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Associations between coastal proximity and children's mental health in Australia

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Abstract

Limited research has explored associations between blue spaces and mental health, specifically in children. This study assessed links between coastal proximity and depression and anxiety among children in Australia and tested whether duration of residency at current address moderated associations. It also explored associations between within-individual changes in coastal proximity and changes in depression and anxiety. Data were from 2400 children aged 11–12 years in Wave 5 (2012) and aged 14–15 years in Wave 6 (2014) of the national Longitudinal Study of Australian Children. Outcomes were children's self-reported symptoms of depression and anxiety. Exposure was coastal proximity (<2, 2–<5, 5–<10, 10–<20, 20–<50, and ≥50 km). Linear models were fitted to examine cross-sectional associations and fixed effects models for within-individual associations. After adjustment for potential confounders, findings suggested that those living close to the coast (<2 km) had lower levels of depression than those living the furthest from the coast (≥50 km) during childhood (Wave 5) but not adolescence (Wave 6). No associations were observed with anxiety. There was weak evidence to suggest residency duration moderated associations. No associations were observed for within-individual changes. Further research is needed to understand whether and what characteristics of coastal environments may benefit children's mental health.

KEYWORDS

anxiety, blue space, children, coastal proximity, depression, mental health

1 | INTRODUCTION

Mental illness among children and adolescents is a global public health challenge (World Health Organization, 2020, 2021b). In Australia, around 14% of those aged 4–17 years in the nationally representative Australian Child and Adolescent Survey of Mental Health and Wellbeing reported experiencing a mental disorder within a 12-month period in 2013–2014 (Lawrence et al., 2016). Although the prevalence of mental disorders varied by age and sex, anxiety disorders had a 6.9% prevalence and major depressive disorder had a prevalence of 2.8% (Lawrence et al., 2016). This finding is concerning as depression and anxiety are associated with reduced social functioning (e.g., capacity to develop and maintain social relationships) and suicide attempts (Brenes, 2007; Lawrence et al., 2021). Children and adolescents who suffer from depression or anxiety may be more inclined to also suffer from such mental illnesses and experience social disadvantage later in life (Beesdo-Baum & Knappe, 2012; Woodward & Fergusson, 2001).

Natural outdoor environments such as green and blue spaces with vegetation and water bodies are increasingly recognised as associated with physical and mental health benefits (Bowler et al., 2010; Geneshka et al., 2021; van den Berg et al., 2015; World Health Organization, 2021a). Proposed pathways for these associations include mitigation, such as reduced air pollution, noise, and heat; "instoration," such as improved physical activity and social cohesion; and restoration, such as reduced stress and attention fatigue (Markevych et al., 2017; White et al., 2020). Effective cognitive and physiological restoration has been highlighted as a likely important pathway (Nieuwenhuijsen et al., 2017; White et al., 2020), with natural environments argued to offer opportunities to engage effortless involuntary attention, restoring mental and attentional capacity (Attention Restoration Theory [Kaplan, 1995]) and reducing stress and negative emotions (Stress Reduction Theory [Ulrich, 1983; Ulrich et al., 1991]). In other words, exposure to nature is proposed to improve mental health because natural environments provide the chance to be away from attention-demanding tasks to spend time in or viewing natural elements that demand less cognitive resources, allowing for the recovery and restoration of attentional capacities and easing of mental and emotional stress (Kaplan, 1995; Ulrich, 1983; Ulrich et al., 1991).

Most studies exploring potential mental health benefits of natural environments have focused on associations with green spaces such as parks and woods, with comparatively fewer studies focusing on blue spaces such as oceans and lakes (Geneshka et al., 2021; Kabisch et al., 2017; Rautio et al., 2018; World Health Organization, 2021a). The current balance of evidence on blue spaces is suggestive of positive associations with better mental health (Beute et al., 2020; Britton et al., 2020; Gascon et al., 2017; White et al., 2020). Research is, however, limited and heterogeneous in study design, exposure, and outcome measures and has mostly been conducted in adult populations in Europe and the United States (Beute et al., 2020; Britton et al., 2020; Gascon et al., 2017; White et al., 2020). Systematic reviews on blue spaces and mental health have all highlighted the need for more studies in this emerging research area (Beute et al., 2020; Britton et al., 2020; Gascon et al., 2017; White et al., 2020). Particularly, calls have been made for more longitudinal studies and natural experiments (Britton et al., 2020; Gascon et al., 2017; Leatherdale, 2019).

Research exploring associations between blue spaces and mental health in younger populations has been conducted in different contexts using different measures of blue space exposures and different mental health outcomes (Amoly et al., 2014; Huynh et al., 2013; Maes et al., 2021; Mavoa et al., 2019). For example, in Canada, the presence of blue space (inland and coastal waters) within school neighbourhoods was associated with positive emotional well-being among adolescents in urban areas but not among those in rural areas (Huynh et al., 2013). In Barcelona, Spain, a higher number of days children went to the beach in a year was associated with fewer peer relationship problems and more prosocial behaviours but not associated with attention-deficit/hyperactivity disorder (ADHD) in children (Amoly et al., 2014). In contrast, no association was found between proximity to coast and presence of inland water in residential neighbourhoods with emotional health and depressive symptoms among urban New Zealand adolescents (Mavoa et al., 2019). To our knowledge, only one longitudinal study has been conducted on links between blue space and mental health in a younger population (Maes et al., 2021). The study, conducted in metropolitan London, the United Kingdom (UK), found no evidence of associations between levels of average daily blue space exposure in residential and school neighbourhoods with cognitive development, emotional, and behavioural problems and overall well-being among adolescents (Maes et al., 2021). Although the evidence base is growing, research on associations between blue spaces and mental health among younger populations is still scarce and so far mainly cross-sectional (Amoly et al., 2014; Huynh et al., 2013; Mavoa et al., 2019), rendering it difficult to draw any conclusions and warranting more studies among these populations.

Limited longitudinal research is likely partly due to the lack of temporal environmental data that are georeferenced to individuals' residential addresses. Longitudinal research would enhance knowledge about temporal associations between blue space and children's and adolescents' health.

This study investigates associations between blue spaces, specifically coastal proximity, with symptoms of depression and anxiety among youth in Australia. It

Key insights
This study linked geocoded data to children's addresses in the Longitudinal Study of Australian Children and explored associations between blue spaces and children's mental health. The study suggested links between coastal proximity and lower levels of depression symptoms during childhood (11–12 years old) but not adolescence (14–15 years old).

also examines whether those potential associations are moderated by the length of time spent at the residential address and whether a change in coastal proximity is linked to a change in symptoms of depression and anxiety.

2 | METHODS

2.1 | Data

Data were sourced from the K cohort (child cohort) of the Longitudinal Study of Australian Children (LSAC), which is the country's only nationally representative infant cohort study (Australian Institute of Family Studies, 2021a). LSAC was initiated in 2003 and is jointly conducted by the Australian Government Department of Social Services, the Australian Institute of Family Studies (AIFS), and the Australian Bureau of Statistics. LSAC tracks two cohorts: one birth cohort (B cohort) of children aged 3–15 months at the start of the study and a child cohort (the cohort used in our analysis) of children aged 4–5 years at the start of the study. LSAC collects data on a wide range of topics, including children's physical, emotional, mental, and social well-being and their family and environmental circumstances (Australian Institute of Family Studies, 2021a). LSAC adopted a two-stage clustered design whereby children were recruited from the Medicare enrolment database, Australia's public health care service. The children's postcodes were then stratified by state and urban/rural status (Australian Institute of Family Studies, 2021b).

The K cohort consists of 4983 children born between March 1999 and February 2000. The cohort members were recruited in 2004 (aged 4–5 years) and have been surveyed every 2 years including direct observations and assessments by interviewers (e.g., in relation to weight and height). At the time of analysis, six waves of data were available: Wave 1 (2004), Wave 2 (2006), Wave 3 (2008), Wave 4 (2010), Wave 5 (2012), and Wave 6 (2014). For each participating child, several adults were asked to respond to questionnaires about the child (e.g., parents, care providers, and teachers) (Australian Institute of Family Studies, 2021b).

This study examined data from Waves 5 and 6 of the LSAC K cohort when the cohort members were 11–12 years old and 14–15 years old, respectively. These time points were chosen because depression and anxiety indicators were not collected in earlier waves; 3460 participants had data for both Waves 5 and 6. Analysis was restricted to children who had complete data on all measures used in the analyses, as described below, at both Waves 5 and 6 (Figure 1). This restriction resulted in a sample size of 2396 children (69.3% of children with data at both waves).

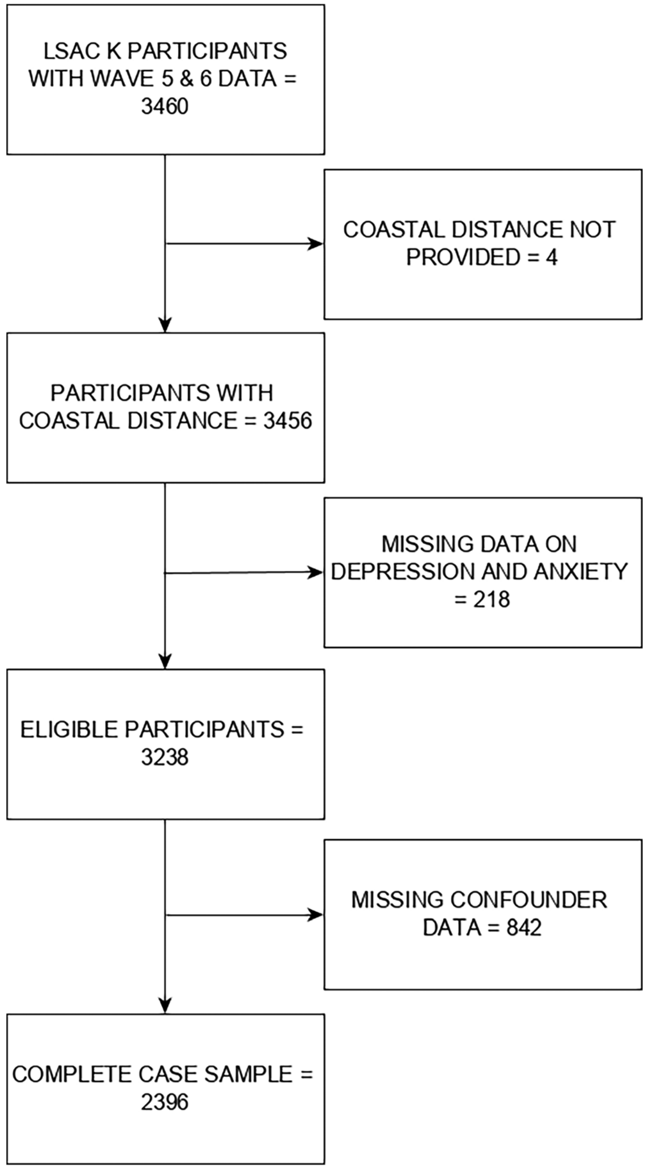

FIGURE 1 Flowchart of participants in the Longitudinal Study of Australian Children (LSAC) K cohort

Ethics approval for the LSAC study was received from the AIFS Ethics Committee, and exemption from further ethics approval was granted by Deakin University to conduct analysis on this dataset.

2.2 | Measures of study variables

2.2.1 | Outcome measures—Depression and anxiety

LSAC measured symptoms of depression using the Short Mood and Feelings Questionnaire (SMFQ). This is a self-report depression checklist of core symptoms for children and adolescents aged 8–16 years. The questionnaire is a 13-item single-factor scale derived from a 34-item depression questionnaire, where total scores range from 0 to 13 with scores higher than 8 indicating symptoms of depression. The SMFQ has been used in previous studies as a measure of depression in children and adolescents and has been reported to correlate with other measures of depression (Sund et al., 2001; Thapar & McGuffin, 1998).

Symptoms of anxiety were measured using a short form of the Spence Children's Anxiety Scale, which consists of eight items derived from a 44-item anxiety questionnaire (Spence, 1997). The children were asked how often they experienced each symptom of anxiety using a 4-point scale ("Never," "Sometimes," "Often," or "Always"), with total scores ranging from 0 to 24 and higher scores indicating higher levels of anxiety (Orgilés et al., 2014).

2.2.2 | Coastal proximity exposure

A variable indicating coastal proximity for each participating child was created by the AIFS based on the child's place of residence. For each LSAC wave, the study child's home address was geocoded in ArcGIS. Coastal data were sourced from the Geoscience Australia Geodata Coast 100K 2004 dataset. The coastal line file was split into points of 100 m, and the Euclidian distance between each participating child's residential address and the nearest coastal point was calculated. In order to prevent disclosure of specific localities, distances under 1 km were rounded to the nearest 100 m, distances under 10 km to the nearest 1 km, and then distances over 10 km to the nearest 10 km; distances over 300 km were top coded to 300 km. The measure was then categorised into distance bands for analyses. The distance bands selected are based upon those used in previous research that explored whether coastal proximity was related to general health for people living in England (<1, >1–5, >5–20, <20–50, and >50 km) (Wheeler et al., 2012). Cut-off points were slightly adjusted to suit the current data distribution, particularly to allow sufficient numbers in groups living closer to the coast. The final distance bands used were <2, 2–<5, 5–<10, 10–<20, 20–<50, and ≥50 km.

2.2.3 | Covariates

Sex of the child (male/female), socio-economic status, parents' health, both parents at home (no/yes), number of siblings (no siblings/1 sibling/2 or more siblings), remoteness (remote or very remote/outer regional/inner regional/major cities) (Australian Bureau of Statistics, 2021), and duration at current residence were all assumed to influence child mental health and included as potential confounders in the models. Socio-economic status was measured using weekly household income (continuous AUD), highest parental education (none, school, other/trade or apprenticeship/diploma or certificate/university qualification; if single parent household, only the education of that parent was used), and socio-economic status of area (Statistical Area Level 2 [SA2]) (Socio-Economic Indexes for Areas [SEIFA]: 10 deciles of The Index of Relative Socio-Economic Disadvantage [IRSD] [Australian Bureau of Statistics, 2018]). Parents' health was defined as at least one parent has poor or fair general health (no/yes). In a single-parent household, only the health of that parent was used.

2.3 | Statistical analysis

Descriptive characteristics of the sample were considered, comparing the characteristics of those in the complete case sample with those omitted because of missing data in the outcome and confounder variables (Table S1). Only participants with complete data on the outcome, exposure, and confounder variables were considered in the analysis.

Separate linear regression models were fitted to examine associations between coastal proximity and each of the outcome variables, depression and anxiety, at Waves 5 and 6, with robust standard errors used to account for the clustering of participants within postal code areas. Model coefficients represent the difference in mean Spence anxiety or SMFQ score between each coastal distance category and the baseline category (≥50 km). To determine if the association differed dependent on the length of time at residence, an interaction between this variable and coastal proximity was included in the models, assuming a linear relationship between the length of time at residence and each outcome. Fixed effects regression models were fitted to examine whether a change in coastal proximity between Waves 5 and 6 was associated with a change in depression or anxiety. Fixed effects regression allows the estimation of subject-specific associations in longitudinal studies, examining within-individual change accounting for any time-invariant confounding (measured and unmeasured) since each participant acts as their own control. The coefficients in the fixed effects regression models can be interpreted as the difference in expected Spence anxiety or SMFQ score for a participant for each coastal distance band compared with living furthest from the coast (≥50 km). A sensitivity analysis was conducted only among those residing in major city areas (Wave 5, $n = 1526$; Wave 6, $n = 1536$) as previous research found relationships between the natural environment and health to be stronger for those living in urban areas (Huynh et al., 2013). To assess the sensitivity of findings to assumptions about the missing data mechanisms, multiple imputation using chained equations with 35 imputations was conducted separately for each wave. Imputation models included all variables in the adjusted analytical models. Adjusted cross-sectional analyses for the coastal proximity and mental health outcomes were compared for the imputed data and complete case analysis.

3 | RESULTS

Descriptive statistics are reported in Table 1. Of the 2396 participants included in the complete case analysis, 12.1% lived within a 2-km distance to the coast at Wave 5, whereas 12.6% lived within this distance at Wave 6. Over half of the participants lived within 20 km of the coast (approximately 55% of participants at each wave). The average Spence anxiety and SMFQ scores at Wave 5 were 5.7 (SD = 4.0) and 3.9 (SD = 5.2), respectively; higher average scores were observed at Wave 6 with 5.9 (SD = 4.6) and 5.3 (SD = 6.6), suggesting a slight worsening in average mental health between waves. There were some differences in the descriptive characteristics of the complete case and omitted samples, with lower median income and duration of residence, and higher percentages in the most disadvantaged deciles among omitted participants (Table S1).

3.1 | Coastal proximity and mental health

Results from the unadjusted and adjusted regression models examining associations between coastal proximity and Spence anxiety score are shown in Figure 2. All confidence intervals included the null value. The estimated effects and confidence intervals suggested that those living nearer the coast had lower mean anxiety scores compared with those who lived the furthest in Wave 5. However, this pattern was not observed in Wave 6.

Figure 3 shows that after adjustment for confounders the average SMFQ score was lower by 0.7 points (95% CI −1.36, −0.01) for those who lived closest to the coast (<2 km) compared with those who lived the furthest in Wave 5. However, the difference was less pronounced at Wave 6 (coefficient: −0.32, 95% CI −1.41, 0.76).

There was only weak evidence to suggest that associations differed dependent on the duration of residence for the Spence Anxiety Scale (Wave 5 adjusted $p = 0.71$, Wave 6 adjusted $p = 0.38$). There was some indication of an interaction effect for SMFQ (Wave 5 adjusted $p = 0.09$, Wave 6 adjusted $p = 0.05$), although patterns differed for each wave. Duration at residence appeared to have minimal impact for those who lived closest to the coast at Wave 5. Furthermore, although generally SMFQ scores appeared lower for those who had lived at their residence longest irrespective of the distance from the residence to the coast, the opposite pattern was observed for those who lived between 2 and 5 km at Wave 6. Interaction plots are shown in the Supporting Information (Figures S1 and S2).

3.2 | Change in coastal proximity and change in mental health

Findings from the fixed effects regression examining change in coastal proximity and change in mental health are shown in Table 2. There was no evidence to suggest that a change in coastal proximity was associated with a change in either the Spence Anxiety Scale or SMFQ.

3.3 | Sensitivity analyses

Findings for children living in major cities were comparable with those for the full sample (Table 3). Results were similar for the multiple imputation and complete case analysis, although for both mental health outcomes, the estimated difference in mean score between those living closest to the coast and those living furthest was greater in the multiple imputation analysis (Figures S3 and S4).

4 | DISCUSSION

This study examined associations between coastal proximity and symptoms of depression and anxiety among children in Australia. It also explored whether these potential associations were moderated by the duration of residency at current home address. The study further investigated whether within-individual change in coastal proximity was linked to change in symptoms of depression and anxiety. Results from Wave 5 suggested that those living close to the coast (<2 km) may have lower levels of depression symptoms than those living far away from the coast (≥50 km). However, this relationship was weaker at Wave 6. No associations were observed between coastal proximity and anxiety symptoms, although at Wave 5, patterns suggested that those who lived nearer to the coast had lower levels of anxiety symptoms compared with those who lived the furthest away. There was weak evidence to suggest the duration of residency at current address moderated associations between coastal proximity and symptoms of depression and anxiety. No associations were observed between changes in coastal proximity and symptoms of depression and anxiety.

TABLE 1 Descriptive characteristics of eligible participants from the Longitudinal Study of Australian Children (LSAC) K cohort ($N = 2396$)

Variable	Wave 5	Wave 6
Outcome variables		
Spence Anxiety Scale, mean (SD)	5.7 (4.0)	5.9 (4.6)
Short Mood and Feelings Questionnaire, mean (SD)	3.9 (5.2)	5.3 (6.6)
Exposure variable		
Proximity to the coast (km), *n* (%)		
<2	291 (12.1%)	302 (12.6%)
≥2 to <5	315 (13.1%)	314 (13.1%)
≥5 to <10	374 (15.6%)	373 (15.6%)
≥10 to <20	346 (14.4%)	344 (14.4%)
≥20 to <50	603 (25.2%)	598 (25.0%)
≥50	467 (19.5%)	465 (19.4%)
Potential confounders/other covariates		
Child sex, female [*n* (%)]	1,168 (48.7%)	1,168 (48.7%)
Two parents at home, yes [*n* (%)]	2,048 (85.5%)	2,024 (84.5%)
Household income ($), median (Q1, Q3)	2,181.8 (1416.3, 3062.2)	2,317.6 (1500.0, 3330.1)
Highest education of parents, *n* (%)		
University qualification	455 (19.0%)	455 (19.0%)
Diploma/certificate	390 (16.3%)	390 (16.3%)
Trade/apprenticeship	398 (16.6%)	398 (16.6%)
School/none/other	1,153 (48.1%)	1,153 (48.1%)
Number of siblings, *n* (%)		
No siblings	233 (9.7%)	283 (11.8%)
1 sibling	1,096 (45.7%)	1,120 (46.7%)
2 or more siblings	1,067 (44.5%)	993 (41.4%)
Parent poor health: Yes [*n* (%)]	531 (22.2%)	531 (22.2%)
Australian Bureau of Statistics (ABS) remoteness index, *n* (%)		
Major cities of Australia	1,526 (63.7%)	1,536 (64.1%)
Inner regional Australia	527 (22.0%)	525 (21.9%)
Outer regional Australia	306 (12.8%)	298 (12.4%)
Remote/very remote Australia	37 (1.5%)	37 (1.5%)
Socio-Economic Indexes for Areas (SEIFA): 10 deciles of the Index of Relative Socio-Economic Disadvantage (IRSD), *n* (%)		
1 (most disadvantaged)	159 (6.6%)	159 (6.6%)
2	182 (7.6%)	185 (7.7%)
3	203 (8.5%)	198 (8.3%)
4	215 (9.0%)	203 (8.5%)
5	230 (9.6%)	231 (9.6%)
6	244 (10.2%)	246 (10.3%)
7	240 (10.0%)	240 (10.0%)
8	257 (10.7%)	269 (11.2%)
9	368 (15.4%)	358 (14.9%)
10 (least disadvantaged)	298 (12.4%)	307 (12.8%)
Duration of residence in home (months), median (Q1, Q3)	94.5 (37.5, 147.0)	105.5 (44.0, 168.0)

Blue spaces may hold therapeutic potential for mental well-being. Families in coastal regions in Southwest England have previously reported psychological benefits of beach visitation such as feelings of happiness and stress relief (Ashbullby et al., 2013). Ways through which blue spaces may benefit mental health may be the visibility of waterbodies inducing mental relaxation (Völker & Kistemann, 2011). Therapeutic effects of

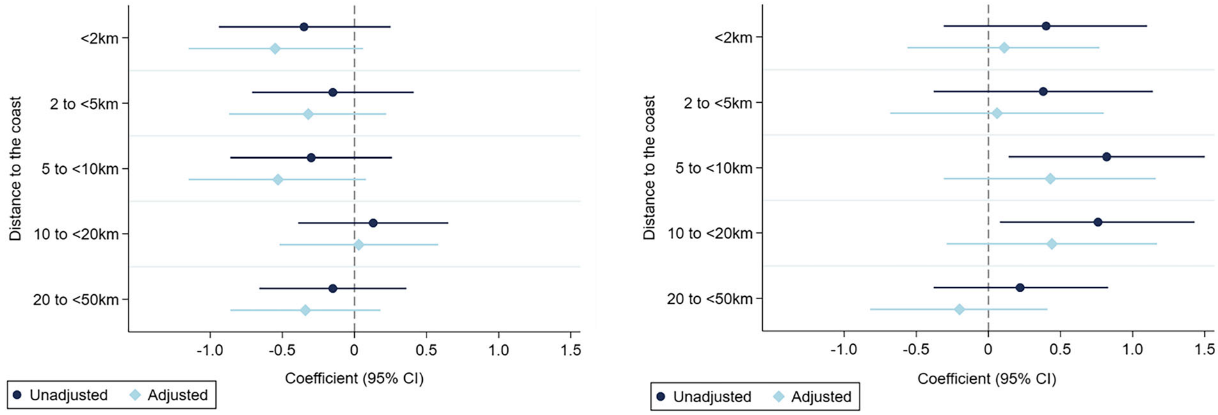

FIGURE 2 Unadjusted and adjusted cross-sectional associations between coastal proximity and Spence anxiety score at Waves 5 (left) and 6 (right). *Coefficient represents the difference in mean Spence anxiety score between each category and the baseline category (≥50 km).

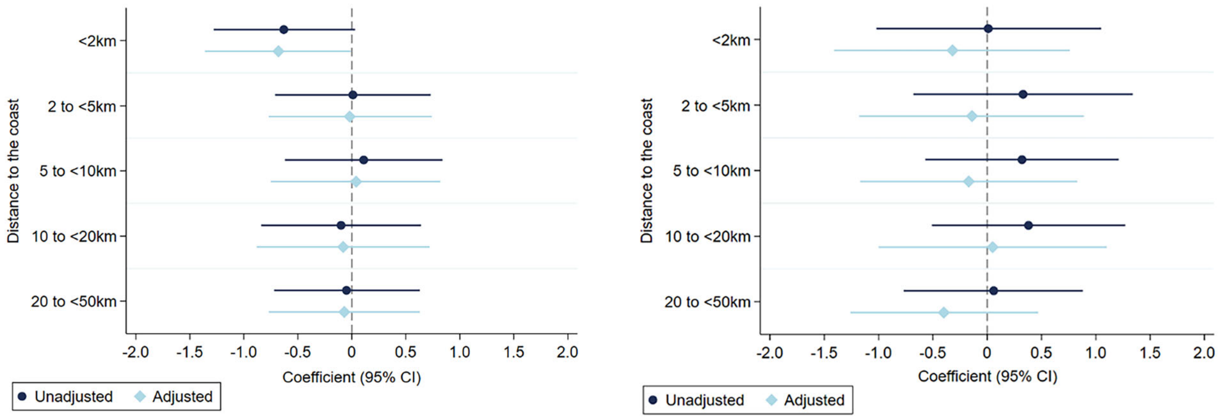

FIGURE 3 Unadjusted and adjusted cross-sectional associations between coastal proximity and SMFQ at Waves 5 (left) and 6 (right). *Coefficient represents the difference in mean SMFQ score between each category and the baseline category (≥50 km).

TABLE 2 Adjusted[a] associations between coastal proximity and mental health from Wave 5 to Wave 6 from fixed effects regression ($N = 2400$)

	Spence anxiety score			SMFQ score		
Proximity to the coast	**Coef.**	**95% CI**	***p***	**Coef.**	**95% CI**	***p***
<2 km	−0.29	(−2.37, 1.79)	0.786	1.47	(−2.27, 5.21)	0.440
≥2 to <5 km	−0.60	(−2.43, 1.22)	0.517	0.40	(−3.06, 3.85)	0.822
≥5 to <10 km	−0.77	(−2.74, 1.20)	0.443	0.15	(−3.31, 3.61)	0.931
≥10 to <20 km	−0.35	(−2.56, 1.86)	0.755	0.91	(−2.50, 4.33)	0.600
≥20 to <50 km	−1.02	(−3.09, 1.06)	0.336	0.10	(−2.52, 2.72)	0.939

[a]Models adjusted time-varying covariates: weekly household income, presence of both parents at home, number of siblings, socio-economic status of area, and the duration at current residence (continuous months). Coefficient compared with baseline category (≥50 km).

viewing blue space were identified in a UK study comparing participants' ratings of preference, affect, and restorative qualities between natural and built scenes containing blue space (White et al., 2010). In New Zealand, greater visibility of blue space was associated with lower psychological distress among adults aged 15 years and over living in a capital city (Nutsford et al., 2016). To examine whether this observed association may be due to residual confounding by wealth, Nutsford et al. (2016) assessed whether another outcome theoretically unrelated to exposure to blue space but highly associated with wealth (tooth missingness) showed an association with blue space. No association was detected between tooth missingness with blue space exposure, but an association was detected with wealth (Nutsford et al., 2016). This

TABLE 3 Adjusted[a] associations between proximity to the coast and mental health for participants living in major city areas

	Wave 5(*N* = 1526)			Wave 6(*N* = 1536)		
	Coef.	95% CI	*p*	Coef.	95% CI	*p*
Outcome: Spence anxiety score						
Proximity to the coast						
<2 km	−0.39	(−1.31, 0.53)	0.406	−0.25	(−1.36, 0.86)	0.655
≥2 to <5 km	−0.31	(−1.21, 0.59)	0.492	−0.48	(−1.56, 0.61)	0.390
≥5 to <10 km	−0.32	(−1.19, 0.55)	0.472	−0.09	(−1.17, 1.00)	0.875
≥10 to <20 km	0.16	(−0.69, 1.01)	0.713	0.03	(−1.03, 1.10)	0.954
≥20 to <50 km	−0.24	(−1.09, 0.60)	0.573	−0.68	(−1.65, 0.30)	0.172
Outcome: SMFQ score						
Proximity to the coast						
<2 km	−0.69	(−1.80, 0.43)	0.228	−0.81	(−2.56, 0.94)	0.363
≥2 to <5 km	−0.12	(−1.26, 1.02)	0.834	−1.25	(−2.87, 0.38)	0.131
≥5 to <10 km	−0.00	(−1.07, 1.07)	0.996	−1.22	(−2.76, 0.33)	0.123
≥10 to <20 km	−0.03	(−1.12, 1.06)	0.955	−1.12	(−2.65, 0.40)	0.148
≥20 to <50 km	0.12	(−0.98, 1.22)	0.829	−0.89	(−2.43, 0.65)	0.255

[a]Models adjusted for sex of child, weekly household income, highest parental education, parents' health, presence of both parents at home, number of siblings, socio-economic status of area, and the duration at current residence (continuous months). Coefficient compared with baseline category (≥50 km).

suggests that findings showing associations between blue space and mental health are unlikely completely measuring residual confounding by wealth.

Although systematic reviews are suggestive of potential beneficial associations between blue spaces and mental health, most research has so far focused on adult populations, leaving younger populations underrepresented (Beute et al., 2020; Britton et al., 2020; Gascon et al., 2017; White et al., 2020). There may be differences in the potential effects of proximity to blue spaces on mental health between children and adults because of differences in the dynamics of the interactions with blue spaces. Although adults may decide how and when they interact with blue spaces, children generally lack that same independent mobility (Carver et al., 2012; Marzi & Reimers, 2018; O'Brien et al., 2000), with parents or guardians likely having a say in children's interactions with blue spaces. Individual factors and family environments may be of greater importance for mental health among children (Cobham et al., 2016; Huynh et al., 2013; Patalay & Fitzsimons, 2018).

Findings suggested a potential association between coastal proximity and lower levels of depression symptoms at Wave 5, whereas no association was found at Wave 6. Differences across waves may be owing to differences in behaviours at different life stages (that is, at Wave 5, children were aged 11–12 years, and at Wave 6, 14–15 years). With changes in their social landscapes and autonomy (Zimmer-Gembeck & Collins, 2008), older children may be spending less time at home with their family and more time with their peers, engaging in different behaviours outside the home such as hanging out with friends away from home. Research has also suggested more emotional and behavioural problems as children age (Merikangas et al., 2010).

We assessed residential proximity to coast, which may not reflect interaction with coastal environments. Although other studies examining proximity to blue spaces and mental health in children have also found no associations (Maes et al., 2021; Mavoa et al., 2019), a study looking at beach visitation among children in Barcelona found that those spending more time at the beach had less behavioural problems and more prosocial behaviours (Amoly et al., 2014). However, parents have also identified barriers to beach visitation such as time scarcity, cost of parking, lack of car access, and cold weather (Ashbullby et al., 2013). Interaction with the coastal environment is likely context and setting dependent (for example, climate, infrastructure to get to the beach, surrounding amenities, quality of the beach, and water). More research is needed to understand whether and what characteristics of blue spaces and how much exposure are needed to benefit (if shown to be causal) children's mental health.

This is the first longitudinal study to explore associations between blue spaces and symptoms of depression and anxiety among children in Australia. It is also the first study to link geocoded data to children's addresses in LSAC. Mental health indicators were internationally recognised measures of depression and anxiety (Orgilés et al., 2014; Spence, 1997; Sund et al., 2001).

This study is not without limitations. Coastal proximity data were categorised and censored at the upper extent because of disclosure concerns, reducing sensitivity. Because of small numbers living closer to the coast, our category closest to the coast was <2 km. This assumes effects are similar for those living very close to the coast and those living less close. Perhaps those living closest to the coast (e.g., <500 m) may benefit more than those further away who, although living close by may not get as exposed to the coast. This study did not capture the use, view, or quality of blue spaces; this may be a crucial part of the association between blue spaces and mental health (Beute et al., 2020). There was an undifferentiated treatment of coastal proximity, assuming closer proximity means increased visitations (Elliott et al., 2020) and better mental health, regardless of actual morphology, infrastructure, amenities, etc. Future work should untangle mechanisms linking coastal proximity and children's mental health differentiating between specific coastal environments. Self-selection cannot be excluded. It is unknown whether parents chose to locate nearer the coast as their child, or themselves, had poor mental health. As LSAC has only collected mental health outcomes in recent waves, changes in earlier childhood cannot be tracked. There was a high proportion of missing confounder data, with some differences in characteristics (such as socio-economic status) between the participants analysed and those omitted. This may limit the generalisability of the results. Further, our findings are from a national study conducted among children in Australia. Results could be different from those in other countries as most of the Australian population lives along the coastline.

This study suggested that children living close to the coast (<2 km) have lower levels of depression symptoms than those living far away from the coast (≥50 km) during childhood (aged 11–12 years) but not adolescence (aged 14–15 years). No associations were observed between coastal proximity and anxiety symptoms. There was weak evidence to suggest the duration of residency at current address moderated associations between coastal proximity and depression and anxiety. Changes in coastal proximity were not associated with changes in symptoms of depression and anxiety.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

ETHICAL APPROVAL

Ethics approval for the LSAC study was received from the AIFS Ethics Committee, and exemption from further ethics approval was granted by Deakin University to conduct analysis on this dataset.

DATA AVAILABILITY STATEMENT

LSAC data are available for approved users from the Australian Data Archive Dataverse system.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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