviewing & editing. **MF:** Visualisation, Writing – review & editing.

## Declaration of Competing Interest

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.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2023.127977.

## References

Alcock, I., White, M.P., Pahl, S., Duarte-Davidson, R., Fleming, L.E., 2020. Associations between pro-environmental behaviour and neighbourhood nature, nature visit frequency and nature appreciation: evidence from a nationally representative survey in England. Environ. Int. 136, 105441 https://doi.org/10.1016/j.envint.2019.105441.

Arnberger, A., Allex, B., Eder, R., Ebenberger, M., Wanka, A., Kolland, F., Wallner, P., Hutter, H.P., 2017. Elderly resident's uses of and preferences for urban green spaces during heat periods. Urban For. Urban Green. 21, 102–115. https://doi.org/10.1016/j.ufug.2016.11.012.

Arnberger, A., Allex, B., Eder, R., Wanka, A., Kolland, F., Wiesböck, L., Mayrhuber, E.A. S., Kutalek, R., Wallner, P., Hutter, H.P., 2021. Changes in recreation use in response to urban heat differ between migrant and non-migrant green space users in Vienna, Austria. Urban For. Urban Green. 63, 127193 https://doi.org/10.1016/j.ufug.2021.127193.

Arnberger, A., Eder, R., Allex, B., Hutter, H.P., Wallner, P., Bauer, N., Zaller, J.G., Frank, T., 2018. Perceived health benefits of managed and unmanaged meadows in a mountain biosphere reserve - an experimental study in the Austrian Alps. Eco. Mont. 10 (1), 5–14. https://doi.org/10.1553/eco.mont-10-1s5.

Benjamini, Y., Hochberg, Y., 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J. R. Stat. Soc. Ser. B: Methodol. 57 (1), 289–300. https://doi.org/10.2307/2346101.

Boyd, F., White, M.P., Bell, S.L., Burt, J., 2018. Who doesn't visit natural environments for recreation and why: A population representative analysis of spatial, individual and temporal factors among adults in England. Landsc. Urban Plan. 175, 102–113. https://doi.org/10.1016/j.landurbplan.2018.03.016.

Bratman, G.N., Hamilton, J.P., Daily, G.C., 2012. The impacts of nature experience on human cognitive function and mental health. Ann. N. Y. Acad. Sci. 1249 (1), 118–136. https://doi.org/10.1111/j.1749-6632.2011.06400.x.

Buckland, M., Pojani, D., 2023. Green space accessibility in Europe: A comparative study of five major cities. Eur. Plan. Stud. 31 (1), 145–167. https://doi.org/10.1080/09654313.2022.2088230.

Bundesforschungszentrum für Wald (BFW), 2018. Die österreichische Waldinventur. Retrieved March 30, 2022, from ⟨https://www.klimaaktiv.at/dam/jcr:bd47bbf5-a5dd-467d-8720-fea3b39424da/Waldinventur_September_final.pdf⟩.

Bundesministerium für Landwirtschaft, Regionen und Tourismus (BMLRT), 2021. Tourismus Österreich 2020. Retrieved March 30, 2022, from ⟨https://info.bmlrt.gv.at/dam/jcr:52aff7a7-4580-4f8b-9386-5b6fd44a4afb/Tourismusbericht%202020_bf.pdf⟩.

Colley, K., Irvine, K.N., Currie, M., 2022. Who benefits from nature? A quantitative intersectional perspective on inequalities in contact with nature and the gender gap outdoors. Landsc. Urban Plan. 223, 104420 https://doi.org/10.1016/j.landurbplan.2022.104420.

de Bell, S., White, M., Griffiths, A., Darlow, A., Taylor, T., Wheeler, B., Lovell, R., 2020. Spending time in the garden is positively associated with health and wellbeing: Results from a national survey in England. Landsc. Urban Plan. 200, 103836 https://doi.org/10.1016/j.landurbplan.2020.103836.

Derose, K.P., Han, B., Williamson, S., Cohen, D.A., RAND Corporation, 2015. Racial-ethnic variation in park use and physical activity in the City of Los Angeles. J. Urban Health 92, 1011–1023. https://doi.org/10.1007/s11524-015-9994-8.

Elliott, L.R., White, M.P., 2020. BlueHealth International Survey Methodology and Technical Report. https://doi.org/10.17605/OSF.IO/7AZU2.

Elliott, L.R., White, M.P., Taylor, A.H., Herbert, S., 2015. Energy expenditure on recreational visits to different natural environments. Soc. Sci. Med. 139, 53–60. https://doi.org/10.1016/j.socscimed.2015.06.038.

European Environment Agency , 2012. European Catchments and Rivers Network System (ECRINS).

Flournoy, E.B., 2021. The rising of systemic racism and redlining in the United States of America. J. Sustain. Soc. Change 13, 6.

Garrett, J.K., Clitherow, T.J., White, M.P., Wheeler, B.W., Fleming, L.E., 2019. Coastal proximity and mental health among urban adults in England: the moderating effect of household income. Health Place 59, 102200. https://doi.org/10.1016/j.healthplace.2019.102200.

Gentin, S., Pitkänen, K., Chondromatidou, A.M., Præstholm, S., Dolling, A., Palsdottir, A. M., 2019. Nature-based integration of immigrants in Europe: a review. Urban For. Urban Green. 43, 126379 https://doi.org/10.1016/j.ufug.2019.126379.

Godtman Kling, K., Margaryan, L., Fuchs, M., 2020. In) equality in the outdoors: gender perspective on recreation and tourism media in the Swedish mountains. Curr. Issues Tour. 23, 233–247. https://doi.org/10.1080/13683500.2018.1495698.

Grellier, J., White, M.P., Albin, M., Bell, S., Elliott, L.R., Gascón, M., Gualdi, S., Mancini, L., Nieuwenhuijsen, M.J., Sarigiannis, D.A., van den Bosch, M., Wolf, T., Wuijts, S., Fleming, L.E., 2017. BlueHealth: a study programme protocol for mapping and quantifying the potential benefits to public health and well-being from Europe's blue spaces. BMJ Open 7 (6). https://doi.org/10.1136/bmjopen-2017-016188.

Guan, J., Wang, R., Van Berkel, D., Liang, Z., 2023. How spatial patterns affect urban green space equity at different equity levels: a Bayesian quantile regression approach. Landsc. Urban Plan. 233, 104709 https://doi.org/10.1016/j.landurbplan.2023.104709.

Haaland, C., Konijnendijk van den Bosch, C., 2015. Challenges and strategies for urban green-space planning in cities undergoing densification: a review. Urban For. Urban Green. 14, 760–771. https://doi.org/10.1016/j.ufug.2015.07.009.

Han, Y., He, J., Liu, D., Zhao, H., Huang, J., 2023. Inequality in urban green provision: a comparative study of large cities throughout the world. Sustain. Cities Soc. 89, 104229 https://doi.org/10.1016/j.scs.2022.104229.

Holland, I., DeVille, N.V., Browning, M.H., Buehler, R.M., Hart, J.E., Hipp, J.A., Mitchell, R., Rakow, D.A., Schiff, J.E., White, M.P., Yin, J., James, P., 2021. Measuring nature contact: a narrative review. Int. J. Environ. Res. Public Health 18 (8), 4092. https://doi.org/10.3390/ijerph18084092.

Jimenez, M.P., Deville, N. v, Elliott, E.G., Schiff, J.E., Wilt, G.E., Hart, J.E., James, P., 2021. Associations between nature exposure and health: a review of the evidence. Int. J. Environ. Res. Public Health 18, 4790. https://doi.org/10.3390/ijerph18094790.

Lenaerts, A., Heyman, S., de Decker, A., Lauwers, L., Sterckx, A., Remmen, R., Bastiaens, H., Keune, H., 2021. Vitamin Nature: how coronavirus disease 2019 has highlighted factors contributing to the frequency of nature visits in Flanders, Belgium. Front. Public Health 9, 646568. https://doi.org/10.3389/fpubh.2021.646568.

Lin, B.B., Fuller, R.A., Bush, R., Gaston, K.J., Shanahan, D.F., 2014. Opportunity or orientation? Who uses urban parks and why. PLoS One 9, e87422. https://doi.org/10.1371/journal.pone.0087422.

Lottrup, L., Stigsdotter, U.K., Meilby, H., Corazon, S.S., 2012. Associations between use, activities and characteristics of the outdoor environment at workplaces. Urban For. Urban Green. 11, 159–168. https://doi.org/10.1016/j.ufug.2011.12.006.

Mitchell, R., Astell-Burt, T., Richardson, E.A., 2011. A comparison of green space indicators for epidemiological research. J. Epidemiol. Community Health 65, 853–858. https://doi.org/10.1136/jech.2010.119172.

Mitchell, R., Popham, F., 2008. Effect of exposure to natural environment on health inequalities: an observational population study. Lancet 372, 1655–1660. https://doi.org/10.1016/S01406736(08)61689-X.

Moran, M.R., Bilal, U., Dronova, I., Ju, Y., Gouveia, N., Caiaffa, W.T., Friche, A.A., de, L., Moore, K., Miranda, J.J., Rodríguez, D.A., 2021. The equigenic effect of greenness on the association between education with life expectancy and mortality in 28 large Latin American cities. Health Place 72, 102703. https://doi.org/10.1016/j.healthplace.2021.102703.

Morris, E.A., Blumenberg, E., Guerra, E., 2020. Does lacking a car put the brakes on activity participation? Private vehicle access and access to opportunities among low-income adults. Transp. Res. Part A: Policy Pract. 136, 375–397. https://doi.org/10.1016/j.tra.2020.03.021.

Muhar, A., Schauppenlehner, T., Brandenburg, C., Arnberger, A., 2007. Alpine summer tourism: The mountaineers' perspective and consequences for tourism strategies in Austria. For. Snow Landsc. Res. 81, 7–17.

Nesbitt, L., Meitner, M.J., Girling, C., Sheppard, S.R.J., Lu, Y., 2019. Who has access to urban vegetation? A spatial analysis of distributional green equity in 10 US cities. Landsc. Urban Plan. 181, 51–79. https://doi.org/10.1016/j.landurbplan.2018.08.007.

Nghiem, L.T.P., Zhang, Y., Oh, R.R.Y., Chang, C., Tan, C.L.Y., Shannahan, D.F., Lin, B.B., Gaston, K.J., Fuller, R.A., Carrasco, L.R., 2021. Equity in green and blue spaces availability in Singapore. Landsc. Urban Plan. 210, 104083 https://doi.org/10.1016/j.landurbplan.2021.104083.

Pearce, J.R., Mitchell, R.J., & Shortt, N.K., 2015. Place, space, and health inequalities. In K. E. Smith, C. Bambra, & S. E. Hill (Eds.), Health Inequalities: Critical Perspectives (pp. 192–205). Oxford University Press.

Rigolon, A., 2016. A complex landscape of inequity in access to urban parks: a literature review. Landsc. Urban Plan. 153, 160–169. https://doi.org/10.1016/j.landurbplan.2016.055.017.

Rigolon, A., Browning, M.H.E.M., McAnirlin, O., Yoon, H., 2021. Green space and health equity: a systematic review on the potential of green space to reduce health disparities. Int. J. Environ. Res. Public Health 18 (5), 1–29. https://doi.org/10.3390/ijerph18052563.

Rosa, C.D., Larson, L.R., Collado, S., Cloutier, S., Cabicieri Profice, C., 2023. Gender differences in connection to nature, outdoor preferences, and nature-based recreation among college students in Brazil and the United States. Leis. Sci. 45, 135–155. https://doi.org/10.1080/01490400.2020.1800538.

Schüle, S.A., Hilz, L.K., Dreger, S., Bolte, G., 2019. Social inequalities in environmental resources of green and blue spaces: a review of evidence in the WHO European region. Int. J. Environ. Res. Public Health 16 (7), 1216. https://doi.org/10.3390/ijerph16071216.

Shanahan, D.F., Bush, R., Gaston, K.J., Lin, B.B., Dean, J., Barber, E., Fuller, R.A., 2016. Health benefits from nature experiences depend on dose. Sci. Rep. 6 (1), 28551. https://doi.org/10.1038/srep28551.

Sharifi, F., Levin, I., Stone, W.M., Nygaard, A., 2021. Green space and subjective well-being in the Just City: a scoping review. Environ. Sci. Policy 120, 118–126. https://doi.org/10.1016/j.envsci.2021.03.008.

Smith, G., Gidlow, C., Davey, R., Foster, C., 2010. What is my walking neighbourhood? A pilot study of English adults' definitions of their local walking neighbourhoods. Int. J. Behav. Nutr. Phys. Act. 7, 1–8. https://doi.org/10.1186/1479-5868-7-34.

Statistics Austria , 2021. Konsumerhebung 2019/20. Retrieved March 30, 2022, from ⟨https://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/soziales/ausstattung_privater_haushalte/059000.html⟩.

Statistics Austria, 2022. Austria. Figures. Data. Facts. Retrieved March 30, 2022, from ⟨https://www.statistik.at/wcm/idc/idcplg?IdcService=GET_NATIVE_FILE&dDocName=029252.

Sun, Y., Saha, S., Tost, H., Kong, X., Xu, C., 2022. Literature review reveals a global access inequity to urban green spaces. Sustainability 14, 1062. https://doi.org/10.3390/su14031062.

Twohig-Bennett, C., Jones, A., 2018. The health benefits of the great outdoors: a systematic review and meta-analysis of greenspace exposure and health outcomes. Environ. Res. 166, 628–637. https://doi.org/10.1016/j.envres.2018.06.030.

Wang, R., Feng, Z., Pearce, J., 2022. Neighbourhood greenspace quantity, quality and socioeconomic inequalities in mental health. Cities 129, 103815. https://doi.org/10.1016/j.cities.2022.103815.

Wen, M., Zhang, X., Harris, C., Holt, J., Croft, J., 2013. Spatial disparities in the distribution of parks and green spaces in the USA. Ann. Behav. Med. 45, 18–27. https://doi.org/10.1007/s12160-012-9426-x.

White, M.P., Alcock, I., Grellier, J., Wheeler, B.W., Hartig, T., Warber, S.L., Bone, A., Depledge, M.H., Fleming, L.E., 2019. Spending at least 120 min a week in nature is associated with good health and wellbeing. Sci. Rep. 9, 7730. https://doi.org/10.1038/s41598-019-44097-3.

White, M.P., Elliott, L.R., Grellier, J., Economou, T., Bell, S., Bratman, G.N., Cirach, M., Gascon, M., Lima, M.L., Lõhmus, M., Nieuwenhuijsen, M., Ojala, A., Roiko, A., Schultz, P.W., van den Bosch, M., Fleming, L.E., 2021. Associations between green/blue spaces and mental health across 18 countries. Sci. Rep. 11, 8903. https://doi.org/10.1038/s41598-021-87675-0.

White, M.P., Elliott, L.R., Wheeler, B.W., Fleming, L.E., 2018. Neighbourhood greenspace is related to physical activity in England, but only for dog owners. Landsc. Urban Plan. 174, 18–23. https://doi.org/10.1016/j.landurbplan.2018.01.004.

Wüstemann, H., Kalisch, D., Kolbe, J., 2017. Access to urban green space and environmental inequalities in Germany. Landsc. Urban Plan. 164, 124–131. https://doi.org/10.1016/j.landurbplan.2017.04.002.

Xu, C., Haase, D., Pribadi, D.O., Pauleit, S., 2018. Spatial variation of green space equity and its relation with urban dynamics: a case study in the region of Munich. Ecol. Indic. 93, 512–523. https://doi.org/10.1016/j.ecolind.2018.05.024.

Zanon, D., Doucouliagos, C., Hall, J., Lockstone-Binney, L., 2013. Constraints to park visitation: a meta-analysis of North American studies. Leis. Sci. 35, 475–493. https://doi.org/10.1080/01490400.2013.831294.