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Coastal proximity and mental health among urban adults in England: The moderating effect of household income

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ABSTRACT

After adjusting for covariates, self-reported general health in England is higher among populations living closer to the coast, and the association is strongest amongst more deprived groups. We explored whether similar findings were present for mental health using cross-sectional data for urban adults in the Health Survey for England (2008–2012, N ≥25,963). For urban adults, living ≤1 km from the coast, in comparison to > 50 km, was associated with better mental health as measured by the GHQ12. Stratification by household income revealed this was only amongst the lowest-earning households, and extended to ≤5 km. Our findings support the contention that, for urban adults, coastal settings may help to reduce health inequalities in England.

1. Introduction

1.1. Overview

Poor mental health is among the leading causes of disability worldwide (World Health Organisation, 2018). In England, approximately one in six adults (17 %) surveyed were suffering symptoms of a common mental disorder (CMD), such as anxiety or depression (McManus et al., 2016). However, there is mounting evidence that exposure to natural environments is associated with various benefits for mental health and wellbeing (hereby referred to as 'mental health'; see reviews by Bratman et al., 2012; Frumkin et al., 2017; Hartig et al., 2014; Trostrup et al., 2019). Much of this work reports positive associations between green space and mental health, where measured or tested exposures include neighbourhood vegetation, green exercise, and residential proximity to green space (e.g. Barton and Pretty, 2010; Beyer et al., 2014; Cox et al., 2017b; de Vries et al., 2013; Gascon et al., 2015; McEachan et al., 2016). This may be particularly the case for those in urban areas where nature exposures can be limited (Cox et al., 2017a).

Concurrently, a smaller, yet growing, amount of research suggests that blue spaces (aquatic environments such as coasts, rivers, and lakes) are associated with a range of aspects related to improved mental health. These include: enhanced general health and wellbeing (reviewed by Gascon et al., 2017; see also Wheeler et al., 2012; White et al., 2013a; Völker et al., 2018; Volker and Kistemann, 2011; Wood et al., 2016); increased physical activity levels (White et al., 2014); improved psychological restoration (White et al., 2010; White et al., 2013b); reduced psychological distress (Nutsford et al., 2016); and lower mortality rates (Crouse et al., 2018). A range of blue space exposures have been explored in these studies including area coverage, presence/absence, visibility and perceived and objective proximity.

There is also evidence that socioeconomic status may act as an effect-modifier, or moderator, of the nature-health relationship (see Hartig et al., 2014; Markevych et al., 2017; Mitchell et al., 2015). For example, several cross-sectional studies find that the association between natural environments and mental health is stronger within more deprived areas, or that health inequality gradients are lessened where green/blue space is more available (e.g. Wheeler et al., 2012; Maas et al., 2006; McEachan et al., 2016; Mitchell and Popham, 2008; Mitchell et al., 2015; van den Berg et al., 2016; Ward Thompson et al., 2012; however, see also Mitchell and Popham, 2007).

Again, however, most of this work has examined socioeconomic deprivation as a moderator of health regarding various measures of green space, with exposure to blue spaces receiving less empirical investigation (Markevych et al., 2017). Indeed, to the best of the authors' knowledge, only two studies have explicitly tested this relationship. First, Wheeler et al. (2012) found that the relationship between living closer to the coast in England and self-reported general health was strongest amongst communities within areas of higher socioeconomic deprivation. More recently, Crouse et al. (2018) examined the association between blue space and mortality in Canada, with results suggesting a similar pattern of effect-modification but lacking statistical power for some outcomes. A further study investigated the moderating

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effect of educational attainment, one aspect of socioeconomic status, on the relationship between both blue spaces and green spaces on various mental and physical health outcomes. They found a significant interaction between blue space and both health outcomes for those with the lowest educational attainment (de Vries et al., 2016).

Thus, although there have been encouraging findings, research examining the links between blue space and mental health remains limited (Gascon et al., 2017). Furthermore, despite growing health inequalities (Barr et al., 2015; Thomson et al., 2018), we currently have a poor understanding of how this relationship might vary between different levels of socioeconomic deprivation (Mitchell et al., 2015).

1.2. The current research

The aim of the present research was to investigate: (1) the association between mental health, as measured using two different indicators of common mental disorders (CMD), and the blue space exposure of coastal proximity, as used in Wheeler et al. (2012) for urban residents; and (2) variations in this association according to household income. The study therefore aimed to directly build on work by Wheeler et al. (2012) through focusing on self-reported mental health (as opposed to general health) as the dependent variable and at household level (instead of area level) deprivation in the form of household income, as the moderating variable. We used the Health Survey for England (HSE), a comprehensive, nationally representative survey which includes various measures of health, health behaviours and socio-demographics (Aresu et al, 2009, 2010, 2011; Boniface et al., 2012; Bridges et al., 2013). Based on the literature previously introduced, we hypothesised that: (a) CMD likelihood would decrease as coastal proximity increased; and (b) this association would be stronger amongst lower income households.

2. Methods

2.1. Sample

Secondary cross-sectional data were utilised from the HSE for English adults for the years 2008–2012 (pooled; aged 16+; adults N = 45,063). All inhabitants of selected households are eligible for interview and full sampling details can be found in (Aresu et al, 2009, 2010, 2011; Boniface et al., 2012; Bridges et al., 2013). Trained interviewers ask respondents a set of core questions related to their health, lifestyle, and background, with additional sections which vary each year.

The GHQ12 was not included in 2011 (n adults 2008–2010 and 2012 = 36,453), or the EQ5D in 2009 (n adults 2008 and 2010–2012 = 40,418), reducing the available samples for our analyses. Both the prevalence of mental health disorders and the relationships between natural environments and health have been found to vary by urbanity (see Alcock et al., 2015; Maas et al., 2006; Mitchell and Popham, 2007; Peen et al., 2010; Wheeler et al., 2012; Wood et al., 2016). Further, access to health services (Bauer et al., 2018; Chukwusa et al., 2019) and characteristics of natural environments are very different between urban and rural areas. We therefore focused only on urban residents, which are those individuals categorised by the trained interviewers as living in an '*Urban*' setting, as opposed to '*Rural or isolated dwellings*' or '*Town and Fringe*' (Bibby and Brindley, 2013). Available urban adults sample sizes were 28,662 (GHQ12) and 31,906 (EQ5D). For respective analyses, we excluded those with missing responses for GHQ12 and the anxious/depression dimension of the EQ5D, therefore the full samples were 26,099 and 28,885 for GHQ12 and anxious/depression respectively.

The richness of the dataset enabled the inclusion of a range of potential confounding factors which may also relate to mental health, including: income, age, sex and the presence of limiting longstanding illnesses. We also included the health risk factors smoking status and body mass index (BMI), as these have received limited attention in previous studies exploring environment-health relationships (Mitchell, 2013).

We categorised responses of "Item not applicable", "No answer/refused" and "Don't know" as missing and calculated the sample sizes. Missing data categories were excluded where there were < 20 respondents in a category (see Supplemental Table 2). This led to final analysis sample sizes of 25,963 (GHQ12) and 28,723 (EQ5D Anxiety/depression).

2.2. Coastal proximity

Following previous approaches (Wheeler et al., 2012; White et al., 2013a), coastal proximity was measured in terms of the Euclidean distance (km) from the population density weighted centroid of respondents' Lower-layer Super Output Area (LSOA, as at 2001 Census) to the nearest coastline. There are approximately 32,500 LSOAs in England, each with a mean area of 4 km^2 and containing an average population of around 1500 (Wheeler et al., 2012). Following Wheeler et al. (2012), we operationalised coastal proximity using five categories: (1) 0–1 km; (2) > 1–5 km; (3) > 5–20 km; (4) > 20–50 km; (5) > 50 km. As with previous studies (Wheeler et al., 2012; White et al., 2013a), we used > 50 km as the reference category to enable us to test if the likelihood of having a CMD decreases with proximity to the coast. This also allowed us to compare 'coastal' (i.e. < 50 km; as used in EU definitions e.g. defining coastal regions (Eurostat, 2018)) respondents with 'inland' (i.e. ≥ 50 km) respondents (White et al., 2013b).

2.3. Self-reported mental health

Mental health was measured through two outcomes. The first was the 12-item version of the General Health Questionnaire (GHQ12; Goldberg et al., 1997), available 2008–2010 and 2012, a self-reported measure widely used by health practitioners and researchers to indicate the likelihood or 'caseness' of an individual having a high risk of a CMD. Following established recommendations for the GHQ12, results were dichotomised with scores of four or above widely considered predictive of a high risk of common mental health disorders such as anxiety or depression (Fryers et al., 2004; Katikireddi et al., 2012; Mann et al., 2011; Semlyen et al., 2016). The two outcome categories for this measure were therefore: high likelihood of a CMD (GHQ12 score ≥ 4); and low likelihood of a CMD (GHQ12 score < 4).

The second outcome was the anxiety and depression dimension of the EQ-5D-3L (hereafter referred to as the EQ5D; EuroQol Research Foundation, 2018). The EQ5D is a standardised measure of health-related quality of life (EuroQol Research Foundation, 2018), incorporating five dimensions, which has been used by practitioners and researchers (EuroQol, 2018; Hulme et al., 2004; Park et al., 2011) and utilised in studies exploring environmental characteristics (de Oliveira et al., 2013; Kyttä et al., 2011). Although the intended use is as a composite scale, here we use a single dimension – anxiety and depression. This dimension has been associated with anxiety and/or depression measured using a diagnostic scale (Mini International Neuropsychiatric Interview (Supina et al., 2007)), found to align with the GHQ12 (Bohnke and Croudace, 2016) and used for the same purpose in other studies (Semlyen et al., 2016). It should be noted that it was not found to be responsive to changes in anxiety or depression for those clinically diagnosed (Crick et al., 2018) and therefore not necessarily a measure of clinical diagnoses of anxiety and depression. As with the GHQ12, it is a self-completed scale. There are three possible response options, with respondents reporting whether they are not anxious or depressed; moderately anxious or depressed; or extremely anxious or depressed at the time of completion. These responses were dichotomised into the categories 'Not anxious/depressed' and 'At least moderately anxious/depressed' (moderate or extreme anxiety/depression) to account for the skewness in data and low sample sizes within the extremely anxious depressed category (n = 648; 2 % of total).

2.4. Area level controls

In line with previous research (Wheeler et al., 2012; White et al., 2017; Mitchell and Popham, 2007), we controlled for area level deprivation (English Index of Multiple Deprivation, Noble et al., 2007), as well as green space and freshwater coverage at LSOA level to explore the unique effect of coastal proximity. The English Index of Multiple Deprivation (IMD) consists of area measures of crime, employment, education, and income and has been found to be related to mental health (Bellis et al., 2012) and moderate the coastal-health relationship (Wheeler et al., 2012). Percentage greenspace coverage was based on the generalised land use database (GLUD; Department for Communities and Local Government, 2007) for LSOAs and incorporated all area level green spaces, not including private gardens. Percentage freshwater coverage of the LSOA was derived from the CEH Land Cover Map 2007 (Morton et al., 2011).

2.5. Household level controls

We also included household and individual level covariates which may also relate to mental health. Equivalised household income, which takes into account the number of household members, was used to assess household level deprivation (reference category = highest income quintile). Household income has been found to be related to a range of mental health disorders (Domenech-Abella et al., 2018; Kahn et al., 2000; Sareen et al., 2011). The upper and lower bounds of each quintile vary by year and are given in Supplemental Table 1. Car access was also included at the household level (ref = access).

2.6. Individual level controls

Individual level controls were based on confounders of mental health identified by similar research with large survey datasets (Wheeler et al., 2012; White et al., 2013a; White et al., 2013b; Beyer et al., 2014; Crouse et al., 2017; Stranges et al., 2014). These included: sex (reference = female), age (reference = 16–34 years old), highest qualification level (reference = none/foreign/other), economic status (reference = in employment/student), relationship status (reference = single), year (reference = 2008), presence of limiting longstanding illnesses (reference = no limiting longstanding illness), cigarette smoking status (reference = never smoked cigarettes at all), and weight (body mass index; BMI; reference = normal weight).

2.7. Data linkage

Standard licence versions of HSE data only include large area geographical identifiers to preserve anonymity. In order to allocate higher resolution measures of coastal proximity, green space and freshwater, these three variables at LSOA level were supplied by the authors to the data providers (NatCen Social Research) and linked anonymously to HSE data under agreement from the NHS Health and Social Care Information Centre (now NHS Digital). To prevent identification of any individual LSOA of residence, the three environmental variables were constrained to relatively coarse categories; and LSOA and regional identifiers were removed from the linked data and returned to the authors.

2.8. Analyses

Data were analysed using the "survey" package (version 3.34; Lumley, 2018) in R Studio Version 3.4.2. Generalised linear models (GLM) using a quasi-binomial error structure (appropriate when analysing complex survey data (Lumley, 2018)) and household clusters, to account for multiple respondents within households and provide robust standard errors, were used to identify correlations between coastal proximity and mental health. We were not able to include clustering by LSOA as this had been removed by the data providers for anonymity. The data were weighted using the interview weights provided in the dataset to account for selection, non-response and population biases (Aresu et al, 2009, 2010, 2011; Boniface et al., 2012; Bridges et al., 2013). We calculated the odds ratios (OR) and 95% confidence intervals (CI) of participants having either a high likelihood of a CMD (GHQ12 ≥ 4) or of reporting a status of at least moderately anxious/depressed for this dimension of the EQ5D.

We present unadjusted models (nature exposures only) and fully-adjusted models to examine how coastal proximity was associated with mental health before and after adding the controls. A sensitivity analysis was also carried out with > 20 km as a reference category. We then stratified our analysis by household income, whereby we analysed the relationships between coastal proximity and mental health using fully-adjusted (unweighted) GLMs for each household income quintile. This enabled us to observe variations in the relationship between coastal proximity and mental health by household income. We had an *a priori* prediction that the effects would be strongest in the lowest income quintiles, however, we also carry out analyses interacting coastal proximity and household income.

3. Results

3.1. Full model/sample results

Table 1 presents descriptive statistics of the un-stratified mental health models. In the GHQ12 model sample, the proportion of people with a high risk of a common mental disorder (CMD) closely resembled previous national averages (McManus et al., 2016), with approximately 15 % of participants reporting a high likelihood of suffering from a CMD. In comparison, CMD prevalence was slightly higher in the EQ5D model, likely due to the different method of measurement, with approximately 22 % of respondents reporting at least moderate anxiety or depression. CMD prevalence was also greater amongst more deprived areas and lower earning households (Table 1). For the years 2008, 2010 and 2012 where both the GHQ12 and anxiety and depression were present, the correlation was 0.50 (kendall's τ, $p < 0.001$).

Table 2 displays the unadjusted and adjusted odds ratios (OR) with 95% confidence intervals (CI) of respondents having a high risk of CMD for the full model samples (un-stratified) of both outcomes. Respondents were less likely to report an at risk GHQ12 score of ≥4 if they lived up to 1 km of the coast compared to > 50 km (OR_{adj} = 0.78, 95 % CI = 0.65 – 0.95).

No significant ($p < 0.05$) associations were found between coastal proximity and CMD likelihood for either the GHQ12 outcome or anxiety/depression EQ5D dimension in the unadjusted models. Similarly, there were no significant associations between coastal proximity and the anxious/depression dimension of the EQ5D in the adjusted model.

Respondents living in areas of 80–100 % greenspace were less likely to report at risk scores of the GHQ12 and being at least moderately anxious or depressed in the unadjusted models (and 60–80 % with the EQ5D dimension). However, neither of these associations held in the adjusted models.

Freshwater coverage of > 5–100 % was found to be related to the anxious/depression dimension of the EQ5D in both the unadjusted and adjusted models (OR_{adj} = 0.78, 95 % CI = 0.63 – 0.96). However, it was not related to GHQ12 in either the unadjusted or adjusted model.

The results from our sensitivity analysis with > 20 km as a reference category were similar, giving us confidence in our results (Supplementary Table 3). As with a reference category of > 50 km, we find significant associations between living ≤1 km from the coast and the GHQ12 (≤1 km *vs.* > 20 km OR_{adj} = 0.79, 95 % CI = 0.66–0.94).

Table 1
Descriptive statistics for the un-stratified GHQ12 (N = 25,963) and EQ5D (N = 28,723) models.

Variables	GHQ12						EQ5D					
	Full model sample		Low risk of CMD[a] (score < 4)		High risk of CMD[a] (score ≥4)		Full model sample		Not anxious or depressed		At least moderately anxious or depressed	
	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted %age
Total Ns	25963		21984	84.88	3979	15.12	28723		22275	78.38	6448	21.62
LSOA[b] level variables												
Coastal proximity												
0–1 km	1532	5.75	1315	86.03	217	13.97	1826	6.17	1413	78.01	413	21.99
> 1–5 km	3202	11.68	2729	85.70	473	14.30	3394	11.27	2635	78.88	759	21.12
> 5–20 km	3781	13.46	3186	84.77	595	15.23	4400	13.93	3372	77.70	1028	22.30
> 20–50 km	7252	30.10	6171	85.07	1081	14.93	7921	29.71	6216	79.13	1705	20.87
> 50 km (ref)	10196	39.01	8583	84.36	1613	15.64	11182	38.92	8639	77.97	2543	22.03
Freshwater coverage												
> 5–100 %	712	2.74	602	84.83	110	15.17	776	2.67	627	81.89	149	18.11
> 1–5 %	1607	6.09	1386	86.81	221	13.19	1790	6.10	1393	78.19	397	21.81
> 0–1 %	1459	5.42	1244	85.38	215	14.62	1658	5.63	1278	77.81	380	22.19
0 % (ref)	22185	85.75	18752	84.72	3433	15.28	24499	85.59	18977	78.32	5522	21.68
Greenspace coverage												
80–100 %	1697	6.03	1478	87.33	219	12.67	1897	6.15	1516	80.20	381	19.80
60 - < 80 %	3239	11.84	2788	86.23	451	13.77	3539	11.76	2817	80.21	722	19.79
40 - < 60 %	4570	17.04	3842	84.41	728	15.59	5108	17.15	3912	77.26	1196	22.74
20 - < 40 %	7630	29.15	6398	84.11	1232	15.89	8545	29.45	6547	77.97	1998	22.03
0 - < 20 % (ref)	8827	35.93	7478	84.88	1349	15.12	9634	35.49	7483	78.34	2151	21.66
IMD[c]												
Most deprived	5549	21.65	4410	80.26	1139	19.74	6219	21.97	4495	73.83	1724	26.17
2nd most deprived	5540	21.90	4640	84.23	900	15.77	6133	21.82	4674	77.70	1459	22.30
Medium deprived	5051	19.79	4298	85.01	753	14.99	5566	19.67	4343	78.60	1223	21.40
2nd least deprived	4573	17.24	3986	87.30	587	12.70	5118	17.53	4086	80.53	1032	19.47
Least deprived (ref)	5250	19.43	4650	88.49	600	11.51	5687	19.00	4677	82.21	1010	17.79
Household level variables												
Household income quintile												
Lowest	3922	14.76	2969	76.12	953	23.88	4347	14.86	2890	68.07	1457	31.93
Second lowest	4172	15.14	3465	83.27	707	16.73	4662	15.37	3501	76.05	1161	23.95
Middle	4167	15.74	3576	86.22	591	13.78	4640	15.73	3677	80.06	963	19.94
Second highest	4434	17.48	3917	88.18	517	11.82	4853	17.27	3982	82.15	871	17.85
Missing data	4923	19.76	4159	84.38	764	15.62	5478	19.97	4191	77.40	1287	22.60
Highest (ref)	4345	17.12	3898	89.85	447	10.15	4743	16.80	4034	85.34	709	14.66
Car access												
No	5503	20.79	4277	78.04	1226	21.96	6165	20.91	4173	68.92	1992	31.08
Yes (ref)	20460	79.21	17707	86.68	2753	13.32	22558	79.09	18102	80.88	4456	19.12
Individual level variables												
Age categories												
75+	2615	8.13	2188	83.63	427	16.37	2875	8.01	2110	73.24	765	26.76
55 - 74	7344	23.65	6328	86.01	1016	13.99	8036	23.56	6132	76.47	1904	23.53
35 - 54	9049	35.18	7558	83.93	1491	16.07	10060	35.25	7702	77.15	2358	22.85
16–34 (ref)	6955	33.05	5910	85.40	1045	14.60	7752	33.18	6331	82.28	1421	17.72
Highest qualification												
Higher ed/Degree	8203	32.73	7130	86.83	1073	13.17	9294	33.27	7596	81.89	1698	18.11
NVQ3/A level	3944	16.98	3364	85.64	580	14.36	4429	17.19	3609	82.27	820	17.73
NVQ1/NVQ2/GCSE	6989	26.97	5888	84.66	1101	15.34	7650	26.81	5858	77.46	1792	22.54
Other/none (ref)	6827	23.33	5602	81.86	1225	18.14	7350	22.73	5212	71.38	2138	28.62
Working status												

(continued on next page)

Table 1 (*continued*)

Variables	GHQ12						EQ5D					
	Full model sample		Low risk of CMD[a] (score < 4)		High risk of CMD[a] (score ≥4)		Full model sample		Not anxious or depressed		At least moderately anxious or depressed	
	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted % age	Unweighted N	Weighted %age
ILO unemployed[d]	803	3.54	576	72.26	227	27.74	923	3.58	601	66.91	322	33.09
Retired/other inactive	9532	30.82	7634	79.43	1898	20.57	10430	30.64	7248	68.96	3182	31.04
In work/student (ref)	15628	65.64	13774	88.12	1854	11.88	17370	65.77	14426	83.40	2944	16.60
Sex												
Male	11497	48.75	9986	86.90	1511	13.10	12668	48.76	10275	81.54	2393	18.46
Female (ref)	14466	51.25	11998	82.96	2468	17.04	16055	51.24	12000	75.37	4055	24.63
Relationship status												
In a relationship	16207	61.27	14132	87.25	2075	12.75	17870	61.25	14427	81.06	3443	18.94
Widow/separated./ divorced	4484	14.60	3530	78.33	954	21.67	4980	14.58	3394	67.89	1586	32.11
Single (ref)	5272	24.13	4322	82.84	950	17.16	5873	24.17	4454	77.91	1419	22.09
Limiting illness presence												
Limiting illness		22.13	4341	67.77	2024	32.23	7046	22.09	3981	56.64	3065	43.36
Non-limiting longstanding illness		18.22	4498	89.38	514	10.62	5442	17.95	4355	79.86	1087	20.14
No longstanding illness (ref)		59.65	13145	89.86	1441	10.14	16235	59.95	13939	85.95	2296	14.05
BMI-[e]												
Obese	5869	21.71	4837	82.65	1032	17.35	6517	21.87	4824	75.10	1693	24.90
Overweight	8412	31.93	7316	86.95	1096	13.05	9237	31.65	7328	79.84	1909	20.16
Underweight	373	1.70	294	80.26	79	19.74	399	1.63	298	77.55	101	22.45
Missing data	3386	12.37	2736	81.61	650	18.39	3835	12.76	2846	75.17	989	24.83
Normal weight (ref)	7923	32.30	6801	85.84	1122	14.16	8735	32.10	6979	80.49	1756	19.51
Smoking status												
Current smoker	5587	22.19	4398	79.16	1189	20.84	6151	22.02	4279	70.53	1872	29.47
Used to smoke	8099	29.21	6915	85.46	1184	14.54	8952	29.20	6981	78.68	1971	21.32
Never smoked (ref)	12277	48.61	10671	87.15	1606	12.85	13620	48.79	11015	81.74	2605	18.26
Year												
2012	5591	21.53	4702	84.31	889	15.69	5696	19.92	4500	79.80	1196	20.20
2011	-	–	–	–	–	–	5891	20.35	4277	73.78	1614	26.22
2010	5857	22.80	4956	84.71	901	15.29	5865	20.76	4473	76.94	1392	23.06
2009	3308	12.99	2728	82.68	580	17.32	–	–	–	–	–	–
2008 (ref	11207	42.68	9598	85.94	1609	14.06	11271	38.96	9025	80.82	2246	19.18

[a] CMD = common mental disorder.
[b] LSOA = Lower-layer Super Output Area; [c] IMD = Indices of Multiple Deprivation; [d] ILO = International Labour Organisation; [e] BMI = Body Mass Index.

Table 2
Unadjusted and adjusted regression models predicting the likelihood of respondents having poor metal health as assessed using the GHQ12 and anxiety/depression component of the EQ5D. Significant results are highlighted in bold type.

	GHQ12 ($\geq$4)						EQ5D: at least moderately anxious/depressed					
	Unadjusted			Adjusted			Unadjusted			Adjusted		
term	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*
LSOA level variables[a]												
Coastal proximity												
0–1 km	0.87	0.73–1.04	0.121	**0.78**	**0.65–0.95**	**0.011**	0.99	0.85–1.14	0.836	0.90	0.78–1.05	0.195
> 1–5 km	0.90	0.80–1.02	0.091	0.90	0.79–1.02	0.108	0.95	0.85–1.05	0.330	0.93	0.83–1.04	0.188
> 5–20 km	0.97	0.86–1.09	0.592	0.99	0.87–1.12	0.845	1.02	0.93–1.12	0.709	1.01	0.92–1.11	0.818
> 20–50 km	0.94	0.86–1.04	0.229	0.97	0.88–1.07	0.507	0.93	0.86–1.01	0.083	0.97	0.89–1.05	0.451
> 50 km (ref)												
Freshwater coverage												
> 5–100 %	0.99	0.78–1.26	0.949	0.95	0.74–1.21	0.656	**0.79**	**0.65–0.97**	**0.022**	**0.78**	**0.63–0.96**	**0.020**
> 1–5 %	0.87	0.74–1.03	0.098	0.85	0.72–1.02	0.074	1.03	0.89–1.19	0.709	1.05	0.91–1.21	0.541
> 0–1 %	1.03	0.86–1.24	0.758	1.03	0.85–1.26	0.768	1.09	0.95–1.25	0.239	1.12	0.96–1.31	0.141
0 % (ref)												
Greenspace coverage												
80–100 %	**0.82**	**0.69–0.97**	**0.023**	0.90	0.75–1.08	0.267	**0.86**	**0.75–0.99**	**0.043**	0.87	0.75–1.02	0.082
60 - < 80 %	0.90	0.79–1.02	0.103	0.97	0.85–1.11	0.643	**0.88**	**0.79–0.98**	**0.019**	0.91	0.82–1.02	0.122
40 - < 60 %	1.04	0.93–1.16	0.504	1.02	0.91–1.15	0.720	1.06	0.97–1.16	0.218	1.02	0.92–1.12	0.763
20 - < 40 %	1.06	0.96–1.16	0.263	1.05	0.95–1.16	0.387	1.01	0.94–1.10	0.741	0.99	0.91–1.07	0.781
0 - < 20 % (ref)												
IMD[b]												
Most deprived				**1.21**	**1.05–1.38**	**0.008**				1.04	0.92–1.17	0.518
2nd most deprived				1.08	0.94–1.24	0.257				0.99	0.89–1.11	0.922
Medium deprived				**1.17**	**1.03–1.34**	**0.020**				1.07	0.96–1.20	0.230
2nd least deprived				1.05	0.91–1.21	0.509				1.00	0.90–1.13	0.939
Least deprived (ref)												
Household level variables												
Household income quintile												
Lowest				**1.40**	**1.19–1.64**	**< 0.001**				**1.37**	**1.19–1.56**	**< 0.001**
Second lowest				**1.24**	**1.06–1.44**	**0.007**				**1.19**	**1.05–1.36**	**0.007**
Middle				1.15	0.99–1.33	0.074				1.12	0.99–1.27	0.082
Second highest				1.13	0.97–1.31	0.119				**1.20**	**1.06–1.36**	**0.004**
Missing data				**1.21**	**1.04–1.40**	**0.012**				**1.22**	**1.08–1.39**	**0.002**
Highest (ref)												
Car access												
No				**1.15**	**1.03–1.27**	**0.010**				**1.24**	**1.14–1.36**	**< 0.001**
Yes (ref)												
Individual level variables												
Age categories												
75+				**0.41**	**0.34–0.50**	**< 0.001**				**0.55**	**0.46–0.65**	**< 0.001**
55 - 74				**0.54**	**0.47–0.63**	**< 0.001**				**0.78**	**0.69–0.88**	**< 0.001**
35 - 54				1.00	0.89–1.12	0.984				**1.23**	**1.12–1.35**	**< 0.001**
16–34 (ref)												
Highest qualification												
Higher ed/Degree				**1.19**	**1.05–1.34**	**0.005**				0.97	0.88–1.08	0.601
NVQ3/A level				1.12	0.98–1.29	0.105				**0.85**	**0.76–0.96**	**0.007**
NVQ1/NVQ2/GCSE				1.03	0.92–1.15	0.649				0.95	0.86–1.04	0.251
Other/none (ref)												
Working status												
ILO unemployed[c]				**1.97**	**1.62–2.39**	**< 0.001**				**1.72**	**1.46–2.03**	**< 0.001**
Retired/other inactive				**1.47**	**1.32–1.64**	**< 0.001**				**1.55**	**1.42–1.70**	**< 0.001**
In work/student (ref)												
Sex												
Male				**0.79**	**0.73–0.86**	**< 0.001**				**0.75**	**0.70–0.80**	**< 0.001**
Female (ref)												
Relationship status												
In a relationship				**0.80**	**0.71–0.89**	**< 0.001**				**0.78**	**0.71–0.86**	**< 0.001**
Widow/separated./divorced				1.12	0.98–1.28	0.098				1.07	0.95–1.20	0.282
Single (ref)												
Limiting illness presence												
Limiting illness				**4.28**	**3.90–4.69**	**< 0.001**				**4.15**	**3.84–3.50**	**< 0.001**
Non-limiting longstanding illness				**1.19**	**1.06–1.34**	**0.003**				**1.62**	**1.48–1.77**	**< 0.001**
No longstanding illness (ref)												
BMI[d]												
Obese				1.08	0.97–1.21	0.140				1.07	0.98–1.17	0.154
Overweight				0.95	0.86–1.06	0.373				1.03	0.94–1.12	0.511
Underweight				1.23	0.92–1.65	0.161				1.04	0.79–1.36	0.794
Missing data				1.12	0.99–1.26	0.071				1.03	0.92–1.15	0.608
Normal weight (ref)												
Smoking status												
Current smoker				**1.40**	**1.26–1.54**	**< 0.001**				**1.55**	**1.43–1.69**	**< 0.001**

(*continued on next page*)

Table 2 (*continued*)

	GHQ12 (≥4)						EQ5D: at least moderately anxious/depressed					
	Unadjusted			Adjusted			Unadjusted			Adjusted		
term	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*	OR	95 % CI	*p*
Used to smoke				**1.13**	**1.03–1.24**	**0.011**				**1.09**	**1.01–1.17**	**0.033**
Never smoked (ref)												
Year												
2012				**1.17**	**1.06–1.30**	**0.003**				**1.12**	**1.02–1.23**	**0.022**
2011										**1.62**	**1.48–1.77**	**< 0.001**
2010				1.11	1.00–1.23	0.053				**1.32**	**1.21–1.45**	**< 0.001**
2009				**1.30**	**1.15–1.47**	**< 0.001**						
2008 (ref)												
Intercept	−1.68			−2.52			−1.25			−2.16		
N	25963			25963			28723			28723		
Households	16592			16592			18419			18419		
AIC[e]	22056.47			19951.43			29987.95			26890.79		
Cox & Snell *pseudo-R^2* (%)	0.1			8.1			0.1			10.5		

[a] LSOA = Lower-layer Super Output Area; bIMD = Indices of Multiple Deprivation; cILO = International Labour Organisation; dBMI = Body Mass Index; eAIC = Akaike's Information Criterion.

3.2. Results stratified by household income

We find some significant interactions between coastal proximity and household income for both the GHQ12 measure and the anxiety/depression of the EQ5D (Supplemental Table 4).

Full results for each income quintile are presented in supplementary materials (Supplemental Tables 5–9), with a summary of the key coastal proximity findings in Fig. 1. As can be seen, living near the coast (≤5 km) is associated with lower ORs (than living > 50 km) of poor mental health as measured by both the GHQ12 (0–1 km OR_{adj} = 0.58, 95 % CI = 0.39 – 0.87; > 1–5 km OR_{adj} = 0.76, 95 % CI = 0.59 – 0.98) and the anxiety/depression sub-scale of the EQ5D (0–1 km

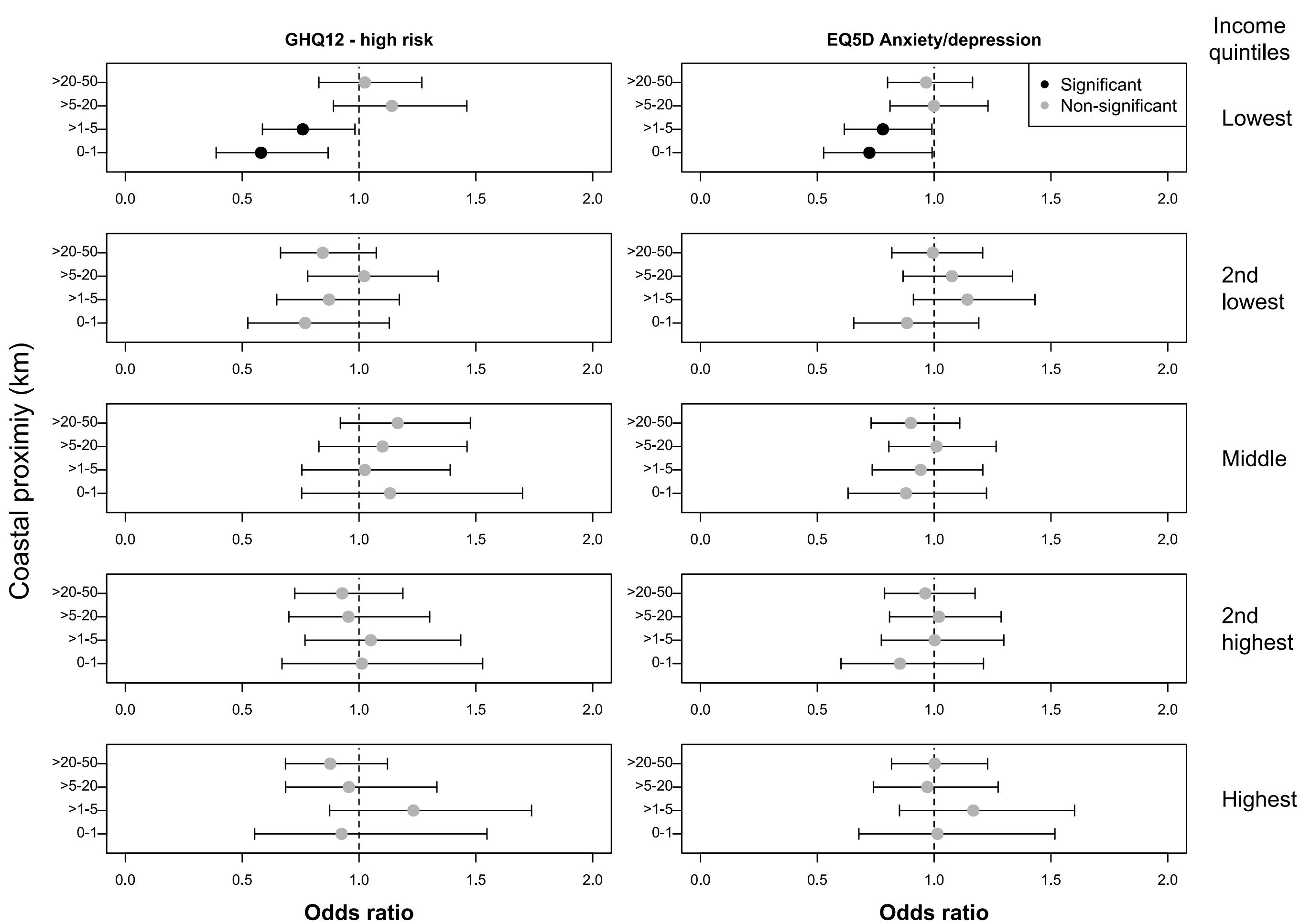

Fig. 1. The relationship between coastal proximity (reference category > 50 km) and mental health for each household income quintile. Note: results are fully adjusted; CMD likelihood presented as odds ratios with 95% confidence intervals. Full model results in Supplemental Tables 5–9.

OR_{adj} = 0.72, 95 % CI = 0.53 – 0.99; > 1–5 km OR_{adj} = 0.78, 95 % CI = 0.62 – 0.99) for individuals in the lowest household income quintile only. There were no other significant associations between coastal proximity and mental health for those in the higher household income quintiles.

4. Discussion

In sum, we have explored the association between two measures of mental health and coastal proximity for urban English adults using four years of pooled data from the Health Survey for England. After adjusting for a range of relevant covariates, those living 0–1 km from the coast had significantly lower odds of being at high risk of a CMD, as measured by the GHQ12 and compared to those living further than 50 km. Coastal proximity was not found to be related to the anxiety/depression EQ5D dimension.

As predicted, income quintile was a strong predictor of mental health outcomes, and other socioeconomic factors (e.g. employment, relationship and smoking status) were also largely consistent with earlier work (Katikireddi et al., 2016; Stranges et al., 2014). However, we find BMI not to be significantly related to mental health contrasting with research by Stranges et al. (2014) using the HSE. Conversely, we find that those who used to smoke were more likely to have poorer mental health whereas this was not found by Stranges et al. (2014). We also find not having access to a car was significantly related with worse mental health whilst this was not found in earlier HSE years (Riva et al., 2011).

Stratifying by household income revealed that the relationship between coastal proximity and mental health outcomes was present only for those with the lowest household incomes and extended to < 5 km. Specifically, the results imply that people living in urban areas in the lowest household income quintile are less likely to suffer from a common mental disorder (CMD) such as anxiety or depression if they live within 5 km of the coast, compared to those living in urban areas further inland (> 50 km). In particular, living within 1 km of the coast is associated with the strongest reductions in CMD likelihood for people from the most economically deprived households. Respondents from this category reported symptoms consistent with a CMD according to the GHQ12 measure with odds that were 40 % less than those living further than 50 km. This is a greater reduction in comparison to being in a relationship (*vs.* single OR_{adj} = 0.78, 95 % CI = 0.63–0.98).

These findings add to the growing evidence base linking blue spaces, particularly coastal environments, with better health and wellbeing (White et al., 2010; Wheeler et al., 2012; White et al., 2013a; Crouse et al., 2018; Gascon et al, 2015; Gascon et al., 2017; Nutsford et al., 2016; Volker and Kistemann, 2011). This study also highlights the potentially beneficial link between coastal proximity and common mental disorders, which have been highlighted as growing issues in countries such as England (McManus et al., 2016). Given that increasingly many people live by and visit the coast in many countries, and even more of them reside in cities, such research is vital for environmental and social policy (Elliott et al., 2018; Pelling and Blackburn, 2014).

This research also supports previous work which suggests that the positive relationship between living in more natural environments and mental health is stronger within more socioeconomically deprived groups (e.g. Wheeler et al., 2012; Maas et al., 2009; Maas et al., 2006; McEachan et al., 2016; Mitchell and Popham, 2008). It also extends prior research that investigated the interaction with area level deprivation (Wheeler et al., 2012), by demonstrating that household income moderates the association between coastal proximity and health, in this case specifically mental health. This suggests that access to the natural environment may, at least partly, offset the adverse health and wellbeing outcomes associated with low incomes. Indeed, recent work by Elliott et al. (2018) finds that recreational visits to the English coast, particularly walking, are more likely to be made by people from some lower socioeconomic backgrounds as compared to other natural environments. Subsequently, ensuring coastal environments are accessible to more socioeconomically deprived communities could therefore help to reduce health inequalities (Elliott et al., 2018).

Although not established in this study, it is plausible that there is a causal relationship between coastal living and mental health. Indeed, it could be that exposure to coastal environments improves mental health through a range of potential mechanisms in the same way as has been proposed for green space, such as through reduced stress, improved air quality and immune functioning, and increased opportunities for social contact and physical activity (Hartig et al., 2014; Markevych et al., 2017). In support of this, de Bell et al. (2017) sought to test whether the same mechanisms that have been proposed to explain the relationship between green space and health also applied in blue space visits. Most people identified psychological benefits or social interactions as the most important perceived benefit from their most recent blue space visit. Similarly, higher levels of blue space visibility were associated with lower levels of psychological distress in Wellington, New Zealand, whilst green space visibility was not found to be related (Nutsford et al., 2016) and, in Ireland, a sea view was found to be related to lower depression scores (Dempsey et al., 2018). Earlier work by (Bauman et al., 1999) also suggests that living by the coast is associated with increased opportunities for physical activity.

More recently, White et al. (2014) found that people in England who lived closer to the coast were more likely to visit the coast and, subsequently, achieve their recommended weekly physical activity levels. Combined with the finding that approximately 271 million recreational visits are made each year to coastal environments in England (Elliott et al., 2018), this suggests that the mental health of English coastal urban dwellers (who are more likely to visit the coast) is better than those in urban areas inland because of certain salutary mechanisms, such as physical activity.

There were several unexpected findings in our research. For instance, in contrast to previous research (e.g. de Bell et al., 2017; MacKerron and Mourato, 2013; Völker et al., 2018), we found that whilst living in closer proximity to coastal environments was significantly linked to improved mental health outcomes, living in areas with more freshwater coverage was not related overall according to the GHQ12 measure. However, freshwater coverage was related to the anxiety/depression EQ5D dimension. Freshwater coverage may be specifically related to anxiety and depression, while the GHQ12 measure is slightly broader (Jackson, 2007). Further, we found more people were at least moderately anxious or depressed under the EQ5D measure than were at high risk of a CMD as measured under the GHQ12, suggesting that this measure is perhaps a more sensitive measure of mental health.

Similarly, green space coverage was not consistently related to mental health after adjusting for confounders, as with Nutsford et al. (2016). This is despite growing evidence that living within greener environments is positively connected to general mental health and wellbeing (see Hartig et al., 2014), as well as more specific factors associated with mental health, such as reduced stress levels (Cox et al., 2017c; Van den Berg et al., 2010), reduced rates of antidepressant prescriptions (Taylor et al., 2015), and increased psychological restoration (White et al., 2013b).

As previously discussed, it may therefore be that coastal environments are particularly important for mental health in comparison to green spaces. Similar conclusions were drawn in Hong Kong, where blue space visits were linked to mental health whilst visits to green spaces were not related (Garrett et al., 2019). Our result may also be due to the coarse measures used here to assess green space coverage. While the GLUD data are based on a high resolution cartographic database, it does not capture any measures of quality or accessibility that may be important modifiers of any health benefits of proximity to green space (Wheeler et al., 2015; Markevych et al., 2017). However, a relationship with self-reported health has previously been detected using a similar measure elsewhere (Mitchell and Popham, 2007).

4.1. Limitations and future work

Beyond the potential limitations associated with self-reporting health (e.g. Lee and Dugan, 2015), the cross-sectional nature of our study means the results should be interpreted cautiously before making generalisations about a causal relationship between coastal proximity and common mental disorders (Gascon et al., 2017). Future work should therefore examine the potential factors mediating this link, such as physical activity. More longitudinal and experimental research (e.g. White et al., 2013a; White et al., 2015; Annerstedt et al., 2012) is also needed to elucidate a causal relationship and determine whether living by the coast for an extended period remains beneficial for mental health, as well as if these coastal benefits are consistently greater than living in areas with more green space and freshwater coverage. Further, our measure does not capture variations in accessibility and quality which can relate to visit frequency and mental health benefits (Garrett et al., 2019; Wyles et al, 2016, 2017).

We were also not able to account for clustering at the LSOA level which may have resulted in smaller standard errors as we cannot account for some potential non-independence within the data. However, we have included LSOA level controls including additional nature exposures and IMD.

4.2. Conclusion

To summarise, we found that the relationship between coastal proximity and mental health was strongest for those urban adults in more deprived households. This builds on previous research investigating coastal proximity and health inequalities at the community level. Our results therefore add further evidence that the coast might act as a mental health resource, particularly for people living in more socioeconomically deprived circumstances. Ensuring access to these environments may therefore have a role to play in reduction of health inequalities (Allen and Balfour, 2014). At a time of increasing urbanisation, mental health disorders and degradation of coastal and marine environments, such research should be developed and translated to inform relevant environmental, planning and public health policies.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2019.102200.

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