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Residence in coastal communities in adolescence and health in young adulthood: An 11-year follow-up of English UKHLS youth questionnaire respondents.

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A B S T R A C T

We used the UK Household Longitudinal Study to examine whether community type (inland or coastal) in adolescence (10–15 years) was associated with five adult health outcomes assessed over 11 waves of follow-up (2009–22). When the analyses were stratified on area deprivation, four of the five health outcomes – self-rated, long-standing illness, psychological distress and mental functioning - showed worse health in increasingly more deprived communities, and to a greater extent in the most deprived communities that are coastal. For all but self-rated health, associations were robust to additional adjustment for adolescent gender, ethnicity, household income, tenure, and life satisfaction.

1. Introduction

Across the globe, more than a third of the population lives less than 100 km from the coast (Reimann, 2023). A small but growing international literature has shown that people who lived closer to the coast reported better self-rated health and well-being than those living inland (Wheeler et al., 2012, 2015; Garrett et al., 2019; Hooyberg et al., 2020; Geiger et al., 2023; Ballesteros-Olza et al., 2020; White et al., 2013; Pasanen et al., 2019). A number of these studies are from population samples in the United Kingdom (Wheeler et al., 2012, 2015; Garrett et al., 2019; White et al., 2013; Pasanen et al., 2019). This is in direct contradiction to a report published in 2021 by the Chief Medical Officer (CMO) for England highlighting that coastal communities have some of the worst health outcomes in England, with low life expectancy and high rates of many major diseases (Whitty, 2021). The report showed a high prevalence of disease and health risk factors in coastal areas, including heart disease, diabetes, cancer, mental health, and Chronic Obstructive Pulmonary Disease. Some of the coastal health effect is likely due to coastal areas containing high proportions of older people (ONS, 2020). However, the CMO report pointed out that differences in the prevalence of most medical conditions tended to be to be highest where populations were relatively young (Whitty, 2021).

Recent United Kingdom (UK) policy initiatives are re-acknowledging that where you live is related to your health. This is emphasised in the 'levelling up' agenda that is a core plank of the current Conservative government's legislative agenda, as exemplified by the goal to reduce the gap in healthy life expectancy across local authorities by 2030 and increase healthy life expectancy across all local authorities overall by five years by 2035 (DLUHC, 2022). The international evidence-base to support the need for placed-based interventions suggests where people have ever lived is important for later life health, and the longer lived in a deprived neighbourhood (e.g., high poverty or disadvantage levels) has a cumulative effect (Jivraj et al., 2020).

Explanations for why English coastal towns have poorer health than inland communities are unclear. A 2007 Department for Communities and Local Government Select Committee report on coastal towns recognised that many coastal communities share common characteristics of inward migration of older people, transient populations, outward migration of young people, poor quality housing, physical isolation, a reliance on a seasonal economy, and high deprivation levels (CLGC, 2007). The latter is usually measured in England by the Index of Multiple Deprivation, which ranks every small area in England from 1 (most

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deprived area) to 32,844 (least deprived area) by combining information from the seven domains covering income deprivation, employment deprivation, education, skills and training deprivation, health deprivation and disability, crime, barriers to housing and Services, and living environment deprivation (Ministry of Housing, 2019). Coastal towns were once thriving centres of commerce, but many have experienced stark economic declines in recent decades. Hence, correlations between coastal communities and health could be explained by area deprivation. However, ecological correlations between whether a community is coastal or not and health are not fully explained by disproportionate levels of high deprivation areas and older people in coastal areas (Whitty, 2021).

A recent report from the Coastal Communities Alliance, and partners, very clearly shows that English coastal communities that have experienced industrial decline (e.g., seaside holidays, fishing, and shipbuilding) have worsened socio-economic problems (Emmins et al., 2023). For example, local authorities that contain active ports and seaside resorts have a higher prevalence of depression, a higher proportion of 15 years olds that smoke, higher rates of hospital admissions for alcohol attributable conditions and higher Index for Multiple deprivation scores compared with local authorities with inland or inactive port coastal communities. It is worth noting that not all coastal communities in England are deprived. According to the UK Office for National Statistics (ONS), only half of coastal towns in England and Wales are deprived. This is however high when compared to 30% of non-coastal towns considered deprived (ONS, 2020).

However, in the above analyses, as well as the innovative studies on coastal communities by the CMO and Coastal Communities alliance, correlations are ecological. There are known statistical problems in assuming that correlations at the group level exist at the individual level, i.e., ecological fallacy (Sedgwick, 2015). As far as we are aware, the current study is the first of its kind to test the hypothesis that living in a coastal community in adolescence is related to the development of poorer health in adulthood using individual data linked to place of residence. We assess coastal community status at an age before most health conditions have developed, in early adolescence, and follow up individuals over 11 years to see (1) whether young adult health is different for those individuals who were adolescents in coastal compared with inland communities, (2) whether the coastal community association with adult health differs by the level of area deprivation in the community, and (3) whether adult health differences can be explained by individual demographic, socio-economic and well-being measures during adolescence.

2. Methods

The UK Household Longitudinal Survey (HLS), also called Understanding Society, is a nationally representative longitudinal study that interviews all sampled household members annually. The first wave was conducted in 2009–2010, with the General Population Sample comprising 40,000 households from the entirety of the UK, chosen through a two-stage stratified (region, then postcode) sampling frame (UKHLS, 2024a). Young people aged 10–15 complete a youth questionnaire, whilst respondents aged 16 and over complete the adult survey. Each household recruited at the first round of data collection are then visited each year to collect information on changes to their household and individual circumstances. The latest wave for analysis was collected during June 2020–May 2022, resulting in a maximum eleven years of follow-up data for each individual.

For this analysis, we used a pooled wave design, where all English youths who self-completed a questionnaire in adolescence (aged 10–15 years) were followed over time for any responses to selected health outcomes in the adult (age 16+) self-completion questionnaires. Each respondent's baseline wave was the wave when they had completed a youth questionnaire at the age of 15 years. If the respondent did not complete a questionnaire at the age of 15 years, the questionnaire where the respondent was closest in age to 15 years was used. In keeping with the focus of this paper to investigate potential explanations of associations, covariates were only included at the point where they would be considered a confounder, not a mediator of relationships. Fig. 1 details the Causal Framework linking adolescent coastal status to adult health outcomes.

2.1. Measures

Coastal community status: Coastal community status was determined from the lower-super output area (LSOA) identifier for the youth respondent for their adolescent baseline wave. At each study wave, each youth respondent's usual residence was recorded. Staff at the Institute for Social and Economic Research (ISER) provided each respondent's lower-super output (LSOA) identifier for the 2011 Census for all waves (University of Essex, I.S.E.R., 2022). In 2011, there were 32,844 LSOAs in England, which comprised between 400 and 1200 households and a usually resident population between 1000 and 3000 persons (ONS and 2011 Census, 2012).

LSOA identifiers were then used to link individual youth records to coastal community status, as defined in the Appendix of the CMO of England's 2021 report and provided by the University of Plymouth's Centre for Coastal Communities. A detailed definition is available in the report (Whitty, 2021), but briefly "coastal" LSOAs were defined as those that included or overlapped built-up areas, which lay within 500 m of the "Mean High Water Mark" (excluding tidal rivers). All other LSOAs in England were classified as "inland".

For the sensitivity analysis, the longitudinal "coastal" and "inland" data on each respondent was used to create a 'moved' variable. A respondent had 'moved' if they had changed coastal community status since their adolescent baseline wave at any follow-up wave, either from coastal-to-inland or inland-to-coastal. The inland category was also split into 'London' and 'non-London' to create a three-category coastal community classification.

2.2. Health outcomes

Five health outcomes were chosen to gain a fuller perspective of health in young adulthood from different dimensions.

1. Overall health – Self-rated health (SRH) was the health indicator in the data set that best captured overall health, based on the question: *"In general, would you say your health …"*. The original five categories were collapsed into four consisting of: excellent (1), very good (2), good (3), and fair or poor (4)?"
2. Long-standing illness or disability (LSIID) – This was assessed by the question *"Do you have any long-standing physical or mental impairment, illness, or disability? By 'long-standing' I mean anything that has troubled you over a period of at least* 12 months *or that is likely to trouble you over a period of at least* 12 months*."*
3. Mental health - In the UKHLS, the only two mental health-related measures available in every wave are the 12-item General Health Questionnaire (GHQ-12) and the Mental Component Summary (MCS) score from the 12-item Short-Form Survey (SF-12) (Preetz et al., 2021). GHQ-12 is included as a measure of psychological distress (Goldberg et al., 1997). An example question is, "Have you recently been able to concentrate on whatever you're doing?" with four possible responses of 'better than usual', 'same as usual', 'less than usual' and 'much less than usual'. Score ranges from 0 (the least distressed) to 36 (the most distressed), and is the summary score from 12 items, each scored on a four-point Likert scale running from high to low for positively worded questions and the reverse for negatively worded ones. Lower scores thus indicate better mental health. The MCS score corresponds to mental health functioning, with a range from 0 (low functioning) to 100 (high functioning). In the SF-12, six mental health-related questions were asked about

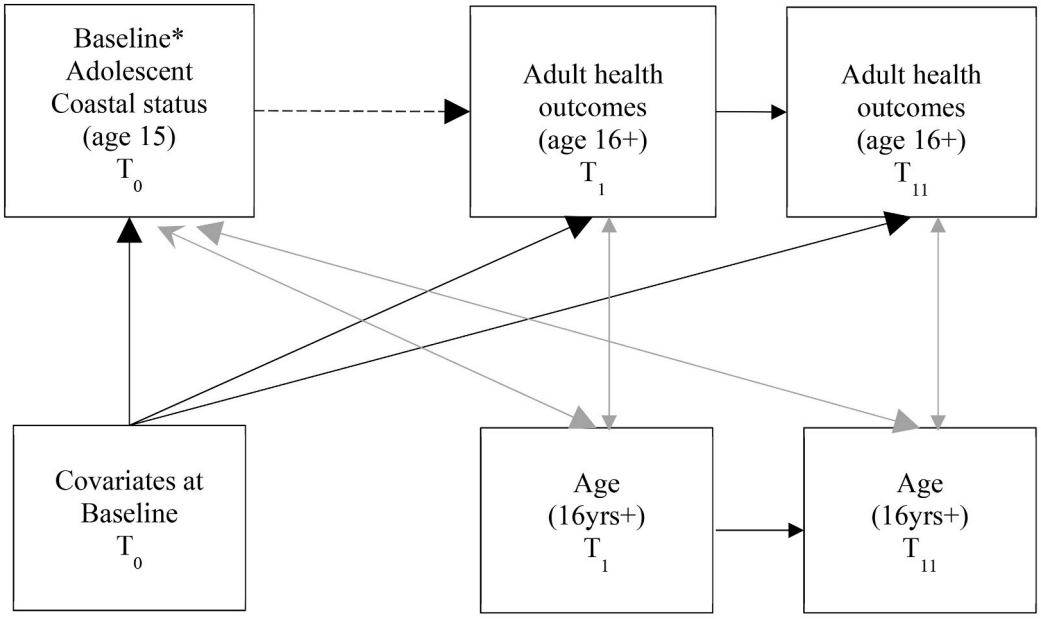

Fig. 1. Causal Framework linking adolescent coastal status to adult health outcomes.
* Baseline is the wave the respondent was age 15 years, or the next closest available age if the respondent did not complete a questionnaire at age 15 years. Dotted line = hypothesized association; grey line = bi-directional association.

mental well-being in the last four weeks. For example, "how much of the time have you accomplished less than you would like as a result of your physical health?", with five responses of 'all of the time', 'most of the 'time', 'some of the time', 'a little of the time' and 'none of the time'. Answers to these items were converted to a single score by the Ware et al. (2002) method, calibrated against population norms, by the UKHLS research team.

4. Physical health – The physical component summary (PCS) score from the SF-12 was used to assess physical health. The PCS score also ranges from 0 to 100, with a higher score indicating higher functioning (Ware et al., 2002).

Respondents were required to have completed questions that would allow derivation of all five health outcomes for at least one adult (age 16+) follow-up study wave. See Supplementary Table 2, rows 6 and 7, for the number of respondents at each wave who had completed any adult questionnaire and had data on all five health outcomes respectively.

2.3. Covariates

Based on prior research (Garrett et al., 2019; Geiger et al., 2023; White et al., 2013), we included a range of covariates that could be possible alternative explanations for why associations would be seen between coastal community residence and health (i.e., confounders): age at health measurement and seven covariates measured in adolescence (area deprivation, gender, ethnicity, gross household income, tenure, and life satisfaction). Only age was fitted in models at adult ages, as coastal residence can influence all other covariates, making them potential mediators of the relationships tested, which requires a different analytical methodology. The adolescent measurement corresponds to when coastal community residence was measured for each respondent, ranging from age 10–15 years. Area deprivation was measured by the 2011 Townsend Index, a z-score summary variable of four census variables (unemployment, non-car ownership, non-home ownership and overcrowding) at the LSOA level, that had been split into quintiles by the ONS (Statistics, 2020). Sex was classified by asking youth 'are you male or female?'. Gross monthly income is from all household members, with income components imputed for all proxy and within household non-respondents by Institute for Social and Economic Research. To compare incomes for households of different size and composition, interviewed at different waves, each gross household income value was adjusted for the Organization for Economic Cooperation and Development (OECD)-modified equivalence scale, by dividing each household's income value by the equivalisation value provided (Forter et al., 2012), and by the consumer price inflation base year set at the mid-point of the study's first wave (January 2010) (Beckett, 2024). Tenure was collapsed from the UKHLS 8-group classification to three categories of homeowner, social renter, or private renter/other. Adolescent life satisfaction was used as a proxy for adolescent well-being and collected using a 7-point scale where participants were asked to tick the smiley face that best described how they felt about their life as a whole.

2.4. Statistical analyses

All covariates measured at 'adolescence' (study wave, gender, ethnicity, gross household income, life satisfaction and Townsend Index), and age at baseline, were compared by coastal community status in adolescence using analysis of variance for continuous variables and the chi-square statistic for categorical variables.

To specify the survey design, the svyset command in STATA was used with household number indicated as the sampling unit, specifying sample weighting from the wave 12 longitudinal weights and the stratum identifier variable. The specific weight selected (l_indscus_lw) was created by staff at ISER to reflect the specific sample: 'l' as the last wave of the analysis, 'ind' for individual persons, 'sc' for self-completion, 'us' for the GPS sample and 'lw' for longitudinal weight (UKHLS, 2024b).

The STATA xtset was then used to specify data to be panel data with more than one wave of data per person.

The main analysis included fitting associations of the five health outcomes with adolescent coastal community status (reference = inland community) using regressions models with estimates at the individual and study wave. SRH was fitted as ordinal logistic [STATA command xi: xtologit] with four categories: (1) Excellent, (2) Very good, (3) Good or (4) Fair/Poor, LSIID as logistic [STATA xi: xtlogit] (reference = no (0)) and the remaining three outcomes as linear regression [STATA xi: streg] (GHQ-12, SF-12 MCS and SF-12 PCS). In each regression model statement, the vce cluster option in STATA, using LSOA codes as the cluster variable, was used to take account of the clustering of individuals within LSOAs.

Initially, models were only adjusted for age at time of health outcome. Next, to check whether relationships between coastal community and health varied by gender or Townsend index, interaction terms were separately added to the age-adjusted models. There was no evidence of interaction by gender for any health outcome. All covariates were added to models in the following order: gender, ethnicity, household income, tenure, and life satisfaction. The latter covariate added last to test for whether associations were due to health in adolescence, with life satisfaction the best proxy variable for health in the youth questionnaires.

For presentation purposes, the coefficients from final models were then used to estimate adjusted predictions (probabilities) for each health outcome, assuming all covariate values were at the mean. The difference between the adjusted predictions associated with living in a coastal community in adolescence and the adjusted predictions associated with not living in a coastal community in adolescence are known as marginal effects at the means.

To assess the influence of attrition on the results, associations were re-run without longitudinal weighting. In order to check that amplification of area deprivation associations with health in coastal communities were not due to relatively small numbers of youth residing in the most deprived quintiles, sensitivity analysis was conducted where the top two deprivation quintiles were merged. Additional analysis was also conducted where inland communities were split into London and non-London categories, to check that health differences were not just due to residence in London, where pre-pandemic health outcomes were better for people living in London than surrounding regions (Ceely, 2022). To check that findings were not attributable to residential mobility, final models were re-run on study members who had not moved from their community type classification since adolescence.

3. Results

Of the 14,746 youths who self-completed a questionnaire at least once, a total of 11,814 lived in England at the age of coastal community assessment. Of these, a total of 2922 were too young to complete an adult (age16+) questionnaire during the follow-up period, 3566 were age 16+ at follow-up but did not complete any adult questionnaires, 309 were missing health outcomes and 96 covariate data, resulting in a sample size of 4921 youth with 18,324 observations (mean = 3.7, range 1–11). Exclusions by number of observations, reason, and study wave are in Supplementary Table 1. Of English youths, a higher proportion of included than excluded adolescents had completed a questionnaire at an earlier wave, younger age, non-White ethnicity, lived in social or private rented homes, reported the highest life satisfaction scores, and lived inland, and lived in the three most deprived, communities (see Supplementary Table 2).

Sample characteristics for individuals in adolescence are in Table 1. A lower proportion of coastal, than inland, adolescents were ethnic minorities, homeowners or social renters or lived in the most deprived LSOAs. The distribution of health outcome observations, for the entire sample, inland communities and coastal communities are shown in Supplementary Table 3, summed across study waves.

Table 1
Distribution of health outcomes and covariates for analysis sample: all, Inland community, Coastal community, UKHLS youth sample, 2009–2021 (n = 4961).

	Total	Inland	Coastal	P values differences Inland vs Coastal
N, %	4921	4157 (84.4)	764 (15.5)	–
Study wave, %				
1	10.2	10.0	11.5	
2	11.6	11.2	13.9	
3	11.8	12.0	10.5	
4	11.0	11.0	11.3	
5	10.0	10.2	9.3	
6	9.9	9.8	10.5	
7	10.2	10.5	8.1	
8	9.5	9.6	8.9	
9	6.8	6.9	6.5	
10	6.0	6.1	5.6	
11	3.0	2.8	3.9	0.139
Age, mean (SD)	14.8 (0.6)	14.7 (0.6)	14.8 (0.6)	0.223
Gender, % female	52.0	52.2	51.1	0.641
Ethnicity, % minority	29.9	33.9	8.0	<0.001
Mean gross weekly household Income (SD)[a]	389 (250)	390 (256)	381 (2203)	0.350
Tenure, %				
Homeowner	67.8	67.6	69.0	
Social renter	22.1	22.9	17.5	
Private renter/Other	10.2	9.5	13.5	<0.001
Life Satisfaction, %				
1 (highest)	23.9	23.6	26.0	
2	37.4	38.3	32.5	
3	23.2	22.8	25.3	
4	9.8	9.8	9.8	
5	3.3	3.3	3.4	
6	1.8	1.7	2.1	
7 (lowest)	0.6	0.5	0.9	0.072
Townsend Index, %				
1 (least deprived)	31.5	31.9	29.5	
2	18.7	17.7	24.5	
3	15.5	14.5	20.8	
4	17.7	17.7	17.8	
5 (most deprived)	16.6	18.3	7.0	<0.001

[a] Each wave separately adjusted for consumer price inflation since January 2010 (mid-point UKHLS baseline) and household size according to the OECD equivalised method.

In age-adjusted models (see Table 2), only for two of the five health outcomes, self-rated health and long-standing impairment, illness, or disability (LSIID), were there associations between coastal community residence. For example, UKHLS respondents who lived in a coastal community during adolescence had 41% higher odds (95% Confidence Interval (CI) 1.03, 1.92) of self-reporting a LSIID, than if they had been an adolescent in an inland community. There was no association between coastal community residence in adolescence and GHQ-12 scores, SF-12 mental component summary (MCS) scores or SF-12 physical component summary (PCS) scores.

However, interaction terms between coastal community residence and the top two area deprivation quintiles were statistically significant for almost all health outcomes, except SF-12 PCS scores (see Supplementary Table 4); so, results are presented including these interaction terms for these four health outcomes (see Table 3). Overall, the findings suggest that those who had lived in coastal areas have worse health if the coastal area was deprived. For example, if a UKHLS youth respondent had lived in one of the most deprived coastal communities in adolescence, their age-adjusted odds of a LSIID in young adulthood was 8.8 times higher (95% CI: 2.7, 28.7), compared to the least deprived inland communities (Table 3, model 1, section B). The only demographic covariate that substantially reduced this amplification effect for any of the health outcomes was ethnicity, with associations only apparent for SRH, GHQ-12 and MCS in adjusted models (Table 3, model 5). Additional

Table 2
Age-adjusted associations of Coastal Community residence (vs Inland) in adolescence with five health outcomes in young adulthood, UKHLS youth sample, 2009–2021 (n = 4,921, observations = 18,324).

	Odds ratio lower self-rated health (95% CI) [a,b]	Odds ratio long-standing impairment, illness, or disability[b] (95% CI)	Mean difference GHQ-12 scores (95% CI) [b]	Mean difference MCS scores [c] (95% CI)	Mean difference PCS scores[c] (95% CI)
Coastal (ref = Inland)	**1.23 (1.01, 1.49)**	**1.41 (1.03, 1.92)**	0.31 (−0.08, 0.70)	−0.76 (−1.54, 0.02)	0.11 (−0.33, 0.55)
Age at health outcome	1.15 (1.13, 1.17)	1.17 (1.13, 1.21)	0.23 (0.19, 0.27)	−0.67 (−0.75, −0.60)	0.07 (0.02, 0.11)

Bolded text indicates significant at p-value<0.05.
[a] Model fitted as ordinal logistic regression with four categories: (1) Excellent, (2) Very good, (3) Good or (4) Fair/Poor.
[b] Higher score equals worse health.
[c] Lower score equals worse health.

adjustment for adolescent life satisfaction did reduce, but not entirely explain, these three associations (Table 3, model 6).

There was also evidence that living in the most deprived inland communities had lower odds of a LSIID, lower mean GHQ-12 scores (less distressed) and higher MCS scores (better functioning), than the least deprived inland areas, but this was explained by adjustment for ethnicity (Table 3, model 3).

Figs. 2–4 shows the predicted mean scores of SF-12 MCS (2) and GHQ-12 (3), and predicted probabilities of SRH (4), in adulthood by coastal community and Townsend index residence in adolescence, after adjustment for all covariates but life satisfaction. For the less deprived Townsend index quintiles (1–4), predicted health outcomes for coastal and inland community adolescents were broadly similar. However, in the most deprived quintile, inequalities in MCS and GHQ-12 widen. For example, predicted adult MCS scores hovered around 46 with, confidence intervals overlapping, for both adolescent community groupings. However, for the most deprived quintile (5), predicted mean scores for coastal adolescents show a lower mean score of 43.9 (95% CI: 41.5, 46.3), compared to inland adolescents 45.5 (43.9, 47.0). Predicted probabilities of LSIID and predicted mean scores of PCS are in supplementary materials (see Fig. 4).

Sensitivity analyses showed that results were unchanged when longitudinal weights were excluded (Supplementary Table S5). As well, results were similar when the top two deprived quintiles were collapsed into four categories (Supplementary Table S6). Results were also unchanged when restricting the sample to the 4803 youth (97.6%) who had not moved between a coastal or inland community since adolescence (Supplementary Table S7). When inland LSOAs were split into London and non-London (Supplementary Table S8), London adolescents had better health as young adults than coastal adolescents, when measured through SRH, long-standing illness, and GHQ-12 scores. Similar health patterns were seen for inland non-London, compared to coastal, community adolescents, but only for the most deprived quintiles.

4. Discussion

In this nationally sampled study of adolescents and young adults living in England from 2009 to 2020, adolescents living in a coastal community reported worse self-rated health and more long-standing impairment, illness, or disability than adolescents who had lived inland. When the analyses were stratified on area deprivation, the negative relationship between coastal residence and health was apparent for an additional two health outcomes – GHQ-12 and SF-12 mental component summary scores - but restricted to the most deprived communities. For all but self-rated health, associations were robust to additional adjustment for adolescent gender, ethnicity, household income, tenure, and life satisfaction.

The finding that coastal community residence was associated with worse SRH and LSIID is consistent with the 2021 CMO report (Whitty, 2021) but counter to the other UK and international studies showing closer proximity to the coast is associated with better SRH (Wheeler et al., 2012, 2015; Garrett et al., 2019; Hooyberg et al., 2020; Geiger et al., 2023; Ballesteros-Olza et al., 2020; White et al., 2013; Pasanen et al., 2019). The most likely explanation is that our study and the CMO report are based on the same geographic classification of coastal, based on LSOAs, while the other studies are based on distance of residence to the coast. It is entirely possible that living next to blue space promotes good health and well-being through psychological improvement (i.e. stress reduction and cognitive restoration) and promotion of physical activity (White et al., 2020), yet there are also be other qualities of deprived English coastal towns that are impacting on young people's health and well-being (e.g., lack of employment opportunities).

Why our study did not find similar associations to the CMO report with the other three mental and physical health outcomes and coastal residence is unclear. One possibility is that data for the CMO report are

Table 3
Adjusted associations of health in young adulthood across 11 waves of follow-up, by Coastal Community residence (vs Inland) in adolescence, UKHLS youth sample, 2009–2021 (n = 4,921, observations = 18,324): Townsend index as quintiles.

	Model 1: Age at health outcome only	Model 2: + Gender	Model 3: + Ethnicity	Model 4: +15 y Household Income[a]	Model 5: +15 y Tenure	Model 6: +15 y Life Satisfaction
(A) Odds ratio 1-unit lower self-rated health (95% CI)[b,c]						
Coastal, 15 y	1.03 (0.73, 1.45)	1.05 (0.74, 1.47)	1.04 (0.74, 1.46)	1.02 (0.73, 1.43)	1.03 (0.74, 1.45)	1.02 (0.75, 1.40)
Townsend Index, 15 y						
2	**1.28 (1.03, 1.59)**	**1.30 (1.05, 1.62)**	**1.33 (1.07, 1.65)**	**1.27 (1.03, 1.57)**	1.23 (0.99, 1.52)	1.16 (0.95, 1.43)
3	**1.91 (1.49, 2.45)**	**1.91 (1.49, 2.44)**	**2.07 (1.61, 2.65)**	**1.92 (1.50, 2.46)**	**1.72 (1.35, 2.20)**	**1.52 (1.21, 1.92)**
4	**1.53 (1.23, 1.92)**	**1.54 (1.23, 1.92)**	**1.81 (1.43, 2.29)**	**1.60 (1.26, 2.03)**	**1.39 (1.09, 1.77)**	**1.29 (1.03, 1.61)**
5 (most deprived)	1.18 (0.94, 1.49)	1.19 (0.95, 1.49)	**1.53 (1.17, 2.00)**	**1.30 (0.99, 1.71)**	1.02 (0.76, 1.36)	0.97 (0.75, 1.27)
Townsend*Coastal						
2	1.40 (0.84, 2.31)	1.36 (0.82, 2.26)	1.34 (0.81, 2.23)	1.34 (0.81, 2.24)	1.34 (0.80, 2.23)	1.29 (0.80, 2.08)
3	**0.56 (0.32, 0.99)**	**0.56 (0.32, 0.99)**	**0.53 (0.31, 0.93)**	**0.53 (0.30, 0.91)**	**0.55 (0.31, 0.95)**	0.66 (0.40, 1.10)
4	1.85 (0.99, 3.45)	1.79 (0.95, 3.37)	1.55 (0.83, 2.91)	1.55 (0.83, 2.90)	1.55 (0.84, 2.86)	1.36 (0.77, 2.41)
5 (most deprived)	**2.35 (1.15, 4.78)**	**2.34 (1.18, 4.66)**	1.88 (0.93, 3.82)	1.88 (0.93, 3.81)	1.96 (0.95, 4.07)	1.84 (0.95, 3.55)
(B) Odds ratio LSIID (95% CI)[c]						
Coastal, 15 y	0.73 (0.42, 1.28)	0.74 (0.42, 1.30)	0.72 (0.41, 1.26)	0.72 (0.41, 1.26)	0.73 (0.42, 1.28)	0.72 (0.41, 1.24)
Townsend Index, 15 y						
2	1.38 (0.98, 1.95)	1.39 (0.99, 1.97)	**1.47 (1.04, 2.08)**	**1.47 (1.04, 2.07)**	1.36 (0.96, 1.92)	1.30 (0.93, 1.84)
3	1.27 (0.88, 1.85)	1.27 (0.88, 1.84)	**1.67 (1.14, 2.44)**	**1.66 (1.13, 2.44)**	1.33 (0.91, 1.96)	1.18 (0.81, 1.74)
4	0.91 (0.61, 1.35)	0.91 (0.61, 1.35)	1.53 (0.99, 2.33)	1.51 (0.98, 2.33)	1.15 (0.74, 1.78)	1.06 (0.69, 1.64)
5 (most deprived)	**0.54 (0.37, 0.79)**	**0.54 (0.38, 0.79)**	1.26 (0.81, 1.95)	1.24 (0.79, 1.95)	0.78 (0.48, 1.27)	0.73 (0.45, 1.17)
Townsend*Coastal						
2	1.58 (0.68, 3.66)	1.54 (0.66, 3.58)	1.46 (0.63, 3.40)	1.46 (0.63, 3.40)	1.46 (0.63, 3.39)	1.45 (0.63, 3.31)
3	1.60 (0.64, 3.98)	1.62 (0.65, 4.03)	1.31 (0.53, 3.24)	1.30 (0.53, 3.23)	1.42 (0.57, 3.50)	1.64 (0.68, 3.97)
4	**2.69 (1.06, 6.83)**	**2.66 (1.04, 6.84)**	1.66 (0.66, 4.22)	1.66 (0.66, 4.22)	1.60 (0.64, 3.99)	1.42 (0.58, 3.50)
5 (most deprived)	**8.78 (2.69, 28.66)**	**8.75 (2.69, 28.44)**	**4.26 (1.27, 14.28)**	**4.26 (1.27, 14.27)**	**4.62 (1.34, 15.96)**	**4.11 (1.27, 13.29)**
(C) Mean difference GHQ-12 score (95% CI)[c]						
Coastal, 15 y	−0.39 (−1.02, 0.25)	−0.33 (−0.95, 0.28)	−0.35 (−0.27, 0.26)	−0.33 (−0.95, 0.28)	−0.33 (−0.94, 0.29)	−0.37 (−0.92, 0.18)
Townsend Index, 15 y						
2	0.04 (−0.40, 0.48)	0.10 (−0.31, 0.51)	0.14 (−0.27, 0.56)	0.19 (−0.23, 0.61)	0.15 (−0.27, 0.57)	0.04 (−0.36, 0.44)
3	0.32 (−0.18, 0.83)	0.31 (−0.17, 0.80)	**0.49 (0.00, 0.98)**	**0.57 (0.08, 1.07)**	0.46 (−0.05, 0.96)	0.17 (−0.28, 0.63)
4	−0.12 (−0.57, 0.33)	−0.12 (−0.56, 0.32)	0.24 (−0.25, 0.72)	0.38 (−0.12, 0.87)	0.27 (−0.26, 0.74)	0.04 (−0.42, 0.51)
5 (most deprived)	**−0.83 (-1.30, -0.36)**	**−0.82 (-1.28, -0.37)**	−0.27 (−0.81, 0.27)	−0.08 (−0.5964, 0.48)	−0.32 (−0.93, 0.28)	−0.45 (−1.01, 0.10)
Townsend*Coastal						
2	0.99 (−0.06, 2.03)	0.88 (−0.12, 1.88)	0.84 (−0.16, 1.84)	0.84 (−0.17, 1.85)	0.84 (−0.17, 1.85)	0.74 (−0.18, 1.66)
3	−0.34 (−1.42, 0.73)	−0.32 (−1.35, 0.72)	−0.45 (−1.49, 0.59)	−0.43 (−1.46, 0.60)	−0.40 (−1.44, 0.64)	0.02 (−0.88, 0.92)
4	**1.47 (0.31, 2.63)**	**1.35 (0.20, 2.51)**	1.04 (−0.12, 2.20)	1.04 (−0.12, 2.19)	1.01 (−0.14, 2.17)	0.74 (−0.34, 1.82)
5 (most deprived)	**2.09 (0.44, 3.74)**	**2.08 (0.57, 3.59)**	**1.61 (0.07, 3.15)**	**1.61 (0.07, 3.15)**	**1.64 (0.08, 3.19)**	**1.40 (0.06, 2.73)**
(D) Mean difference MCS score (95% CI)[d]						
Coastal, 15 y	0.66 (−0.64, 1.97)	0.55 (−0.72, 1.82)	0.58 (−1.60, 1.86)	0.55 (−0.72, 1.81)	0.54 (−0.73, 1.81)	0.67 (−0.48, 1.83)
Townsend Index, 15 y						
2	−0.55 (−1.44, 0.35)	−0.66 (−1.52, 0.19)	−0.74 (−1.60, 0.12)	−0.86 (−1.72, −0.00)	−0.79 (−1.66, 0.07)	−0.56 (−1.37, 0.25)
3	−0.93 (−1.93, 0.07)	−0.91 (−1.86, 0.05)	**−1.25 (-2.21, -0.29)**	**−1.43 (-2.40, −0.47)**	**−1.25 (-2.24, −0.26)**	−0.66 (−1.55, 0.24)
4	0.58 (−0.29, 1.45)	0.57 (−0.28, 1.43)	−0.11 (−1.04, 0.81)	−0.43 (−1.37, 0.50)	−0.20 (−1.15, 0.74)	0.21 (−0.66, 1.07)
5 (most deprived)	**1.88 (0.95, 2.81)**	**1.86 (0.96, 2.76)**	0.79 (−0.28, 1.87)	0.38 (−0.72, 1.48)	0.76 (−0.421, 1.94)	1.01 (−0.06, 2.08)
Townsend*Coastal						
2	−1.72 (−3.84, 0.41)	−1.51 (−3.57, 0.55)	−1.43 (−3.49, 0.63)	−1.42 (−3.49, 0.65)	−1.43 (−3.50, 0.64)	−1.24 (−3.12, 0.64)
3	0.67 (−1.61, 2.95)	0.62 (−1.61, 2.84)	0.87 (−1.35, 3.08)	0.83 (−1.38, 3.05)	0.78 (−1.44, 3.00)	−0.10 (−2.01, 1.82)
4	**−2.68 (-4.92, -0.44)**	**−2.44 (-4.70, -0.17)**	−1.83 (−4.09, 0.42)	−1.82 (−4.08, 0.43)	−1.79 (−4.03, 0.45)	−1.24 (−3.26, 0.79)
5 (most deprived)	**−5.14 (-8.06, -2.23)**	**−5.11 (-7.78, -2.43)**	**−4.20 (-6.90, -1.49)**	**−4.20 (-6.89, -1.50)**	**−4.24 (-6.95, -1.52)**	**−3.70 (-6.44, −0.96)**

Bolded text indicates significant at p-value<0.05.

[a] Each wave separately adjusted for consumer price inflation since January 2010 (mid-point UKHLS baseline) and household size according to the OECD equivalised method.

[b] Model fitted as ordinal logistic regression with four categories: (1) Excellent, (2) Very good, (3) Good or (4) Fair/Poor.

[c] Higher score equals worse health.

[d] Lower score equals worse health.

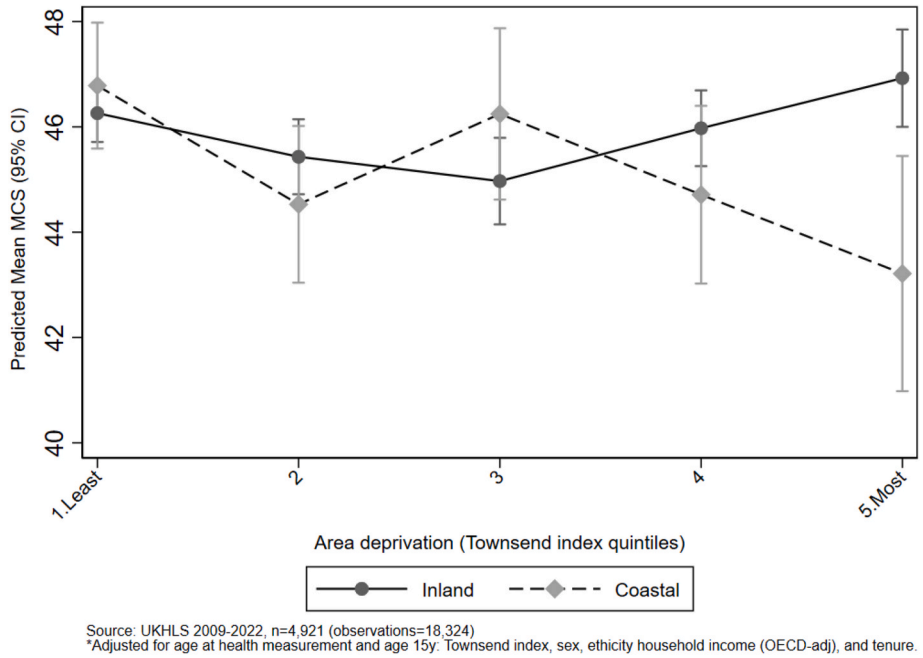

Fig. 2. Predicted mean SF-12 Mental Component Summary (MCS) scores (95% Confidence interval) in adulthood (16+) by Coastal Community type and Townsend Index in adolescence (aged 10–15 years).

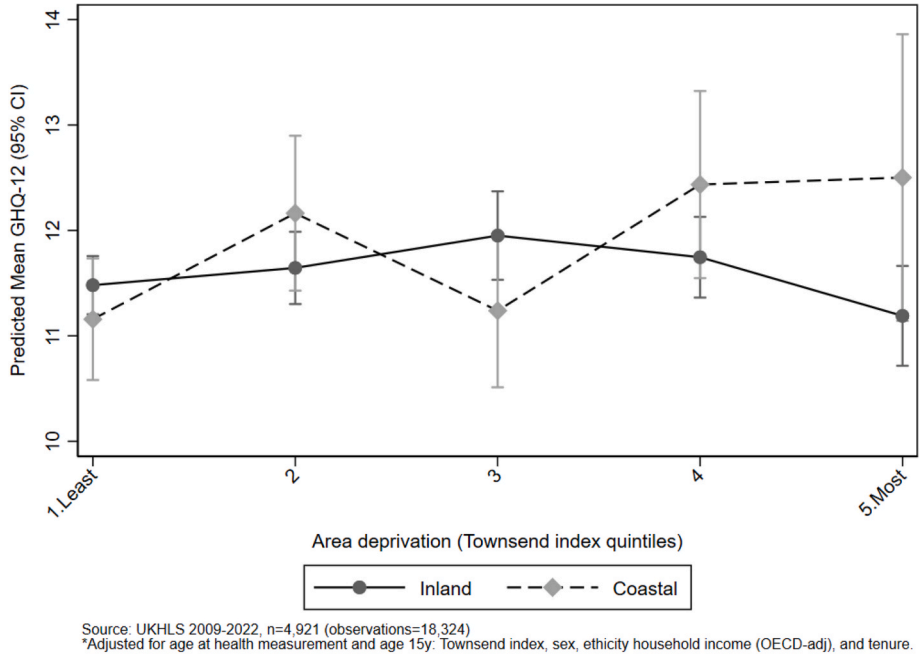

Fig. 3. Predicted mean GHQ-12 (95% Confidence interval) in adulthood (16+) by Coastal Community type and Townsend Index in adolescence (aged 10–15 years).

based on mortality and health service data for all ages (Whitty, 2021), while our data are self-reported and cover young adult ages only. Our sample is likely to be too young to see physical health differences, as chronic conditions are most prevalent at older ages (Boersma et al., 2020; Roberts et al., 2015), with health inequalities widening over the life course (Chen et al., 2023). Our study is an improvement on the CMO results in other ways, in that it is longitudinal and based on individual-level data (i.e., not prone to ecological fallacy).

The deleterious association between area deprivation and health is only apparent for young adults who were living in deprived coastal communities during their adolescence. This is relatively consistent with the CMO analysis, where prevalence rates for most chosen conditions tended to be higher in coastal communities than in equivalent non-coastal LSOAs. In contrast to the CMO report (Whitty, 2021), we did find an association between coastal residence and mental health. This could be because we used mental health measures that capture a broader spectrum of psychological distress and well-being, GHQ-12 and SF-12 mental component summary scores, rather than a clinical diagnosis of mental health disorders. Another possible explanation for the different findings may be that ethnicity confounded the relationship between coastal residence and mental health in the CMO report. In our data, ethnic minority youths reported better mental health and well-being than white youths, and they were much more likely to reside in deprived and inland LSOAs (data not shown). The former relationship

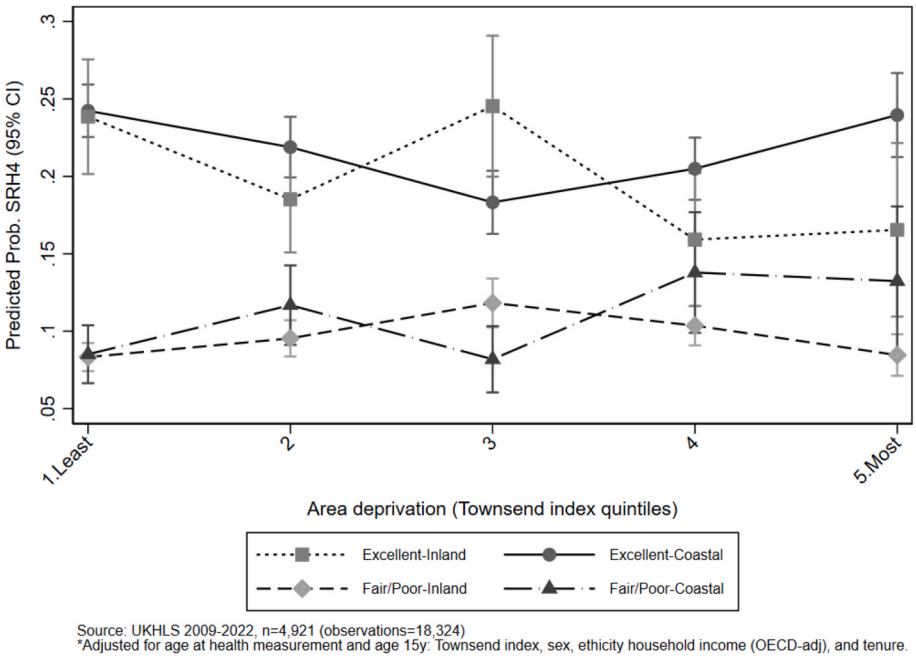

Fig. 4. Predicted probability (95% Confidence interval) of excellent and fair/poor self-rated health responses in adulthood (16+) by Coastal Community type and Townsend Index in adolescence (aged 10–15 years).

has been shown in another national youth sample, the Millennium Cohort Study (Ahmad et al., 2022), supporting our results of an excess mental health burden for youth residing in disadvantaged coastal communities.

It is unclear though why residence in the most deprived coastal communities would be associated with worse health for young adults than equivalent places inland. Given that other research has shown that proximity to 'blue space' is associated with better health and wellbeing (Wheeler et al., 2012, 2015; Garrett et al., 2019; Hooyberg et al., 2020; Pasanen et al., 2019; White et al., 2020), an excess of poor health in deprived coastal communities is something of a conundrum and a concern. One explanation is that within area deprivation categories, environmental factors that harm or hurt health are different in coastal compared to inland communities, or that young people living in deprived coastal communities are not able to protect themselves against the negative effect of place to the same extent as a young person in an inland deprived community: perhaps due to erosion of public services in the recent era. A recent New Zealand study has shown that young people residing in neighbourhoods with higher accessibility to health-constraining environments (fast-food outlets, takeaway outlets, dairy outlets and convenience stores, alcohol outlets, and gaming venues) had higher odds of any mental health condition (Hobbs et al., 2023). It could be the case that these sorts of detrimental environmental exposures are worse in deprived, coastal communities or that escaping them is more difficult because health promoting resources are less accessible due to the intrinsic isolation of coastal communities. Evidence was mixed for health promoting environments (e.g., green space) in the New Zealand study (Hobbs et al., 2023), and a systematic review (Fleckney et al., 2021) concluded that effects were likely due to bias and selection effects. Many coastal communities share common characteristics of high deprivation levels, a higher proportion of low wage and insecure jobs, transient populations, outward migration of young people, poor quality housing and geographic isolation (CLGC, 2007). Future studies should explore the mechanisms driving poorer health in coastal youth to design effective solutions to reduce this health inequality.

A major strength of our study was the ability draw upon a nationally representative, longitudinal sample of youth. Due to data availability, we were only able to examine English adolescents, so results may not be generalisable to Wales, Scotland, and Northern Ireland. However, coastal areas in other areas of the UK outside England that had economies reliant on tourism, fishing or ports and shipbuilding have experienced similar economic declines to similar English coastal communities (CLGC, 2007), so we would expect results to be similar.

Another major strength is the longitudinal nature of the data. We were able to assess coastal community status in early adolescence, with follow-up occurring over 11 years; well before most physical health conditions have developed (Boersma et al., 2020; Roberts et al., 2015). It is however known that a third of mental disorders begin before the age of 14 years (Solmi et al., 2022). In our sample, the average age of baseline assessment was 14.8 years, so there could be reverse causality if children who developed a mental disorder in late childhood were more likely to move to a coastal community. We tried to account for this in our analysis by adjusting for life satisfaction in adolescence, the only measurement of mental health or well-being that was available in the data set for all eleven baseline waves. However, there could be residual confounding due to the imperfect proxy. But given that only 2% of youth respondents moved between coastal and inland communities between adolescence and young adulthood, reverse causality seems unlikely. Coupled with consistent findings across four different health measures, collected on average 3.7 times for each person, there is a strong argument that residing in a coastal community in adolescence is leading to the development of poor health sooner in adulthood.

Regarding limitations, there was a fair amount of attrition during the follow-up period. Most occurred because the youths had not reached the age of 16 by the last survey wave in 2021–22. But there were also a sizable number of youths who were eligible but did not complete an adult questionnaire. It is possible that correlations between coastal residence and poor health are due to strong outward migration of younger adults away from coastal communities (Stephenson et al., 2022). We could not assess this as only 2.4% of the sample moved between coastal and inland communities between the adolescent and any adult survey. However, there is unlikely to be a large amount of selection bias, as coastal youth were only slightly more likely to be included in the sample than inland youth (44.1% and 41.2% respectively). Therefore, if coastal residence is causally related to development of poor health, our results are likely to be due to under-estimate the relationship between

coastal residence and health. As with all observational studies, there is the possibility of unmeasured confounding.

In conclusion, findings from this study suggest that strategies to level up the health of the English population needs to pay particular attention to the health of young people in deprived coastal communities. Given the increasing concern about rates of youth mental health (DfE, 2023), resources should be targeted toward identifying the key drivers of poor mental health in these areas. This could include building in mental health outcomes into evaluations of government-led programmes, such as 'Levelling Up' (DLUHC, 2023a) and the 'Long-Term Plan for Towns funds' (DLUHC, 2023b). The National Health Service also has mental health as one of the five clinical areas requiring accelerated improvement for the most deprived 20% of the population, through their Core20PLUS programme (Service, 2021), although it is unclear which coastal communities will be targeted with which interventions. Through the 'Well-being of Future Generations Act of 2015', the Welsh government requires each public body listed in the act to create objectives, and act, to improve the economic, social, environmental, and cultural well-being of Wales (Government, 2015). Our results support creation of an English equivalent with specific funding dedicated to Levelling Up the well-being of youth across the country.

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CRediT authorship contribution statement

Emily T. Murray: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Avril Keating:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Claire Cameron:** Funding acquisition, Writing – review & editing. **Rachel Benchekroun:** Investigation, Project administration, Writing – original draft, Writing – review & editing. **Sam Whewall:** Writing – review & editing. **Cara Booker:** Methodology, Writing – review & editing. **Stephen Jivraj:** Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2024.103239.

References

Ahmad, G., et al., 2022. Explaining ethnic variations in adolescent mental health: a secondary analysis of the Millennium Cohort Study. Soc. Psychiatr. Psychiatr. Epidemiol. 57 (4), 817–828.
Ballesteros-Olza, M., Gracia-de-Renteria, P., Perez-Zabaleta, A., 2020. Effects on general health associated with beach proximity in Barcelona (Spain). Health Promot. Int. 35 (6), 1406–1414.
Beckett, D., 2024. CPI INDEX 00: ALL ITEMS 2015=100. ONS.
Boersma, P., Black, L.I., Ward, B.W., 2020. Prevalence of Multiple chronic conditions among US adults, 2018. Prev. Chronic Dis. 17, E106.
Ceely, G., 2022. Health in England: 2015 to 2019. Office for National Statistics.
Chen, Y., Zhao, Y., 2023. Widening or convergence, the trajectories of health inequalities induced by childhood SES across the life course: evidence from China. SSM Popul Health 21, 101324.
CLGC, 2007. Coastal Towns: Second Report of Session 2006–07. The Stationery Office Limited, London. House of Commons.
DfE, 2023. State of the Nation 2022: Children and Young People's Wellbeing.
DLUHC, 2022. Levelling up the United Kingdom.
DLUHC, 2023a. New levelling up and community investments, 30/06/2023 [cited 2023 20/10/2023]; Available from: https://www.gov.uk/government/collections/new-levelling-up-and-community-investments.
DLUHC, 2023b. Long-Term Plan for Towns Funds.
Emmins, N.L.C., Munro, R., Pragnell, M., 2023. Communities on the edge: assessing the need for Levelling up in England's coastal authorities. Pragmatix Advisory 120.
Fleckney, P., Bentley, R., 2021. The urban public realm and adolescent mental health and wellbeing: a systematic review. Soc. Sci. Med. 284, 114242.
Forter, M., d'Ercole, M., 2012. The OECD approach to measuring income distribution and poverty. In: Besharov, D., Couch, K. (Eds.), Counting the Poor: New Thinking about European Poverty Measures and Lessons for the United States. Oxford University Press, Oxford.
Garrett, J.K., et al., 2019. Coastal proximity and mental health among urban adults in England: the moderating effect of household income. Health Place 59, 102200.
Geiger, S.J.W.M.P., Davison, S.M.C., Zhang, L., McMeel, O., Kellet, P., Fleming, L.E., 2023. Coastal proximity and visits are associated with better health but may not buffer health inequalities. Communicat. Earth Environ. 4.
Goldberg, D.P., et al., 1997. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. Psychol. Med. 27 (1), 191–197.
Government, W., 2015. Well-being of Future Generations (Wales) Act 2015: the Essentials. Welsh Government.
Hobbs, M., et al., 2023. The environment a young person grows up in is associated with their mental health: a nationwide geospatial study using the integrated data infrastructure, New Zealand. Soc. Sci. Med. 326, 115893.
Hooyberg, A., et al., 2020. General health and residential proximity to the coast in Belgium: results from a cross-sectional health survey. Environ. Res. 184, 109225.
Jivraj, S., et al., 2020. The impact of life course exposures to neighbourhood deprivation on health and well-being: a review of the long-term neighbourhood effects literature. Eur. J. Publ. Health 30 (5), 922–928.
Ministry of Housing, C.L.G., 2019. English indices of deprivation 2019 [cited 2024 5th March]; Available from: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019.
ONS, 2020. Coastal Towns in England and Wales: October 2020.
Whitty, C., 2021. Chief Medical Officer's Annual Report 2021: Health in Coastal Communities. Chief Medical Officer's Annual Report, p. 259.
ONS, *2011 Census: Population And Household: Estimates For Small Areas In England and Wales*, 2012. March 2011.
Pasanen, T.P., et al., 2019. Neighbourhood blue space, health and wellbeing: the mediating role of different types of physical activity. Environ. Int. 131, 105016.
Preetz, R., et al., 2021. Longitudinal changes in life satisfaction and mental health in emerging adulthood during the COVID-19 pandemic. Risk and protective factors. Emerg. Adulthood 9 (5), 602–617.
Reimann, L., Athanasios, T., Vafeidis, Honsel, Lars E., 2023. Population development as a driver of coastal risk: Current trends and future pathways. Coastal Futures 1 (e14), 1–12.
Roberts, K.C., et al., 2015. Prevalence and patterns of chronic disease multimorbidity and associated determinants in Canada. Health Promot Chronic Dis Prev Can 35 (6), 87–94.
Sedgwick, P., 2015. Understanding the ecological fallacy. BMJ 351, h4773.
Service, N.H., 2021. Core20PLUS5 an Approach to Reducing Health Inequalities: Supporting Information.
Solmi, M., et al., 2022. Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies. Mol. Psychiatr. 27 (1), 281–295.
Statistics, O.f.N. (Ed.), 2020. 2011 Census: Aggregate Data. UK Data Service.
Stephenson, C., Harrison, K., 2022. Movers and stayers: localising power to level up towns. Movers and Stayers: Localising Power to Level up Towns. Demos: London.
UKHLS, 2024a. Study design [cited 2024 8th March]; Available from: https://www.understandingsociety.ac.uk/documentation/mainstage/user-guides/main-survey-user-guide/study-design/.

UKHLS, 2024b. Selecting the correct weight for your analysis - understanding Society [cited 2024 15th March]; Available from: https://www.understandingsociety.ac.uk/documentation/mainstage/user-guides/main-survey-user-guide/selecting-the-correct-weight-for-your-analysis/.
University of Essex, I.S.E.R., 2022. Understanding Society: Waves 1-12, 2009-2021: Special Licence Access, Census 2011 Lower Layer Super Output Areas; United Kingdom Household Longitudinal Study; UKHLS. 2022, twelfth ed. UK Data Service.
Ware, J.E., et al., 2002. How To Score Version 2 of the SF-12 Health Survey. With a Supplement Documenting Version 1. Quality Metric Incorporated, Lincoln, RI.
Wheeler, B.W., et al., 2012. Does living by the coast improve health and wellbeing? Health Place 18 (5), 1198–1201.
Wheeler, B.W., et al., 2015. Beyond greenspace: an ecological study of population general health and indicators of natural environment type and quality. Int. J. Health Geogr. 14, 17.
White, M.P., et al., 2013. Coastal proximity, health and well-being: results from a longitudinal panel survey. Health Place 23, 97–103.
White, M.P., et al., 2020. Blue space, health and well-being: a narrative overview and synthesis of potential benefits. Environ. Res. 191, 110169.