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The impact of area-level socioeconomic status in childhood on mental health in adolescence and adulthood: A prospective birth cohort study in Aotearoa New Zealand

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ABSTRACT

Mental health conditions pose a significant public health challenge, and low area-level socioeconomic status (SES) is a potentially important upstream determinant. Childhood exposure might have influences on later-life mental health. This study, utilises data from the Christchurch Health and Development Study birth cohort, examining the impact of area-level SES trajectories in childhood (from birth to age 16) on mental health at age 16 and from age 18–40 years. Findings revealed some associations between distinct SES trajectories and mental health. The study underscores the importance of using a spatial lifecourse epidemiology framework to understand long-term environmental impacts on later-life health.

1. Introduction

Globally (World Health Organization [WHO], 2021) and in Aotearoa New Zealand (NZ) (Ministry of Health [MOH], 2022), the increasing prevalence of mental health conditions pose a significant public health challenge and burden. In 2018, an estimated 13% of the global population suffered from mental health conditions, with higher prevalence rates of 15% in high-income countries (WHO, 2022). The economic burden of mental health conditions, including reduced productivity and treatment expenses, reached approximately $2.5 trillion in 2010 and could rise to $6 trillion by 2030 (Bloom et al., 2012), exceeding the combined costs of cancer, diabetes, and chronic respiratory disease (WHO, 2022). In NZ, in 2019, 23% of adolescents reported clinically significant depressive symptoms, 42% reported possible anxiety disorders, and 21% have had suicidal ideation (Sutcliffe et al., 2023). Overall, 24% of NZ adults (over age 15), have been diagnosed with depression or an anxiety disorder (MOH, 2022). Inequities in mental health conditions also exist by ethnicity. For instance, Māori adolescents (aged 13–18) were 1.4 times more likely to experience significant depressive symptoms compared to their Pākehā peers—referring primarily to European New Zealanders who have no Polynesian ethnic ancestry (Clark et al., 2022). The causes of mental health conditions are multifaceted in aetiology; however, upstream social and environmental determinants are increasingly considered important (Allen et al., 2014).

Area-level socioeconomic status (SES), which captures the socioeconomic disadvantages or advantages of an area in which an individual lives or works, has been recognised as an important upstream determinant of mental health (Fone et al., 2014; Jakobsen et al., 2022; WHO, 2021). Theoretical mechanisms underpinning the influence of area-level SES on individuals' mental health may operate through the social and built environments within those areas (Diez Roux and Mair, 2010). For instance, areas with lower SES have been found to be associated with lower perceived safety, aesthetic quality, and place attachment, potentially influencing the mental health of residents living in these areas (Mouratidis, 2020). Additionally, areas with higher SES tend to have a more health-promoting built environment including better access to

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nature, facilities for physical activity, and nutritious food options (Marek et al., 2021), thus influencing individuals' mental health directly or indirectly through shaping health-related behaviours (Galster, 2011). Many studies, which are largely cross-sectional, have reported associations between low area-level SES and heightened mental health risks, even after adjusting for other important factors such as family SES (Dowdall et al., 2017; Fone et al., 2014; Mann et al., 2022; Ostir et al., 2003; Silver et al., 2002; Sundquist and Ahlen, 2006). However, other evidence, some of which is longitudinal, suggests that such associations may be largely attenuated by individual and family background factors (Holmgren et al., 2021; Lofors et al., 2006; Motoc et al., 2019; Pikhartova et al., 2009; Propper et al., 2005; Wight et al., 2009) or other area-level factors, such as the perceived neighbourhood environment (Mohan and Barlow, 2023; Salvatore and Grundy, 2021). Nevertheless, the evidence on the associations between area-level SES and mental health exhibits some heterogeneities, stemming from differences in study designs and the metrics employed to measure area-level SES. Longitudinal studies with follow-up periods exceeding five years, were less likely to report significant associations compared to those with shorter-term follow-up (Richardson et al., 2015). Additionally, studies that measured area-level SES from a single aspect were less likely to report significant associations than studies that applied composite metrics of area-level SES (Sui et al., 2022), which may fail to capture the complexity of SES at the area level, potentially leading to an inability to replicate the consistently strong relationships typically observed across various health and social outcomes. Thus, to establish a robust relationship between area-level SES and mental health conditions, longitudinal studies with extended follow-up periods and more sophisticated measures of area-level SES may be required.

The focus of research on area-level SES and mental health has shifted towards a lifecourse approach, requiring an investigation into the full spectrum of exposure to area-level SES from the beginning of life rather than a singular segment of life (Desjardins et al., 2023; Jia, 2019; Nandi and Welsh, 2013; Visser et al., 2021). A lifecourse approach emphasises the importance of exposure in early life, such as childhood. In childhood, the area-level SES of the context where children grow up may play an important role in their growth, maturation, and biological development, as well as subsequent mental health (Caspi et al., 2020; Curtis et al., 2004; Leventhal and Brooks-Gunn, 2000; Villanueva et al., 2017). Furthermore, a lifecourse approach underscores that the impact of area-level SES on mental health might accumulate over time, resulting in effects that may not be immediately evident in current health outcomes but manifest as lagged implications for long-term or later-life health (Jia, 2019; Nandi and Welsh, 2013). Notably, two recent studies using a lifecourse approach revealed that residing in areas with the lowest SES during childhood has adverse effects on mental health conditions in adolescence (Bakolis et al., 2023) and at age 70 (Pearce et al., 2018). Despite this, most studies in this domain have applied cross-sectional study designs or longitudinal approaches with short-to medium-term follow-ups, with fewer investigations spanning across the entire lifecourse (Mair et al., 2008; Richardson et al., 2015; Robinette et al., 2017; Visser et al., 2021). This has hindered the exploration of whether area-level SES influences are more important at a particular life stage and whether there are cumulative or lagged effects of area-level SES influences on mental health in later life.

The literature on the longitudinal study of area-level SES and mental health presents several limitations. First, the dynamic nature of individuals and areas has been largely ignored (Campbell et al., 2021; Morris et al., 2018; Shackleton et al., 2018). Individuals may relocate among areas with varying SES over their lifecourse (Robinette et al., 2017) and the SES of areas can also change over time (Deng et al., 2024). Failure to account for these changes in both aspects may lead to misclassification of area-level SES exposure, potentially biasing evidence (Harari-Kremer et al., 2022; Hodgson et al., 2015). Second, most studies measured the area-level SES at discrete time points in life (Bakolis et al., 2023; Pearce et al., 2018), instead of capturing the trajectories of changing area-level SES exposure over time. Trajectories can offer insights into the temporal dynamics of exposure to area-level SES, uncovering nuanced heterogeneity over time that would otherwise be overlooked when relying solely on averaged exposure measures at several discrete time points. Trajectory analysis also offers advantages by leveraging all available information in longitudinal data with missing values, thus overcoming the inherent challenge of missing values commonly encountered in longitudinal studies due to loss to follow-up (Shackleton et al., 2018). Third, in existing studies exploring the lifecourse impact of area-level SES on mental health, crucial covariates such as parental mental health histories and changes in parental relationships were often absent (Bakolis et al., 2023; Pearce et al., 2018). Fourth, most studies primarily focused on a singular mental health condition like depression, the associations between area-level SES and other mental health conditions like anxiety disorders and suicidal ideation have not been well established (Dupéré et al., 2009). Fifth, whilst the lagged effects of area-level SES on mental health have been discussed (Morris et al., 2018), most longitudinal studies only focused on the current mental health conditions. There is a lack of evidence exploring the lagged effects on mental health. Addressing these limitations is crucial to advancing scientific understanding of the influence of area-level SES on mental health conditions.

Against this background, our study used data from the Christchurch Health and Development study (CHDS), a prospective birth cohort study, to identify trajectories of area-level SES exposure using latent class growth models and examine the associations between area-level SES trajectories experienced during childhood (0–16 years) and three mental health conditions in adolescence (at age 16 years) and in adulthood (age 18–40 years). The three mental health conditions include depressive symptoms, anxiety disorders, and suicidal ideation. Latent class growth models were developed to identify subgroups who share similar trajectories over time, which has been increasingly employed in epidemiology studies to better understand within individuals and between individuals' variability in health-related exposure and outcomes over time (Curtis et al., 2021; Nguena Nguefack et al., 2020; Shackleton et al., 2018). Moreover, it offers a unique advantage in identifying high-risk subgroups within the studied population (Burton-Jeangros et al., 2015), such as individuals consistently exposed to low area-level SES or those transitioning from high to low SES areas. These subgroups may warrant additional attention from a policymaking perspective.

2. Methods

2.1. Participants

The Christchurch Health and Development Study (CHDS) is a prospective birth cohort study that collected data on 1265 individuals (630 females) born in 1977 in Christchurch, New Zealand. Christchurch is the largest city on NZ's South Island (Hobbs et al., 2022). At the time when CHDS cohort members were born, Christchurch had an estimated 296, 600 population, which accounted for around 9.4% NZ population at that time (Department of Statistics NZ, 1978). The birth cohort comprises 97 % of all births in Christchurch hospital occurring during that period. The cohort data was collected at birth, four months, yearly until age 16 years, and then at age 18, 21, 25, 30, 35 and 40 years. Up until now, 3.6% (n = 45) of the cohort have passed away before reaching 40 years old. Throughout the study, information has been collected using diverse methods including interviews with parents (birth to age 16); interviews directly with the cohort members (from age 8 onwards); reports from teachers, standardised tests; official records from medical and other sources. Details about the CHDS have been published elsewhere (Fergusson and Horwood, 2001, 2013). All aspects of data collection received ethical approval by the Canterbury Regional Health and Disability Ethics Committee and all data were collected with the explicit written consent of cohort members.

2.2. Outcomes - adolescent and adult mental health conditions

At age 16, 21, 25, 30, 35 and 40 years, cohort members were questioned about their mental health conditions since the previous interview (14–16, 18–21, 21–25, 25–30, 30–35, and 35–40 years). Adolescent mental health was defined for the interval of 14–16 years and adult mental health was defined across the five intervals from age 18–40 years.

2.2.1. Depressive symptoms

Cohort members were questioned about symptoms of major depression based on the relevant components of the Composite International Diagnostic Interview (CIDI) items (WHO, 1993) and Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria (American Psychiatric Association and Association, 1994). Cohort members who met DSM criteria for experiencing a major depressive episode at any point within an assessment period were assigned a value of one, and zero otherwise.

2.2.2. Anxiety disorders

Using the CIDI and DSM as a basis, cohort members were asked about symptoms associated with various anxiety disorders including generalized anxiety disorder, panic disorder, agoraphobia, social phobia and specific phobia. Cohort members who met DSM criteria for one or more anxiety disorders within an assessment period were assigned a value of one, and zero otherwise.

2.2.3. Suicidal ideation

Cohort members were surveyed using custom-written survey items about whether they had ever thought about killing themselves or had attempted suicide during the assessment period (Fergusson et al., 2008). Based on this gathered information, cohort members who did report experiencing any suicidal ideation within an assessment period were assigned a value of one, and zero otherwise.

2.3. Area-level socioeconomic status measures

A historical time-series area-level deprivation metric (Deng et al., 2024) was used to define the SES of areas where cohort members resided from birth to age 16 years. The metric was constructed for the years 1981, 1986, and 1991 at the Census Area Unit (CAU) level. The maps for the metric were provided in online Supplementary Material Fig. S1. It was created using two variables, unemployment and non-home ownership, sourced from census data. Area-level SES was split into quintiles, where quintile one (Q1) represented the highest SES areas and quintile five (Q5) represented the lowest SES areas. The metric was based on consistent variables, geographic basis, and statistical methods across the three years, allowing comparisons of area-level SES over time. The metric has been validated in previous research and can be a proxy for area-level SES in NZ from 1981 to 1991 (Deng et al., 2024). The metric was linked to the geocoded home coordinates at each wave closest in time. More specifically, the 1981 data was linked to eight waves of data from birth (1977) to age six (1983); the 1986 data was linked to five waves of data from age seven (1984) to 11 (1988); the 1991 data was linked to five waves of data from age 12 (1989) to 16 (1993).

2.4. Covariates

A series of variables were chosen from the CHDS database to adjust the associations between childhood trajectories of area-level SES and adolescent and adult mental health conditions. Please see online Supplementary Material Table S3 for the description of the variables. These variables were selected because they: (a) are theoretically relevant in predicting childhood area-level SES and (b) are known to be associated with one or multiple mental health conditions. These variables were divided into childhood covariates and adulthood covariates. Childhood covariates include individual characteristics (i.e., gender, ethnicity), family background (i.e., maternal age at birth, maternal education at birth, father's occupational status at birth, family type at birth), and family functioning (parental relationship stability, family living standard, residential moves, parental criminal offending, parental alcohol problems, parental mental health problems). Adulthood covariates span domains of individual and family circumstances (i.e., age, whether living with partner, number of dependent children, living in owned house), individual SES (i.e., occupational status, highest education attainment, welfare dependence), potential triggers of mental health conditions (i.e., count of life events, alcohol problem, tobacco use disorder, illicit substance disorder), and area-level factor (average area-level SES experienced in adulthood). Childhood covariates were used to adjust the associations between childhood trajectories of area-level SES and adolescent mental health conditions. Both childhood and adulthood covariates were used for adjusting the associations between childhood trajectories of area-level SES and adult mental health conditions.

2.5. Statistical analysis

2.5.1. Identifying latent classes of childhood area-level socioeconomic trajectories

Childhood area-level SES trajectories were classified using Latent Class Growth Analysis (LCGA) (Herle et al., 2020). This analysis was performed using Mplus 8.3. The LCGA identified subgroups of cohort members who followed similar trajectories across area-level SES quintiles from birth to age 16. The area-level SES at each wave was treated as an ordinal variable. Several models of different number of classes and polynomial forms (i.e., linear, quadratic, and cubic) were fitted. Models of different trajectory classes were compared using several criteria including Bayesian Information criterion (BIC), sample-adjusted BIC (SBIC), Akaike Information Criterion (AIC), entropy, and the sample size in the smallest class. We selected the model with a lower BIC, SBIC, AIC, higher entropy as well as ensuring the interpretability of trajectories and reasonable sample size in the smallest class (Nagin, 2005). In LCGA, missing data were managed through a Maximum Likelihood (ML) algorithm. The ML algorithm does not impute or replace missing values; instead, it utilises the available data within each case to compute the parameter that is most likely to have generated the observed data (Sinha et al., 2021).

2.5.2. Examining the associations between childhood area-level socioeconomic trajectories and adolescent mental health conditions (at age 16)

The associations between area-level SES trajectories in childhood and adolescent mental health conditions were tested using logistic regression models. The models were constructed with the classes of area-level SES trajectories as the independent variable and the adolescent mental health conditions as the dependent variables. The models were adjusted by childhood covariates of interest (see online Supplementary Material Table S3 for covariate details).

2.5.3. Examining associations between childhood area-level socioeconomic trajectories and adult mental health conditions (age 18–40)

This analysis pooled the repeated observations of three mental health conditions (depressive symptoms, anxiety disorders, and suicidal ideation) at ages 21, 25, 30, 35 and 40 years for the intervals 18–21, 21–25, 25–30 and 35–40 years to obtain an estimate of the population-averaged associations between the classes of area-level SES trajectories in childhood and adult mental health conditions. Descriptive analyses were used to show the percentages (%) and counts (n) of cohort members experiencing mental health conditions within each class of childhood area-level SES trajectories, at each assessment age (See online Supplementary Material Tables S6–S11). Population-averaged associations were examined using a generalized estimating equation (GEE) logistic

regression modelling framework in which each of the mental health conditions was modelled as a function of the classes of area-level SES trajectories using the five waves of repeated-measures data simultaneously. The models were adjusted by both childhood and adulthood potential covariates (see online Supplementary Material Table S3 for covariate details). All analyses were conducted using STATA 17. A significance level of $\alpha = 0.05$ was set to determine statistical significance. We also conducted sensitivity analyses to test whether incorporating different covariates led to different conclusions compared to including all selected covariates in the models. Stepwise selection was used to choose two subsets of covariates: the first containing only covariates with p-values lower than 0.05, and the second containing only covariates with p-values lower than 0.1.

2.5.4. Sample size and sample bias

The sample entered into the analysis were those who have at least 9 area-level SES observations available, and the number of consecutive missing observations for area-level SES is no longer than 4, also they need to have all three mental health conditions measured at age 16, and at least one observation available for all three mental health conditions from age 18 to 40. Therefore, the sample size in the logistic regression model was 972, and in the population-averaged model was 951. These samples represented 77.9 % of the cohort members surviving to 16 years (n = 1248) and represented 77.9 % of the cohort members surviving to 40 years (n = 1221). We compared the analysis sample with surviving members of the cohort assessed at age 16 and 40, respectively, to examine if selection bias resulting from sample attrition processes had an impact on the findings. Online Supplementary Material Table S1 and Table S2 both show statistically insignificant differences between the included samples and the surviving members at age 16 and age 40, respectively.

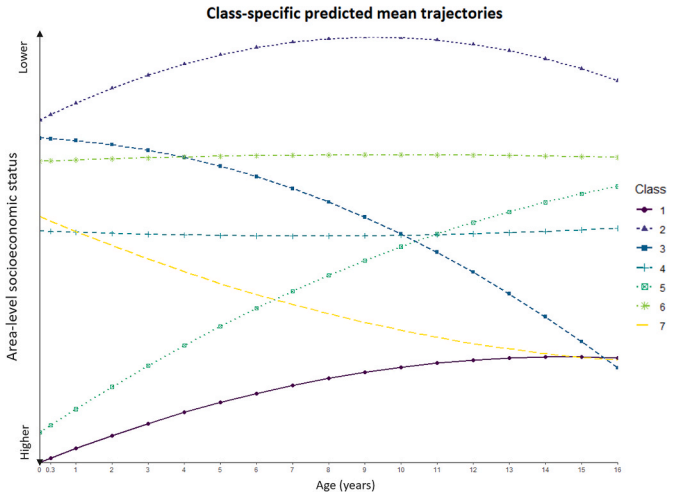

Fig. 1. Trajectories of area-level socioeconomic status experienced by cohort members in Christchurch Health and Development Study from birth to age 16 years, identified by Latent Class Growth Analysis.

3. Results

3.1. Childhood area-level socioeconomic status trajectories

The LCGA identified seven distinct trajectories of area-level SES from birth to age 16, as shown in Fig. 1. The seven-classes model was chosen as it has the lowest BIC, AIC, SBIC, has relative high entropy, identifies subgroups of interest, and has reasonable sample size in the smallest class. The diagnostics of the model fit are provided in online Supplementary Material Table S4. The seven classes are characterised as follow. Class 1: *Consistent Affluence* (15%) represents the subgroup of cohort members who consistently lived in the highest SES areas throughout the childhood. Contrastingly, Class 2: *Prolonged Deprivation* (5%) consists of members born in areas of the lowest SES and continually moved or remained in the lowest SES areas throughout childhood. Class 3: *Transitioning to Prosperity* (11%) includes cohort members born in relatively low SES areas who gradually transitioned to higher SES areas. Class 4: *Consistent Middle Status* (25%) represents cohort members who consistently lived in middle SES areas. Class 5: *Transitioning Away from Affluence* (6%) consists of the small subgroup of cohort members born in the highest SES areas but transitioned to middle SES areas over time. Class 6: *Consistent Lower-Middle Status* (22%) includes members who consistently lived in lower-middle SES areas in childhood. Class 7: *Transitioning Towards Affluence* (17%) represents cohort members born in middle SES areas who transitioned to highest SES areas over time. See online Supplementary Material Table S5 for a breakdown of childhood sociodemographic characteristics by the classes of trajectories.

3.2. Associations between childhood area-level socioeconomic trajectories and adolescent mental health conditions (at age 16)

The associations between childhood trajectories of area-level SES and mental health conditions were examined using logistic regression models, with Class 1 (Consistent Affluence) as the reference class. The modelling results before adjustment are presented in online Supplementary Material Table S12, while the adjusted results are displayed in Table 1.

Overall, most associations between childhood trajectories of area-level SES and mental health conditions at age 16 in both unadjusted and adjusted models were insignificant. However, one trajectory stood out. Before adjustment, compared to cohort members consistently residing in the highest SES areas (Class 1), those transitioning from the highest SES to middle SES areas (Class 5: Transitioning Away from Affluence) during childhood exhibited a 2.59 [1.10, 6.08] times higher risk of depressive symptoms at age 16. After adjusting for childhood covariates, this association remained significant, with the relative risk

Table 1
Adjusted logistical regression models for examining the associations between the identified area-level socioeconomic status trajectories in childhood and mental health conditions (depressive symptoms, anxiety disorders, and suicidal ideation) measured at age 16.

	Depressive symptoms	Anxiety disorders	Suicidal ideation
Class 1 - Consistent Affluence (n = 142)	1 (REF)	1 (REF)	1 (REF)
Class 2 - Prolonged Deprivation (n = 53)	1.28 [0.46, 3.55]	1.10 [0.45, 2.69]	1.83 [0.77, 4.34]
Class 3 - Transitioning to Prosperity (n = 103)	0.70 [0.27, 1.79]	0.88 [0.42, 1.84]	1.07 [0.50, 2.27]
Class 4 - Consistent Middle Status (n = 239)	1.11 [0.53, 2.33]	0.84 [0.45, 1.56]	0.74 [0.39, 1.43]
Class 5 - Transitioning Away from Affluence (n = 58)	**2.81 [1.14, 6.95]** *	1.04 [0.42, 2.55]	0.48 [0.15, 1.51]
Class 6 - Consistent Lower-Middle Status (n = 216)	1.18 [0.55, 2.56]	0.79 [0.41, 1.53]	1.04 [0.54, 2.03]
Class 7 - Transitioning Towards Affluence (n = 161)	0.77 [0.33, 1.81]	0.64 [0.32, 1.28]	0.78 [0.39, 1.58]

Notes: Results are presented as Relative Risk Ratio [95% Confidence Intervals]. * denotes $p \leq 0.05$.
The models were adjusted by gender, ethnicity, maternal age at birth, maternal education at birth, father's occupational status at birth, family type at birth, parental relationship stability from birth to age 16, family living standard from birth to age 10, residential moves from birth to age 16, parental criminal offending, parental alcohol problems, parental mental health problems.

Table 2
Adjusted population-averaged models for examining the associations between the identified area-level socioeconomic status trajectories in childhood and mental health conditions (depressive symptoms, anxiety disorders, and suicidal ideation) measured from age 18 to 40.

	Depressive symptoms	Anxiety disorders	Suicidal ideation
Class 1 - Consistent Affluence (n = 142)	1 (REF)	1 (REF)	1 (REF)
Class 2 - Prolonged Deprivation (n = 53)	0.92 [0.48, 1.77]	0.97 [0.50, 1.88]	1.19 [0.43, 3.25]
Class 3 - Transitioning to Prosperity (n = 103)	1.09 [0.66, 1.80]	0.78 [0.47, 1.32]	1.28 [0.56, 2.93]
Class 4 - Consistent Middle Status (n = 239)	0.86 [0.56, 1.32]	**0.48 [0.30, 0.76]** **	0.86 [0.40, 1.83]
Class 5 - Transitioning Away from Affluence (n = 58)	1.14 [0.63, 2.06]	0.69 [0.36, 1.33]	0.89 [0.32, 2.52]
Class 6 - Consistent Lower-Middle Status (n = 216)	0.75 [0.47, 1.20]	**0.43 [0.26, 0.71]** ***	0.61 [0.26, 1.40]
Class 7 - Transitioning Towards Affluence (n = 161)	0.87 [0.55, 1.36]	**0.54 [0.34, 0.88]** *	0.51 [0.22, 1.23]

Notes: Results are presented as Relative Risk Ratio [95% Confidence Intervals].
* denotes $p \leq 0.05$, ** denotes $p \leq 0.01$, *** denotes $p \leq 0.001$.
The models were adjusted by gender, ethnicity, maternal age at birth, maternal education at birth, father's occupational status at birth, family type at birth, parental relationship stability from birth to age 16, family living standard from birth to age 10, residential moves from birth to age 16, parental criminal offending, parental alcohol problems, parental mental health problems, age, whether living with partner, number of dependent children, living in owned house, occupational status, highest education attainment, welfare dependence, count of life events, tobacco use disorder, alcohol problems, illicit substance disorder, and average area-level SES experienced in adulthood.

ratio increasing slightly to 2.81 (95% Confidence Intervals = [1.14, 6.95]). On the other hand, cohort members who consistently resided in the lowest SES areas (Class 2: Prolonged Deprivation) during childhood demonstrated a 2.19 [1.01, 4.74] times higher risk of having suicidal ideation at age 16 compared to those who lived in the highest SES areas during childhood (Class 1) in the unadjusted model. However, this association was attenuated after adjustment by individual characteristics, family background, and family functioning factors. Additionally, no significant associations were found between any classes of area-level SES trajectories in childhood and anxiety disorders in either the unadjusted or adjusted models. Models with subsets of covariates with p-values less than 0.05 and p-values less than 0.1 selected by stepwise selection were run in the sensitivity analyses. The results of the sensitivity analyses were consistent with those of the main analysis (see online Supplementary Material Table S14 and Table S15).

3.3. Associations between childhood area-level socioeconomic trajectories and mental health conditions from age 18 to 40

The associations between childhood trajectories of area-level SES and pooled mental health conditions in adulthood from age 18 to 40 were examined using population-averaged models. Class 1 (Consistent Affluence) was used as the reference class. The results of unadjusted models were provided in online Supplementary Materials Table S13, while the results of adjusted models were presented in Table 2.

Briefly, no significant associations were observed between childhood trajectories of area-level SES and adult depressive symptoms either in the unadjusted or in the adjusted models. Interestingly, while the unadjusted model did not show a significant association between childhood trajectories of area-level SES and adult anxiety disorders, the adjusted model indicated some notable associations. Specifically, compared to cohort members from Class 1 (Consistent Affluence), those from Class 6 (Consistent Lower-Middle Status), Class 4 (Consistent Middle Status), and Class 7 (Transitioning Towards Affluence) exhibited 52%, 57%, and 46% reduced risks of experiencing anxiety disorders in adulthood, respectively. In terms of suicidal ideation, before adjustment, cohort members from Class 2 (Prolonged Deprivation) and Class 3 (Transitioning to Prosperity) had 2.60 [1.39, 4.87] and 2.05 [1.19, 3.54] times higher risks of having suicidal ideation during age 18 and 40, respectively, compared to those from Class 1 (Consistent Affluence). However, these associations were fully attenuated after accounting for individual characteristics, family background, family functioning in childhood as well as individual and family circumstances, individual SES, and potential triggers of mental health problems in adulthood. Models with subsets of covariates with p-values less than 0.05 and p-values less than 0.1 selected by stepwise selection were run in the sensitivity analyses. The results of the sensitivity analyses were consistent with those of the main analysis (see online Supplementary Material Table S16 and Table S17).

4. Discussion

This study examined the impact of childhood trajectories of area-level SES from birth to age 16 on mental health conditions in adolescence at age 16 and across adulthood from age 18 to 40 using prospectively collected birth cohort data from CHDS. This study generated three key findings. First, a transition from high to low area-level SES during childhood was associated an increased risk of depressive symptoms in adolescence. Second, a decreased risk of anxiety disorders in adulthood from 18 to 40 years was evident among three trajectories of childhood area-level SES (Class 4: Consistent Middle Status, Class 6: Consistent Lower-Middle Status, and Class 7: Transitioning Towards Affluence) after accounting for childhood and adulthood covariates, compared to the Class 1 (Consistent Affluence). The three classes shared an origin of being born into around middle SES areas, suggesting a potential protective effect of living in middle SES areas in early childhood on adult anxiety disorders in this cohort. Third, it is important to note that this study generally found mixed associations relating trajectories of area-level SES in childhood and mental health conditions in adolescence or adulthood after adjusting individual- and family-level covariates. Our study contributes to scientific understanding by using a spatial life-course epidemiology framework to better capture the trajectories of area-level SES exposures in childhood that may drive later-life health outcomes for at-risk populations (Delmelle et al., 2022; Desjardins et al., 2023).

This study found that the trajectory transitioning downwards from the higher SES areas to middle SES areas in childhood was associated with a 2.81 times higher risk of having depressive symptoms in adolescence relative to stably living in the highest SES areas in childhood. This finding is consistent with an earlier cohort study, revealing that each one percentage increase in area disadvantage at age four is associated with an average increase of 0.02 in the total score of the neuroticism scale between ages 13 and 15, even after accounting for the father's social class (Bakolis et al., 2023). The adverse impact of downward moves on health outcomes have also been documented elsewhere (Norman et al., 2005; Tseliou et al., 2016; Tunstall et al., 2012). Health geography has a longstanding debate regarding the influence of area-level exposure on health outcomes versus the possibility that individuals with certain health conditions tend to relocate to areas characterised by specific attributes (e.g., lower SES), a phenomenon known as selective migration (Norman et al., 2005). In the present study, the well-established time sequence between area-level exposure and health outcomes can largely avoid such selective migration bias in this finding. However, it is important to note that the confidence

intervals for this association are wide, indicating some uncertainties in the effect size of this association. This is probably due to low sample size in class 5 (Transitioning away from affluence).

In our study, we found that most of associations between area-level SES trajectories in childhood and mental health conditions in adolescence were null after accounting for individual- and family-level factors. Although there is limited evidence in this area, this finding closely aligns with a systematic review which suggested that longer-term follow-up studies were less likely to reveal significant associations between area-level SES and depression (Richardson et al., 2015). In addition, these findings of null associations are also consistent with previous longitudinal studies which have examined the associations between exposure to area-level SES and mental health in children and young adults (Airaksinen et al., 2015; Allen and Goldman-Mellor, 2018; Barzilay et al., 2021; Yildiz et al., 2019; Zammit et al., 2010, 2014). While many cross-sectional or shorter-term longitudinal studies highlighted the detrimental effects of low area-level SES on mental health (Dowdall et al., 2017; Fone et al., 2014; Mann et al., 2022; Ostir et al., 2003; Silver et al., 2002; Sundquist and Ahlen, 2006), these associations may not persist once sufficient adjustment for confounding factors have been considered. This, in turn, emphasises the importance of investigating the impact of environmental factors on health outcomes from a lifecourse perspective (Curtis et al., 2013).

This study did not find a significant delayed impact of childhood exposure to area-level SES on adult depressive symptoms and suicidal ideation. However, these findings contrast with three other longitudinal studies. Pearce et al. (2018) demonstrated that growing up in the most socially disadvantaged neighbourhoods had a detrimental impact on mental health conditions at age 70, even after accounting for factors like father's occupational status and unhealthy childhood behaviours. Another extensive cohort study spanning 69 years showed that a one percentage point increase in area disadvantage from ages four to 26 was associated with a 0.06 increase in the total Psychiatric Symptom Frequency score at age 43, after adjusting for educational attainment and cognitive ability at age 15 (Bakolis et al., 2023). Additionally, Elovainio et al. (2020) noted that individuals residing in disadvantaged areas during childhood and adolescence were more likely to experience depressive symptoms in adulthood, after accounting for their family's SES and other risk factors during childhood. Despite these disparities in findings, all three studies shared limitations in their limited time resolution of childhood area-level SES exposure and a focus on adjusting for fundamental sociodemographic variables as covariates as opposed to the adjustment of a comprehensive range of individual- and family-level covariates in both childhood and adulthood. Furthermore, the variations in defining area-level SES between these studies and the present study may also contribute to the different results observed. Additionally, our study also found unexpected results indicating that childhood trajectories of area-level SES might exhibit a delayed impact on anxiety disorders lasting until age 40, where individuals residing in areas with middle SES during their early years had around a 50% lower likelihood of experiencing anxiety disorders in adulthood. These associations were not significant before adjustment but emerged as significant after adjustment, implying the joint influence of area-level SES and other covariates on anxiety disorders in adulthood, as the associations became significant only after including these covariates in the model.

To the authors' knowledge, this study is one of the first that has investigated annually measured area-level SES from birth to age 16 and examined its associations with mental health conditions of adolescents and adults up to the age of 40. This study possesses the following strengths. First, this study used a high-quality prospectively collected birth cohort data, the CHDS. The CHDS offers accurate residential addresses of cohort members collected annually from birth to age 16, minimizing recall bias in the study's findings. The CHDS also offers crucial individual and family-level covariates for robust model adjustments. Second, this study considered the changes in area-level SES from both individuals' and areas' aspects, which can largely avoid misclassification errors in exposure measurement. Third, this study applied a novel LCGA to examine the trajectories of area-level SES across the entire childhood. This approach optimised the use of available information and effectively addresses challenges arising from missing data due to follow-up loss—an inevitable problem in cohort studies spanning decades. Fourth, this study examined multiple mental health conditions including depressive symptoms, anxiety disorders, and suicidal ideation. This could add new knowledge to the current literature on how area-level SES differentially affects different mental health conditions. Fifth and most importantly, the study employed a spatial lifecourse epidemiology framework to explore the associations between area-level SES and mental health conditions. This framework offers distinct advantages in confirming the temporal sequence of exposure and outcomes, examining the significance of early exposure, and assessing the cumulative and delayed impacts of area-level SES exposure.

While the strengths of this study demonstrated above, the study findings should be interpreted considering the following limitations. First, this is an observational study which cannot infer causality. Second, the study's sample size is relatively small, thereby restricting the statistical power of the findings. Third, the area-level SES metric employed in this study has inherent limitations. It only focuses on material aspects of SES within areas, such as unemployment and non-home ownership, while the broader concept of area-level SES typically encompasses other dimensions like education and physical access to facilities. The restricted scope of the metric might have obscured significant associations between area-level SES and mental health conditions. The geography unit used in this study are statistical areas CAUs, which might not accurately reflect an individual's perceived neighbourhood. While personalised neighbourhood boundaries would be better, little evidence has been able to operationalise these definitions (Campbell et al., 2021). Fourth, this study only captured the area-level SES exposure around residential locations, ignoring the fact that individuals might spend a lot of time outside their homes, such as children may spend many hours in schools. Fifth, other important variables that may be related to area-level SES exposure, such as urbanicity/rurality and comorbidities, were not controlled in the present study because of the lack of lifecourse data on these variables. Sixth, the findings in this study are from a birth cohort in 1977 from Christchurch, New Zealand and therefore may not be generalisable to other contexts. Lastly, cohort members experienced changes from the DSM-III to the DSM-5. Changes in diagnostic criteria for certain disorders occurred over time, and interview questions were adapted accordingly, potentially impacting the consistency of assessments across different diagnostic criteria versions.

To further advance our understanding in this field, future research should incorporate a broader spectrum of area-level SES metric, such as the accessibility of facilities, perceptions of neighbourhood environments, and adopt personalised neighbourhood boundaries. Additionally, it is crucial to extend the assessment of area-level SES beyond residential locations, incorporating other settings like workplaces and schools where individuals spend substantial time. While the present study primarily concentrated on investigating the impact of childhood exposure on later-life health outcomes, the findings suggest that childhood might not necessarily represent the most sensitive period for later-life health. Interestingly, Jivraj et al. (2019) highlighted that exposure during late-early-adulthood and mid-life might have a larger influence on mid-life health outcomes than exposure during early life. Consequently, future studies should build upon this insight by exploring the associations between exposure to area-level SES during mid-life and subsequent mid-life health outcomes. The present study examined the associations between childhood exposure to area-level SES and mental health in later-life. Future study can extend the present study by investigating whether childhood exposure to area-level SES is associated with changes in mental health in later-life. The interaction effects of gender, ethnicity, and SES in the lifecourse associations between area-level SES and mental health were also not examined in the present study due to limited sample size. This remains an important area for future research with a larger

sample size. Lastly, we acknowledge that LCGA is one of many approaches to operate longitudinal exposure data. Future studies should consider exploring alternative methods, such as averaging exposure over time, to corroborate the findings from the present study.

5. Conclusion

In conclusion, our study showed mixed associations between childhood exposure to area-level SES and adolescent mental health. Specifically, downward transitions from higher SES areas to lower SES areas appear to elevate the risk of depressive symptoms in adolescence, even after considering critical individual- and family-level factors. Additionally, no delayed effects of childhood area-level SES on adult depressive symptoms or suicidal ideation were identified. However, exposure to middle area-level SES during early childhood seemed to exhibit a protective delayed effect against adult anxiety disorders. This study applied a spatial lifecourse epidemiology framework to examine long-term effects of environmental exposure on later-life health. These findings provide some valuable insights into the complex relationships between exposure to childhood area-level SES and mental health across lifecourse.

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CRediT authorship contribution statement

Bingyu Deng: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Geraldine F.H. McLeod:** Writing – review & editing, Supervision, Investigation, Formal analysis, Conceptualization. **Joseph Boden:** Writing – review & editing, Supervision, Investigation, Formal analysis. **Clive E. Sabel:** Writing – review & editing, Supervision, Formal analysis, Conceptualization. **Malcolm Campbell:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Phoebe Eggleton:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Matthew Hobbs:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT 3.5 in order to improve language and readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Data availability

The CHDS data are not freely available as we do not currently have ethical approval to upload these data to any repository and this prevents us from sharing this data in this way. However, data are available on request, subject to approval by the Christchurch Health and Development Study Director: chds.uoc@otago.ac.nz.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2024.103246.

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