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Who in England Engages in Outdoor Water-Based Recreation and Who Does the Most?

Running title: **Who goes onto or next to the water?**

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Abstract: Visits to coastal and inland-waterways have strong associations with many health and economic benefits but are also opportunities for exposure to environmental pollution. In England, few balanced survey samples exist which can facilitate accurate identification of correlates with recreation in blue spaces. This information could support risk assessment for likelihood of exposure and message targeting in case of environmental threats. We process data from a recent (2022-2023) and large (n = 177,551) survey of English residents to describe demographic, seasonal and regional correlates with any participation in water-based recreational activities in previous year (logistic regression model), and in the previous 28 days (zero-inflated negative binomial regression). Activities studied were: surfing and paddleboarding; open water swimming; scuba-diving and snorkelling; canoeing and kayaking; angling. Summer was associated with most frequent participation, winter with fewest sessions except for rowing. Anglers were group most likely to be socially vulnerable: less likely to be university educated, more likely to be disabled and especially likely to be male. People resident in rural locations were more likely to participate at least once in prior year, but did not have higher participation rates in the previous 28 days. Regional variations in specific activities may suggest where demand for water recreation is unmet. The results provide a reference description of outdoor water-recreationalists doing specific types of activity in England and may be useful when designing emergency messages and otherwise setting policy with regard to management of microbiological, radiological or chemical hazards in coastal and inland waters.

Keywords: seasonal; swimming; open-water; angling; paddle-sports

Introduction

Outdoor water-based recreation is increasingly popular in England UK. (University of Brighton *et al.* 2015, RYA 2023). England is an island nation with a temperate climate, long coastline and an inland landscape featuring many accessible rivers and lakes. Diverse health and economic benefits have been linked to time spent in "blue spaces" (Gascon *et al.* 2017, White *et al.* 2020, Cromley & Mackintosh 2021, Geneshka *et al.* 2021). However, open water locations are also prone to environmental contamination which means that contact with open water pose hazards to human health. Arising from our interests in environmental health hazards and emergency preparedness we analysed engagement in outdoor water-based recreational activities (OWBRA) in a recent period (2021-2022). Understanding who engages in specific types of OWBRA and when they engage, could be vital to designing effective communication in case of a public health emergency related to water pollution or for other risk factors such as storms and flooding. There is increasing public awareness and concern about environmental pollution in such waterways, especially from microbiological pathogens in discharged wastewater and sewage (The Rivers Trust 2024). Sewage discharges are common following relatively high rainfall events when wastewater storage units threaten to overflow and inundate a local area (Hammond *et al.* 2021). The magnitude of potential health hazard from

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such discharge events is unclear, not least because obtaining precise information about exactly when and where sewage discharges have happened is difficult (Hammond *et al.* 2021) due to political, logistical and commercial issues.

A high burden of hazardous inert and microbiological agents is a chronic problem in English waterways (Crowther *et al.* 2001, Binns 2023). Large illness outbreaks after water-recreation exposure have been documented. For instance, 338 cases with gastro-intestinal illness (Cryptosporidium and Giardia pathogens) were linked to a single open water river swimming event in the River Thames, London UK in October 2012 (Hall *et al.* 2017). Altogether, 32 cases of confirmed infection (mostly with norovirus but also with rotavirus, sapovirus, campylobacter, adenovirus and E. Coli) in persons reporting gastrointestinal illness symptoms were linked to a triathlon in the North sea near Sunderland, UK in July 2023 (North East Health Protection Team 2023). The post-recreation risk of illness is thought to depend on ingesting or having facial exposure to outdoor waters. A meta-analysis published in 2020 of 92 outbreak reports linked to water-recreation (66/92 related to swimming) concluded that swimming was the highest risk activity while activities with lower risk of swallowing untreated water (eg fishing, boating) might have a lower risk of illness. However, a systematic review of international cohort studies updated to 2021 (Adhikary *et al.* 2022) catalogued gastro-intestinal, skin and respiratory infections linked to windsurfing, canoeing, rafting, jet-skiing and other non-swimming recreation in multi-national fresh water settings.

The management of any public health risk depends in major part on communication with persons who might be at risk. Understanding which groups are most likely to be water-recreationalists relates to effective message targeting. Any public messaging related to a broad public health threat should be disseminated widely. However, it seemed likely that persons who tend to participate in particular OWBRA could have specific commonly measured demographic features. These traits could be useful to identify because public health messages may also be most effective when tailored for precise demographic groups (Noar *et al.* 2009, Lustria *et al.* 2013). Such tailoring could be especially important if the target groups are relatively socially vulnerable; sometimes the most vulnerable groups are the hardest to reach with public health messages (Wilkin *et al.* 2011, Lindsey *et al.* 2022).

Here we used a secondary data analysis to link the likelihood of people undertaking specific water-based recreational activities to self-reported and independently observed social or demographic characteristics. We applied statistical methods, including proportionality tests and multivariable regression, to data from a balanced and large all-England survey on participation in OWBRA in the most recent 12 months, and frequency of participation in the most recent 28 day period.

Methods

Data

The Active Lives Survey 21/22 (ALS2122) is the most recently published output in a series of annual surveys of physical activity and possible determinants or correlates undertaken by Sport England and Arts Council England with support from the central government Office for Health Improvement and Disparities (Sport England undated). The ALS targets all private households in England. Minimum eligible respondent age is 16 years. Completed questionnaires are rewarded with a £5 gift voucher. Residential households invited to complete the survey are randomly selected but stratified to try to obtain responses that are balanced compared to national distribution of households in regions, by rurality and relative social deprivation, with an equal number of invitations sent out each calendar month. The ALS runs each year from mid-November to mid-November. The ALS target is to obtain about 180,000 responses per year; a participating household is surveyed only once in each survey wave. Data were cleaned by the provider and supplied as anonymised individual responses to each question on an online repository (UK Data Archive). Resolution was monthly, regional and categorical with regard to date of completion, household location (9 regions),

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age (17 groups) and gender (3 groups). In the ALS2122, there were > 177,000 individual responses available.

The ALS2122 asked about participation in a large and wide range of possible physical activities, indoor or outdoor, as well as volunteering and general well-being questions. Detailed questions asked about frequency of engaging in each activity in the last 28 days and any participation in prior 12 months. Additionally, there were questions about demographic traits, residence location and ethnic identity. Most of the ALS data were collected digitally, but a paper mode also existed for participants who prefer completion on paper. Most questions were voluntary. There tended to be more missing answers for participants who replied using paper mode.

We consider only specific outdoor-water-linked recreation activities where at least 1000 respondents in the ALS2122 reported engagement in the previous 12 months. The eligible activities were: angling (n=2885); open water swimming (n=10,096); sailing (n=2369); Scuba-diving or snorkelling (n=1300); rowing on water (not indoors, n = 1679); surfing and paddleboarding (n=5172); canoeing and/or kayaking (n=7109). Surfing and paddleboarding were combined by the provider and not possible to disaggregate, as were scuba-diving and snorkelling. OWBRA mentioned in the ALS2122 for which there were fewer than 1000 participants in preceding year were life-saving (n=167) and outdoor water classes (n=2). Because of their lack of specificity about being OWBRA rather than land-based, we did not undertake analysis of engagement in triathlon or the umbrella "Adventure, outdoor and watersport" categories in the ALS2122.

Candidate correlates

We focused on linking participation with socio-demographic traits that are commonly reported or available, as well as traits frequently mentioned in previous literature as linked to participation rates. Within the ALS we considered the following variables for potential relationship with likelihood of or frequency of participation: seasonality, age, gender, geographical region, ethnicity, deprivation decile, relative rurality, education level.

Participation in outdoor recreation in England tends to be strongly seasonal (Boyd *et al.* 2018), peaking in relatively warmer months with longer daylight length. Survey replies had monthly temporal resolution: the data indicated that a survey was completed within a specific 30 day period, although not exact date. The month for response period were delimited as starting from a mid-month date (such as 16 November) until the middle of the subsequent month (eg., 15 December). There was no further distinction within this 30 day period about when the survey was returned. To assign seasonality and allow for the combined effects of variable day lengths, ambient outdoor temperatures and likelihoods of inclement rain and wind, we defined three seasonal periods for survey completion date: winter (responses received mid-November 2021 to mid February 2022, around 5 weeks before until 8 weeks after the winter solstice), transition season (responses received either mid February to mid April or mid September to mid-November 2022) and summer (responses received mid April-mid September 2022, approximately 9 weeks before until 12 weeks after the summer solstice).

Age was available in 17 groups. Youngest was 16-19 followed by 5 year age groups (eg 20-24) with top category being age 95+. For ease of interpretation, we included age as a continuous linear variable in our models, using the median possible age for each group, eg. 22 for group 20-24. If age expressed linearly was not a significant predictor, we trialled a quadratic form for age (ie., age + age^2) for which has been shown to be an appropriate expression in previous analysis of ALS data (Brainard *et al.* 2019), and retained the quadratic expression if statistically significant.

We only considered gender if coded as male or female due to small numbers of 'other' (n=841) or missing answers (n=257). Ethnicity was considered as one of four levels as available in the ALS2122, white British (over 80% of respondents), white non-British (second largest group), Asian excluding Chinese (third largest group) or other (combined remaining 4 available categories, each comprising < 2% of total). Region location was one of nine standard regions widely used for administrative data analysis in England (Wikipedia 2023). The Index of Multiple Deprivation 2019 (IMD2019; McLennan *et al.* 2019) is a nationally estimated multi-factorial ordinal ranking of deprivation relative to all other areas in England, and was available in the ALS2122 as decile rank.

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Each decile contains 10% of the English population. In the IMD2019, low rank (1) is most deprived decile and high rank (10) is least deprived.

Disability status for respondents was available in the ALS2122 as not answered, limiting, non-limiting or none. We handled this as a binary variable in our models: living with a limiting disability or not. Rurality in the ALS2122 was assigned from a nationally developed multi-factorial landscape classification programme (Bibby and Brindley 2012). This categorisation had ten groups, 4 of which were 'urban' and 6 were 'rural'. For simplicity, we only considered a simple division, rural or urban. Respondents reported their highest educational attainment. The highest category was undergraduate university degree or higher. In our analysis, we only consider education level as a binary attribute (yes = actual or equivalent of an undergraduate university degree; no = other/lower education level).

Analysis

We report how many sessions on average occurred per respondent in the most recent 28 day period, stratified by type of OWBRA and the three seasonal periods. Our approach is a modified hurdle regression. Conventionally, hurdle regression in the second stage only concerns non-zero responses to the first stage (logit modelling) for the exact same outcome. A conventional hurdle model analysis plan would only predict count of sessions in prior 28 days for participants who had any prior 28 day participation. However, in the ALS2122 data, most persons who had participated at least once in the prior year had not also participated in the prior 28 days, which is likely due to seasonality. Hence, we felt justified in treating all individuals with any prior year history of OWBRA as potential participants in the most recent 28 days, in the second stage model, albeit with the option of an appropriate logistic link function (based on seasonality in our approach) to predict excess zeros.

In both first and second models we used as reference groups: male gender; most deprived deciles (1-3); London respondents (9.2% of all respondents) and winter season. Analysis was undertaken in Stata 17. A significance threshold of $p < 0.05$ was applied.

In the first stage of our modified hurdle model approach, we applied logistic regression to look for demographic variables that correlated with likelihood of participation (binary outcome) in the previous 12 months in each water-activity. Final adjusted models for the first stage were obtained by putting all the candidate predictors into the models, then removing each least significant correlate and reassessing significance levels, repeatedly, until all remaining correlates had significance at $p < 0.05$.

Secondly, using a zero-inflated negative binomial (ZINB) model to predict 28-day session count with a link function (logistic model to predict excess zeros based on seasonality), we tested which variables significantly correlated with frequency of participation in most recent 28 day period (immediately prior to survey date), only among those who had participated at least once in previous 12 months. Again, a step-wise approach was taken to generate the final models by singly removing any non-significant factors until all remaining variables had significant association. If seasonality was not significant in the link function, we respecified the model for frequency of participation as a simple negative binominal regression.

Interpretation

We anticipated that the ALS2122 data might not be representative of the national population with respect to key demographic traits. Therefore, in this analysis of OWBRA participation, we interpret the results relative to the demographic profile of all survey respondents rather than the national population. This limitation in the sample meant we could only conclude (for instance) that participants in a particular activity were more likely to be female than male or from relatively more or less deprived areas than the other ALS2122 respondents.

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Results

The ALS2122 had 177,551 responses. Counts of individuals who reported at least one of each eligible OWBRA in preceding 12 months are in Table 1, with summary statistics for age, sex, rurality, education level, having a limiting disability and deprivation status. The same statistics are summarised for the full survey dataset and with respect to national composition (sources for which are given in Table 1 notes). The ALS2122 respondents were not highly representative of the national adult population in all respects. Rural-dwelling residents were proportionally represented in the ALS2122 compared to national data. Females, people with 'white' ethnic identity and persons with a limiting disability were somewhat over-represented in the ALS2122 compared to national estimates. ALS2122 respondents were somewhat older (median age 52) than the average age 16+ adult nationally (median age 47). Adults living in the most deprived areas or without university degrees were especially under-represented.

Demographic traits in Table 1 are compared between OWBRA participants and other respondent participants (respondents without any prior 12 month history of the same OWBRA) using proportionality tests (most outcomes, chi-square) and comparisons of distribution of age values (Mann Whitney U test). All comparisons had statistical significance meaning the OWBRA-participant groups were different from non OWBRA history individuals at $p < 0.05$, except for median age of sailors (57 for sailors, 52 for other survey respondents), and percentage of persons who reported scuba/snorkelling and also lived in a rural area (22.5% vs. 21.7% for other survey respondents).

Participation at least once in previous 12 months

The results of multivariable models to predict at least one event of OWBRA in last 12 months are shown in Table 2 for each activity. Odds ratios are reported with 95% confidence intervals. In adjusted models, relative to all ALS2122 respondents, likelihood of prior 12 month participation tended to decrease with higher age or presence of limiting disability, while tending to increase if respondent was male or had a university degree. The trends varied between OWBRA. For instance, being female was especially uncommon among anglers. In contrast, 55.7% of ALS2122 respondents were female; the proportions of participants who were female and reported any 12 month participation that came closest to 55.7% were for swimming (57.5%), canoeing/kayaking (54.0%) and surfing/paddleboarding (58.0%). Having a limiting disability and lower deprivation were not significant predictors in the angling model, but were quite predictive in the other 12-month participation models. Any participation was more likely by rural dwellers. There were strong regional differences in participation rates. Scuba/snorkelling was much more likely in London than anywhere else, swimming or paddle sports were more likely in southern areas of England, region had little link to angling except that there were fewer reported anglers from the North East. Having a university degree was linked to higher likelihood of participation in all OWBRA except angling, where the relationship was significantly reversed. Seasonality of reporting any session was significant with respect to 12 month participation for only canoeing/kayaking and scuba/snorkelling.

Table 1. Demographic traits of ALS2122 participants who participated at least once in previous 12 months in water-based activities.

	Participant count	Age, years (median) U	% female χ	% with university degree(s) χ	% white χ	% living in a rural area χ	% with limiting disability χ	% living in 3 most deprived deciles χ
All survey respondents	177,551	52	55.7	52.3	86.8	21.7	20.8	23.1
Respondents who engaged in…								
Open water swimming	10,096	42	57.5	77.0	91.8	23.2	9.5	16.6
Canoeing, kayaking	7109	47	54.0	73.2	92.3	27.3	9.7	13.6
Surfing, paddleboarding	5172	42	58.0	76.2	94.3	25.6	7.2	11.9
Angling	2885	57	17.2	46.6	95.2	30.3	19.6	20.4
Sailing	2369	57 ns	41.1	76.4	93.0	31.7	11.7	12.3
Rowing on water	1679	47	49.4	67.5	88.7	26.4	12.8	16.1
Scuba-diving, snorkelling	1300	42	48.2	77.4	89.2	22.5 ns	7.0	15.7
National comparison (age 16+)	48.6 mln	47	51.5	33.8	83.6	21.3	17.7	30

Notes: See text for category definitions. Superscripts χ = chi square test; U = Mann Whitney U test. All demographic traits for OWBRA partakers were significantly different from non-same-OWBRA participants in full survey at $p < 0.05$ using these tests, except where denoted ns (= not significantly different). The national statistics were for persons age 16+ only, and in 2021 where possible. However, some data were only available for somewhat different age groups, not 2021 and most available data were for England and Wales populations combined; England has a resident population almost twenty times larger than Wales. Sources for national data in Table 1: **Median age and % female** for persons age 16+, mid 2021 estimates, England and Wales, from https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland; **Total population and England and Wales white ethnic identity** (including British, traveller, Roma, Irish and other white), persons age 16+, 2021 Census: https://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/ethnicity/articles/ethnicgroupbyageandsexenglandandwales/census2021**Prevalence of adults with university education** from 2021 Census, England and Wales, persons age 16+ : https://www.ons.gov.uk/peoplepopulationandcommunity/educationandchildcare/bulletins/educationenglandandwales/census2021;**Rurality** based on 2020 data for all-age English population, figure quoted at. https://www.gov.uk/government/statistics/key-findings-statistical-digest-of-rural-england/key-findings-statistical-digest-of-rural-england.**Disability** statistic is from 2021 Census data, England and Wales, for all-ages, stated at https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/bulletins/disabilityenglandandwales/census2021.

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Table 2. Adjusted logistic models predicting participation in specific OWBRA in previous 12 months, among ALS2122 respondents.

	Open water swimming	Canoeing, kayaking	Surfing, paddleboarding	Angling	Sailing	Rowing on water	Scuba-diving, snorkelling
Age	0.97, 0.97-0.97	0.97, 0.96-0.97	0.96, 0.96-0.96	0.99, 0.99-1.00	0.99, 0.99-1.00	0.98, 0.97-0.98	0.97, 0.96-0.97
Female		0.87, 0.83-0.91		0.16, 0.15-0.18	0.57, 0.52-0.61	0.74, 0.67-0.82	0.68, 0.61-0.77
Disabled	0.53, 0.50-0.57	0.56, 0.52-0.61	0.41, 0.37-0.46		0.64, 0.56-0.74	0.74, 0.64-0.87	0.41, 0.32-0.51
Ethnicity							
WO	1.31, 1.22-1.41	0.81, 0.73-0.89	0.66, 0.58-0.74	0.88, 0.74-1.06	0.91, 0.77-1.08	1.17, 0.97-1.41	1.31, 1.09-1.58
AxC	0.18, 0.15-0.21	0.26, 0.22-0.31	0.12, 0.09-0.16	0.18, 0.13-0.27	0.32, 0.24-0.44	0.53, 0.40-0.71	0.30, 0.21-0.43
O	0.53, 0.48-0.59	0.45, 0.39-0.52	0.36, 0.30-0.42	0.35, 0.26-0.47	0.45, 0.34-0.59	0.80, 0.63-1.02	0.70, 0.54-0.91
IMD							
dec. 4-7	1.21, 1.13-1.29	1.42, 1.31-1.54	1.56, 1.42-1.72		1.24, 1.07-1.43	1.27, 1.09-1.48	1.26, 1.06-1.50
dec. 8-10	1.25, 1.17-1.33	1.69, 1.56-1.83	2.01, 1.82-2.22		1.43, 1.24-1.65	1.38, 1.17-1.61	1.51, 1.27-1.80
Rural	1.15, 1.09-1.21	1.35, 1.27-1.43	1.20, 1.12-1.29	1.45, 1.33-1.58	1.55, 1.41-1.71	1.35, 1.19-1.52	1.19, 1.03-1.37
Region							
SE	0.91, 0.84-0.99	1.32, 1.19-1.46	1.34, 1.19-1.50	1.14, 0.95-1.37	1.02, 0.87-1.20	0.96, 0.79-1.17	0.66, 0.54-0.80
SW	1.16, 1.07-1.27	1.47, 1.31-1.64	1.97, 1.74-2.23	1.17, 0.96-1.43	1.00, 0.83-1.19	1.15, 0.93-1.43	0.87, 0.70-1.08
E	0.63, 0.58-0.69	1.16, 1.04-1.30	0.84, 0.73-0.96	1.19, 0.99-1.44	0.77, 0.65-0.92	1.06, 0.86-1.30	0.57, 0.46-0.72
EM	0.46, 0.42-0.51	0.71, 0.62-0.80	0.61, 0.52-0.71	1.06, 0.87-1.29	0.35, 0.28-0.44	0.52, 0.40-0.67	0.46, 0.36-0.60
WM	0.45, 0.40-0.50	0.78, 0.69-0.89	0.76, 0.65-0.88	1.08, 0.89-1.32	0.37, 0.29-0.46	0.66, 0.52-0.83	0.37, 0.28-0.48
YH	0.50, 0.45-0.56	0.67, 0.59-0.77	0.64, 0.55-0.75	1.12, 0.92-1.37	0.42, 0.34-0.52	0.69, 0.54-0.88	0.43, 0.33-0.56
NE	0.54, 0.48-0.62	0.71, 0.62-0.80	1.01, 0.85-1.20	0.75, 0.57-0.98	0.34, 0.24-0.47	0.62, 0.45-0.87	0.66, 0.48-0.90
NW	0.57, 0.52-0.62	1.01, 0.90-1.13	0.83, 0.73-0.95	1.00, 0.82-1.20	0.52, 0.43-0.63	0.73, 0.59-0.91	0.49, 0.39-0.62
University degree	2.77, 2.63-2.91	2.22, 2.08-2.35	2.53, 2.37-2.71	0.79, 0.73-0.85	2.59, 2.34-2.86	1.63, 1.46-1.82	2.54, 2.21-2.92
Season							
Transitn		1.11, 1.04-1.19					1.95, 1.64-2.30
Summer		1.15, 1.08-1.23					1.60, 1.35-1.89

Notes for Table 2: Values are odds ratio, 95% CI. Reference values for categorical variables (OR= 1.0) are male gender, British white ethnicity, IMD deciles 1-3, London region, winter season. IMD: Index of multiple deprivation 2019; dec.: decile group for IMD, Transitn: transition months between winter and summer. Ethnicity codes: WO White other (not British white); AxC any Asian except Chinese; O any other non-white ethnic identity. Region codes: EM East Midlands, E East of England, NE North East, NW North West, SE South East, SW South West, WM West Midlands, YH Yorkshire and Humber. Empty cell means variable not in model.

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Participation frequency in previous 28 days.

Table 3 shows how many sessions on average were undertaken, on average, in each seasonal period, only for persons who had at least one session of the same OWBRA activity in preceding 12 months. Summer was the season with highest participation in all OWBRA except rowing or scuba-diving and snorkelling. Winter was the period with lowest 28-day participation rates for all OWBRA except scuba-diving/snorkelling.

Table 3. Average number of sessions in most recent 28 days, per respondent in each activity, by season.

Season	Winter	Transition months	Summer
Activity			
Open water swimming	0.50	0.91	1.84
Canoeing, kayaking	0.19	0.47	0.85
Surfing, paddleboarding	0.19	0.49	1.01
Angling	0.89	1.26	1.78
Sailing	0.46	1.10	1.76
Rowing on water	1.81	2.36	2.24
Scuba-diving, snorkelling	0.28	0.19	0.25

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Results for negative binomial multivariable models to predict most recent 28 day frequency of engaging in each activity are shown in Table 4. Most models were constructed with a link function based on seasonality to predict excess zeros, but the link function was not significant for frequency of rowing sessions, so this was constructed with a simple negative binomial distribution. Incident risk ratios (IRR) are shown for the negative binomial part of the models, odds-ratios for the logistic link function (zero-inflation predictions). In the link models, significantly lower odds ratios means less likelihood of zero participation, or more participation. Although increased age tended to be associated with declining 12 month participation, age had no association or frequency increased with age for most of the OWBRA in Table 4. Female gender was linked to more open water swimming sessions, but fewer canoeing/kayaking, angling or sailing sessions. Having a limiting disability was significantly linked to more angling sessions but not linked to frequency of other OWBRA. Relative deprivation was only associated with frequency of rowing sessions, with residents of the least deprived deciles having significantly more sessions than deciles 1-7. With reference group being Londoners, greater or lower frequency of OWBRA sessions was linked to specific regions for swimming, canoeing, surfing and sailing: there tended to be highest frequency in the south east and south west. Having a university degree had a negative association with frequency of surfing or angling sessions and was not significantly linked to other OWBRA.

Relative to winter survey months, there was much lower probability of zero sessions for most OWBRA in transition months or summer, rowing being an exception (seasonally indifferent). Rurality of respondent location had no significant association with frequency of sessions for any of these OWBRA. Ethnicity was only relevant to frequency for anglers; persons not identifying as British white, other white or Asian not Chinese had fewer sessions.

Table 4. Adjusted zero inflated negative binomial models predicting frequency of sessions in most recent 28 days, in specified OWBRA.

	Open water swimming	Canoeing, kayaking	Surfing, paddleboarding	Angling	Sailing	Rowing on water	Scuba-diving, snorkelling
Age	1.01, 1.008-1.014	1.01, 1.01-1.01		1.01, 1.006-1.016	1.01, 1.00-1.01		1.02, 1.00-1.03
Female	1.23, 1.13-1.34	0.80, 0.71-0.90		0.75, 0.60-0.93	0.71, 0.60-0.84		
Disabled				1.33, 1.08-1.59			
Ethnicity							
WO				0.84, 0.58-1.22			
AxC				0.57, 0.24-1.35			
O				0.40, 0.21-0.79			
IMD							
dec. 4-7						1.09, 0.79-1.50	
dec. 8-10						1.52, 1.09-2.10	
Region							
SE	1.08, 0.94-1.26	1.50, 1.18-1.92	1.38, 1.03-1.86		1.59, 1.16-2.19		
SW	1.21, 1.03-1.42	1.28, 0.98-1.69	2.23, 1.65-3.02		1.52, 1.07-2.15		
E	0.94, 0.79-1.12	1.58, 1.21-2.06	1.37, 0.98-1.93		1.29, 0.91-1.84		
EM	0.75, 0.62-0.92	1.84, 1.37-2.46	1.38, 0.95-2.01		1.60, 1.04-2.46		
WM	0.79, 0.64-0.97	1.12, 0.82-1.53	1.07, 0.73-1.55		1.03, 0.66-1.60		
YH	0.86, 0.70-1.06	1.34, 0.98-1.84	1.12, 0.75-1.67		1.11, 0.73-1.69		
NE	0.84, 0.64-1.10	1.26, 0.82-1.94	2.11, 1.37-3.25		1.10, 0.61-1.98		
NW	0.74, 0.62-0.88	1.27, 0.97-1.66	1.22, 0.87-1.71		1.18, 0.81-1.73		
University degree			0.84, 0.71-1.00	0.78, 0.67-0.90			
Link function to predict excess zeros OR, 95%CI							
Season						Not done, link	
Transitn	0.37, 0.31-0.44	0.23, 0.17-0.31	0.24, 0.17-0.33	0.48, 0.33-0.70	0.40, 0.30-0.55	function was not	0.52, 0.23-1.18
Summer	0.08, 0.06-0.10	< 0.01, <0.01-∞	< 0.01, <0.01-∞	0.12, 0.04-0.36	0.18, 0.13-0.25	significant	0.36, 0.16-0.81

Notes for Table 4: Values in main function are incidence risk ratio (IRR), 95%CI except for link function which is OR, 95%CI. Reference values for categorical variables (IRR= 1.0) are male gender, IMD deciles 1-3, London region, winter season. IMD: Index of multiple deprivation 2019; dec.: decile group for IMD, Transitn: transition months between winter and summer. Ethnicity codes: WO White other (not British white); AxC any Asian except Chinese; O any other non-white ethnic identity. Region codes: EM East Midlands, E East of England, NE North East, NW North West, SE South East, SW South West, WM West Midlands, YH Yorkshire and Humber. Empty cell means variable not in model.

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Discussion

Like many voluntary surveys, the ALS2122 has more responses from females, relatively more educated and less deprived individuals compared to the national population. The demographic comparisons in our models are therefore best interpreted relative to the population who responded to the ALS2122. We can most confidently say that anglers tend to have quite different demographics from the average ALS2122 respondent and from other OWBRA participants: anglers were much less likely to be university educated, more likely to be represented across deprivation groups and be living with or without a limiting disability, and more likely to engage frequently even if they have a limiting disability. Angling has been discussed previously as an especially accessible OWBRA for disabled persons (Lindsay *et al.* 2022). Ethnicity was a strong predictor for likelihood of any participation in the OWBRA, but was only relevant to frequency of participation for anglers. The diversity of ethnic groups encompassed by the 'Other' category suggests does not enable us to confidently identify which ethnic groups truly under-participated much less why. Targeted over-sampling would be required to explore the barriers and facilitators for participation experienced by specific ethnic minorities. We note that compared to some other recent surveys of British anglers (Bull 2009, Hyder *et al.* 2021, Lindsay *et al.* 2022, Wilson *et al.* 2023), the ALS2122 collected information from relatively more individuals who had a recent history of angling who were not white British males.

There was a tendency for southern and eastern parts of England to have higher 12 month participation rates compared to northerly/western areas. Broadly generalised, British weather is warmer in the south and wettest in the north and west. There were significantly higher participation rates in the South West for surfing, open water swimming, paddle sports and sailing. The South West region has especially well developed facilities and infrastructure for surfing (Vergnault 2017) and other water sports in coastal waters. In a contrasting regional pattern, among ALS2122 respondents, angling was more likely to have been practiced if respondent lived outside London. Region was less linked to 28 day frequency of angling than other OWBRA, although there were still significant regional variations for all OWBRA. Seasonality was important for most of the participation or frequency models, there were many more sessions in summer, spring or autumn than in winter. However, rowing on water was an exception to this trend; there was not substantially less rowing in winter than other seasonal periods.

When people are most likely to have been in, on or next to the water is relevant to when contamination events could cause most harm. Deliberate or inadvertent Illegal release of chemical or radiological pollutants are likely to be remain especially difficult to foresee. Microbiological and toxic hazards arising in open water from natural processes, sometimes following over-nutrient supply (Cooper *et al.* 2022, Krokowski 2023) are only somewhat easier to predict. Locations and dates of sewage and wastewater runoff contamination have the potential be quickly detectable, if storm drain flows are monitored. Until recently, discharge information tended to be very incomplete, non-specific and hard to obtain (Woodward 2023), but may become more available in future if concern over waterways pollution continues to be a high profile political issue and because monitoring of runoff and sewage release events is increasingly required (Vaughan 2023).

Rurality increased likelihood of at least one participation in prior 12 months for all groups except scuba and snorkelling, but rurality was not linked to high frequency of participation in the second stage models. This finding suggests that rural residence may create opportunities to try OWBRA infrequently, but not necessarily more opportunity to practice the OWBRA regularly. Although higher age was linked to lower likelihood of participation in last 12 months, higher age was linked to more participation in most recent 28 days in adjusted models. This finding may reflect adults who are retired or semi-retired and have more leisure time. Although females were under-represented for any participation in most OWBRA, female gender sometimes predicted higher frequency of participation. As a result, the data evidence that any public health warnings would need to target multiple genders.

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It is hard to definitively validate how representative the ALS2122 respondents were of all British persons who partook of these OWBRA in 2021-2022, not least because every comparator UK sample also has likely bias. Arguably, compared to other UK surveys of similar or same target groups, the ALS2122 balanced sampling strategy is likely to be less biased while the ALS questionnaire collected more complete information about specific OWBRA participation rates. Of the OWBRA addressed in our analysis, angling has had perhaps the most surveyed participants in the UK. Previous angler surveys in the UK also overwhelmingly recruited males. (males were consistently > 95% of sample; Bull 2009, Anderson *et al.* 2014, Hyder *et al.* 2021, Lindsay *et al.* 2022, Wilson *et al.* 2023). Population surveys about participant profile for the other OWBRA in our analysis are less available, and where background information about participants was published, it tends to have limited detail, may lack disaggregation by specific activity, or contain limited detail beyond gender and age.

Females comprised 65% of replies in a 2020 survey of members undertaken by the Outdoor Swimming Society (Outdoor Swimmer 2021), having increased from 50% in 2017. 87% of the 2020 respondents were age 40+. Oliver *et al.* (2023) collected demographic information from 717 Scottish open water swimmers in 2021, in a cross-sectional analysis of perceived activity risks and benefits. Their respondents were recruited via a large Facebook group (97,000 members). This sample was overwhelmingly female (91.6%), mostly age 35-54 (61.8%) and the majority (> 64.5%) had an annual household income that was above the concurrent national average (about £27,000).

Demographic information and biosecurity habits of 599 entirely British recreational kayakers and canoeists were collected in about 2012 Anderson *et al.* (2014). Their sample was 70% male and the largest respondent group (42.4%) was age 35-54 years old. Anderson *et al.* (2014) found that the sex distribution of their kayaking/canoeing sample was not significantly different from the sex ratio for persons registered with the British Canoe Union, but lacked comparator data to validate if their sample was representative with regard to age. Motives to undertake sea kayaking for mostly American, Canadian and at least one British participant in 2004 were explored by O'Connell (2010). This sample was 57.4% male; 92% Caucasian. 73% had a university degree and median age was 46.6 years (range 16-70 years).

Women comprised 38% of British Canoeing membership in 2022 (Paddle UK undated), with stand up paddle boarding (SUP) being the most popular paddling activity for female members. Schram and Furness (2017) reported that 31% of stand up paddleboarding respondents were female in an Australian survey of 154 recreational SUPers who specified their gender.

Recruited via marinas where they were harboured, social media interest groups and social media profiling, Christensen *et al.* (2023) collected demographic data in about 2019 from 71 British boat owners (including sailboat owners) of whom 77.6% were male and 53.1% were age 45-64. 42.2% had a university degree. Both sailing and rowing have strong anecdotal reputations as sports dominated by affluent white males: older men in sailing and young men in rowing (World Sailing Trust 2021, Spender-Elliott 2022, O'Neill 2023). However, British Rowing reported that 48% of membership were female in 2013 (British Rowing undated).

That surfing is viewed if not formally documented to be a predominantly young male sport is widely recognised (Wheaton 2019), but prevalence of other attributes seems to be far less documented. Why surfing can be an expensive pastime and therefore inaccessible to more deprived households was described in an evaluation of a surfing programme for troubled youth in Cornwall UK (Hignett *et al.* 2018).

Analysis of several large UK surveys have reported broadly about demographic profiles of OWBRA participants while not disaggregating by type of activity. Socio-economic status, age and sex were directly linked to participation rates in coastal and inland waterway proximity recreation in an analysis of 326,755 responses to the Monitor of Engagement with the Natural Environment survey (Natural England 2015) from 2009-2016 (Elliott *et al.* 2018). Elliott *et al.* (2018) found that females, persons in the middle socio-economic groups and persons age 35-64 were more likely to go to beaches; males, age 65+ and higher socio-economic groups were more likely to visit coastal non-beach environments and inland water locations were more likely to be visited by males, persons age 35-64 and higher socio-economic groups. Elliott *et al.* (2018) also observed seasonal differences in visit

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frequency (higher visit rates in summer) and some differences in visit rates depending on residence region.

Limitations

We have explored the potential to use ALS2122 information to describe likely demographic profile and assess possible social group vulnerability with regard to encountering potentially contaminated British coastal and inland waters. However, there are limitations in what we can confidently interpret from the ALS2122 data, particularly arising because it is a secondary data analysis.

The surfing/paddleboarding category in ALS2122 is potentially highly heterogenous. Surveys of ocean surfers indicate consistently that surfing tends to be an especially male and relatively young sport (Dickerson 2019), but being male and young was not strongly reflected in our participation model for surfing and paddleboarding. This category in the ALS2122 probably encompasses two distinctly different groups: relatively young males who surf in coastal waters and a more gender-balanced, older group who go out stand-up paddleboarding, more typically on inland waterways.

There were low sample counts for most specific ethnic minorities in the ALS2122. There is likely huge heterogeneity in culturally-linked recreation preferences in ethnic subgroups that the ALS2122 could not capture. A challenge in a balanced survey like the ALS2122 is that it may inherently not capture enough data about small minority groups to describe them adequately. Ethnic minority groups would need to be over-sampled to confidently explore specific ethnic identity relationships with likelihood or frequency of participation in OWBRA.

We could only assign Seasonality broadly because resolution for date of survey completion was over any of 30 days in preset monthly periods, not individual dates. Seasonality being significant in some of the 12-month participation models may reflect recall bias; people are more likely to remember a recent activity than one they did many months ago. That seasonality was significant in some of the 12-month-participation models suggests another potential complication with regard to identifying which social groups had highest chance of environmental hazard exposure: possible history of foreign travel, and that the activities were only memorable because they happened in unusual (vacation) circumstances. The ALS2122 did not ask where the activity took place in UK or abroad. The OWBRA may have happened on holiday in waters outside the home region and even outside of the UK. It was also not possible in this dataset to identify how many OWBRA sessions were in coastal versus inland waters. We acknowledge that for some respondents, likelihood of participation had nothing to do with concurrent British weather conditions or potential environmental hazards in British waters or specific water courses.

Conclusion

Among persons participating in the common OWBRA analysed in this study, we can most confidently expect that anglers are the most likely to be members of socially vulnerable groups: anglers are more likely to live in the most deprived areas or have a limiting disability.

For most outdoor water based recreational activities, any participation in the previous 12 months tended to negatively correlate with increased age, presence of disability, female gender, ethnicity that was not white and British. People without university degrees were less likely to report specific OWBRA in the previous 12 months.

Among respondents with any prior 12 month participation, frequency of most specific types of OWBRA in previous 28 days was positively correlated with age but rarely with most other traits. Region of residence was an exception; there was considerable statistically significant variation by region for both 12-month and 28-day participation. The regional data suggest not only where relatively more individuals might be exposed in case of environmental contamination, but also where there may be under-served demand for additional suitable “blue space” recreation. Specific research would be useful to determine which communication channels could be most effective for rapid communication with different types of OWBRA participants, especially to reach persons who engage more casually and sporadically rather than routinely.

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