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Regular Article

Patterns of resilient functioning in early life: Identifying distinct groups and associated factors

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Abstract

Resilience, the capacity to maintain or regain functionality in the face of adversity, is a dynamic process influenced by individual, familial, and community factors. Despite its variability, distinct resilience trajectories can be identified within populations, yet the predictors defining these distinct groups remains largely unclear. Here, using data from the Avon Longitudinal Study of Parents and Children (ages 0-18), we quantify resilience as the remaining variance in psychosocial functioning after taking into account the exposure to adversity. Growth mixture modeling identified seven distinct resilience trajectories, with over half of the study population maintaining resilience throughout early life. Factors increasing the likelihood of resilient trajectory membership included a less emotional temperament, high cognitive abilities, high self-esteem, low levels of autistic social traits, strong sibling relationships, high maternal care, and positive school experiences. Among the socioeconomic factors considered, maternal education – a significant indicator of socioeconomic status – and birth-order were associated with resilient trajectories. Our findings underscore the importance of fostering cognitive abilities, self-esteem, social relationships, positive school experiences, and extracurricular engagement to bolster resilience in adversity-exposed individuals and communities. This research informs resilience-focused interventions in mental health, education, and social policy sectors, and prompts further exploration of socioeconomic influences on resilience trajectories.

Keywords: resilience; early-life adversity; protective factors; ALSPAC; trajectory modeling

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Introduction

Psychological resilience is often understood as the capacity to maintain or recover one's functionality in the face of adversity, although its definition remains contentious, with various interpretations in the literature (Southwick et al., 2014). However, there is a lot of variation in how researchers define, study, and measure resilience. Recent research aims to standardize the measurement and definition of resilience by quantifying it as the remaining variance in psychosocial functioning after taking into account the exposure to adversity (Ioannidis et al., 2020).

The dynamic nature of resilience

Current research highlights the importance of temporal dynamics for conceptualizing and operationalizing resilience in helping us understand how individuals cope with adversity over time, and how they adapt and transform in response to changing circumstances (Bonanno et al., 2015; Ioannidis et al., 2020; Kalisch et al., 2017, 2020). The adaptive nature of an individual's capacity to maximize the likelihood of positive outcomes when faced with increased risk or adversity can only really be understood by looking at how they change over time because resilience is not necessarily a fixed trait; it can vary depending on the nature and severity of stressors, as well as the individual's resources and support systems (Luthar et al., 2000). This perspective emphasizes the dynamic nature of resilience and expands on studies focussing on resilience as a fixed trait. Therefore, resilience reflects an individual's trajectory of functioning following exposure to heightened risk or adversity (Bonanno & Diminich, 2013). Understanding how individuals deal with adversity differently and how this ability changes over time can help us develop strategies that support individuals in coping with stressors and adversities over time, emphasize the importance of ongoing support and resources to maintain and enhance resilience, while also offering us the unique opportunity to understand important determinants of resilient trajectories.

Latent growth modeling and resilience

Previous studies that have looked at how individual's functioning changes over time in response to stress and adversity have found significant variation between individuals. (Bonanno & Mancini, 2012; Galatzer-Levy et al., 2018; Infurna & Luthar, 2017). Data-driven modeling approaches, such as latent growth mixture modeling and latent growth curve analysis (LGCA), have been used to identify different trajectories of change following adversity. These approaches study repeated measures data over time and

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focus on between-person differences in stability and change. Briefly, latent growth models are a statistical method used to understand how a certain behavior or outcome changes over time within individuals. It is "latent" because it is based on underlying unobserved factors that influence the change, rather than directly observed measures. Latent growth models estimate the initial level or intercept of the behavior, the rate of change or slope, and the individual differences in these two factors. The model allows researchers to examine how the growth trajectory of a given behavior differs between individuals and groups, and to identify predictors of such differences. While our study focuses specifically on the impacts of ACEs, we believe it contributes to the broader understanding of resilience across the early lifespan. We acknowledge that our study does not include other well-known resilience groups such as those with chronic or terminal illness, or disability. However, our aim is to identify homogenous subpopulations of individuals who share similar patterns of resilient functioning over time, particularly in the context of ACEs (Masten, 2014).

Within longitudinal studies of adjustment following adversity, the most commonly observed trajectories are resilience, recovery, chronic low, and growth (see Fig. 1). Within these trajectories, resilience is considered a trajectory of stable, healthy levels of psychological functioning following adversity (Galatzer-Levy et al., 2018; Infurna, 2021). Recovery can be observed by a decrease in psychological functioning due to adversity, followed by a return to previous levels of functioning. Growth encompasses enduring improvements as a result of the adversity (Infurna, 2021). Of note here is that the outcome in these models is some measure of psychological functioning. To our knowledge, despite the rapid proliferation of trajectory-based approaches to studying adjustment following potential trauma (Galatzer-Levy et al., 2018), no studies to date use a quantitative measure of resilience as the outcome.

The residuals approach to measuring resilience

Traditional measures of psychological functioning often capture an individual's current state or level of functioning. These measures, while valuable, do not necessarily account for the individual's exposure to adversity. In other words, two individuals may have the same level of psychological functioning, but one may have achieved this in the face of significant adversity, demonstrating resilience, while the other may not have faced such adversity.

The residuals approach to measuring resilience (Cahill et al., 2022), on the other hand, quantifies resilience as the residual variance in psychosocial functioning after accounting for the exposure to adversity (Ioannidis et al., 2020). This approach captures the individual's ability to maintain or recover functionality in the face of adversity, providing a measure of resilience that is adjusted for adversity. It allows us to identify individuals who perform better or worse than expected given their level of adversity, providing a more nuanced understanding of resilience.

By using this approach with latent growth modeling, we can capture the dynamic nature of resilience, showing how it changes over time in response to varying levels of adversity. This allows us to identify distinct subgroups of individuals who share similar patterns of resilient functioning over time. Using a quantitative measure of resilience has the further advantage of enabling the use of trajectory membership as an outcome in future genetic/epigenetic association studies as it draws on the statistical power of the whole sample, rather than having a diagnostic criteria or binary categorization of resilience.

The role of adverse childhood experiences (ACEs)

The residuals method for measuring resilience is based on the understanding that multiple factors contribute to psychosocial functioning. One of these factors is exposure to Adverse Childhood Experiences (ACEs). Research has consistently shown a strong association between ACEs and various physical and mental health outcomes (Felitti et al., 1998; Hughes et al., 2017). However, there is often a significant amount of variance in psychosocial functioning outcomes that cannot be explained solely by ACEs. The residuals approach aims to quantify resilient functioning as the residual variance in psychosocial functioning that remains after accounting for the influence of ACEs.

Resilience factors

A systematic review found that resilient functioning after adversity is facilitated by a combination of individual, family and community resilience factors (RFs) that support individuals to adapt and recover from ACEs (Fritz et al., 2018). At the individual level, factors such as cognitive reappraisal, low suppression of emotion, and a secure attachment have been found to be important. At the family level, factors such as extended family support, family cohesion, and positive parenting practices have been found to be related to resilience. At the community level, high social support and positive community environments have been found to change psychosocial and behavioral outcomes. While the wider literature suggests that RFs at the individual, family and community level are associated with a reduced likelihood of developing psychosocial problems (Crush et al., 2018; Fritz et al., 2018; Schaefer et al., 2018), no studies to date have examined how RFs predict latent subgroup membership of individuals who share mean levels of resilient functioning over time. By examining how RFs predict latent subgroup trajectories of resilient functioning over time, we can gain a better understanding of how relevant different RFs may be for different groups of people. Further, we can establish when certain RFs are more important for maintaining or gaining a resilient trajectory. Ultimately, this more granular understanding can inform the development of more targeted interventions for promoting resilience and preventing psychosocial problems. Additionally, by identifying subgroups of individuals who share similar levels of resilient functioning over time, we can gain insight into the underlying mechanisms that contribute to resilient functioning and identify potential targets for future research. This can help to fill the gaps in knowledge about resilience and its underlying mechanisms and contributes to a more nuanced understanding of resilience and its role in promoting mental health.

Aims and objectives

To address this, we are using a quantitative approach to establish resilience across the early lifecourse, using the residuals approach to measure resilience across different time periods (Cahill et al., 2022), then identifying quantitatively distinct latent subgroups of individuals who share similar patterns of resilient functioning over time. This approach allows us to hypothesize that these latent populations are differentiated not only by their level of resilient functioning, but also by how they change over time. These latent resilient groups can then be examined to establish the covariates, socioeconomic and resilience factors that determine trajectory membership. In this study, we define "resilience" as the dynamic ability to maintain or reclaim functionality in the face of adversity.

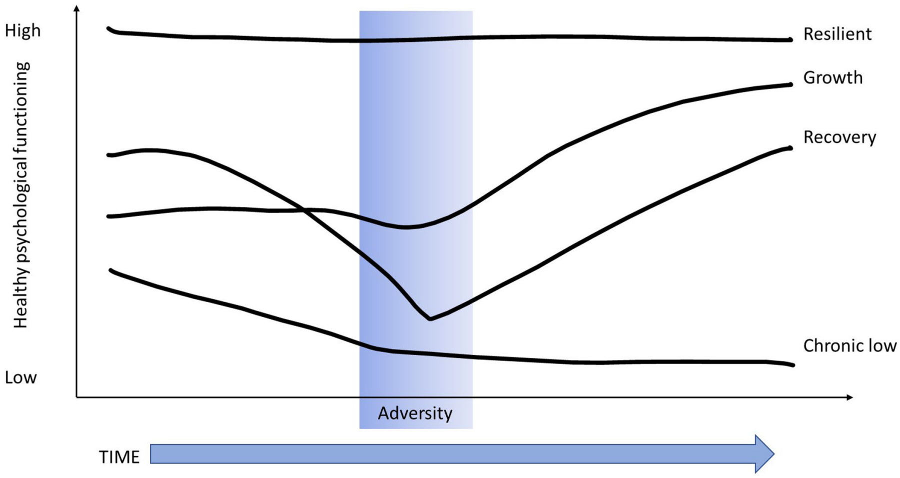

Figure 1. Graphical illustration of the most common trajectories or paths individuals may follow in the years leading up to and following adversity (Adapted from Infurna, 2021).

Specifically, we operationalize resilience using the residuals approach, where it is represented as the residual variance in psychosocial functioning after accounting for exposure to adversity. This approach emphasizes resilience as a process rather than a static state, aligning with the perspective of positive psychology and the understanding that resilience can evolve over time in response to adversity (Southwick et al., 2014). Contrasting with resilience, we use the term "vulnerability" to describe individuals more susceptible to negative outcomes when faced with adversity.

The aim of our study is to identify homogenous subpopulations of resilient functioning following childhood adversity using a new method, and to describe the longitudinal patterns specific to each subpopulation. We use established resilience factors at the individual, familial, and community level to explain trajectory membership in the context of early life adversity. By applying a new method for examining resilience, this study contributes to a more nuanced understanding of resilience and its role in promoting mental health. It also provides a foundation for future research to further explore and apply this method in different contexts and populations. Given that our study is centered on the impact of ACEs, we focus on individuals from birth to 18 years, as this is the period typically defined as childhood and adolescence. See Figure 2 for a visual conceptual framework of our model.

Materials and methods

Participants

The analyses use data from the Avon Longitudinal Study of Parents and Children (ALSPAC), a multigenerational, longitudinal cohort study that recruited pregnant women resident in the former Avon Health Authority in southwest England who had an estimated due date between 1st April 1991 and 31st December 1992 (Boyd et al., 2013; Fraser et al., 2013). The total sample size is 15,447 pregnancies, of which 14,901 children were alive at 1 year of age. After removing multiple births, our sample comprised 14,693 participants. The present analysis uses data from the prenatal period through to 18 years old. Please note that the study website contains details of all the data that is available through a fully searchable data dictionary and variable search tool (http://www.bristol.ac.uk/alspac/researchers/our-data/). Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. See Supplementary figure S1 for an overview of the study design and assessment timepoints.

Adverse childhood experiences (ACEs)

In ALSPAC, 18 measures of adverse childhood experiences (ACEs) were collected at multiple time points over a period of 18 years from either the mother, the mother's partner, or the child, respectively using questionnaires or during clinic. Most early life data (0-8 years) is parent-reported with questions asked about ACE exposure since the last questionnaire. For example, "did × occur since 8th birthday"; "x occurred when the child was 6 or 7 years old", "x did not occur within the last 3 years". When the child was 8 years old they began self-reporting ACEs. Information on adversities was also collected at six clinics that the child visited between the ages of 8.5–15.5 years. The participants also retrospectively reported on child maltreatment (several forms of abuse and neglect), in their twenties, but we removed these measures of ACEs due to previously reported poor agreement between prospectively and retrospectively measured data (Baldwin et al., 2019). While we chose to rely on prospective reports of ACEs in this study, we acknowledge that retrospective reports can provide valuable insights into experiences of adversity that may not be captured in prospective reports (Hardt & Rutter, 2004; Reuben et al., 2016). Retrospective reports can capture different aspects of adversity, including experiences that were not reported at the time due to fear or embarrassment, and can provide insights into the individual's interpretation and understanding of their experiences. However, retrospective reports can also be influenced by recall bias, which can affect their accuracy. We acknowledge that our decision to exclude retrospective reports may have resulted in the omission of some experiences of adversity and may have influenced our findings. Future research should consider the potential value of incorporating both prospective and retrospective reports of ACEs to provide a more comprehensive understanding of experiences of adversity and their impact on mental health (Baldwin et al., 2019).

For each early life period considered in the analysis (prenatal, infancy (0–1 years), early childhood (3–6 years), mid childhood (6–9 years), late childhood (9–11 years), transition (11–13 years), adolescence (13–16 years)). ACE constructs were derived as binary measures of exposure as described by Houtepen and colleagues for specific use within the ALSPAC cohort, to encourage replication (Houtepen et al., 2018). An "extended" ACEs approach was used

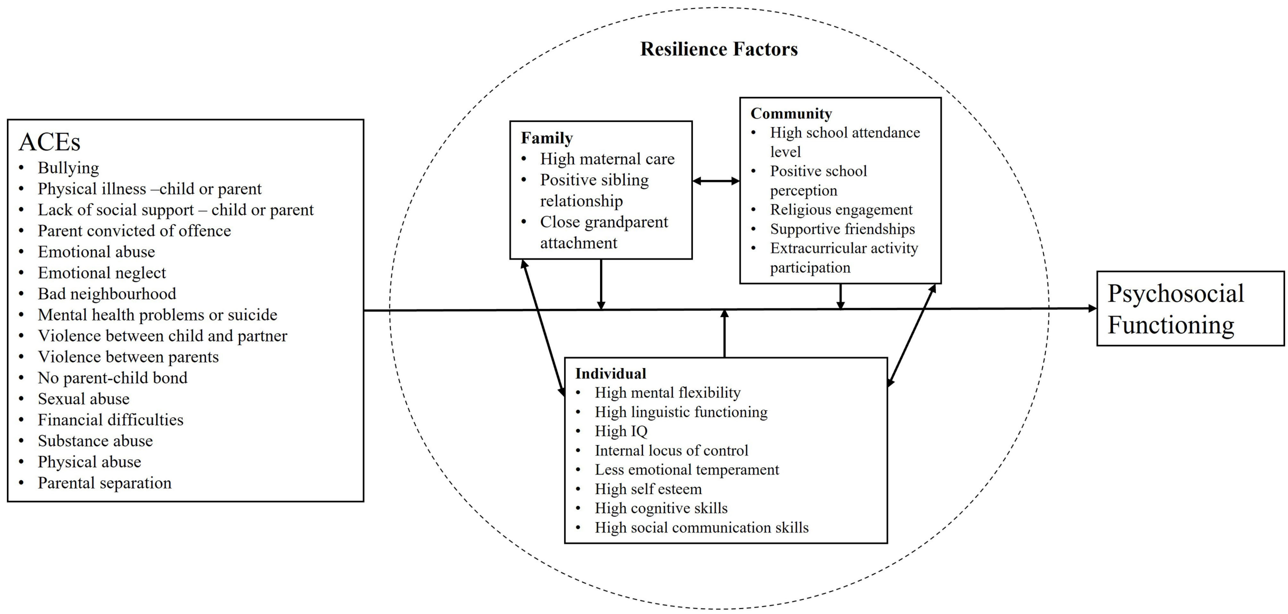

Figure 2. Conceptual framework of psychological resilience among children and adolescence affected by ACEs.

where we considered not only the "classic" ACEs (Felitti et al., 1998), but also additional adversities that have been shown to predict long-term mental health and well-being outcomes such as low parent–child bonding, low social support and financial difficulties (Finkelhor et al., 2015; Houtepen et al., 2018; Yap et al., 2014). If an ACE was reported by more than one informant at the same time point, we combine information from multiple informants to create a more robust measure of each ACE (Houtepen et al., 2018). See Table 1 for each ACE construct, the definition, who responded to the question and what time period the adversity covers. Supplementary table 1 shows the exact variables, timepoints, methods of data collection and dichotomization criteria for each ACE construct.

We have included each individual ACE in our analyses, rather than reporting cumulative ACE scores for several reasons. The ACE score approach assumes that all adversities are correlated (Evans et al., 2013), which has been shown not to be true, specifically within the ALSPAC population (Lacey et al., 2022). Additionally, a specific consideration within resilience research is that measurement of stressor exposures within resilience studies should include a wide range of adversities – what is a stressor for some may not be stressor for others. Further, evidence suggests treating an ACE like an isolated stressor is artificial because any major "stressor" is likely to be followed by other stressors (Kalisch et al., 2015). For instance, a child who has experienced neglect may have a harder time developing healthy relationships and may be more likely to experience additional stressors such as poverty or unemployment later in life. This means that ACEs are often part of a complex web of interconnected stressors, rather than isolated events. Research suggests that people who have experienced multiple ACEs, rather than just one, may be at a higher risk of developing mental health problems, and may have a harder time recovering from them (Anda et al., 2006; Edwards et al., 2003; Felitti et al., 1998). This highlights the importance of treating ACEs not just as isolated stressors, but as part of a broader pattern of vulnerability and resilience in people's lives.

Psychosocial functioning

The Revised Rutter Parent Scale for Preschool Children was used to assess child mental health and behavioral/emotional problems at 3 years 6 months (Elander & Rutter, 1996). The Rutter Behaviour Scale (RBS) was maternally reported and is a 43-item questionnaire based on the Preschool Behaviour Questionnaire (Behar & Stringfield, 1974). The scale yields frequency scores of reported behaviors on three subscales: emotional difficulties, conduct difficulties and hyperactivity difficulties. Responses are scored using a three-point Likert scale and the answer summed to give a total difficulties score.

The Strength and Difficulties Questionnaire (SDQ) is one of the most commonly used ratings of child psychopathology in epidemiological studies (Goodman, 1997). The SDQ questionnaire is reported by the main carer at 6 years 9 months, 9 years 7 months, 11 years 8 months, 13 years 1 month and 16 years 6 months. The SDQ comprises 20 items relating to four different psychosocial scales: emotional symptoms; conduct problems; hyperactivity/inattention and peer problems. Responses are scored using a three-point Likert scale and the answer summed to give a total difficulties score out of 40.

We are using SDQ and RBS total difficulties scores rather than the subscale scores both for simplicity and because we are primarily interested in discovering general resilience mechanisms, i.e., mechanisms that protect not only against single, but several, mental dysfunctions.

Resilience

Using multiple linear regression models, we regressed the total difficulties score of the RBS and SDQ on binary exposures of all ACES experienced before the psychosocial functioning measurement timepoint. We extracted the residuals from each regression model as these reflect a spectrum ranging from risk to resilient functioning i.e., the extent to which an individual has better, or

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Table 1. ACE constructs, definitions, respondents, and time period covered. The first 10 ACE constructs are considered "classic" and those with * are considered "extended" (Felitti et al., 1998)

ACE construct	Definition	Respondent/ Collection type	Time period covered						
			Prenatal	Infancy	Early Childhood	Mid Childhood	Late Childhood	Transition	Adolescence
Sexual Abuse	Child was sexually abused	Child based or child completed questionnaire							
Physical Abuse	Mother or partner was physically cruel/hurt the child	Mother completed and partner completed questionnaire							
Emotional Abuse	Carer was emotionally cruel towards the child	Mother completed and partner completed questionnaire							
Emotional Neglect	Child always feels left out, not understood by parents, carer never asked or listened when child talks about free time	Child completed questionnaire, clinic collection							
Bullying	Child was a victim of bullying on a weekly basis	Child completed questionnaire, clinic collection							
Violence Between Parents	Parents were affected by physically cruel behavior by partner: hitting, choking, beating, strangling, threatening or using a weapon	Mother completed and partner completed questionnaire							
Household Substance Abuse	Parent had alcohol problem, drug addiction or used hard drugs, and cannabis	Mother completed and partner completed questionnaire							
Parental Mental Health Problems	Parent has been diagnosed with schizophrenia, bulimia or anorexia nervosa, hospitalized for psychiatric problems, taken medication for anxiety or depression, attempted suicide or self-harmed, reached clinical cut off on the EPDS	Mother, partner, and child completed questionnaire							
Parent Convicted Offense	Parent has been convicted of an offense	Mother completed and partner completed questionnaire							
Parental Separation	Parents divorced or separated	Mother, partner, and child completed questionnaire							
Financial Difficulties*	Struggled to afford heating/ food, became homeless	Mother completed and partner completed questionnaire							
Poor Neighborhood*	Bad opinion of neighborhood and not happy to live there.	Mother and child completed questionnaire and child clinic session							
Low Social Support – Child*	Has no friends, or no one who understand/support them	Child clinic session							
Low Social Support – Parent*	Has no one to share feelings with	Mother completed and partner completed questionnaire							

(*Continued*)

Table 1. (*Continued*)

ACE construct	Definition	Respondent/ Collection type	Time period covered: Prenatal	Infancy	Early Childhood	Mid Childhood	Late Childhood	Transition	Adolescence
Intimate Partner Violence*	Someone they have been out with has used a form of violence against them	Child clinic session							
Physical Illness – Child*	Have been hospitalized or have a medical condition or physical disability	Child based questionnaire, school completed questionnaire							
Physical Illness – Parent*	Has been hospitalized or has cancer	Mother completed and partner completed questionnaire							
Low Parent–Child Bond*	Parent/child does not feel close. No harmonious adult/ child interaction	Mother completed and partner completed questionnaire and child clinic session							

Note: The yellow shading represents time periods during which the ACEs information was collected.

worse, SDQ outcomes than the average score expected given their exposure to ACEs over the early life periods. This provides six separate quantitative measures of resilience across each individual life course. All ACE predictors were entered into each regression model to capture the cumulative impact of all ACEs on resilience (VanderWeele & Shpitser, 2013). We conducted a variance inflation factor (VIF) analysis to assess multicollinearity among the predictors, and the VIF values were within acceptable limits (O'brien, 2007). See Supplementary table three for outcomes of the regression analyses.

Resilience factors

Potential individual, family and community factors associated with resilience were chosen based on previous studies (Fritz et al., 2018; Khambati et al., 2018) as described elsewhere (Cahill et al., 2022), provided they were available in the ALSPAC dataset. This approach allowed us to examine a broad range of resilience factors, while also acknowledging the constraints of the available data. See supplementary Table 2 for a full description of how each resilience factor was derived within the ALSPAC sample, including methods and times of measurement.

Covariates

The analyses were adjusted for demographic, socioeconomic, lifestyle and health variables that have previously been associated with ACE measures or psychosocial functioning. These included sex of the child (male/female); maternal age at birth; birthweight; gestation; maternal smoking in the 2nd trimester of pregnancy (yes/no); parity, defined as the number of times that the woman had given birth to a child with a gestational age of 24 weeks or more; ethnicity of the child (white/BAME); socioeconomic status based on maternal and partner educational attainment (none/Certificate of Standard Education to University degree); occupational social class as classified by the Office of Population Censuses and Surveys in 1990 (classes I (professional/managerial) to V (unskilled/manual workers)); home ownership at birth (rented/owned); marital status at birth (married/not married) and mother BMI category pre-pregnancy (underweight, normal weight, overweight, obese).

Missing data

Missing data on all ACE items (outcome variables and covariates) were estimated using multiple imputation by chained equations (MI). The proportion of missingness in the analytic sample ranged from 0% to 73.8%, with the mean level of missing data being 43.9%. Sex was the only variable, other than ID, to have 0% missingness and was not imputed. All variables except ID number were used as predictors in the imputation models. MI is a method for estimating missing information under the assumption that the data is Missing at Random (MAR) (Little & Rubin, 2019). However, even if the assumption of Not Missing at Random holds, MI can still produce less biased results compared to listwise deletion (van Ginkel et al., 2020). If all variables associated with the missing data generation processes are included in the imputation models then missing values can be more plausibly imputed (Ploubidis et al., 2014). In this study, ACE measures were calculated for participants who answered at least 50% of the questions used to derive the binary measures of ACEs (Houtepen et al., 2018). It should be noted that these participants have higher socioeconomic status than the full cohort, and therefore including only these participants might result in an underestimation of ACE occurrence and potential selection bias (Howe et al., 2013). To make the MAR assumption more plausible, we included sociodemographic indicators that are associated with missingness such as many of the ACEs, SDQ outcomes, mother's home ownership status at birth, mother and partner's highest educational qualification, maternal age at birth, maternal marital status at birth, birthweight, parity, gestational age, maternal BMI, maternal smoking during pregnancy, alcohol dependency, ethnicity of the child. Given the complexity of the imputation model and the computational resources available, we employed the Multivariate Imputation by Chained Equations (MICE) package

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version 3.11.0 in R 4.0.3, generating 20 imputed datasets with 20 iterations per dataset (Buuren & Groothuis-Oudshoorn, 2010). Comparison of observed and imputed data (Supplementary Table 4) indicated that, as expected, the missingness rate was higher among more deprived participants (Howe et al., 2013), and the disadvantaged sociodemographic indicators (manual social class, low parental education, and rented home tenure) were lower in the original data than in the imputed data. Additionally, the ACE exposure estimates were higher in the imputed data as expected.

Statistical analyses

All analyses were performed in R version 4.0.3 (2020-10-10), *Rstudio* version 1.3.1093 for Windows.

Overview of modeling process:

1. Construct resilience residuals at each time point separately:

Our measure of resilience was derived from the residuals of six multiple linear regression models, one per time point, where the binary exposures of ACEs experienced in the early life periods preceding the outcomes were regressed on the total difficulties score of the SDQ and RBS at that time point.

Model outlines:

Model 1 = RBS at 3 years 6 months ~ Prenatal + Infancy ACEs

Model 2 = SDQ at 6 years 9 months ~ Prenatal + Infancy + Early Childhood ACEs

Model 3 = SDQ at 9 years 7 months ~ Prenatal + Infancy + Early C + Mid C ACEs

Model 4 = SDQ at 11 years 8 months ~ Prenatal + Infancy + Early C + Mid C + Late C ACEs

Model 5 = SDQ at 13 years 1 month ~ Prenatal + Infancy + Early C + Mid C + Late C + Transition ACEs

Model 6 = SDQ at 16 years 6 months ~ Prenatal + Infancy + Early C + Mid C + Late C + Transition + Adolescent ACEs. (See Supplementary table 3 for the results of Models 1–6)

2. Use the residuals derived at stage 1 as the outcomes for the Growth Mixture Model (GMM):

GMM was used to identify group-based longitudinal trajectories of resilient functioning by creating a longitudinal dataset with the six repeated measures of resilience, as derived in step one. This method is characterized by the combination of latent growth modeling with latent class analysis (Herle et al., 2020), and it enabled us to group the study participants into distinct groups representing different levels of resilient functioning over time. The optimal number of trajectories was identified using a multi-step approach (see Supplementary Methods for more information on the construction, interpretation, and criteria of model specification). The optimal class solution was determined using the lowest Bayesian Information Criterion. All GMM analyses was performed using “lcmm” package version 1.9.5 (Proust-Lima et al., 2017).

3. Regress trajectory classes on covariates and resilience factors:

The associations between covariates, resilience factors and resilience trajectories were tested using multinomial logistic regression analysis using “nnet” package version 7.3-17 in R 4.0.3 (Venables & Ripley, 2002). Trajectory membership class was the outcome, with resilience factors and covariates the predictors. Given our interest in finding out what resilience factors are associated with a resilient rather than vulnerable trajectory, the most vulnerable trajectory (Class 1 – Vulnerable to very vulnerable) was chosen as the reference category (see Fig. 3).

Results

Descriptive statistics

The sample is roughly evenly split between male (51%) and female (49%) children. The average maternal age at birth is 28 and most mothers owned their home and were married (74%) at the time of birth. Most children were the first child in their family (45%). An overwhelming majority of participants identified as white (97%), just under a quarter of the mothers were classed as overweight or obese (24%), according to BMI, and mothers and their partners had similar education levels. See Supplementary table 5 for descriptive results of key demographics, outcomes measured at the different timepoints and resilience factors.

The characteristics of the study participants in the observed and imputed data are presented in Supplementary table 4. The distribution of the observed and imputed data are similar, suggesting the MICE analysis achieved its goals. We illustrate the prevalence of ACEs across early life periods in Figure 4, and results of the regression models 1–6 are presented in Supplementary table 3.

Resilience

Resilience was derived at six separate time points using the residuals method as outlined above. Resilience was evenly distributed at each time period (Supplementary Figure 3). The ACEs associated with SDQ outcomes at each time period can be found in Supplementary table 3. ACEs previously associated with psychosocial problems were also associated with an increase in total difficulties as measured by the SDQ, following expected patterns. The term, “vulnerability” is used to contrast with resilience and describe individuals who are more likely to experience negative outcomes in the face of adversity. We acknowledge that vulnerability is not the only antonym of resilience, and that resilience research often involves a spectrum of outcomes, from vulnerability to resilience, with many possible states in between (Masten, 2014).

Group-based trajectories of resilience

We selected a 7-class LGCA model of resilient functioning trajectories (Fig. 3). See Supplementary Methods for more information on the construction, interpretation, and criteria of model specification. Table 2 shows the latent class characteristics of these seven trajectories. In presenting the seven classes of resilient functioning, we have chosen to maintain the order in which they were identified during the analysis, rather than attempting to rank them based on their resilient functioning. This order does not reflect a hierarchy of “worst” to “best” resilience. Each class represents a unique trajectory of resilience and vulnerability over time, reflecting the complex and dynamic nature of resilience. Additionally, when we use the terms “high” or “moderate” we are qualitatively describing the relative levels of resilient functioning observed in the different trajectories, rather than denoting specific cutoff points or categories of resilient functioning.

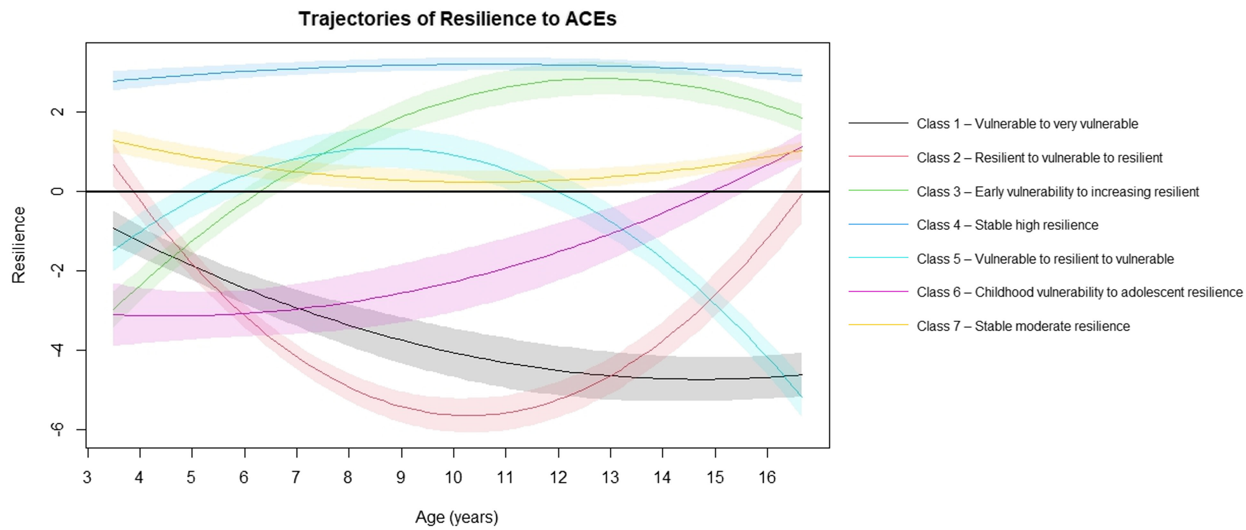

Figure 3. Group-based trajectories of resilience to ACEs. MI ALSPAC sample. Trajectories with a positive score represent resilience and those with a negative score represent vulnerability.

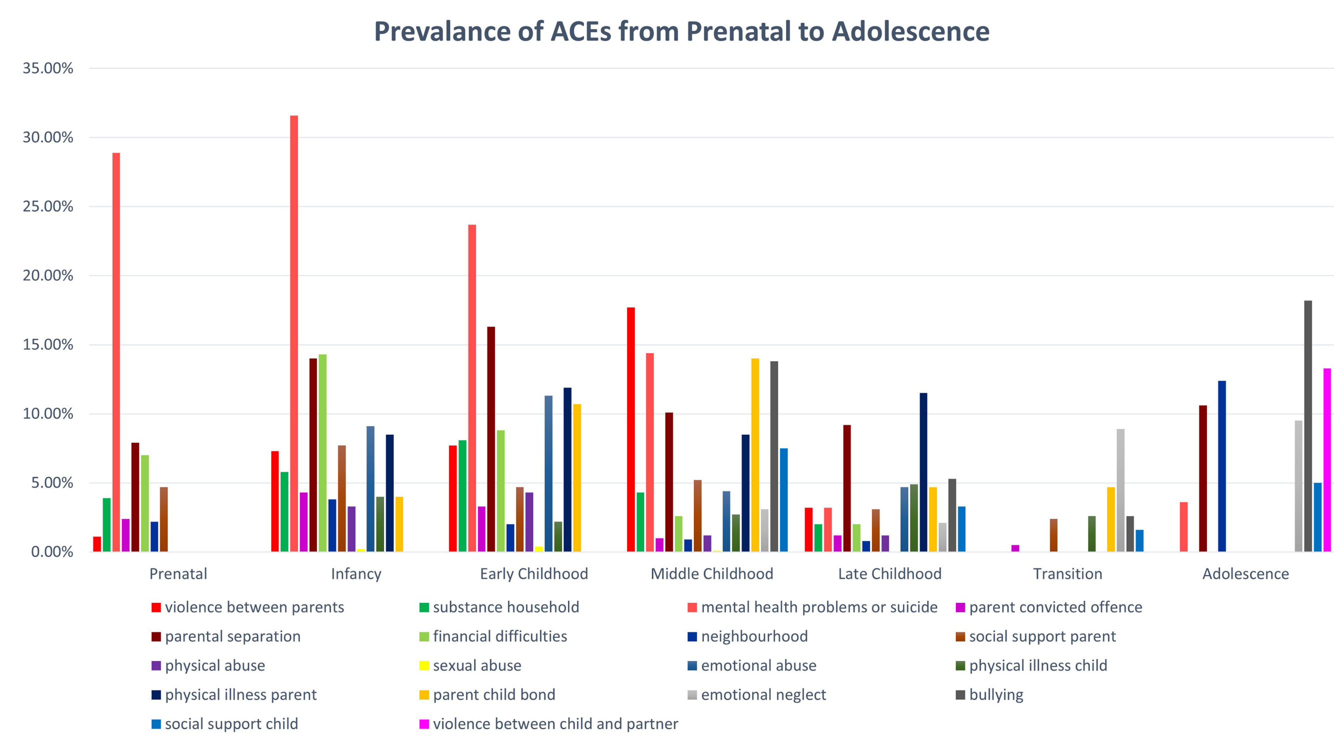

Figure 4. Prevalence of ACEs from prenatal to adolescence. Emotional neglect, bullying, and social support of the child was not measured until middle childhood. Violence between child and partner was only measured in adolescence. Physical abuse, emotional abuse, and physical illness of a parent was only measured until late childhood. Violence between parents, substance abuse in the household, parental convictions, financial difficulties, parental social support, parent–child bond, and physical illness of a child were not collected in adolescence.

Class 1 – Vulnerable to very vulnerable (12.71% of study population), representing participants who were vulnerable in infancy and early childhood with increasing vulnerability into adolescence.

Class 2 – Resilient to vulnerable to resilient (5.76%), representing participants who started off resilient in early life but became vulnerable at approximately 4 years old with increasingly vulnerability throughout the early life course until approximately 10 years old when vulnerability starts to steadily decrease.

Class 3 – Early vulnerability to increasing resilient (13.24%), representing individuals who begin life vulnerable with a rapid decrease in vulnerability until about age 6–7 years when they become resilient and remain resilient at a high level until adolescence.

Class 4 – Stable high resilience (26.16%), representing participants who maintain high levels of resilient functioning throughout the early life course.

Class 5 – Vulnerable to resilient to vulnerable (5.26%), representing individuals who begin life vulnerable, become

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Table 2. Latent class characteristics of the favored LGCA model of individuals within the ALSPAC cohort

		Class 1, $N = 1{,}866$	Class 2, $N = 846$	Class 3, $N = 1{,}945$	Class 4, $N = 3{,}842$	Class 5, $N = 772$	Class 6, $N = 1{,}502$	Class 7, $N = 3{,}914$
		Vulnerable to very vulnerable	Resilient to vulnerable to resilient	Early vulnerability to increasing resilient	Stable high resilience	Vulnerable to resilient to vulnerable	Childhood vulnerability to adolescent resilience	Stable moderate resilience
Sex	Male	974 (52%)	474 (56%)	1,029 (53%)	1,811 (47%)	327 (42%)	865 (58%)	2,012 (51%)
	Female	892 (48%)	372 (44%)	916 (47%)	2,031 (53%)	445 (58%)	637 (42%)	1,902 (49%)
Maternal Age		28 (25, 31)	28 (24, 31)	28 (24, 31)	28 (25, 32)	28 (25, 31)	28(24, 31)	28 (25, 31)
Home Ownership Birth	Owned	1,347 (72%)	555 (66%)	1,433 (74%)	2,933 (76%)	562 (73%)	1,095 (73%)	2,928 (75%)
	Rented	519 (28%)	291 (34%)	512 (26%)	909 (24%)	210 (27%)	407 (27%)	986 (25%)
Marital Status Birth	Not Married	496 (27%)	260 (31%)	550 (28%)	933 (24%)	228 (30%)	424 (28%)	969 (25%)
	Married	1,370 (73%)	586 (69%)	1,395 (72%)	2,909 (76%)	544 (70%)	1,078 (72%)	2,945 (75%)
Parity	0	863 (46%)	419 (50%)	866 (45%)	1,619 (42%)	365 (47%)	704 (47%)	1,745 (45%)
	1	591 (32%)	234 (28%)	660 (34%)	1,250 (33%)	248 (32%)	505 (34%)	1,316 (34%)
	2	291 (16%)	121 (14%)	266 (14%)	646 (17%)	106 (14%)	213 (14%)	567 (14%)
	3	72 (3.9%)	44 (5.2%)	105 (5.4%)	211 (5.5%)	39 (5.1%)	61 (4.1%)	172 (4.4%)
	4	30 (1.6%)	17 (2.0%)	34 (1.7%)	75 (2.0%)	7 (0.9%)	16 (1.1%)	80 (2.0%)
	5+	19 (1.0%)	11 (1.3%)	14 (0.7%)	41 (1.1%)	7 (0.9%)	<5 (0.2%)	34 (0.9%)
Ethnicity	White	1,797 (96%)	808 (96%)	1,880 (97%)	3,714 (97%)	755 (98%)	1,461 (97%)	3,797 (97%)
	BAME	69 (3.7%)	38 (4.5%)	65 (3.3%)	128 (3.3%)	17 (2.2%)	41 (2.7%)	117 (3.0%)
Maternal BMI Category	Underweight	125 (6.7%)	65 (7.7%)	110 (5.7%)	215 (5.6%)	41 (5.3%)	92 (6.1%)	202 (5.2%)
	Normal weight	1,266 (68%)	556 (66%)	1,393 (72%)	2,745 (71%)	547 (71%)	1,042 (69%)	2,780 (71%)
	Overweight	328 (18%)	146 (17%)	318 (16%)	628 (16%)	136 (18%)	255 (17%)	656 (17%)
	Obese	147 (7.9%)	79 (9.3%)	124 (6.4%)	254 (6.6%)	48 (6.2%)	113 (7.5%)	276 (7.1%)
Maternal Highest Education	CSE	462 (25%)	257 (30%)	392 (20%)	781 (20%)	164 (21%)	342 (23%)	825 (21%)
	Vocational	214 (11%)	83 (9.8%)	185 (9.5%)	367 (9.6%)	81 (10%)	147 (9.8%)	437 (11%)
	O level	622 (33%)	253 (30%)	667 (34%)	1,153 (30%)	268 (35%)	501 (33%)	1,347 (34%)
	A level	338 (18%)	167 (20%)	442 (23%)	955 (25%)	152 (20%)	304 (20%)	782 (20%)
	Degree	230 (12%)	86 (10%)	259 (13%)	586 (15%)	107 (14%)	208 (14%)	523 (13%)
Partner Highest Education	CSE	594 (32%)	277 (33%)	518 (27%)	1,031 (27%)	230 (30%)	422 (28%)	1,084 (28%)
	Vocational	172 (9.2%)	81 (9.6%)	164 (8.4%)	307 (8.0%)	59 (7.6%)	144 (9.6%)	386 (9.9%)
	O level	385 (21%)	179 (21%)	393 (20%)	770 (20%)	158 (20%)	333 (22%)	764 (20%)
	A level	419 (22%)	193 (23%)	497 (26%)	912 (24%)	196 (25%)	352 (23%)	943 (24%)
	Degree	296 (16%)	116 (14%)	373 (19%)	822 (21%)	129 (17%)	251 (17%)	737 (19%)

(*Continued*)

Table 2. (*Continued*)

		Class 1, $N = 1,866$	Class 2, $N = 846$	Class 3, $N = 1,945$	Class 4, $N = 3,842$	Class 5, $N = 772$	Class 6, $N = 1,502$	Class 7, $N = 3,914$
		Vulnerable to very vulnerable	Resilient to vulnerable to resilient	Early vulnerability to increasing resilient	Stable high resilience	Vulnerable to resilient to vulnerable	Childhood vulnerability to adolescent resilience	Stable moderate resilience
Birthweight (kg)		3.40 (3.06, 3.72)	3.33 (2.96, 3.68)	3.42 (3.10, 3.74)	3.46 (3.12, 3.76)	3.42 (3.11, 3.74)	3.40 (3.06, 3.74)	3.42 (3.10, 3.76)
Gestation Category	Extremely Preterm	7 (0.4%)	<5 (0.5%)	5 (0.3%)	7 (0.2%)	1 (0.1%)	6 (0.4%)	9 (0.2%)
	Very Preterm	24 (1.3%)	16 (1.9%)	7 (0.4%)	42 (1.1%)	9 (1.2%)	14 (0.9%)	31 (0.8%)
	Late Preterm	85 (4.6%)	51 (6.0%)	88 (4.5%)	154 (4.0%)	30 (3.9%)	83 (5.5%)	186 (4.8%)
	On Time	1,737 (93%)	767 (91%)	1,839 (95%)	3,621 (94%)	729 (94%)	1,389 (92%)	3,665 (94%)
	Post-term	13 (0.7%)	8 (0.9%)	6 (0.3%)	18 (0.5%)	<5 (0.4%)	10 (0.7%)	23 (0.6%)
Maternal Smoking in Pregnancy	No	1,479 (79%)	637 (75%)	1,531 (79%)	3,128 (81%)	618 (80%)	1,129 (75%)	3,152 (81%)
	Yes	387 (21%)	209 (25%)	414 (21%)	714 (19%)	154 (20%)	373 (25%)	762 (19%)
Household Social Class	I - Professional	140 (7.5%)	53 (6.3%)	183 (9.4%)	409 (11%)	74 (9.6%)	118 (7.9%)	354 (9.0%)
	II - Managerial and technical	446 (24%)	202 (24%)	548 (28%)	1,051 (27%)	179 (23%)	443 (29%)	1,038 (27%)
	IIINM - Skilled non-manual	211 (11%)	110 (13%)	216 (11%)	507 (13%)	99 (13%)	140 (9.3%)	453 (12%)
	IIIM - Skilled manual	806 (43%)	341 (40%)	746 (38%)	1,337 (35%)	329 (43%)	602 (40%)	1,519 (39%)
	IV - Partly skilled	166 (8.9%)	71 (8.4%)	158 (8.1%)	313 (8.1%)	61 (7.9%)	117 (7.8%)	327 (8.4%)
	V - Unskilled	97 (5.2%)	69 (8.2%)	94 (4.8%)	225 (5.9%)	30 (3.9%)	82 (5.5%)	223 (5.7%)

resilient at about 5–6 years and remain resilient until about 12 years when they have rapid increasing vulnerability.

Class 6 – Childhood vulnerability to adolescent resilience (10.23%), representing individuals who begin early childhood as vulnerable with slow decreasing vulnerability, reaching resilience about 15 years with increasing resilience after this.

Class 7 – Stable moderate resilience (26.65%), representing participants who maintain moderate levels of resilient functioning throughout the early life course.

Association of resilience factors with trajectories of resilient functioning

Covariates

We adjusted each of the multinomial models for covariates that have previously been associated with measures of psychosocial functioning or outcomes associated with exposure to ACEs. See Supplementary table 6 and Supplementary figure 2 for covariates associations with trajectories (Pseudo r^2: 0.038).

Individual resilience factors

We began by examining which previously reported individual resilience factors were associated with increased odds of membership to each trajectory when compared to belonging to a vulnerable trajectory. We report the stable high resilience and stable moderate resilience trajectory associations first, given our main aim is resilient trajectory membership (Supplementary table 7; Fig. 5a–c).

Stable high resilience trajectory: Individual resilience factors that were associated with increased odds of belonging to a stable high resilient trajectory rather than a vulnerable to very vulnerable trajectory include having high cognitive skills at 6 years 9 months (OR = 2.64 [95% CI: 1.51; 4.63] $p < 0.001$); high reading accuracy at 9 years (OR = 1.02 [95% CI: 1.00; 1.02] $p < 0.001$); a less emotional temperament at 5 years 8 months (OR = 1.23 [95% CI: 1.20; 1.25] $p < 0.001$); high self-esteem at 8 years, on either the scholastic competence (OR = 1.03 [95% CI: 1.01; 1.05] $p = 0.0015$) or global self-worth scale (OR = 1.05 [95% CI: 1.03; 1.07] $p < 0.001$); and having a high (OR = 1.41 [95% CI: 1.12; 1.77] $p = 0.003$) or exceptionally high (OR = 1.68 [95% CI: 1.28; 2.23] $p < 0.001$) compared to average IQ. Conversely, having a low IQ compared to an average IQ (OR = 0.53 [95% CI: 0.42; 0.64] $p < 0.001$), and high autistic social and communication traits at 7 years 7 months (OR = 0.69 [95% CI: 0.68; 0.71] $p < 0.001$) are associated with reduced odds of belonging to a stable high resilient trajectory.

Stable moderate resilience trajectory: Individual resilience factors that were associated with increased odds of belonging to a stable moderate resilience trajectory rather than a vulnerable to very vulnerable trajectory include having a less emotional temperament at 5 years 8 months (OR = 1.12 [95% CI: 1.10; 1.14] $p < 0.001$); high self-esteem at 8 years, on the global self-worth scale, (OR = 1.04 [95% CI: 1.02; 1.06] $p < 0.001$) and having an exceptionally high IQ compared to an average IQ (OR = 1.51 [95% CI: 1.16; 2.00] $p < 0.001$). Conversely, having a low compared to an average IQ (OR = 0.67 [95% CI: 0.54; 0.83] $p < 0.001$), and high autistic social and communication traits at 7 years 7 months (OR = 0.69 [95% CI: 0.68; 0.71] $p < 0.001$) are associated with reduced odds of belonging to a stable high resilient trajectory.

Resilient to vulnerable to resilient trajectory: The only individual resilient factor that was associated with increased odds of belonging to a resilient to vulnerable to resilient trajectory rather than a vulnerable trajectory was having an externalized rather than internalized locus of control (an individual's perceived control over events in their life) at 8 years 6 months (OR = 1.24 [95% CI: 1.03; 1.49] $p = 0.026$).

Early vulnerability to increasing resilient trajectory: Individual resilience factors that were associated with increased odds of belonging to an early vulnerability to increasing resilient trajectory rather than a vulnerable to very vulnerable trajectory include having a less emotional temperament at 5 years 8 months (OR = 1.05 [95% CI: 1.03; 1.07] $p < 0.001$); high self-esteem on the scholastic competence scale at 8 years (OR = 1.04 [95% CI: 1.02; 1.07] $p < 0.001$), having an exceptionally high (OR = 1.55 [95% CI: 1.15; 2.10] $p = 0.004$) or low average (OR = 1.05 [95% CI: 1.03; 1.07] $p < 0.001$) compared to an average IQ. Conversely, having an exceptionally low (OR = 0.58 [95% CI: 0.38; 0.88] $p = 0.011$) or low IQ (OR = 0.74 [95% CI: 0.58; 0.95] $p = 0.02$) and high autistic social and communication traits at 7 years 7 months (OR = 0.85 [95% CI: 0.83; 0.86] $p < 0.001$) are associated with reduced odds of belonging to an early vulnerability to increasing resilient trajectory.

Vulnerable to resilient to vulnerable trajectory: The only individual resilience factor that was associated with increased odds of belonging to a vulnerable to resilient to vulnerable trajectory was having a less emotional temperament at 5 years 8 months (OR = 1.07 [95% CI: 1.05; 1.10] $p < 0.001$). Having a low IQ (OR = 0.63 [95% CI: 0.45; 0.89] $p = 0.008$) compared to an average IQ and high autistic social and communication traits at 7 years 7 months (OR = 0.87 [95% CI: 0.85; 0.89] $p < 0.001$) are associated with reduced odds of belonging to a vulnerable to resilient to vulnerable trajectory.

Childhood vulnerability to adolescent resilience trajectory: Individual resilience factors that were associated with increased odds of belonging to a childhood vulnerability to adolescent resilience trajectory rather than a vulnerable to very vulnerable trajectory include having high reading comprehension at 9 years (OR = 1.02 [95% CI: 1.00; 1.03] $p = 0.0087$) and high scholastic competence at 8 years (OR = 1.02 [95% CI: 1.00; 1.04] $p = 0.044$). Conversely, having a less emotional temperament at 5 years 8 months (OR = 0.97 [95% CI: 0.95; 0.99] $p = 0.002$) and high autistic social and communication traits at 7 years 7 months (OR = 0.97 [95% CI: 0.96; 0.99] $p < 0.001$) are associated with reduced odds of belonging to a childhood vulnerability to adolescent resilience trajectory rather than a vulnerable to very vulnerable trajectory.

Family resilience factors

Next, we examined which previously identified family resilience factors (RFs) were associated with increased odds of membership to each trajectory when compared to belonging to a vulnerable trajectory. See Supplementary table 8 for the results of the multinomial logistic regression analysis and Figure 6a and b for visualized associations (Pseudo $r^2 = 0.074$).

Stable high resilience trajectory: Family resilience factors that were associated with increased odds of belonging to a stable high resilient trajectory rather than a vulnerable to very vulnerable trajectory include having a positive sibling relationship at 11 years (OR = 1.082 [95% CI: 1.07; 1.10] $p < 0.001$) and having high levels of maternal care interactions at 18 months (OR = 1.02 [95% CI: 1.00; 1.03] $p < 0.001$) and 38 months (OR = 1.05 [95% CI: 1.01; 1.10] $p = 0.02$). Conversely, having high levels of maternal care interactions at 11 years (OR = 0.98 [95% CI: 0.97; 0.99] $p < 0.001$) was associated with reduced odds of belonging to a stable high resilient trajectory.

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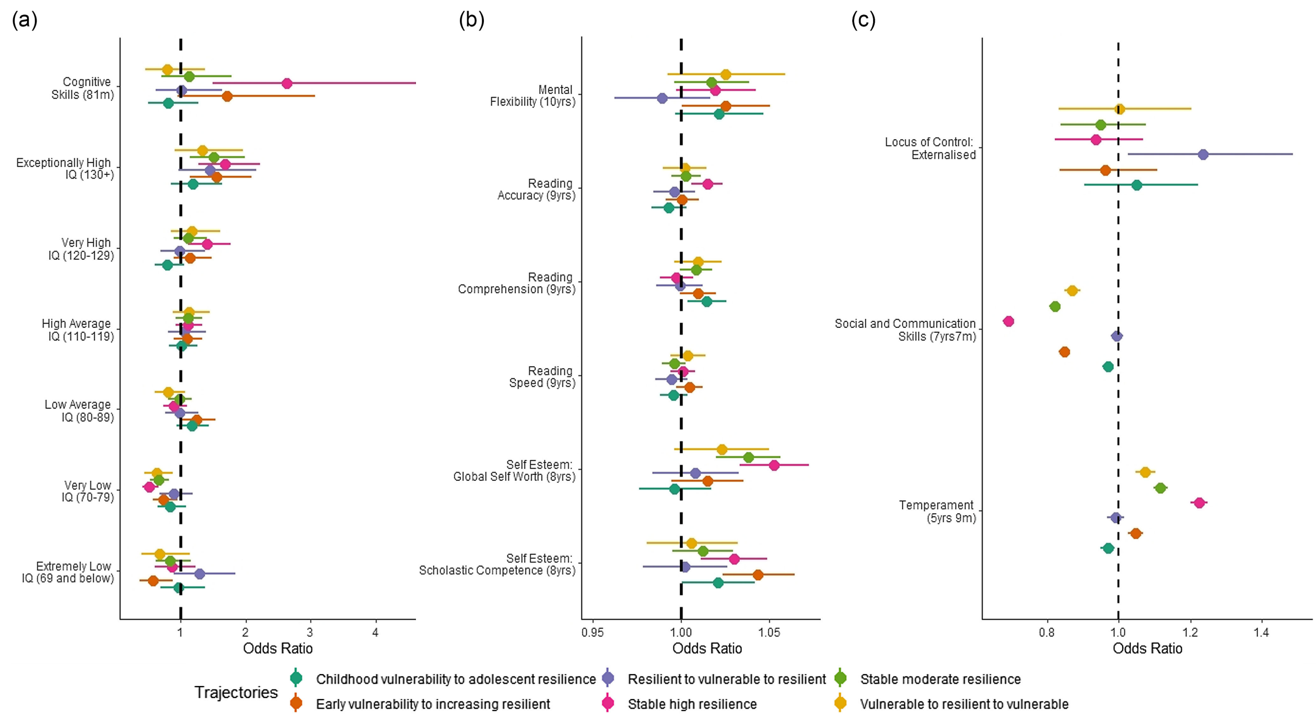

Figure 5. ***a***, ***b***, and ***c***. Associations between individual resilience factors and resilience trajectories compared to the reference category (Class 1 – vulnerable to very vulnerable). Pooled estimates from multinomial logistic regression models across 20 imputed datasets. Adjusted for sex, maternal age, homeownership status at birth, marital status at birth, parity, ethnicity, mother and partners education level, gestation, maternal smoking in 2nd trimester, and maternal BMI. Pseudo $r^2 = 0.267$.

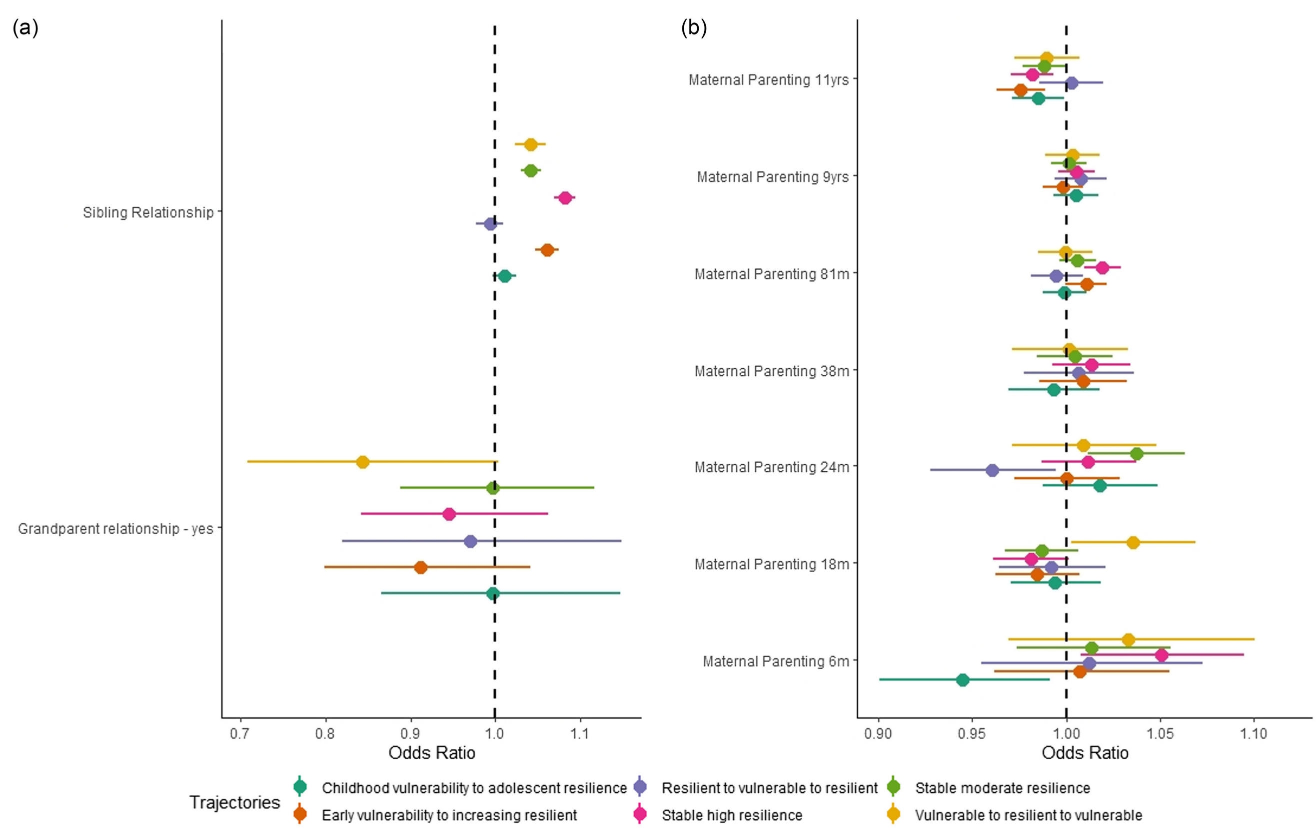

Figure 6. ***a*** and ***b***. Associations between family resilience factors and resilience trajectories compared to the reference category (Class 1 – vulnerable to very vulnerable). Pooled estimates from multinomial logistic regression models across 20 imputed datasets. Adjusted for sex, maternal age, homeownership status at birth, marital status at birth, parity, ethnicity, mother and partners education level, gestation, maternal smoking in 2nd trimester, and maternal BMI. Pseudo $r^2 = 0.074$.

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Stable moderate resilience trajectory: Family resilience factors that were associated with increased odds of belonging to a stable moderate resilient trajectory, rather than a vulnerable to very vulnerable trajectory, include having a positive sibling relationship at 11 years (OR = 1.04 [95% CI: 1.03; 1.05] $p < 0.001$) and having high levels of maternal care interactions at 6 months (OR = 1.04 [95% CI: 1.01; 1.06] $p < 0.005$). Conversely, having high levels of maternal care interactions at 11 years (OR = 0.99 [95% CI: 0.97; 1.00] $p < 0.05$) was associated with reduced odds of belonging to a stable high resilient trajectory.

Resilient to vulnerable to resilient trajectory: The only family resilience factor that was associated with belonging to a resilient to vulnerable to resilient trajectory rather than a vulnerable trajectory was high levels of maternal care interactions at 6 months which reduced odds (OR = 0.96 [95% CI: 0.93; 0.99] $p = 0.023$)

Early vulnerability to increasing resilient trajectory: The only family resilience factor that was associated with increased odds of belonging to an early vulnerability to increasing resilient trajectory rather than a vulnerable trajectory was having a positive sibling relationship at 11 years (OR = 1.06 [95% CI: 1.05; 1.08] $p < 0.001$). Conversely, having high levels of maternal care interactions at 11 years (OR = 0.98 [95% CI: 0.96; 0.99] $p < 0.001$) was associated with reduced odds of belonging to an early vulnerability to increasing resilient trajectory.

Vulnerable to resilient to vulnerable trajectory: Family resilience factors that were associated with increased odds of belonging to a vulnerable to resilient to vulnerable trajectory rather than a vulnerable to very vulnerable trajectory include having a positive sibling relationship at 11 years (OR = 1.04 [95% CI: 1.02; 1.06] $p < 0.001$) and having high levels of maternal care interactions at 9 years (OR = 1.04 [95% CI: 1.00; 1.07] $p < 0.05$).

Childhood vulnerability to adolescent resilience trajectory: The only family resilience factor that was associated with belonging to a childhood vulnerability to adolescent resilience trajectory rather than a vulnerable trajectory was high levels of maternal care interactions at 11 years, which reduced the odds of belonging to this trajectory (OR = 0.98 [95% CI: 0.97; 0.99] $p < 0.05$).

Community resilience factors

Finally, we examined which previously identified community RFs were associated with increased odds of membership to each trajectory when compared to belonging to a vulnerable trajectory. Supplementary Table 9 gives the results of the multinomial logistic regression analysis, which are illustrated in in Figure 7 (Pseudo $r^2 = 0.058$).

Stable high resilience trajectory: Community resilience factors that were associated with increased odds of belonging to a stable high resilient trajectory rather than a vulnerable to very vulnerable trajectory include having supportive friendships at 12 years 6 months (OR = 1.092 [95% CI: 1.06; 1.12] $p < 0.001$); having high school attendance rate at 7 years (OR = 1.56 [95% CI: 1.27; 1.91] $p < 0.001$); having a positive perception of school 11 years (OR = 1.11 [95% CI: 1.09; 1.12] $p < 0.001$); and regularly participating in extracurricular activities at 9 years (OR = 1.21 [95% CI: 1.05; 1.40] $p < 0.05$) and 16 years (OR = 1.33 [95% CI: 1.17; 1.50] $p < 0.001$).

Stable moderate resilience trajectory: Community resilience factors associated with increased odds of belonging to a stable moderate resilient trajectory rather than a vulnerable to very vulnerable trajectory include supportive friendships at 12 years 6 months (OR = 1.072 [95% CI: 1.05; 1.10] $p < 0.001$); high school attendance rate at 7 years (OR = 1.45[95% CI: 1.19; 1.76] $p < 0.005$); having a positive perception of school 11 years (OR = 1.06 [95% CI: 1.05; 1.08] $p < 0.001$); and regularly participating in extracurricular activities at 9 years (OR = 1.23 [95% CI: 1.07; 1.42] $p < 0.005$).

Resilient to vulnerable to resilient trajectory: Community resilience factors that were associated with increased odds of belonging to a resilient to vulnerable to resilient trajectory rather than a vulnerable to very vulnerable trajectory include high school attendance rate at 7 years (OR = 1.40 [95% CI: 1.04 1.89] $p < 0.05$); and regularly participating in extracurricular activities at 16 years (OR = 1.29 [95% CI: 1.08; 1.53] $p < 0.005$).

Early vulnerability to increasing resilient trajectory: Community resilience factors associated with increased odds of belonging to an early vulnerability to increasing resilient trajectory rather than a vulnerable to very vulnerable trajectory include supportive friendships at 12 years 6 months (OR = 1.112 [95% CI: 1.08; 1.15] $p < 0.001$); a positive perception of school 11 years (OR = 1.05 [95% CI: 1.03; 1.07] $p < 0.001$); and regularly participating in extracurricular activities at 16 years (OR = 1.43 [95% CI: 1.25; 1.64] $p<0.001$). Conversely, engagement with religion at 9 years (OR = 0.87 [95% CI: 0.76; 0.99] $p < 0.05$) was associated with reduced odds of belonging to an early vulnerability to increasing resilient trajectory.

Vulnerable to resilient to vulnerable trajectory: Community resilience factors that were associated with increased odds of belonging to a vulnerable to resilient to vulnerable trajectory rather than a vulnerable to very vulnerable trajectory include supportive friendships at 12 years 6 months (OR = 1.075 [95% CI: 1.03; 1.12] $p < 0.001$); high school attendance rate at 7 years (OR = 1.423 [95% CI: 1.04; 1.96] $p < 0.05$) and having a positive perception of school 11 years (OR = 1.04 [95% CI: 1.02; 1.07] $p < 0.001$). Conversely, being engaged with religion at 9 years (OR = 0.77 [95% CI: 0.65; 0.92] $p < 0.005$) was associated with reduced odds of belonging to a vulnerable to resilient to vulnerable trajectory.

Childhood vulnerability to adolescent resilience trajectory: Community resilience factors associated with increased odds of belonging to a childhood vulnerability to adolescent resilience trajectory rather than a vulnerable to very vulnerable trajectory include supportive friendships at 12 years 6 months (OR = 1.06 [95% CI: 1.03; 1.09] $p < 0.001$); a positive perception of school 11 years (OR = 1.02 [95% CI: 1.00; 1.03] $p<0.05$) and regularly participating in extracurricular activities at 16 years (OR = 1.26 [95% CI: 1.08; 1.45] $p < 0.005$).

Discussion

Trajectories of resilience

Using data from a large population cohort, we investigated the associations of resilience factors with longitudinal patterns of resilience from early childhood to adolescence. Our first question was whether the substantial heterogeneity evident in resilience and vulnerability, as measured using the validated residuals method (Cahill et al., 2022), could be characterized by distinct latent groups. Using data from ALSPAC, and accounting for missing data using MI, we identified seven latent groups that demonstrated distinct profiles of change in resilience over the early life course. Despite rapid proliferation of the trajectory approach as a tool to identify patterns in mean levels of functioning indicators over time, to our knowledge no published studies have applied the trajectory approach to resilience using the specific method we employed. We first quantified resilient functioning as the residual variance in psychosocial functioning after accounting for the exposure to

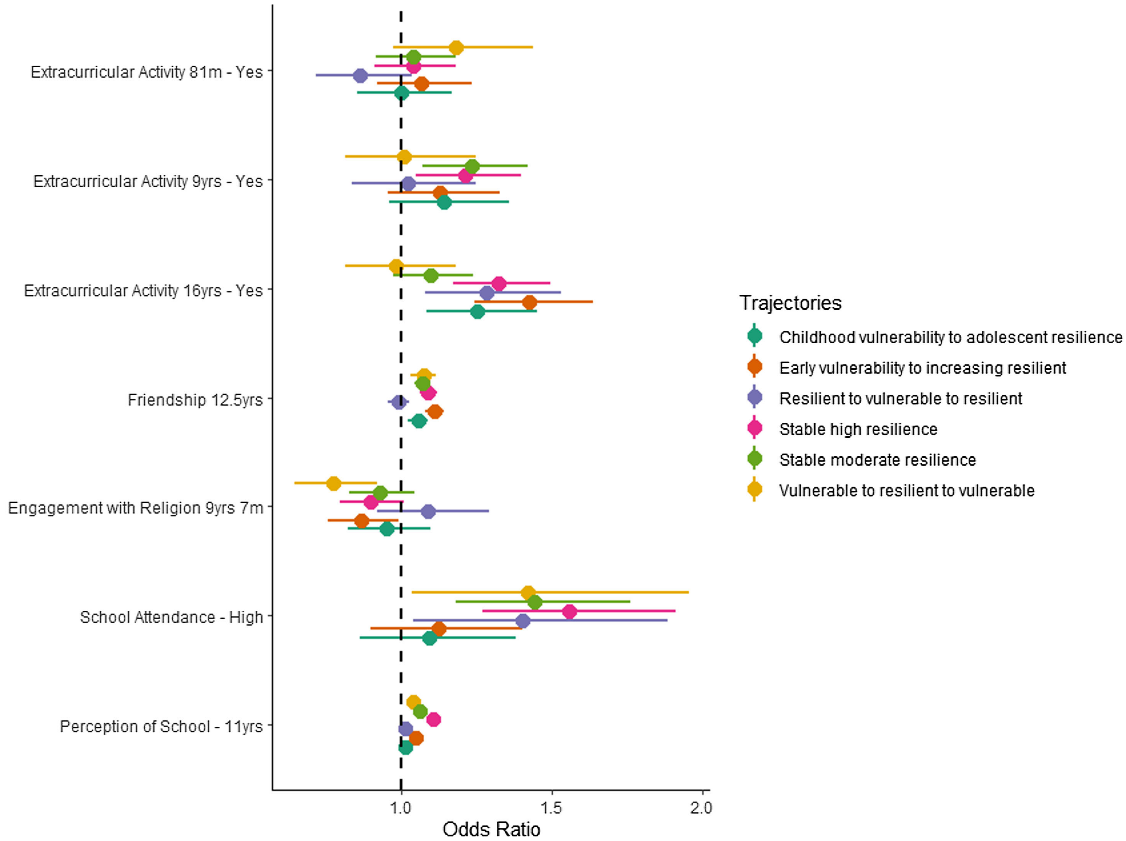

Figure 7. Associations between community resilience factors and resilience trajectories compared to the reference category (Class 1 – vulnerable to very vulnerable). Pooled estimates from multinomial logistic regression models across 20 imputed datasets. Adjusted for sex, maternal age, homeownership status at birth, marital status at birth, parity, ethnicity, mother and partners education level, gestation, maternal smoking in 2nd trimester, and maternal BMI. Pseudo $r^2 = 0.058$.

adversity. We then used latent growth mixture modeling to identify distinct trajectories of resilient functioning over time. This approach provides a novel way to model resilience that captures its dynamic nature and allows for individual differences in resilience to be explored.

We found the most common trajectories were those of stable high (26.16% of study population) and stable moderate resilience (26.65%), representing participants who maintain resilient functioning at moderate and high levels throughout the early life course. The result that over 50% of the study population maintain a resilient trajectory throughout the early life course is highly concordant with previous studies that suggest resilience is the most common response to major life stressors and potential trauma (Bonanno, 2021; Galatzer-Levy et al., 2018; Quale & Schanke, 2010; Schultebraucks et al., 2021; deRoon-Cassini et al., 2010). The five remaining trajectories identified in the study were: vulnerable to very vulnerable (12.71%), vulnerable to resilient (5.76%), early vulnerability to increasing resilient (13.24%), vulnerable to resilient to vulnerable (5.26%), and childhood vulnerability to adolescent resilience (10.23%). These trajectories represent different patterns of vulnerability and resilience in individuals from infancy to adolescence.

In interpreting our findings, it is important to note our operational definition of resilience. Our use of the term "better than average" does not imply a comparison with a static mean score of the entire population. It represents an individual's ability to function above what is expected given their specific exposure ACEs. This dynamic benchmark adjusts based on the adversity level an individual has faced. Our results indicating that over 50% of the study population maintained a resilient trajectory should not be seen as merely scoring above a static mean. It underscores their capability to function above expectations, given their specific adversity exposure. This approach offers a detailed perspective on resilience and emphasizes the multifaceted nature of the resilience construct.

In comparing our findings to previous studies, it is important to consider the age differences in the study populations. The studies we referenced above encompass a range of age groups, with mean ages ranging from 39.1 to 55.96 years. Our study, in contrast, focuses on the early life course, spanning from early childhood to adolescence. This period is critical for the development of resilience and vulnerability to adversity. Our approach, therefore, provides a unique perspective on the dynamic nature of resilience as it unfolds over time, from childhood through adolescence. While our approach may differ from those of the referenced studies, we believe it offers valuable insights into the early life course trajectories of resilience.

Associations of resilience factors with resilience trajectories

The second aim of our research was to identify resilience factors at the individual, familial and community level that explain trajectory membership. We used the vulnerable to very vulnerable trajectory as the reference group because we are interested in identifying resilience factors associated with a resilient or "functioning better

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than expected given exposure to adversity" trajectory. All of the other trajectories have some form of resilience, either consistently resilient, or early or late resilience in the early life course. In this study, we use the term "resilience factors" to refer to variables that have been associated with resilience in previous research. While not all of these factors were predictive of resilience trajectories in our study, we believe that they are important to consider in the context of resilience research. We acknowledge that the effects of these factors on resilience may be complex and context-dependent, and further research is needed to fully understand their role in promoting resilience.

Individual resilience factors A less emotional temperament was associated with increased odds of belonging to a trajectory that experienced resilience through the early life course to adolescence, with the highest increase in odds of being in the stable high trajectory. This finding is consistent with previous research showing that children with less emotional temperaments are less reactive to stressors, better able to regulate their feelings of sadness and anger, more likely to maintain positive adaptation and activate flexible coping strategies to deal with adversity (Ahrens et al., 2021; Compas et al., 2004; Martinez-Torteya et al., 2009; Olson et al., 2002). This capacity for emotion regulation, broadly defined as the ability to identify and accept emotional experiences, control impulsive behaviors when distressed, and flexibly modulate emotional responses as situationally appropriate (Renna et al., 2017), is considered a key mechanism in psychological health, and is crucial for adaptive functioning (Aldao et al., 2010). By contrast, a more emotional temperament at 5 years, which suggests a difficulty in changing one's emotion in order to maintain a preferred emotional state following a stressor, increased the likelihood of belonging to the childhood vulnerability, adolescent resilient trajectory. Individuals in this trajectory are vulnerable until about 14/15 years old. Having good reading comprehension at 9 years and high scholastic competence at 8 years, also increased the odds of belonging to this trajectory. People who cannot regulate their emotional responses effectively to stressors are theorized to experience longer, more severe periods of distress (Aldao et al., 2010). Although resilience encompasses much more than emotion regulation, given the large effect sizes of temperament in this study, and previous research proposing the effective use of emotion regulation as crucial in reducing negative emotions after a stressor (Kay, 2016), we suggest that intervention aimed at emotion regulation for preschool children might be especially warranted as a modality to increase likelihood of belonging to a resilient trajectory (Lee et al., 2020). For example, open and randomized control trials have demonstrated considerable evidence for the utility of emotion regulation therapy (Renna et al., 2020), with music therapy evidenced to help young children manage emotion regulation-based arousal states (Moore & Hanson-Abromeit, 2023).

A higher than average IQ was also associated with increased odds of belonging to a trajectory that experienced resilience through the early life course to adolescence. Specifically, a high IQ increased odds of belonging to stable high resilient trajectory and having an exceptionally high IQ was associated with belonging to a stable high and moderate resilient, and early vulnerability to increasing resilient trajectory. Additionally, having an IQ below 70 was associated with a reduced odds of belonging to a trajectory that experienced resilience throughout the life course. High childhood IQ has been previously identified as a protective factor predicting resilient outcomes that persist from adolescence to adulthood (Luthar et al., 2000; Pargas et al., 2010; Tiet et al., 2001). Well-developed cognitive abilities and above average intelligence allows children to understand what is happening to them, to distinguish between what is controllable and what is not, make more circumstance-appropriate behavioral choices that could help them select and modify more supportive environments and employ a larger range of coping strategies (Buckner et al., 2003; Condly, 2006; Masten et al., 1999). High cognitive skills in early-mid childhood were also associated with increased odds of a stable high resilient trajectory, which have previously been associated with positive adaptation in the face of adversity (Gartland et al., 2019; Jaffee et al., 2007), lower levels of psychiatric disorders, lower rates of conduct problems and higher levels of overall functioning (Malcarne et al., 2000). We note that in our analysis, both validated tests of cognition and parent-rated cognitive skills were included in the same statistical model. The effects measured by cognitive skills variables are not the same as measured by the validated cognitive ability test (IQ). Given the former is a parent-rated measure, this may be providing insight into the parental beliefs about the child, or picking up on other aspects of cognition that are not measured in the standardized IQ test, such as coping ability.

High self-esteem, on both the global self-worth and scholastic competence subscale, was associated with increased odds of belonging to a stable high resilient trajectory. The global self-worth scale was also associated with a moderate resilient trajectory. Self-worth is an intrapersonal characteristic that has been previously reported to impact an individual's potential for resilience (Davey et al., 2003; Reyes, 2008). Individuals with high self-worth have high amounts of self-respect, and have positive feelings about themselves, their environment and their ability to deal with life's challenges, focussing on their strengths (Rutter, 1989; Werner, 1994). The employment of such effective coping strategies may serve as a buffer against the detrimental effects of adversity (Aldao et al., 2010). Higher self-worth has also been linked to positive cognitive reappraisal (Schwerdtfeger et al., 2019), an underlying mechanism that protects against stressors and mediates resilience factors via cognitive processes (Kalisch et al., 2015). High self-worth and low emotional temperament could also be described as generative, setting positive cascades in place that develop other contributing factors such as coping styles and emotion regulation (Luthar et al., 2006).

Among the predictors examined, good social skills, as measured by a low score on the Social Communication Disorders Checklist, showed a significant association with membership in a stable high or stable moderate resilience trajectory, noting that a high score represents a high level of autistic social traits (Skuse et al., 2005). Deficits in social communication can lead to behavior that is antisocial and disruptive (Gilmour et al., 2004), with a high proportion of children who have severe and persistent disruptive behavior found to have social communication impairments (Donno et al., 2010). There is a shared neurodevelopmental basis for autism and early-onset persistent antisocial behavior (Moffitt et al., 2001). While there is some evidence that behavioral-based interventions for teaching social interaction skills to children in a school setting can be highly effective (Camargo et al., 2016; Timler et al., 2007), the success of such interventions are dependent on moderating effects of neurocognitive and emotional regulatory functions of the individual (Fishbein et al., 2006). Given the presence of social communication deficits are considered a potential contributory factor to persistently disruptive behavior (Donno et al., 2010), and highly predictive of a vulnerable trajectory, these findings highlight the importance of effective screening for social communication problems at a young age.

Family Resilience Factors: Previous studies have identified high-quality caregiver relationships and stable family

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environments as resilience factors (Afifi & MacMillan, 2011; Gartland et al., 2019; Haskett et al., 2006). High levels of sibling interaction, as reported at 11 years 8 months by mothers, increased odds of belonging to a trajectory that experienced resilience through the early life course to adolescence. High-quality sibling relationships are a unique context which can have a direct impact on one another's socioemotional development, behavior and adjustment, and have been previously associated with increased resilience (Cahill et al., 2022; Dirks et al., 2015; McHale et al., 2012). Intervening in sibling interactions may be useful to encourage high-quality sibling relationships, with research suggesting that this is best achieved through family-centred approaches that build prosocial sibling interactions, curtail child behavior problems, and strengthen parenting (Stormshak et al., 2009).

A high level of maternal caregiving behavior in infancy increases the likelihood of belonging to a stable moderate resilient trajectory, and in early childhood a high level of maternal care predicts belonging to a stable high resilient trajectory. Interestingly, the same measure of maternal care at 11 years was associated with decreased odds of belonging to a stable high or moderate resilient trajectory. This suggests that the maternal care practices in infancy and early childhood that increased likelihood of resilience, now hinder the likeliness of belonging to a stable high or moderate resilient trajectory. 11 years old is the beginning of adolescence, a period of significant neurobehavioural reorganization whose changes may underlie the increased prevalence of psychopathology and emotion dysregulation observed during this developmental stage (Nelson et al., 2005; Spear, 2000; Thapar et al., 2012). These changes are concomitant with transformations in adolescents' social world, with increased affiliative tendencies towards peers and extra familial relationships, and an increasing need for autonomy (Blakemore & Mills, 2014; Forbes & Dahl, 2010). A limitation is that the maternal care measure in this study only captures maternally reported frequency of interactions and no measure of relationship quality. One potential explanation for the negative effect of maternal care at 11 years on resilience could be that the children who require higher maternal care interactions at this age when their peers are shifting towards autonomy, and those that are difficult or needy are more vulnerable. Future studies would benefit from including measures of maternal relationship quality to explore whether there are any significant differences between childhood and adolescence on these relationship dimensions that could explain the change in direction of this family resilience factor.

Family relationship features, particularly parenting practices and discord, contribute strongly to both the quality of sibling relationships and children's well-being (Stormshak et al., 2009). This suggests the totality of family support is more important for resilience than the quality of support from individual family members (Fritz et al., 2018).

Community Resilience Factors: Among community resilience factors, supportive friendships measured in adolescence, were associated with increased odds of belonging to a trajectory that experienced resilience through the early life course to adolescence. This is corroborated by prior research showing that adolescent friendship support promotes resilient functioning (Cahill et al., 2022; Collishaw et al., 2007; Powers et al., 2009; van Harmelen et al., 2016, 2017). Community resilience factors related to school, including a high attendance rate in mid childhood and positive perception of school at 11 years, were both associated with increased odds of belonging to a trajectory that experienced resilience through the early life course to adolescence. These extrinsic school-based factors are in keeping with the dynamic model of resilience, which conceptualizes resilience not as an individual trait but a process resulting from interactions across the life span, dependent upon context and resources (Cicchetti & Blender, 2006; Kalisch et al., 2017; Rutter, 2012). Ungar (2015) proposes that when stressors are particularly high, environmental factors become more critical for a person's resilience than individual characteristics or cognitive abilities.

Having a positive perception of school at 11 years and supportive friendships at 12 years was associated with the childhood vulnerability, adolescent resilient trajectory. From the individual resilience factors, having a more emotional temperament at 5 years, having good reading comprehension at 9 years and high scholastic competence at 8 years, also increased the odds of belonging to this trajectory. These results are suggestive of a moderating effect of positive engagement of school on individuals with a more emotional temperament. This underscores the importance of fostering positive school experiences and supportive friendships during childhood and adolescence, particularly for individuals with a more emotional temperament. It also highlights the potential role of academic competencies in promoting resilience. These findings suggest that interventions aimed at improving school experiences, strengthening friendships, and enhancing academic competencies could be beneficial for promoting resilience.

Extracurricular activities outside of school have the potential to expose children to supportive adults and peers through structured and supervised activities that promote self-efficacy, competence, and accomplishment (Dworkin et al., 2003; Hansen et al., 2003; Mahoney et al., 2003). As expected, extracurricular activity at 9 years was associated with a stable high and moderate resilient trajectory. Extracurricular activity at 16 years was only associated with the stable high resilient trajectory, the childhood vulnerability-adolescent resilient trajectory and the early vulnerability-increasing resilience trajectory – suggesting an adolescent specific protective factor.

An interesting finding that warrants further investigation is the association between religious engagement at 9 years and trajectory membership. Spirituality, religiosity or religious engagement have been repeatedly reported as a resilience factors (Chen et al., 2020; Helmreich et al., 2017), with a recent systematic review finding a moderate positive correlation between this and resilience (Schwalm et al., 2022). Surprisingly, our findings reported a reduced likelihood of belonging to an early vulnerability-increasing resilient trajectory, and similar effect size of reduced likelihood of belonging to a vulnerable-resilient-vulnerable trajectory than a vulnerable trajectory if there was maternally reported religious engagement at 9 years. This engagement was made up of maternally reported variables of whether the child visited a place of worship, and whether they ever prayed. The measurement does not capture intrinsic spirituality or religiosity and, similarly to the maternal care measure in this study, captures no measure of the individual's relationship to their religious engagement. There is some suggestion that early life religious attendance and health is mediated by adult religiosity (Upenieks & Schafer, 2020), so future research should consider both intrinsic spirituality/religiosity in childhood and later adulthood. Additionally, some studies have found that religious individuals may be more vulnerable to certain mental health problems, such as post-traumatic stress disorder (Bryant-Davis & Wong, 2013).

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Thus, the effect of both individual and parental religious engagement on resilient trajectories needs to be investigated in greater detail in future research.

Socioeconomic factors

Surprisingly, no socioeconomic factors (supplementary table 6) were associated with an increased likelihood of belonging to a stable moderate resilient trajectory. This result accords with our previous findings in our validity analysis of the residuals approach (Cahill et al., 2022), yet is still somewhat unexpected given the socioeconomically stratification of health, with individuals from disadvantaged backgrounds having a higher likelihood of experiencing negative physical and mental health outcomes compared to those from more socioeconomically advantaged backgrounds. (Marmot, 2005; WHO, 2021). This result could reflect the heavily middle-class nature of the parent sample, which is limited in socioeconomic stratification, despite imputation procedures to reduce bias. If social and economic position greatly impacts health, then it is crucial to understand how individuals emotionally and mentally cope with socioeconomic inequality. Belonging to a stable to high resilient trajectory was associated with maternal education to A level and the number of previous children. The association of higher maternal education with a stable high resilient trajectory underscores the significant role of maternal education as an indicator of socioeconomic status in influencing resilience (Reiss, 2013). The residuals approach likely captures the underlying resilience mechanisms of emotionally and mentally coping rather than the socioeconomic disadvantage itself. Clearly, further research is required using a more socioeconomically stratified study population.

It is worth noting that some of the confounding variables, such as socioeconomic position (SEP), can also act as protective factors in their own right (Evans et al., 2013). However, in our study, SEP was not found to be a significant predictor of resilience trajectories. This suggests that, in our sample, the effect of SEP on resilience may be less pronounced than the effects of other factors we considered. We also included a measure of financial difficulties as part of our ACE constructs, which can be seen as a proxy for low SEP. This allowed us to account for the potential impact of SEP on resilience. However, we acknowledge that the relationship between SEP and resilience is complex and multifaceted, and further research is needed to fully understand this relationship in the context of our study population.

Implications and considerations

In this study, we have applied a new method for examining resilience, using established resilience factors as a benchmark. This approach has allowed us to identify resilience factors at the individual, family, and community level, and to understand how these factors interact to promote resilience in the face of adversity. However, the shape and function of these processes may be culturally influenced or may interact with cultural demands and expectations in ways that are poorly understood. The results found here may be unique to the ALSPAC cohort, a cohort that is very white, and with a higher proportion of married mothers who own their own home than the rest of the general population. In future resilience research it will be critical to explore the extent to which factors found to promote resilience in one group will also be replicated across different cultural groups, and how the same factor found across multiple groups may function differently in different cultural contexts. This is of particular significance as cultural and ethnic groups may place varying degrees of importance on individualism, collectivism, and familism, and these dimensions may mediate resilience in different ways for different groups (Gaines Jr et al., 1997; Wright et al., 2013). We therefore need to expand and diversify future research to allow for these results to be translatable at the population level.

Our study has several limitations that should be noted. While we did not condition on any common effects of the ACEs, which should minimize the risk of collider bias (Greenland et al., 1999; Hernán & Monge, 2023), our approach may not fully eliminate the potential for spurious associations. Future research could consider alternative modeling approaches to further explore the relationships between ACEs, resilience, and other factors. While our study leverages the power of latent variable models to identify distinct trajectories of resilience, it is important to acknowledge the limitations of these approaches. Latent variable models make specific assumptions, including homogeneity within classes and the assumption that the observed variables are conditionally independent given the latent variable (Muthén, 2002). These assumptions may not always hold in practice, and violations can impact the accuracy of the model estimates. Additionally, determining the optimal number of classes in latent variable models can be challenging, and different criteria can suggest different solutions (Herle et al., 2020).

Successful adaptation to adversity requires a complex network of interactions between the family, school, neighborhood, community, and culture (Masten et al., 2006; Riley & Masten, 2005). A child's ability to overcome adversity is heavily influenced by these systems and the individuals within them. It is therefore critical to understand the interplay of various resilience factors in promoting mental health resilience. Our findings emphasize the need for a multi-dimensional, interrelated systems model to account for the various factors contributing to resilience following adversity. Additionally, while it was beyond the scope of this paper to examine how each resilience factor interacts with each trajectory, a key area to further examine is how each resilience factor associates with trajectories where individuals do not just maintain resilience, but also show variability/fluctuations throughout the life course. By identifying which resilience factors have an increased association with a change from vulnerability to resilience in the early life course, we would have a better insight into what works and when. The timing of any interventions could be dependent on this knowledge. Therefore, in order to effectively monitor the results over time, in multiple areas and at different system levels, it is necessary to construct complex models that capture changes in resilient functioning throughout the life course.

Conclusion

To our knowledge, this is the first trajectory-based approach to studying childhood adversity using a residuals approach to quantify resilience as the outcome. We identified seven distinct resilience trajectories and described longitudinal patterns specific to each trajectory. Our findings support a systemic framework of resilience and reinforce the effectiveness of our new method for examining resilience. Our findings contribute to a more nuanced understanding of resilience and its role in promoting mental health, and it provides a foundation for future research to further explore and apply this method in different contexts and populations.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0954579423001165.

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