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Development and Assessment of Cumulative Risk Measures of Family Environment and Parental Investments in the Longitudinal Study of Australian Children

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Abstract Longitudinal child cohort studies collect large amounts of information about children's families and the types of activities they participate in. With such a broad array of information to select from, researchers investigating aspects of the family environment may be overwhelmed by the choices available if they only need summary measures reflecting domains of the family environment. Using data from the *Longitudinal Study of Australian Children*, this study aimed to derive and assess summary indices of three domains of the family environment, including a Family Stress Index, Home Education Index and Parenting Index. Indices were derived by identifying a set of candidate indicators, dichotomising the indicators to determine elements of risk, then averaging across the dichotomised items to create measures that captured cumulative risk. Assessments of the three indices suggest that the measures are consistent across time, and have good predictive validity with socioeconomic measures and assessments of children's social-emotional wellbeing and learning outcomes. Structural equation models estimating children's outcomes suggested that models using the indices had comparable model fit to models using the broader array of variables used to construct the indices, but the Parenting Index in particular explained less variation in children's problem behaviour outcomes. Overall, the family environment indices derived in this study may be useful for researchers wishing to simplify complex models or explore the circumstances of children exposed to multiple risks, but less useful in analyses where the primary goal is to explain variance in children's developmental outcomes.

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1 Introduction

Over several decades researchers across a range of academic disciplines have sought to identify and explore socioeconomic inequalities in child development outcomes. With the literature consistently demonstrating that, on average, children from low-socioeconomic backgrounds have poorer outcomes on a range of measures than children from higher socioeconomic backgrounds (Bradley and Corwyn 2002; Duncan and Brooks-Gunn 1997), the research focus naturally turned to identifying the pathways and mechanisms that explain these socioeconomic gradients in child outcomes. Models such as the Family Stress Model (Conger and Conger 2002), the Family Investment Model, the Social Selection Hypothesis and more recently the Interactionist Model of Socioeconomic Influence (Conger and Donnellan 2007) have all identified potential mechanisms that link socioeconomic status to child outcomes. Broadly, these models focus on the family stress environment, and the ability of parents to invest materially and emotionally in their children, describe how these factors are affected by socioeconomic status, and in turn, how they relate to child development outcomes.

Some research studies are concerned with specific aspects of the home environment, for example parent mental health, or parenting style, and how these aspects relate to child outcomes. Other studies may only be concerned with broader home environment factors. For researchers using data from large child cohort studies, there may be a very large number of variables assessing different aspects of the home environment, and decisions need to be made about the best measures to use, and the best way of combining variables. A criticism of conventional multivariate approaches is that they do not explicitly describe the circumstances of children exposed to numerous risks at once. That is, although a regression model can describe the average effects of hostile parenting or maternal depression, for example, unless an interaction term is explicitly modelled this approach does not tell us about the experience of a child exposed to both hostile parenting and maternal depression. Modelling all possible interactions is unwieldy for studies containing numerous independent variables, and is rarely attempted.

Another way of handling multiple variables is to combine separate variables into composite measures. This approach allows researchers to present models that are less complex and more readily understood by a wide audience, including researchers, policy makers and the media. While composite or summary measures are advantageous in their simplicity, researchers also need to be confident that summary measures are still of sufficient quality and do not unnecessarily lose important information. The aim of this study is to describe and assess three indices of children's home and family environments, and to evaluate how well these indices perform compared to a broader array of individual variables.

To provide a context and basis for the derivation of the family environment indices, we first briefly review the theoretical models that explain how socioeconomic status is connected with children's outcomes. We then use these models as a basis for deriving three summary indices of the family environment using the Longitudinal Study of Australian Children.

1.1 Socioeconomic Status and Child Development Outcomes: Background

Disadvantage is associated with poorer outcomes across a number of domains for both adults and children, including physical health (Kahn et al. 2005), social and emotional wellbeing (Mistry et al. 2002; Yeung et al. 2002) and cognitive ability (Bradley and Corwyn 2002; Conger and Conger 2002; Conger et al. 2002; Duncan and Brooks-Gunn 1997; Haveman and Wolfe 1995). As children grow older, these early developmental disadvantages contribute to a higher likelihood of other potential outcomes in adulthood, including early school drop-out (Alexander et al. 1997), poor physical and mental health (Poulton et al. 2002; Repetti et al. 2002), lower educational attainment (Ou and Reynolds 2008) and higher prospects of unemployment (Caspi et al. 1998). The persistence of socioeconomic disadvantage and its negative consequence both across the individual life course, and across generations from parents to children, means that the topic is of great importance and relevance to researchers from a variety of backgrounds including psychology, sociology, epidemiology and economics, as well as to governments, policy makers and providers of social and financial support services.

There are several theoretical frameworks that explain the link between socioeconomic disadvantage and poor outcomes. They can be placed into two broad categories: the Social Causation perspective and the Social Selection perspective. The *Social Causation* perspective suggests that the social conditions in which children are raised lead to different outcomes for advantaged and disadvantaged children (e.g. Conger et al. 2002). In contrast, the *Social Selection* perspective suggests that the traits and dispositions of parents influence both the social status and the outcomes of their children (i.e. there is no causal relationship between low socioeconomic status and poorer outcomes). Combining both of these views, interactionist models (e.g. the Interactionist Model of Socioeconomic Influence) allow for both of these mechanisms, and suggest that individual traits (such as cognitive ability) are both inherited, genetically and socially, and contribute to adult socioeconomic status. We briefly review each of these perspectives in the following section.

1.2 The Social Causation Perspective

The Social Causation view posits that socioeconomic status is a catalyst for other experiences that prompt, facilitate or constrain child development. Within this perspective, the two main models aligned with the Social Causation perspective are the Family Stress Model (Conger and Conger 2002) and the Family Investment Model (Conger and Donnellan 2007).

The Family Stress Model (Conger and Conger 2002) proposes that financial difficulties will adversely affect parents' emotions, behaviours and relationships which in turn impact upon the way they parent and socialised their children. This combination of emotional and financial stress with diminished parenting capability (e.g. harsh, authoritarian parenting) then results in poorer outcomes for children, including their social and emotional wellbeing, health and cognitive wellbeing. Typically, this model is supported in the literature connecting socioeconomic status to social, emotional and behavioural child development outcomes rather than academic or cognitive outcomes (Kahn et al. 2005; Yeung et al. 2002).

The Family Investment Model (Conger and Donnellan 2007) proposes that families with fewer socioeconomic resources are less able to invest in their children, where

investments may take the form of time, money, resources and other social capital. Whereas socioeconomically advantaged families can make larger investments in the development of their children, disadvantaged families have more immediate family needs that need to be addressed before particular developmental needs of children can be addressed (Bradley and Corwyn 2002; Haveman and Wolfe 1994). While research based on the Family Investment Model often focusses on the material and economic investments parents could provide their children, investments may also be non-material and non-tangible investments like parenting style, attitudes and engagement which also foster the development of children and young people.

1.3 The Social Selection Perspective

In contrast to the Social Causation perspective, the Social Selection view conceptualises socioeconomic status (SES) as a range of outcomes that are influenced by individual differences and characteristics such as intelligence and personality. These individual differences facilitate the accumulation of social advantages, but are also transmitted from parents to children, either genetically (Rowe and Rodgers 1997) or by other social and environmental mechanisms (e.g. Becker 1981; Lerner 2003; Mayer 1997). The Social Selection view proposes that the associations between parent SES and child outcomes are caused by a third variable related to individual differences, where both parent SES and child development outcomes are driven by other parental characteristics, like intelligence. For example, a highly intelligent parent who, by virtue of that trait, has had the capability to excel at school, complete tertiary education, and obtain employment providing a high income. The parent passes this trait onto the child (either genetically and/or socially) who then has a high level of cognitive ability. Under the Social Selection model, parental traits drive both the socioeconomic status of the family and the developmental outcomes of the child.

1.4 The Interactionist Model of Socioeconomic Influence

The Social Selection and Social Causation perspectives each have corresponding strengths and weaknesses, and as such, neither perspective provides a complete explanation of socioeconomic gradients in child development outcomes. While the Social Causation view allows for the causal effects that social and economic shocks can have for child development, it does not account for the role of individual differences and human agency on developmental outcomes, or that possessing particular individual traits would benefit a child irrespective of family socioeconomic circumstances. Likewise, the Social Selection view minimises the role that socioeconomic circumstances allows for differential investments in child development. Combining elements of these opposing perspectives together, the Interactionist Model of Socioeconomic Influence (IMSI, Conger and Donnellan 2007), posits that individual attributes developed (or inherited) early in life affect socioeconomic status in adulthood, and adult SES in turn affects functioning as a parent and spouse even after controlling for these earlier traits. This reciprocal process then affects the development of the next generation of children.

Martin et al. (2010) used the interactive model as a framework to examine how problem behaviours in one generation might lead to similar behaviours in the next generation using two generations of family information from the Family Transitions Project. They found problem behaviours in adolescence predicted adult SES, family stress and parental emotional investments in adulthood, along with problem behaviours in their subsequent

offspring. In addition, SES in adulthood also predicted both broad measures of material and emotional investments in their offspring, which in turn predicted child problem behaviour in the next generation. Together, the results were consistent with the IMSI framework.

1.5 Measuring Family Environment Domains

There are many individual characteristics, traits, factors and circumstances that can explain socioeconomic gradients in child development outcomes, all of which interact in complex ways. The Martin et al. study described briefly above distilled a large number of parenting investments and interactions into three summary domains of the family environment that made a potentially complex series of relationships easier to understand. One domain was *family stress*, for example not being able to pay bills, heightened levels of anxiety or depression, or conflict between parents. The second was the *emotional environment* of the household, and in particular, the extent to which parents can emotionally interact with and invest in their children (e.g. through sensitive parenting). The third was the *home education environment,* which corresponds to the educational opportunities and resources that parents make available to their children. Each of these domains was associated with adult SES and children's problem behaviours, and provided a simple explanation about how these domains vary with SES and with children's developmental outcomes. For example, parents with limited financial means will have fewer resources at their disposal to invest in educational materials and experiences, which in turn could affect the cognitive development of children, particularly compared to children whose parents can afford an enriched home environment.

Martin et al. (2010) achieved their simple explanatory model by developing cumulative risk indices. Each risk index was a composite derived by combining a number of categorical and continuous risk factors which were first dichotomised (present = 1; absent = 0) and then summed across the dichotomised indicators to create a continuous index of risk for an individual. Evans et al. (2013) identify a number of advantages to using cumulative risk indices, including the reduction of measurement error (Ghiselli et al. 1981), noting that models based on multiple, correlated predictors can result in unstable estimates and diminished statistical power (Myers and Wells 2003). Evans et al. suggest that the widespread use of cumulative risk factors is due to the consistent finding that multiple risk factor exposure is more detrimental to child development than exposure to single risks, that is, the more risk factors that children are exposed to, the worse their developmental outcomes. They also suggest that examining multiple risk and protective factors where each factor is treated as an independent predictor may not necessarily be an accurate approach when most families experience a 'constellation' of risk and protective factors that co-occur together.

With their many advantages, cumulative risk indices have been used widely in studies of child development (Evans et al. 2013). In their review of the cumulative risk literature, Evans et al. identified over 400 studies using multiple or cumulative risk indices in studies of children's cognitive, social and emotional outcomes. Cumulative risk indices also have their limitations, however, particularly relating to 'lost' information. Across 90 studies that compared cumulative risk indices against more traditional multivariate regression models, they found that risk indices explained less variance in children's outcomes than alternative models in 58 of the studies, and no difference in 30 of the studies.

In one example, Burchinal et al. (2000) compared three analytic approaches for describing a child's level of social risk, including using individual risk variables, factor

scores derived from the risk variables, and a cumulative risk index. Their model comparisons demonstrated that children's cognitive outcomes were predicted best by individual variables. For example, when assessing the variance explained in cognitive development for 4 year old children, individual risk variables explained 35% of the variance, risk factors derived by factor analysis 16%, and the cumulative risk index 13%. Burchinal et al. explain that such a pattern is unsurprising because the risk factors and cumulative risk index retain less information about the child's environment than the individual variables, and that "as with any regression, a variable is able to predict outcomes more precisely when it contains more information about the underlying attribute it is representing" (Burchinal et al. 2000, pp 804). However, the authors also found in longitudinal models that the risk index provided better prediction of patterns of change than the individual risk variables. They suggest that cumulative risk indices may be considered as more reliable measures than individual risk variables because they represent combinations of correlated risk variables, and that use of more reliable measures would increase power to identify associations between risk and individual developmental patterns. That is, power to detect predictors of rate of change especially will be enhanced because rate of change over time is typically estimated less reliably than overall level, or main effects (Rogosa et al. 1982).

Cumulative risk indices have also been shown to be useful for longitudinal studies in other ways, where the use of such indices has been investigated at different points of development. Appleyard et al. (2005) for example, found that cumulative risk measured in middle childhood did not predict adolescent emotional and behavioural problems, while cumulative risk in early childhood did. Atkinson et al. (2015) found that cumulative risk assessed at 5/6, 12/13 and 19/20 years of age predicted a range of outcomes at age 25/26, including depression, intelligence, school dropout, arrest, smoking and poor physical health. Moreover, they also found that early risk accounted for variance beyond that explained by later risk in the prediction of multiple adverse outcomes. Likewise, Mistry et al. (2010) used a cumulative risk approach to examine a range of children's school readiness competencies, finding that risk exposure in infancy was most detrimental for school readiness skills, and partially mediated by risk exposure during the preschool years, as well as family processes and investments. These findings demonstrate that the developmental timing of risk factors is important for child development, and the use of cumulative risk indices provides an effective and efficient way of understanding these relationships over time.

A common criticism of cumulative risk indices is that their derivation and use is typically atheoretical: the selection of variables for inclusion in an index should be related to the outcome of interest (Atkinson et al. 2015; Evans et al. 2013). This is less of a problem for studies where only one outcome is assessed at a time, and Atkinson et al. (2015) note that the majority of cumulative risk studies do so. There are exceptions, however, where multiple outcomes are observed in the same studies (Atkinson et al. 2015; Gubhaju et al. 2013; Mistry et al. 2010). However, how well a risk index performs necessarily depends on the risks being assessed and the child outcome under consideration. For example, as noted earlier, a consistent finding in the literature is that the emotional environment of the home is more strongly associated with children's social and emotional wellbeing than cognitive outcomes, whereas the educational environment or educational 'investments' that parents make in their children is more strongly associated with cognitive outcomes than with social and emotional outcomes (Gubhaju et al. 2013; Kahn et al. 2005; Yeung et al. 2002). Therefore it is important that cumulative risk indices are derived with particular outcomes in mind, or that represent particular constructs of risk.

1.6 Developing Measures of Family Environment with Australian Data

For Australian researchers investigating socioeconomic gradients in child development outcomes, the Longitudinal Study of Australian Children (LSAC) is an important and highly valued research tool providing a wealth of information on Australian children and their families. A multi-disciplinary study of child development over time, the LSAC has collected a wide range of data on children and the factors that are important for their development, including of the child, parents, families, schools, neighbourhoods and communities. Longitudinal data have been collected on parent and family characteristics across a number of domains, including demographic information, physical health, mental wellbeing, relationship wellbeing, financial and mental stress, and parenting style. The study also collects a wide range of information about educational aspects of family life, such as whether the study child goes to local parks, libraries or museums, if they participate in extra-curricular activities, how much time they spend watching TV and other media.

With potentially hundreds of candidate variables relating to the family environment available in the LSAC, cumulative risk indices are an attractive alternative to models that include a large number of explanatory variables that may not fit neatly together in a factor analysis, or if they do, may still form a large number of individual factors that add to analytic complexity. As opposed to item-reduction methods like factor analysis, which require a correlation between the indicator variables, the advantage of calculating cumulative indices is that items do not necessarily have to be correlated. Other studies using LSAC data have previously used cumulative risk indices, but these have focused on broader aspects of economic, social and psychological disadvantage and not necessarily the ways in which parents interact with the study children. For example, Emerson et al. (2011) found that Australian children with cognitive delay were more likely to be exposed to higher levels of multiple environmental risks such as household material deprivation, low household income, poor maternal mental health and angry/harsh parenting. Blakemore et al. (2009a) found that children in families experiencing greater numbers of disadvantages were increasingly less likely to have accessed playgroups and more likely to have been admitted to an emergency department.

In recognition of the complexity of the LSAC data and the numerous ways in which families experience different types of adversity, Gubhaju et al. (2013) used factor analysis to group a large number of adversity markers into 12 lower-order family disadvantage factors, such as time pressure, parenting and economic hardship, and from this identified two higher-order factors broadly described as material and psychosocial adversity. While this study was comprehensive and driven by the data available in the LSAC, the result was 12 lower-order or two higher-order constructs that do not necessarily lend themselves to an analysis of parental investment that accord with theoretical models like the Family Stress Model, or the IMSI, and again, while the measures capture the broader home environment risks, they do not specifically capture the ways in which parents invest in or interact with their children.

In this study, we a derived Family Stress, Home Education and Parenting Index for both the B-cohort (starting at age 0–1 years) and the K-cohort (starting from age 4–5 years) across five waves of the Longitudinal Study of Australian Children (LSAC). The aims of the study were:

1. to describe the derivation of the three family environment measures;
2. to assess the consistency and utility of these measures over time by examining (a) the strength of association each measure had with itself over time, and (b) the strength of

association of each index with family- and neighbourhood-level socioeconomic measures and with children's social-emotional wellbeing and learning outcomes at each wave; and
3. to determine how well the three measures predicted children's subsequent developmental outcomes compared with more detailed models using the individual indicator variables used to derive each measure.

2 Methods and Data

2.1 The Longitudinal Study of Australian Children (LSAC)

The LSAC is a nationally representative, multidisciplinary study of Australian children and their families. Commencing in 2004, five waves of data have been collected every two years from two cohorts of children; 5107 infants aged 3–19 months (babies, or B-cohort) and 4983 children aged 4–5 years (kindergarten, or K-cohort). Table 1 provides a summary of the data collection schedule, age range and sample size for each cohort. This study uses data from both cohorts across all five waves of data collection.

Detailed information about the study design and recruitment of study families is available elsewhere (Soloff et al. 2005, 2006). In brief, the LSAC employed a two-stage clustered sample design. The sampling frame was based on the Medicare Australia enrolment database, with Australian postcode area as the first-stage sampling unit. Approximately 1-in-10 postcodes were randomly selected, and children were then randomly selected within postcode areas. The initial response rate was 54.8% for the B cohort and 47.0% for the K cohort. When compared with 2001 Census data, the initial sample was broadly representative of the Australian population of families with children in the relevant age group, though slightly under-representative of families who were single-parent, non-English speaking, living in rental properties or in remote areas (Soloff et al. 2006). In subsequent waves of data collection, these same characteristics were over-represented in the families who dropped out of the study (Sipthorp and Misson 2009).

Data were collected from multiple informants, using a variety of methods at each wave. The main source of information was the primary caregiver of the study child (Parent 1), who in most cases was the biological mother of the study child. In addition to the in-home interview, Parent 1 was also asked to complete a questionnaire at each wave. Across all waves data were also collected from Parent 2, the study child, parents living elsewhere, teachers and childcare workers. Response rates varied across the various instruments and respondents. Further details are provided in the LSAC User Guide (Australian Institute of Family Studies 2013).

2.2 Construction of Family Environment Indices

We adopted a similar approach to Martin et al. (2010) to derive three indices measuring the family stress environment (Family Stress Index), the home education environment (Home Education Index) and the emotional environment (Parenting Index). Where possible, we used items as similar as possible to those used in their study, which was for a single cohort of children at a single point in time. As the LSAC collected information from two cohorts of children over 5 time points, spanning an age range from birth to 12–13 years, some of the LSAC measures changed over time to reflect different development needs of children

Table 1 Age range, sample size and study retention, B- and K-cohorts, Waves 1–5

	Wave 1 (2004)	Wave 2 (2006)	Wave 3 (2008)	Wave 4 (2010)	Wave 5 (2012)
B-Cohort					
Age (years)	0–1	2–3	4–5	6–7	8–9
Sample size	5107	4606	4386	4242	4085
Sample retention (%)	–	90.2	85.9	83.1	80.0
K-Cohort					
Age (years)	4–5	6–7	8–9	10–11	12–13
Sample size	4983	4464	4331	4169	3956
Sample retention (%)	–	89.6	86.9	83.7	79.4

and families. The variables contributing to each index variable therefore changed from wave to wave, and for each cohort of study children. These measures are described in further detail below, and are summarised in Tables A1 to A3 in the supplementary files.

2.2.1 Family Stress Index

The Family Stress Index was constructed by dichotomising 4 family stress indicators, including financial hardship, maternal psychological distress, marital hostility and ability to raise money in an emergency. Items were dichotomised by assigning approximately one-fifth of the sample experiencing the most stress to a high-stress category, with the remaining sample assigned to a low-stress category. As some of the measures were categorical, an exact 20% and 80% split on each item was not always possible. In this case, the measures were dichotomised at points providing the closest approximation. As one of the measures related to marital hostility, scores were averaged across the indicators rather than summed in order to produce indices with the same range of values for both single- and two-parent families. Table A1 (supplementary file) provides the percentage of the sample in the high stress category on each individual measure, along with the proportion of the sample experiencing the cumulative number of stresses.

Financial hardship was a 6-item measure asking families if they had experienced financial hardships in the previous 12 months, including not being able to pay bills on time, paying a mortgage on time, going without meals, being unable to heat or cool the home, had to pawn or sell something or had sought assistance from a welfare or community organisation. The 20% cut-point corresponded with families who had experienced at least one of the financial difficulties.

Maternal psychological distress was assessed using the Kessler 6-item K6 scale (Kessler et al. 2002), which measures non-specific psychological distress. Mothers were asked how often in the past 4 weeks they had felt nervous; hopeless; restless or fidgety; that everything was an effort; so sad that nothing would cheer you up; or worthless, and responded on a 5-point scale from 0 = all of the time to 4 = none of the time. Responses were reverse coded, summed and adjusted to generate a total score ranging from 0 to 24, where high scores represented greater levels of non-specific psychological distress. While scores of 13 or higher correspond with probable severe mental illness (Kessler et al. 2003), a lower cut-point of 6 + has identified mild to moderate non-specific psychological distress (Furukawa et al. 2003; Prochaska et al. 2012). This cut-point classified between 15 and 27% of the sample, depending on cohort and age.

Marital hostility was a 5-item scale asking about the frequency of disagreements between partners about basic child-rearing issues, awkward or stressful conversations, anger or hostility, and arguments that end in people pushing, hitting, kicking or shoving. Response options ranged from 1 (never) to 5 (always). Responses were averaged to create a total score. The highest ~20% of the sample was identified as having high marital hostility.

Ability to raise money asked respondents how hard it would be to raise $2000 in one week in the case of an emergency. Families were coded as having high financial stress if they would have to do something drastic, or could not raise the money, identifying approximately 20% of the sample, though this figure decreased in later waves (see Table A1, supplementary file).

2.2.2 Home Education Index

The items selected for the Home Education Index related to children's activities and educational enrichment. Each measure was dichotomised to identify the 20% of the sample with the lowest educational inputs. All measures were then averaged to create a total educational environment score, where higher scores represented stronger educational environments. Families with a score of 1.0 for example, were in the highest 80% on all of the indicators. Table A2 in the supplementary file provides the percentage of the sample in the low education category on each individual measure. Each indicator is described below.

The *home activities index* assessed the frequency with which a number of activities occurred each week, from 0 (not in past week) to 3 (6–7 days). Activities included telling stories to the child, reading to the child, drawing pictures or other crafts, playing music, singing or dancing, playing with toys or games, involving the child in everyday activities like cooking, or playing a game outdoors. Scores were averaged across the items and the lowest ~20% were coded as having low home activities. Cut-points typically identified children participating (irrespective of frequency) in none or only one of the activities.

The *out of home activities index* was the number of activities the study child had participated in during the previous month, including going to a movie, playground or swimming pool, a sporting event where the child wasn't a player, to a concert or play, attended a school, cultural or community event, or visited a museum or art gallery. Cut-points identified children as participating in none or one of the activities low education, with children participating in at least 2 out of home activities coded as high education.

Number of books in the home was a single item asking how many books the child has in the home: none; 1–10; 11–20; 21–30; or more than 30. The lowest 20% were identified as those who had fewer than 30 books in the home.

Number of *extracurricular activities* was included at waves when study children were of school age, and related to extracurricular or extra cost activities that were not part of normal school activities. Items varied from wave to wave, but included activities such as swimming, gymnastics, team sport, musical instruments or singing, ballet or dance, children's religious group, language classes or other academic classes. For each wave, the total number of 'yes' responses was derived, and the lowest ~20% of children participating in the activities were coded assigned to the low education category. The cut-point corresponded to children participating in none or one of the activities, depending on cohort and age.

Weekday TV watching was assessed by a single item asking how many hours on a typical weekday does the child watch TV, DVDs or videos at home? Children who watched more than 3 h on a typical weekday were assigned to the low education environment

category. A similar item was asked about weekend TV watching, however this item did not discriminate between children very well and was therefore excluded.

Educational expectations was a single item asking parents how far they thought the study child will go in their education, ranging from leaving school before finishing secondary school, to obtaining a post-graduate qualification at university. Parents believing the child would not progress beyond secondary school were assigned as having low educational expectations.

2.2.3 Parenting Index

The Parenting Index was derived from a range of parenting scales assessing different parenting styles and ways of interacting with the study child. The LSAC parenting items have previously been analysed to determine the most appropriate derivation and use of composite measures for each of the parenting scales, for example, using total summed scores or weighted factor scores (Zubrick et al. 2014). Their analysis concluded that the optimal approach for researchers depends on the nature of their intended use, and suggested that if users wanted to compare the relative positioning of respondents (e.g. high versus low warmth), then simple additive scores would be appropriate. As cumulative risk indices take an approach of dichotomising the parenting measures, we use simple summed composite measures to derive the Parenting Index and not weighted factor scores. The selection of the parenting dimensions included in the index were guided by data availability in the LSAC, those that were assessed in multiple waves, and those which have shown to be related to child development outcomes in previous research.

We used responses from the mother of the study child. On each composite parenting scale score, the $\sim$20% of mothers with the lowest scores on the measures (or highest scores for the angry and hostile parenting scales) were assigned to the poor parenting category (lowest 20% = 0; remaining 80% = 1). The dichotomised measures were then averaged to give a total score ranging from 0 to 1, with higher scores representing more positive parenting. Table A3 provides the percentage of the sample assigned to the poor parenting category for each measure, and the percentage of families in the high category for 0 up to 6 of the measures.

Parental warmth was a 6-item scale asking parents how often they express affection by hugging, kissing and holding the child; hug or hold the child for no particular reason; tell the child how happy he/she makes you; have warm, close times together with the child; feel close to the child both when they are happy and upset. Responses ranged from 1 (never/almost never) to 5 (always/almost always). Scores were summed over the 6 items, with higher scores representing warmer parenting. The measure was dichotomised by assigning the lowest $\sim$20% to the low warmth category.

Parenting consistency was a 5-item scale asking how often: parents make sure the child does something they've asked them to; follow through on threats of punishment if the child continues to do something; the child gets away with things they think should be punished (reversed); the child get out of punishment if they set their mind to it (reversed) and how often the child ignores punishment. Responses ranged from 1 (never) to 5 (all the time). Responses were summed across the items, with higher scores representing higher levels of consistency. The lowest $\sim$20% of responses were assigned to the low consistency category.

Inductive reasoning was a 3-item scale asking parents how often in the last 6 months they: talked it over and reason with the child when they misbehaved; gave the child reasons why rules should be obeyed; and explained to the child why they were being corrected.

Responses ranged from 1 (never) to 5 (always), and were summed across the items, with higher scores representing higher levels of reasoning. The lowest ~20% of responses were assigned to the low reasoning category.

Angry parenting was a 4-item scale asking parents how often they: disapproved of the child's behaviour, were angry when they punished the child, felt they had problems managing the child in general; or told the child that they are bad or not as good as others. Responses ranged from 1 (never/almost never) to 5 (all the time), and were summed across the items with higher scores representing higher levels of angry parenting. The highest ~20% of responses were assigned to the high anger category.

Hostile parenting (Wave 1, 2 and 3 for the B-cohort only) was a 5-item scale asking parents how often in the past 4 weeks: had they been angry with the child; had they raised their voice or shouted at the child; had the child got on their nerves when they cry; had they lost their temper with the child; or had left the child alone in his/her bedroom when they were particularly irritable or upset. Responses ranged from 1 (not at all) to 10 (all the time), and the highest ~20% of responses on the summed score were assigned to the high hostility category.

Parenting self-efficacy was based on a 4-item scale. At Wave 1 for the B-cohort (0–1 year), mothers were asked how good they were at keeping the study child amused, calming the study child, keeping the study child busy and at routine caring tasks. In subsequent waves the efficacy items asked mothers how often the child behaved in a manner different from the way they wanted them to, that the child's behaviour was more than they could handle, that they were good at getting the child to do what they wanted them to do, and how often mothers felt they were in control when caring for the child. Responses ranged from 1 (never/almost never) to 5 (always/almost always) with the lowest ~20% of responses on the summed score assigned to the low efficacy category.

Co-parenting (excluding Wave 2) was a 3-item scale asking respondents how often their partner was a resource or support to them in raising their children, how often they were a resource or support to their partner, and how often they felt their partner understands and is supportive of their needs as a parent. Responses ranged from 1 (never) to 5 (always) with the lowest ~20% of responses on the summed score assigned to the low co-parenting category.

2.3 Socioeconomic Measures

Family-level SES was measured using a composite measure of family disadvantage derived from parents educational attainments, household income and occupational prestige [socioeconomic position (SEP); Blakemore et al. 2009b]. The measure is standardised to have a mean of 0 and standard deviation of 1, where higher scores represent higher levels of family-level SES.

Neighbourhood-level SES was measured using the *Socioeconomic Index for Advantage* (SEIFA), a summary measure of the socioeconomic conditions of people living in an area. The SEIFA is derived by the Australian Bureau of Statistics and linked to the LSAC. It is scored on a continuum of disadvantage (low values) to advantage (high values) which is derived from census variables related to both advantage and disadvantage such as income and tertiary education. Neighbourhood-level SES scores range from 1 (disadvantaged) to 10 (advantaged).

2.4 Child Development Outcomes

2.4.1 Social and Emotional Wellbeing

We used two measures of social and emotional wellbeing. Social and emotional wellbeing was predominantly assessed using the Strengths and Difficulties Questionnaire [SDQ, (Goodman 1997; 2001)] which was collected across Waves 1–5 for the K-cohort and at Waves 3, 4 and 5 for the B-cohort commencing at age 4–5 years. The SDQ is a 25-item scale comprising 5 sub-scales covering peer relationships, conduct problems, hyperactivity, emotional problems and pro-social behaviour. Total scores were calculated by summing scores on the peer, conduct, hyperactivity and emotional problems sub-scales. Scores could range from 0 to 40, with higher scores representing poorer functioning.

For the B-cohort at Wave 1 and 2, the Social-Emotional Outcome Index was used to measure social and emotional wellbeing. The outcome indices were created by the Australian Institute of Studies for the LSAC (Sanson et al. 2010a, b). At Wave 1 the index was based on temperament, assessed by the approach, irritability and cooperativeness subscales of the Short Temperament Scale for Infants [STSI, (Sanson et al. 1987)], measuring the infant's sociability, responsiveness, volatility and amenability. At Wave 2 the index was based on the internalising, externalising and social competence subdomains of the Brief Infant Toddler Social Emotional Adjustment (BITSEA) scale (Briggs-Gowan et al. 2004). For each measure at Waves 1 and 2, scores were combined and age- and gender-standardised to have a mean of 0 and standard deviation of 1, with higher scores representing better social-emotional wellbeing.

2.4.2 Learning Outcomes

Three measures of learning outcomes were used for the study. For the first three waves for each cohort, we used the Learning Outcome Index. At Waves 4 and 5 for both cohorts we used the teacher-rated Academic Rating Scale for maths and literacy scores. We also used the four test scores from the National Program of Literacy and Numeracy (NAPLAN), which are linked to the LSAC dataset for families who consented to data linkage.

The Learning Outcome Index, like the Social-Emotional Outcome Index, was a summary measure of children's learning development derived for the first three waves of the LSAC. For the B-cohort at Wave 1 (0–1 year) the index was based on the Communication and Symbolic Behavior Scale Developmental Profile—Infant/Toddler Checklist (CSBS-DP, Wetherby and Prizant 2001). At Waves 2 (2–3 years) and 3 (4–5 years), and for the K-cohort across all three waves, the measure was based on a range of tests assessing vocabulary, teacher and parent ratings of reading, writing and numeracy skills, and approach to learning using the Who Am I instrument (de Lemos and Doig 1999). Scores were combined and age- and gender-standardised to have a mean of 0 and standard deviation of 1, with higher scores representing better learning outcomes.

The Academic Rating Scale provides a measure of school performance in literacy and numeracy, based on teacher-report. The scales in the LSAC were adapted from the versions developed for the Early Childhood Longitudinal Study (National Center for Education Statistics n.d.). Scores are based on teachers' assessments of students relative to other children of the same age level. At Wave 4, the scales consisted of 10 literacy and 8 numeracy items for the B-cohort, and 9 literacy and 10 numeracy items for the K-cohort. At Wave 5, the scales consisted of 9 literacy and 9 numeracy items for the B-cohort and 9

literacy items for the K-cohort. For each scale, scores were summed and scaled to range from 1 to 5, with higher scores representing greater proficiency.

The NAPLAN is a suite of standardised tests of numeracy, reading, spelling and writing, and has been administered to all Australian students in Years 3, 5, 7 and 9 each year since 2008. The scores in each learning domain are standardised and scaled to compare children's and school's performances over time. Scaled scores can range from 0 to 1000. During the Wave 3 and Wave 4 home visits parental consent was sought to link children's NAPLAN data to the LSAC database. For this study, we use the Year 3 NAPLAN scales for the B-cohort and the Year 7 NAPLAN scales for the K-cohort. Year 3 measures were obtained when study children were aged around 8–9 years, and Year 7 measures around 12–13 years, which broadly corresponds to the age of the study children at Wave 5.

2.5 Analytic Strategy

Cross-sectional and longitudinal analyses were conducted to determine the reliability and predictive validity of the indices. First, the longitudinal reliability of the measures was assessed by producing a series of cross-wave correlation tables for each index using Pearson correlation coefficients. A series of correlation matrices was then produced to determine how well each of the three family environment indices correlated with each other but also with other measures that we would expect the indices to correlate with given the results of the broader literature. Measures included family-level socioeconomic disadvantage, neighbourhood-level socioeconomic disadvantage, children's learning outcomes and children's social and emotional wellbeing.

Finally, structural equation models were estimated to assess how well each of the Wave 4 family environment indices predicted selected Wave 5 social-emotional wellbeing and learning outcomes, and how these models compared to models using the individual items used to derive the composite measures. Wave 5 outcome measures were selected to ensure variable comparability between the B- and K-cohorts. A Literacy latent factor was estimated using the Year 3 reading, writing and spelling scales of the NAPLAN for the B-cohort, and similarly the same Year 7 scales were used for the K-cohort. Literacy measures were selected (i.e. numeracy was excluded) as initial models showed poor model fit when numeracy was included in the latent measure. For both cohorts, a Child Behaviour Problems latent factor was estimated using the Wave 5 conduct and hyperactivity subscales of the SDQ. Again, initial models estimating a latent variable from the four problem subscales of the SDQ showed poor model fit. As the Child Behaviour Problems latent factor had better fit than a latent variable estimated from the emotional and peer problems subscales, the Child Behaviour Problems latent factor was chosen for the comparative models.

For each development outcome (Literacy and Child Behaviour Problems), and each cohort, 5 models were estimated and compared on a range of model fit statistics and the variance explained in the child outcome measures. Model A estimated the outcome measure as a function of the Family Stress Index, Home Education Index, and the Parenting Index. Model B then replaced the Family Stress Index with the individual, continuous items used to construct the composite index (i.e. financial hardship, marital hostility, maternal psychological distress and difficulty raising money) Similarly, Model C replaced the Home Education Index with the individual items comprising the index, and Model D replaced the Parenting Index with the individual parenting variables. Finally, Model E replaced each of the composite indices with all of the individual variables. Standardised coefficients are presented for all models.

We compare a range of model fit statistics to determine the extent to which each of the family environment indices performs against the models using the separate indicators. Model fit was evaluated using the root mean square error of approximation (RMSEA), the comparative fit index (CFI) and goodness of fit index (GFI). For the RMSEA a score below 0.06 indicates good model fit, and score below 0.08 indicates adequate model fit, while scores above 0.10 indicate poor model fit. For the CFI a score equal to and above 0.95 indicates good model fit. We also estimate the R^2 values of the outcome measures to determine how much of the variation in the outcome measures could be accounted for by the family environment indices, compared to the models using individual items with more variation. Chi-square statistics are also reported, however, this statistic can be overly influenced by sample size, correlations and multivariate non-normality (Kline 2011).

All analyses were performed using SAS 9.4. Structural equation models were estimated using the CALIS procedure and full information maximum likelihood. Using maximum likelihood provides more consistent, less biased estimates for missing data (Schafer 1997).

3 Results

3.1 Correlations Between Family Environment Constructs

The means and standard deviations of each family environment index, and the correlation between the indices across all waves are provided in Table 2 (B-cohort) and Table 3 (K-cohort). Both within- and between-waves, the correlations between the family environment indices were statistically significant, but low in magnitude. Higher scores on the Family Stress Index were associated with lower scores on the Home Education Index (B-cohort range $r = -0.09$ to -0.24; K-cohort $r = -0.11$ to -0.28). Higher Family Stress Index scores were also associated with lower Parenting Index scores (B-cohort $r = -0.09$ to -0.31; K-cohort $r = -0.13$ to -0.28), and higher scores on the Home Education Index were associated with higher Parenting Index scores (B-cohort $r = 0.09$ to 0.25; K-cohort $r = 0.13$ to 0.24). The small correlation coefficients suggest that the indices are largely independent of one another and share at best 9% of their variance.

3.2 Between-wave Correlations of Family Environment Indices

The between-wave correlations for each family environment index are also provided in Tables 2 and 3. These correlations provide an indication of the stability of the indices over time. The between-wave correlations for the Family Stress Index, for example, show that families experiencing greater levels of stress at Wave 1 tended to experience greater levels of stress at subsequent waves, with correlation coefficients ranging from 0.36 to 0.60 for the B-cohort and 0.41 to 0.60 for the K-cohort. Correlation coefficients of similar magnitude were observed for the Home Education Index, and the Parenting Index. The majority of the coefficients were larger than 0.30, suggesting moderate to strong relationships over time for both cohorts and that each of the indices have good stability over time. The correlations are not so large or strong to suggest that these family environment constructs are inflexible or unresponsive to other shocks or changes in the family (e.g. family breakdown, or the changing developmental needs of children over time). As would be expected with longitudinal measures, the coefficients from adjacent waves were larger than for data collected further apart. For example, for the K-cohort the correlations

Table 2 B-cohort, Wave 1 to Wave 5: mean and standard deviation (SD) of the family stress, home education and parenting indices, and the cross-wave correlation coefficients for each index

Measure	Mean	SD	Family stress					Home education					Parenting				
			W1	W2	W3	W4	W5	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
Family stress																	
Wave 1 (0–1 year)	0.24	0.30	1.0														
Wave 2 (2–3 years)	0.21	0.25	0.45	1.0													
Wave 3 (4–5 years)	0.22	0.27	0.40	0.54	1.0												
Wave 4 (6–7 years)	0.19	0.24	0.40	0.51	0.56	1.0											
Wave 5 (8–9 years)	0.19	0.24	0.36	0.48	0.53	0.60	1.0										
Home education																	
Wave 1 (0–1 year)	–	–	–	–	–	–	–	–									
Wave 2 (2–3 years)	0.78	0.24	−0.12	−0.20	−0.20	−0.18	−0.16	–	1.0								
Wave 3 (4–5 years)	0.78	0.20	−0.09	−0.16	−0.17	−0.15	−0.14	–	0.44	1.0							
Wave 4 (6–7 years)	0.83	0.19	−0.14	−0.23	−0.22	−0.21	−0.18	–	0.44	0.41	1.0						
Wave 5 (8–9 years)	0.81	0.22	−0.11	−0.16	−0.17	−0.15	−0.15	–	0.38	0.35	0.49	1.0					
Parenting																	
Wave 1 (0–1 year)	0.78	0.26	−0.18	−0.13	−0.10	−0.09	−0.09	–	0.09	0.08	0.10	0.09	1.0				
Wave 2 (2–3 years)	0.77	0.27	−0.13	−0.17	−0.14	−0.11	−0.11	–	0.23	0.17	0.20	0.20	0.29	1.0			
Wave 3 (4–5 years)	0.77	0.23	−0.21	−0.27	−0.31	−0.24	−0.20	–	0.21	0.23	0.25	0.23	0.29	0.43	1.0		
Wave 4 (6–7 years)	0.77	0.24	−0.15	−0.19	−0.19	−0.23	−0.20	–	0.19	0.20	0.24	0.19	0.24	0.36	0.53	1.0	
Wave 5 (8–9 years)	0.75	0.25	−0.16	−0.18	−0.19	−0.21	−0.24	–	0.18	0.18	0.21	0.21	0.26	0.34	0.52	0.60	1.0

All correlation coefficients are significant at $p < 0.001$. Note: Home Education Index not derived at Wave 1 (age 0–1 year)

Table 3 K-cohort, Wave 1 to Wave 5: mean and standard deviation (SD) of the family stress, home education and parenting indices, and the cross-wave correlation coefficients for each index

Measure	Mean	SD	Family stress					Home education					Parenting				
			W1	W2	W3	W4	W5	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
Family Stress																	
Wave 1 (4–5 year)	0.27	0.34	1.0														
Wave 2 (6–7 years)	0.18	0.27	0.50	1.0													
Wave 3 (8–9 years)	0.20	0.28	0.46	0.55	1.0												
Wave 4 (10–11 years)	0.20	0.27	0.44	0.52	0.57	1.0											
Wave 5 (12–13 years)	0.19	0.27	0.41	0.46	0.53	0.60	1.0										
Home Education																	
Wave 1 (4–5 year)	0.81	0.24	−0.18	−0.22	−0.21	−0.21	−0.18	1.0									
Wave 2 (6–7 years)	0.76	0.26	−0.19	−0.28	−0.25	−0.22	−0.22	0.51	1.0								
Wave 3 (8–9 years)	0.77	0.24	−0.13	−0.17	−0.20	−0.19	−0.16	0.35	0.45	1.0							
Wave 4 (10–11 years)	0.76	0.25	−0.11	−0.15	−0.18	−0.17	−0.18	0.36	0.44	0.40	1.0						
Wave 5 (12–13 years)	0.76	0.24	−0.12	−0.16	−0.21	−0.19	−0.19	0.35	0.42	0.38	0.43	1.0					
Parenting																	
Wave 1 (4–5 year)	0.75	0.23	−0.17	−0.17	−0.16	−0.16	−0.13	0.23	0.21	0.16	0.15	0.14	1.0				
Wave 2 (6–7 years)	0.82	0.20	−0.18	−0.22	−0.17	−0.15	−0.14	0.18	0.23	0.13	0.16	0.13	0.41	1.0			
Wave 3 (8–9 years)	0.81	0.21	−0.22	−0.23	−0.28	−0.22	−0.21	0.18	0.24	0.20	0.18	0.17	0.41	0.52	1.0		
Wave 4 (10–11 years)	0.76	0.22	−0.19	−0.22	−0.21	−0.26	−0.24	0.16	0.22	0.18	0.20	0.17	0.35	0.48	0.57	1.0	
Wave 5 (12–13 years)	0.80	0.20	−0.20	−0.20	−0.22	−0.24	−0.28	0.15	0.21	0.16	0.20	0.21	0.34	0.45	0.51	0.61	1.0

All correlation coefficients are significant at $p < 0.001$

between the Wave 1 Family Stress Index and the Wave 2, 3, 4, and 5 indices were 0.50, 0.46, 0.44 and 0.41 respectively.

3.3 Within-wave Predictive Validity

The within-wave correlation coefficients estimating the association between the family environment indices, socioeconomic variables and learning outcomes are provided in Table 4 (B-cohort) and Table 5 (K-cohort). For the B-cohort, the Wave 1 (0–1 year) Parenting Index was not significantly correlated with the socioeconomic measures, and only weakly correlated with the socioeconomic measures for both cohorts at later waves. Also, for the B-cohort at Wave 1 (0–1 year) the Family Stress Index was not significantly correlated with the learning outcome index. With these exceptions, for both cohorts and for all waves, the family environment indices were significantly correlated with family-level SES and neighbourhood-level SES. Higher family- and neighbourhood-level SES scores were associated with lower scores on the Family Stress Index, and higher scores on the Home Education Index and Parenting Index. The correlations were typically stronger for family-level than neighbourhood-level SES, which would be expected given that the immediate family-level SES would have greater bearing on the family environment than the neighbourhood-level SES.

Tables 4 and 5 also show that each family environment index was significantly associated with children's learning and social-emotional outcomes. Higher Family Stress Index scores and lower Home Education and Parenting Index scores were associated with poorer learning and social-emotional outcomes. Though the strength of the correlations varied across waves depending on the measures being assessed, the Home Education Index was typically more strongly associated with learning outcomes than with social-emotional outcomes, and the Parenting Index and Family Stress Index were more strongly associated with social-emotional outcomes than with learning outcomes.

3.4 Comparative Models

The models estimating learning outcomes for the B-cohort at 8–9 years and the K-cohort at 12–13 years are presented in Table 6. For the B-cohort, the results for Model A suggest that the Family Stress, Home Education and Parenting Indices were all significant and independent predictors of the Literacy latent factor. The RMSEA (0.06), CFI (1.00) and TLI (0.99) were all in the acceptable range indicating good model fit. Together, the family environment indices explained 6% of the variation in the Literacy latent factor.

The subsequent models replacing each of the family environment indices with the individual items also had good model fit with comparable RMSEA, CFI and TLI values across the models. Replacing the Home Education Index with the individual education items (Model C) saw the R^2 value increase from 0.06 to 0.11. Replacing all of the indices with the corresponding individual items (Model E) saw the R^2 value increase to 0.13.

For the K-cohort the Parenting Index was not a significant predictor of the Literacy latent factor after controlling for the Family Stress Index and Home Education Index, and the indices together explained only 4% of the variation in Literacy. Replacing the Home Education Index with the individual education items only increased the R^2 to 0.06. Otherwise, model fit was comparable across all of the five models, with all RMSEA values 0.05 or less.

Table 7 provides a similar pattern of results for the Child Behaviour Problems latent factor for the B-cohort at Wave 5 (8–9 years). Again, the family environment indices were

Table 4 B-cohort, Waves 1 to Wave 5: within-wave correlation coefficients between the derived family environment indices, family-level and neighbourhood-level SES, learning outcomes and social-emotional outcomes

Measure	Family stress	Home education	Parenting	Family SES	Neigh. SES	Learning outcome	Soc. Emot. outcome	ARS Maths	ARS Literacy	SDQ
Wave 1 (0–1 year)										
Family SES	−0.25	–	*ns*	1.0						
Neighbourhood SES	−0.10	–	*ns*	0.42	1.0					
Learning outcome	*ns*	–	0.13	−0.10	−0.04	1.0				
Social-emotional outcome	−0.13	–	0.30	*ns*	−0.05	0.12	1.0			
Wave 2 (2–3 years)										
Family SES	−0.26	0.32	0.01	1.0						
Neighbourhood SES	−0.14	0.21	0.07	0.43	1.0					
Learning outcome	−0.15	0.29	0.25	0.17	0.10	1.0				
Social-emotional outcome	−0.28	0.28	0.39	0.17	0.11	0.40	1.0			
Wave 3 (4–5 years)										
Family SES	−0.27	0.28	0.13	1.0						
Neighbourhood SES	−0.16	0.17	0.07	0.40	1.0					
Learning outcome	−0.18	0.25	0.17	0.32	0.23	1.0				
Social-emotional outcome	−0.27	0.18	0.44	0.17	0.12	0.24	1.0			
Wave 4 (6–7 years)										
Family SES	−0.18	0.32	0.09	1.0		–				
Neighbourhood SES	−0.15	0.24	0.08	0.38	1.0	–	–			
ARS Maths	−0.13	0.19	0.07	0.22	0.13	–	–	1.0		
ARS Literacy	−0.15	0.23	0.13	0.23	0.12	–	–	0.82	1.0	
SDQ total score	0.32	−0.24	−0.38	−0.16	−0.12	–	–	−0.24	−0.29	1.0
Wave 5 (8–9 years)										

Table 4 continued

Measure	Family stress	Home education	Parenting	Family SES	Neigh. SES	Learning outcome	Soc. Emot. outcome	ARS Maths	ARS Literacy	SDQ
Family SES	−0.24	0.32	0.12	1.0		–	–			
Neighbourhood SES	−0.16	0.15	0.09	0.39	1.0	–	–			
ARS Maths	−0.18	0.21	0.11	0.26	0.14	–	–	1.0		
ARS Literacy	−0.18	0.22	0.13	0.27	0.15	–	–	0.84	1.0	
SDQ total score	0.29	−0.19	−0.38	−0.16	−0.16	–	–	−0.32	−0.35	1.0

ARS Academic Rating Scale, *SDQ* Strengths and Difficulties Questionnaire. Family SES was measured using derived socioeconomic position variables. Neighbourhood SES was measured using the Socioeconomic Index for Advantage, an area-level index derived by the Australian Bureau of Statistics

All correlation coefficients are statistically significant at $p < .001$ except where noted

Table 5 K-cohort, Waves 1 to Wave 5: within-wave correlation coefficients between the derived family environment indices, family-level and neighbourhood-level disadvantage, learning outcomes and social-emotional outcomes

Measure	Family stress	Home education	Parenting	Family SES	Neigh. SES	Learning outcome	ARS Maths	ARS Literacy	SDQ
Wave 1 (0–1 year)									
Family SES	−0.24	0.37	0.14	1.0					
Neighbourhood SES	−0.11	0.19	0.05	0.43	1.0				
Learning outcome index	−0.16	0.28	0.13	0.30	0.18	1.0			
SDQ score	0.29	−0.29	−0.27	−0.28	−0.16	−0.30	–	–	1.0
Wave 2 (2–3 years)									
Family SES	−0.30	0.42	0.09	1.0					
Neighbourhood SES	−0.14	0.26	0.07	0.44	1.0	–			
ARS Maths	−0.13	0.20	0.07	0.25	0.14	–	1.0		
ARS Literacy	−0.16	0.23	0.10	0.27	0.13	–	0.82	1.0	
SDQ score	0.33	−0.25	−0.36	−0.22	−0.14	–	−0.24	−0.29	1.0
Wave 3 (4–5 years)									
Family SES	−0.31	0.35	0.13	1.0					
Neighbourhood SES	−0.15	0.25	0.06	0.42	1.0	–			
ARS Maths	−0.12	0.17	0.06	0.26	0.14	–	1.0		
ARS Literacy	−0.15	0.18	0.10	0.26	0.12	–	0.82	1.0	
SDQ score	0.30	−0.23	−0.42	−0.21	−0.12	–	−0.28	−0.33	1.0
Wave 4 (6–7 years)									
Family SES	−0.24	0.29	0.10	1.0					
Neighbourhood SES	−0.15	0.20	0.05	0.39	1.0	–			
ARS Maths	−0.15	0.16	0.08	0.25	0.15	–	1.0		
ARS Literacy	−0.16	0.18	0.12	0.24	0.14	–	0.76	1.0	
SDQ total score	0.35	−0.17	−0.39	−0.16	−0.13	–	0.33	−0.37	1.0
Wave 5 (8–9 years)									
Family SES	−0.27	0.34	0.14	1.0					

Table 5 continued

Measure	Family stress	Home education	Parenting	Family SES	Neigh. SES	Learning outcome	ARS Maths	ARS Literacy	SDQ
Neighbourhood SES	−0.18	0.17	0.05	0.38	1.0	–			
ARS Literacy	−0.19	0.28	0.15	0.24	0.12	–	–	1.0	
SDQ total score	0.34	−0.27	−0.39	−0.18	−0.14	–	–	−0.38	1.0

ARS Academic Rating Scale, *SDQ* Strengths And Difficulties Questionnaire. Family SES was measured using derived socioeconomic position variables. Neighbourhood SES was measured using the Socioeconomic Index for Advantage, an area-level index derived by the Australian Bureau of Statistics

All correlation coefficients are statistically significant at $p < .001$

Table 6 Comparison of models predicting the Literacy latent factor for the B-cohort (8–9 years) and K-cohort (12–13 years)

	Model A	Model B	Model C	Model D	Model E
B-cohort					
Measurement model					
Literacy → Year 3 reading	0.82**	0.82**	0.82**	0.82**	0.82**
Literacy → Year 3 writing	0.87**	0.86**	0.87**	0.86**	0.87**
Literacy → Year 3 spelling	0.92**	0.92**	0.92**	0.92**	0.92**
Structural equation model					
Family stress index	−0.10**	[a]	−0.10**	−0.08**	[d]
Home education index	0.18**	0.17**	[b]	0.19**	[d]
Parenting index	0.04*	0.06**	0.07**	[c]	[d]
Model fit indicators					
Chi-square (DF)	36.5 (5)**	42.4 (13)**	57.4 (13)**	54.4 (15)**	80.7** (31)
RMSEA	0.04	0.02	0.03	0.02	0.02
CFI	1.00	1.00	1.00	1.00	1.00
GFI	1.00	1.00	1.00	1.00	1.00
TLI	0.99	0.99	0.99	0.99	0.99
R-square	0.06	0.07	0.11	0.07	0.13
K-cohort					
Measurement model					
Literacy → Year 7 reading	0.80**	0.80**	0.80**	0.80**	0.80**
Literacy → Year 7 writing	0.90**	0.90**	0.90**	0.90**	0.90**
Literacy → Year 7 spelling	0.93**	0.93**	0.93**	0.93**	0.93**
Structural equation model					
Family stress index	−0.13**	[a]	−0.13**	−0.13**	[d]
Home education index	0.14**	0.13**	[b]	0.14**	[d]
Parenting index	0.01	0.02	0.03	[c]	[d]
Model fit indicators					
Chi-square (DF)	52.8 (5)**	57.4	86.1 (13)**	67.7 (15)**	112.9** (31)
RMSEA	0.05	0.03	0.04	0.03	0.02
CFI	0.99	1.00	0.99	1.00	1.00
GFI	1.00	1.00	1.00	1.00	1.00
TLI	0.98	0.99	0.98	0.99	0.99
R-square	0.04	0.05	0.06	0.06	0.08

** $p < 0.001$; * $p < 0.05$

[a] Family Stress Index replaced with financial hardship, maternal psychological distress (K6), marital hostility and difficulty raising money

[b] Home Education Index replaced with activities in the home, activities out of the home, books in the home, extracurricular activities, and hours of weekday television viewing

[c] Parenting Index replaced with maternal warmth, efficacy, consistency, inductive reasoning, angry parenting and co-parenting scales

[d] All indices replaced with variables listed in a, b, and c

all significant and independent predictors of the Child Behaviour Problems latent factor (Model A), and the RMSEA (0.05), CFI (1.0) and TLI (0.96) were all in the acceptable range suggesting good model fit. Together, the family environment indices explained

Table 7 Comparison of models predicting the Child Behaviour Problems latent factor for the B-cohort (8-9 years) and K-cohort (12-13 years)

	Model A	Model B	Model C	Model D	Model E
B-cohort					
Measurement MODEL					
SDQ → Conduct subscale	0.82**	0.83**	0.82**	0.78**	0.78**
SDQ → Hyperactivity subscale	0.61**	0.61**	0.62**	0.65**	0.65**
Structural equation model					
Family stress index	0.17**	[a]	0.18**	0.12**	[d]
Home education index	−0.11**	−0.11**	[b]	−0.14	[d]
Parenting index	−0.35**	−0.34**	−0.36**	[c]	[d]
Model fit indicators					
Chi-square (DF)	11.4 (1)**	24.1 (5)**	26.4 (5)**	33.8 (6)	55.2 (14)**
RMSEA	0.05	0.03	0.03	0.03	0.03
CFI	1.00	1.00	0.99	0.99	1.00
GFI	1.00	1.00	1.00	1.00	1.00
TLI	0.96	0.97	0.97	0.99	0.99
R-square	0.22	0.22	0.23	0.41	0.42
K-cohort					
Measurement model					
SDQ → Conduct subscale	0.82**	0.82**	0.81**	0.78**	0.78**
SDQ → Hyperactivity subscale	0.63**	0.63**	0.64**	0.66**	0.67**
Structural equation model					
Family stress index	0.20**	[a]	0.20**	0.15**	[d]
Home education index	−0.10**	−0.10**	[b]	−0.11**	[d]
Parenting index	−0.40**	−0.39**	−0.41**	[c]	[d]
Model fit indicators					
Chi-square (DF)	1.5 (1)	10.7 (5)	27.7 (5)**	16.4 (6)**	44.4**
RMSEA	0.01	0.02	0.03	0.02	0.02
CFI	1.00	1.00	0.99	1.00	1.00
GFI	1.00	1.00	1.00	1.00	1.00
TLI	1.00	1.00	0.97	1.00	0.99
R-square	0.28	0.29	0.30	0.44	0.47

** $p < 0.001$

[a] Family Stress Index replaced with financial hardship, maternal psychological distress (K6), marital hostility and difficulty raising money

[b] Home Education Index replaced with including activities in the home, activities out of the home, books in the home, extracurricular activities, and hours of weekday television viewing

[c] Parenting Index replaced with maternal warmth, efficacy, consistency, inductive reasoning, angry parenting and co-parenting scales

[d] All indices replaced with variables listed in a, b, and c

22% of the variation in the Child Behaviour Problems latent factor. Replacing the Parenting Index with the individual items comprising the index (Model D) saw the R^2 value almost double to 0.42, with only a minor change in the fit statistics (e.g. RMSEA = 0.03).

Table 7 shows a similar pattern for the K-cohort as for the B-cohort. The family environment indices explained 28% of the variation in Child Behaviour Problems, and the model fit was very good (RMSEA = 0.01). Again, replacing the Parenting Index with the individual parenting items increased the R^2 to 0.44, but otherwise the model fit statistics were comparable.

Together, the results of Tables 6 and 7 suggest that the derived family environment indices perform well when assessing the model fit statistics, compared to models including the individual items. While minor variations in the amount of variance explained were observed for children's learning outcomes using cumulative risk indices as opposed to individual items, children's problem behaviours were sensitive to the measures used. The Parenting Index in particular explained about half as much variance in children's behaviour problems than the individual items used to derive the risk index.

4 Discussion

This study aimed to derive a series of cumulative risk indices that describe domains of children's family environment, and to assess the validity and utility of these measures. Based on the theoretical models of how socioeconomic status connects with children's learning and social-emotional outcomes, we derived a Family Stress, Home Education and Parenting Index for two cohorts of study children across five waves of data collection with an age range spanning 0–1 year to 12–13 years. The purpose of creating these measures was to distil a large number of individual items available in the Longitudinal Study of Australian Children datasets into simple summary measures that proxy for these aspects of children's family environments. If found to be sound and useful measures, then the risk indices could potentially be used in other analyses that require simple proxy measures of family stress and parenting investments. Researchers working with datasets from similar longitudinal cohort studies may also draw upon these methods to construct similar indices that assess cumulative risk in different domains.

The approach of dichotomising and taking the mean across the dichotomised measures to assess either the cumulative risk (for Family Stress) or cumulative investment (for Home Education and Parenting) produced adequate summary indices that could be useful in onward research. Each measure was stable over time but not so great in magnitude that there was no scope for variability over time to reflect potential positive or negative shocks that may influence the family environment (e.g. a windfall or job loss). Indices in consecutive waves were more strongly correlated than at waves further apart, as would be expected with most longitudinal measures. With few exceptions, discussed below, the family environment indices were significantly correlated with both socioeconomic measures and children's social-emotional and learning outcomes, indicating that the measures may be useful in determining the pathways or mechanisms that explain poorer outcomes for children from disadvantaged backgrounds. When the family environment indices were compared against competing models that replaced each index with the individual variables used to comprise them, the model fit statistics were as good as the competing models. However, the indices explained less variation in the child outcome latent factors than models using a larger number of variables. In particular, replacing the Parenting Index with the individual measures almost doubled the amount of explained variance in children's behaviour problems from 22 to 42% for the B-cohort and from 28 to 44% for the K-cohort. Replacing the Home Education Index with the individual items also saw increases in the

amount of variance explained in learning outcomes, though the magnitude was much smaller, from 6 to 11% for the B-cohort and from 4 to 6% for the K-cohort. Replacing the Family Stress index with the individual items did not improve the R^2 values for either of the outcome measures for either cohort.

By describing the circumstances of children exposed to multiple risks at once, the cumulative risk indices offer an advantage that is not available when using the individual items. For example, the Family Stress Index indicates that for each additional high stress experience the latent child behaviour problems factor increases by 0.17, when controlling for the Home Education Index and Parenting Index. This approach gives a clear indication that there is a small subpopulation of children exposed to multiple stress experiences with substantially elevated behavioural problems.

The results of these analyses indicate that cumulative risk indices are useful and reliable measures over time, although caution still needs to be applied in terms of which types of risk (or investment) can be accumulated in this way, for which developmental outcome, and for which analyses. The cumulative risk measures we examined here explained only a small proportion of the variance in children's literacy outcomes, and the use of the individual items fared little better. For children's learning outcomes, therefore, the Family Stress, Home Education and Parenting Indices may be of considerable use in further research. For children's social and emotional wellbeing outcomes, however, researchers would be trading off a substantial amount of explained variance if they substituted individual parenting items with the Parenting Index. This pattern is not unexpected, given the previous studies that have compared cumulative risk indices against alternative methods using a larger number of items (Burchinal et al. 2000; Evans et al. 2013), and the degree of 'lost' information observed in this study was similar to that observed by Burchinal et al. (2000). Yet, it is important to note that this relationship was only observed for particular cumulative risk indices and for particular child outcomes (i.e. the Parenting Index and child problems), and it was not the case that all risk indices explained less variance in children's outcomes than the individual variables. Our results suggest that the Family Stress and Home Education Indices can be confidently used in studies examining children's social and emotional wellbeing.

Importantly, Burchinal et al. (2000) also found that cumulative risk indices performed much better than individual variables in longitudinal models predicting patterns of change. While we did not test this in the current study, it remains that one of the major strengths of using cumulative risk indices is how they can be used in the types of longitudinal analyses that the LSAC and other cohort studies were designed for. As we noted earlier, cumulative risk indices may be considered as more reliable than individual risk variables and therefore more powerful predictors of developmental patterns (Rogosa et al. 1982), which would not be apparent in cross-sectional analyses such as those detailed in the current study. Also, other longitudinal studies examining cumulative risk at different stages of the life course found cumulative risk indices to be an effective and efficient way of understanding these relationships over time (Appleyard et al. 2005; Atkinson et al. 2015; Mistry et al. 2010). For these reasons, and for others outlined by Evans et al. (2013) including ease of interpretation, cumulative risk indices should not be discounted simply because they explain less variance in particular analyses.

Though the family environment indices were derived for all waves, measures pertaining to the Wave 1 for the B-cohort may be less reliable than in subsequent waves. This concern is particularly relevant if the indices are used longitudinally. For the B-cohort in particular, there were few developmentally appropriate indicator variables to assess the home learning environment as the capabilities of infants are less than those of older children. In addition,

the stress that accompanies the arrival of an infant into a household may mean that the measures used to assess financial stress and mental wellbeing may not distinguish very well between different levels of stress, as many families would experience stress during this time. Furthermore, the ways in which mothers interact with infants is very different to interactions with older children. These factors could explain why the Parenting Index was not significantly correlated with either family-level or neighbourhood-level SES, or similarly why the Family Stress Index was not significantly associated with learning outcomes for the B-cohort at Wave 1.

The analysis comparing the family environment indices against models using individual indicator variables suggested that the Parenting Index was a significant predictor of children's literacy for the B-cohort at age 8–9 years, though with very small effect size, and was not a significant predictor of literacy for the K-cohort at 12–13 years. Previous studies using LSAC data have found an association between learning outcomes and particular parenting styles, such as maternal warmth and parental efficacy (Dockery et al. 2013), though others have found less consistent results when a larger range of family background variables are controlled for, including indicators of family stress (Fiorini and Keane 2014). Similarly, other international studies have failed to document significant relationships between warm and punitive parenting styles and cognitive outcomes in children (Yeung et al. 2002). In this context, the failure to find an association between parenting and learning outcomes is unlikely to reflect problems in the quality of the measure.

We also found either very small or non-significant correlations between the family- and neighbourhood-level socioeconomic measures and the Parenting Index, depending on the cohort and wave. Previous research has consistently shown that economic disadvantage is associated with less positive and more negative parenting (Bradley and Corwyn 2002), and in this context these findings are not consistent with the broader literature. However, other studies suggest that the relationship between socioeconomic disadvantage, negative parenting and children's outcomes is contingent on the presence of family stress, a pattern that is explained by the Family Stress Model. As Barnett (2014) notes, many parents living in poverty exhibit effective, sensitive parenting behaviours despite the considerable challenges they face, and in such cases, positive parenting can serve as resource or protective factor for children experiencing other risks associated with poverty. Yet the presence of stressors such as depression, anxiety or a hostile relationship with another caregiver, may reduce the emotional resources they have available to parent with warmth, consistency, and reasoning. Recent research, which used the indices derived in this study to examine the relationship between family joblessness and children's outcomes, found that the relationship between parent joblessness and children's social and emotional wellbeing was largely explained by indirect effects, where parent joblessness was associated with increased family stress, which in turn was associated with lower Parenting scores and then with child problems (Author et al. np). The indirect pathway excluding family stress did not account for the relationship between joblessness and children's social-emotional wellbeing problems. The results suggest that while disadvantaged families may experience financial hardship, if they do not experience stressful events that can coincide with hardship, such as anxiety, instability, or marital hostility, then they are also less likely to parent in ways that include low warmth, hostility, or consistency.

A limitation to the family environment indices is that they largely pertain to maternal interactions with the child, particularly for the indicators relating to parenting. While co-parenting and marital hostility measures were included in the Family Stress Index, the Parenting Index measures were based on mothers' responses as mothers in the LSAC are the primary caregivers of the study children. Fathers were also surveyed in the LSAC, but

there are large amounts of missing data for those who do not live with the study child, and survey response rates are also lower for residing fathers than for mothers (Cusack and Defina 2014). Moreover, including fathers' responses in the derivation of the family environment indices would have largely excluded single-parent families from analysis. Often, these are the families of greatest interest to researchers concerned with socioeconomic disadvantage.

In conclusion, the Family Stress Index, Home Education Index and the Parenting Index appear to be robust and useful proxy measures of salient aspects of children's home environments that are relevant to their cognitive and social-emotional development. Researchers need to exercise some caution regarding the use of the Parenting Index and children's social and emotional wellbeing outcomes, particularly in cross-sectional analyses. However, LSAC users—and users of datasets from other similar cohort studies—may find these family environment indices useful in longitudinal analyses, in studies where researchers need to simplify complex models, or where researchers are interested in the experience of children exposed to multiple risks. Readers wishing to use the indices described in this study are encouraged to contact the authors.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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