Poverty Dynamics and Child Well-Being: Evidence from the "Growing up in Ireland" Study

Introduction

A large quantitative research literature has documented the association between poverty and children's outcomes within a range of well-being indicators, including cognitive ability, education, and social and behavioural development (Van Lancker and Vinck 2019). Children from low income households do worse, on average, in cognitive tests (Gregg *et al*. 2008) and in emotional and behavioural development assessments (Blanden *et al*. 2007; Davies and Woitach 2008). Meanwhile, qualitative research has emphasised the negative consequences of poverty for children's well-being and relationships (Ridge 2002; Treanor 2020). However, it is difficult to disentangle any effect that household income may have in and out of itself from that of its correlates, such as parental education, occupational class, or neighbourhood quality.

Moreover, to the extent that income impacts children's outcomes, the specific pathways and mechanisms remain poorly understood. In a systematic review of experimental, quasi-experimental and observational longitudinal studies on the relationship between household income and child outcomes, Cooper and Stewart (2021) noted both direct causal effects of household income on children's cognitive and behavioural development and indirect effects via parental well-being and the home environment. However, many of these studies were from the United States, and the evidence base was richer for cognitive than non-cognitive outcomes. The positive effects of income were more pronounced among those whose incomes were lower to start with.

At the same time, low household income is not necessarily a sufficient indicator of poverty as a predictor of child outcomes. Poverty is a multidimensional concept that – at least in the European Union – is usually measured using indicators of low disposable household income, enforced lack of socially perceived necessities (i.e. material deprivation), and

difficulty making ends meet (i.e. financial strain) (Guio *et al*. 2018). A study using birth cohort data for the United Kingdom found that a combination of all three of these indicators of poverty was associated with the highest levels of child behaviour problems (Schenck-Fontaine and Panico 2019). It highlighted the importance of considering the multidimensional nature of poverty in analyses of child development. A recent study using Irish birth cohort data showed that it is financial strain rather than household income that is associated with behaviour problems in middle childhood and adolescence (Gibbons *et al*. 2023). An earlier study using US data found that material hardship (a latent factor based on deprivation and financial strain indicators) mediated the effect of household income on family processes (Gershoff *et al*. 2007).

The present study adds to this literature by investigating the association between multidimensional poverty and children's cognitive and behavioural development between the ages of 9 months and 9 years in Ireland. Using four waves of longitudinal data for the 2008 birth cohort from the nationally representative "Growing Up in Ireland" (GUI) study in a dynamic structural equation modelling framework, we aim to disentangle the direct contemporaneous effects of poverty on child outcomes from the indirect effects accruing over time via earlier poverty, outcomes, parental investments, and parental stress. By observing children (within their households) at the ages of 9 months, 3 years, 5 years, and 9 years, we elucidate the roles of parental investments and parental stress as mediators of poverty during the formative years of childhood. The period up to 9 years of age is critical for cognitive, social, emotional, and physical development (see Britto *et al*. 2013).

The two main theoretical perspectives to analyse the effects of poverty (and socio-economic inequality more broadly) on children's outcomes are the Family Investment Model (FIM) and the Family Stress Model (FSM). The FIM posits that parents use their financial, social, and human capital to foster their children's skills and well-being (Bradley and Corwyn 2002; Heckman 2006; Lareau 2011). Meanwhile, the FSM postulates the links between

economic hardship, economic pressure, parental psychological distress, inter-parental and parent-child relationships, and, finally, child outcomes (see Masarik and Conger, 2017).

Both models enjoy substantial multi- and inter-disciplinary empirical support, but they are usually employed separately. FIM-based studies tend to analyse differences in cognitive ability and educational outcomes (Duncan *et al*. 2017). FSM is primarily used to predict child mental health, subjective well-being, and behavioural adjustment (Chzhen *et al*. 2021; Ponnet 2014), but several FSM-based studies focussed on education-related outcomes (Justice *et al*. 2019; Schoon, Hope, *et al*. 2010).

The two models can also be incorporated into a hybrid one to analyse cognitive and behavioural development. A growing evidence base provides support for doing so. For example, Yeung *et al.* (2008) examined both family investment and family stress processes as mediators of household income effects on cognitive and behavioural outcomes at age 3-5, using data from the 1997 Child Development Supplement of the US Panel Study of Income Dynamics. They found that the home learning environment played a significant role in mediating the effect of income on children's cognitive outcomes, while maternal emotional stress and parenting practices did so for behaviour outcomes, but the model including all the mediating pathways performed better than the ones focusing on separate pathways. Meanwhile, Gershoff *et al.* (2008) estimated 'hybrid' models with parental investment, parenting stress and parenting behaviour as mediators of family income effects on children's cognitive and behaviour outcomes at the age of 6, using US data from the Early Childhood Longitudinal Study. They too found that parental investment mediated the effects of household income on children's cognitive outcomes, but parenting stress and behaviours did so for both behavioural outcomes and cognitive outcomes. More recently, Layte (2017) used longitudinal data from the UK Millennium Cohort Study to analyse the role of the home learning environment and parental mental health as mediators in the relationship between social class, child cognitive ability and

behavioural problems, and teacher-assessed educational performance using. Parental mental health and parental investments (e.g. reading to the child at age 3) had direct effects both on child cognitive ability and behavioural adjustment, supporting a hybrid FIM-FSM model.

Poverty and child development: Evidence from longitudinal studies

A growing body of evidence from longitudinal studies has found the link between household poverty and children's outcomes. Using British birth cohort data, Dickerson and Popli (2016) identified large cumulative negative effects of persistent poverty on children's cognitive development between the ages of 3 and 7. Hansen and Joshi (2007) showed that by the age of three, some disadvantaged children were lagging a full year behind their better-off peers in terms of cognitive development, social skills, and school readiness. The results are supported by Schoon *et al*. (2010), who further suggested that the significant negative relationship between persistent financial hardship and children's cognitive development could be mitigated by positive parenting in the UK.

Birth cohort studies show that it is not only differences between poor and non-poor households that are related to inequalities in children's outcomes, but there is an income gradient more generally. Using data for Ireland (i.e. GUI), McMullin *et al*. (2020) documented a substantial household income gradient in children's cognitive ability at the ages of 3 and 5. Washbrook *et al.* (2014) showed that higher income in early childhood was associated with higher cognitive ability scores and fewer behaviour problems in middle chilhood, based on English birth cohort data from the Avon Longitudional Study of Parents and Chilren. In a cross-country comparative study of children's early cognitive development, Bradbury *et al.* (2019) found larger gaps in children's test scores between high-income and middle-income households in the US than in Australia, Canada or the UK, while the gaps between middle-income and

low-income households were largely similar. They explain this finding as evidence of a greater concentration of non-monetary resources among high-income households in the US.

Longitudinal studies have also been invaluable for establishing the associations between family resources more generally and children's cognitive development. Bradbury *et al*. (2015) found that educational achievement was strongly tied to family resources and investment in children during the pre-school period, such as centre-based childcare, books available at home, and home-learning activities in Australia, Canada, the US, and the UK. Caro *et al*. (2009) tested the trajectory of Canadian students' academic achievement from 7 to 15 years old and found that the socio-economic status gradient in academic achievement was stable in early childhood but increased during school years. Meanwhile, Skopek and Passaretta (2021) found that achievement gaps by parental education in Germany were already large by the time children started school and remained stable throughout the school years. Similar findings were documented for the Netherlands and the UK (Passaretta *et al*. 2022). A recent analysis of GUI data by McGinnity *et al.* (2022) showed that occupational social class differentials in reading achievement at age 9 persisted even after accounting for vocabulary scores at age 3, early childhood education and care attendance, and length of school exposure.

Poverty also contributes to differences in children's mental health and social and behavioural development from an early age. By the age of 14, British children with at least one spell in income poverty had a higher risk of stress, emotional and behavioural difficulties, and low subjective wellbeing than those who had not been in income poverty (Rees 2019). Meanwhile, British children living in families experiencing both material deprivation and financial strain were at the highest risk of behaviour problems at age 7 (Schenck-Fontaine and Panico 2019). Financial strain was associated with greater externalised behavioural difficulties in Irish adolescents (Gibbons *et al*. 2023).

Current study

We build on this literature by integrating the FIM and FSM frameworks to analyse the consequences of multidimensional poverty for both cognitive and behavioural development in early to middle childhood. First, we document differences in children's outcomes at age 9 by the number of waves they had been in multidimensional poverty. Second, we model the mechanisms through which household poverty affects cognitive and behavioural development between the ages of 9 months and 9 years.

We operationalize the main FIM channel as parental activities stimulating children's learning (e.g. reading to the child at age 3) and the key FSM pathway as parenting stress reported by the mother. FIM predicts that poverty will affect children's cognitive and behavioural development primarily via parental activities rather than directly (Hypothesis 1), while FSM emphasizes parental psychological distress and inter-family relationships as the key mediators (Hypothesis 2). A hybrid model suggests that both pathways underlie the association between poverty and child outcomes over time (Hypothesis 3). We also explore the possibility that cognitive and behavioural outcomes reinforce each other over time (Hypothesis 4).

The Irish case

The Irish context is particularly relevant to the study of longer-term consequences of poverty for child development because of the economic crisis of 2008-2011 that followed more than ten years of the 'Celtic Tiger' boom. Between the onset of the economic crisis in 2008 and the first signs of economic recovery in 2013, the levels of material deprivation, income poverty and financial strain have risen sharply, particularly among families with children (Nolan and Maître 2017). Thus, using longitudinal data for 2008-2017, we focus on a period of substantial macro-economic turbulence and fluctuation in household incomes when many families with children would experience economic hardship at least once. Indeed, other studies

using data from GUI documented reductions in household incomes (Layte and McCrory 2018), subjective perceptions of the recession (Reinhard *et al*. 2018), widespread parental job loss (Mari and Keizer 2021), and increased difficulty making ends meet (Watson *et al*. 2016) at GUI Wave 2 in 2011.

Substantial fluctuation in poverty indicators in the GUI sample over the course of the Great Recession helps analyse the short and longer-term consequences of multidimensional poverty for children. Indeed, other studies have utilised the exogenous shock of the Great Recession and GUI's data collection spanning the crisis and its aftermath to better understand the role of changing household economic circumstances for children. For example, Sprong *et al.* (2022) described the socio-demographic characteristics of Irish households with children that experienced different trajectories of economic hardship during the recession and recovery. Mari and Keizer (2021) estimated the effects of parental job loss on child cognitive ability and behaviour problems. Layte (2022) analysed the effects of financial strain on children's performance in state examinations. Gibbons *et al.* (2023) studied the effects of changes in household income, financial strain, and material deprivation on internalised and externalised behavioural difficulties in early to middle childhood and in adolescence.

Method

Growing up in Ireland and the study sample

We use data for the '08 Cohort from the GUI study (https://www.growingup.gov.ie/). It collects a rich set of household demographic and socio-economic indicators as well as child cognitive and behavioural outcomes. The '08 cohort is a nationally representative sample of around 11,000 children born in 2008, randomly sampled from the Child Benefit register that includes all children resident in Ireland. GUI families were visited for the first time in 2008/2009 when the study child was 9 months old (Wave 1) and followed up again when the

child was 3 years old (Wave 2, 2011), 5 years old (Wave 3, 2013) and 9 years old (Wave 4, 2017). See Thornton *et al*. (2013) for further details of the GUI sampling methodology.

Our study sample includes those who took part in each of these four waves ($N = 7{,}507$). To account for non-random attrition across the waves, we re-weight our data using the weighting factors provided in the GUI dataset specifically for this balanced sample. This is important because children from less socio-economically advantaged backgrounds were under-represented at Wave 4 and the longitudinal weights adjust for that (Quail *et al*. 2019). However, these weights do not correct for non-random non-response to survey questions. Income variables are particularly vulnerable to item non-response (see Table 1). Therefore, we estimate our multivariate models (i.e., dynamic structural equation models) using the maximum likelihood with missing values estimator. It draws on all the available information instead of listwise deleting any observation with a missing value on any of the variables in the analysis. Therefore, our analytic sample includes all 7,507 households who took part in all four waves, even if they did not give valid responses to every question. For comparison, a balanced sample based on listwise deletion of missing values would include only 5,000 households.

Wave 1 data collection coincided with the onset of the financial and economic crisis in Ireland. Yet it was in fact at Wave 2 (2011) that households with children experienced some of its worst effects, which were compounded by the austerity measures the government introduced after the 'bail-out' by the European Union and the International Monetary Fund in 2010. According to monthly seasonally adjusted unemployment statistics for the 25-74 age group (CSO, 2021), unemployment peaked at 13% between Waves 2 and 3 and fell to its pre-crisis levels of around 5% by the time of the age 9 data collection in 2017.

Measures: Outcomes, predictors, and mediators

When the study child was 9 months old, the primary caregiver answered a battery of questions from the Ages and Stages Questionnaire, 2nd edition (ASQ-2). The primary caregiver is almost always the mother of the study child (99.9% at Wave 1, 98.4% at Wave 2, 97.9% at Wave 3 and 97.4% at Wave 4). We refer to the primary caregiver as the mother from here onwards for simplicity. ASQ-2 is a screening tool to check an infant's progress in the areas of communication, gross motor skills, fine motor skills, problem solving, and personal-social development (Squires *et al*. 1999). Following Nixon *et al*. (2013), we rely on the 10-month interval ASQ-2 questionnaire as the one most appropriate for 9-month-olds. The continuous scores for each sub-scale (0-60) load on one latent factor, which accounts for 43% of the total variance in these items in the unweighted Wave 1 sample. We use this as a measure of both cognitive development and behavioural development at 9 months.

Trained interviewers administered age-appropriate cognitive ability tests in the child's home at ages 3, 5 and 9. Two British Ability Scales (BAS) tests were used at ages 3 and 5: Naming Vocabulary and Picture Similarity (Elliot *et al*. 1996). We use the corresponding standardised test scores available in the GUI user database that adjust for the differential difficulty of the items. Following Jones and Schoon (2008) and Chzhen and Bruckauf (2019), who used BAS scores from the UK Millennium Cohort Study, we derive latent cognitive ability scores using principal component analysis in each wave. The two sub-scales load on one factor, which explains 70% of the total variance in these sub-scales at age 3 and 64% at age 5.

A different batch of cognitive assessments were administered at age 9: the Drumcondra Primary Reading Test Revised (DPRT-R) and the Selective Attention Test (SAT). The DPRT-R is based on the Irish national primary school curriculum (Educational Research Centre 2007). We use the logit scores provided in the GUI user database, which adjust for the difficulty of the items and the child's age at interview. Meanwhile, the SAT assesses children's ability to locate 80 small symbols on a map within a minute, while ignoring distracting information. It

measures attentional capacity rather than reading ability or curriculum knowledge (Manly *et al*. 1999). We use the number of correctly identified symbols out of 80 alongside the DPRT-R logit score to derive a latent cognitive ability factor. The resulting factor explains 56% of the total variance. We normalize it to have the mean of 100 and the standard deviation of 15 for use in descriptive analyses (Figure 3).

We use the Strengths and Difficulties Questionnaire (SDQ) (R. Goodman 1997) to measure children's behavioural development at ages 3, 5 and 9. We employ the total score on each of the four (mother-reported) sub-scales: emotional symptoms, conduct problems, hyperactivity/inattention, and peer relationship problems. Responses to each item include 'Certainly true', 'Somewhat true', and 'Not true', resulting in the scores from 0 to 10 on each sub-scale and from 0 to 40 in total. Higher scores correspond to more difficulties. The four sub-scales load on one factor in each wave, explaining 45% of the total variance at age 3, 48% at age 5 and 52% at age 9.

Each wave of the GUI study collects data on annual disposable household income (from all sources) after taxes and benefits, adjusted for household size and composition using the Irish equivalence scale. This scale is very similar to the modified OECD scale used by Eurostat. The national relative income poverty measure in Ireland is the share of the population living in households with annual disposable equivalised income below 60% of the national median. The measure is rooted in Townsend's (1979) theory of relative deprivation, as it benchmarks one's own position in the national income distribution to the level of income that would approximate "the minimum acceptable way of life in the member state in which they live" (European Council 1984, p. 1) According to this measure, the share of children under 18 in Ireland living in income-poor households fluctuated around 20% between 2008 and 2017 (Central Statistics Office, 2019).

Yet we do not have a reliable measure of the national median income to replicate the official Irish relative income poverty indicator in the GUI sample. Official poverty statistics use data from the nationally representative cross-sectional annual Statistics on Income and Living Conditions survey, which differs substantially from the GUI study in its sampling methods and the dates of data collection. Therefore, we use 60% of the wave-specific median as the income poverty line in each wave. This produces the rates of 20% in Wave 1, 16% in Wave 2, 16% in Wave 3 and 17% in Wave 4. The falling or stable poverty rate during a recession is an artefact of linking the poverty line to the national (or sample) median income, which fell during the recession. Yet this income poverty measure still captures the spirit of Townsend's relative poverty approach because it allows us to compare the outcomes of the poorest children to their better-off peers even at a time of changing macro-economic circumstances.

However, the issue of the poverty line aside, low household income does not automatically mean that people are living in poverty (Mack and Lansley 1985; Townsend 1979). For example, some households can draw on savings and other assets in times of hardship (Lister 2004), while even higher income households may have significant needs that their incomes do not meet. Therefore, we also include measures of material deprivation and financial strain in the analysis. We define financial strain using the mother's response to the question about the household's ability to make ends meet. This ranges from 1 'with great difficulty' to 6 'very easily'. We recoded this into a binary variable where 1 indicates 'with difficulty or great difficulty' and 0 'with some or no difficulty'.

We measure material deprivation using nine items referring to the household's ability to afford goods or activities that are customary in the Irish society. These are: eating meals with meat, chicken, or fish (or a vegetarian equivalent) every second day; having a roast joint at least once a week; buying new rather than second-hand clothes; each household member having

a warm waterproof coat; two pairs of strong shoes; replacing worn-out furniture; keeping the home adequately warm; having family for friends for a drink or meal once a month; buying presents for family or friends at least once a year. Households that report enforced lack of two or more of these nine items are counted as materially deprived in our descriptive analysis (see Figures 3 and 4). We use the ordinal (0-9) material deprivation measure in our structural equation models.

To create a measure of multidimensional poverty history for our descriptive analyses (Figures 3 and 4), we count the number of waves in which the study child lived in a multidimensionally poor household. We construct a measure that draws on low income, material deprivation and financial strain: those who are subject to at least two of these 'dimensions' are counted as multidimensionally poor. We then combine those who were in multidimensional poverty in all four waves (from 9 months until 9 years) as well as those who experienced poverty in any three waves into the group that experienced persistent poverty. As a result, 78.5% of the age 9 (Wave 4) sample who took part in all four waves were never in multidimensional poverty, 13.4% experienced it once, 5.6% twice ('intermittent') and the remaining 2.5% were in persistent multidimensional poverty.

Parental investment in the child's early learning was assessed at ages 3 (Wave 2) and 5 (Wave 3) using questions about the frequency of age-appropriate cognitively stimulating activities. However, very little such information is available at Wave 1. We use the question about how often the child's mother talked to the baby while doing other things, scored on a 5-point-scale from 1 "Never" to 5 "Always".

At Wave 2 (age 3), the mother reported how many days in an average week anyone at home: reads to the child; helps the child learn ABC or alphabet; helps the child learn numbers or counting; helps the child learn songs, poems, or nursery rhymes; plays board games with the child; paints, draws or colours with the child. These items are scored on a 7-pont scale from 0

to 7 days a week. They form a reliable scale ($\alpha = 0.70$) and load on one latent factor (accounting for 40% of the total variance).

At Wave 3 (age 5), the mother reported how often she: played with the child using toys, games, or puzzles; visited the library; read to the child; used a computer with the child in educational ways; and went on educational trips together (e.g., to museums, farms). Each item was scored on a 5-point scale from 1 "Never" to 5 "Every day". These five items form a scale with modest internal consistency ($\alpha = 0.45$) but removing any of these items does not increase the reliability of the scale, so we kept them all. All these items load on one factor (accounting for 33% of the total variance).

We use self-reported information on parenting stress. It is measured using the six-item parenting stressors sub-scale of the Parental Stress Scale (Berry and Jones 1995). It potentially taps into both the parental psychological distress and disrupted parenting aspects of the FSM. Mothers are asked if they agree or disagree with statements regarding their relationship with the child: Caring for my child sometimes takes more time and energy than I have to give; The major source of stress in my life is my child; Having a child leaves me little time and flexibility in my life; Having a child has been a financial burden; It is difficult to balance different responsibilities because of my child; Having a child has meat having too few choices and too little control over my life. The questions are scored on a 5-point scale from 1 "Strongly Agree" to 5 "Strongly Disagree". We reverse code these items so that higher values refer to greater stress. These parenting stress items load on one factor, accounting for 43% of the total variance at Wave 1, 47% at Wave 2 and 49% at Wave 3. The Cronbach's alpha for each wave is acceptable: 0.73 for Wave 1, 0.77 for both Wave 2 and Wave 3.

Maternal depression – measured using an 8-item version of the Centre for Epidemiological Studies Depression Scale – could be used instead of parenting stress to operationalise a key FSM pathway. However, maternal depression exhibits less variation over

time than parenting stress and may have a shared unobserved genetic component with children's behavioural difficulties. Having re-estimated our models using maternal depression instead of parenting stress, our findings were qualitatively the same (see Table S9 in Supplementary Materials). Table 1 summarises the definition of outcomes, predictors and mediators used in each wave.

Table 1 Measures of outcomes, predictors, and mediators

	Age 9 months	**Age 3 years**	**Age 5 years**	**Age 9 years**
Cognitive ability	ASQ-2	BAS	BAS	DPRT-R; SAT
Behaviour problems	ASQ-2	SDQ	SDQ	SDQ
Poverty	Disposable household income below 60% of the median wave-specific median; material deprivation; financial strain.	Disposable household income below 60% of the median wave-specific median; material deprivation; financial strain.	Disposable household income below 60% of the median wave-specific median; material deprivation; financial strain.	Disposable household income below 60% of the median wave-specific median; material deprivation; financial strain.
Home learning environment	Frequency of talking to the baby (1 item).	Frequency of age-appropriate cognitively stimulating activities.	Frequency of age-appropriate cognitively stimulating activities.	
Parental stress and parent-child relationship	Parenting Stressors sub-scale.	Parenting Stressors sub-scale.	Parenting Stressors sub-scale.	

Table 2 shows summary statistics for each wave. The rates of material deprivation and financial strain peaked at Wave 3 (2013). Most children in the sample live with two parents rather than one, have a mother with upper secondary education or lower rather than tertiary education, and have no or just one other child under 18 in the household (who is not necessarily a full sibling) rather than two or more.

Table 2 Summary statistics

		Age 9 months		Age 3 years		Age 5 years		Age 9 years	
		M (SD)	*N*	M (SD)	*N*	M (SD)	N	M (SD)	*N*
Low household income (*ref.* 60% of the median or above)		0.20	7,507	0.16	7,507	0.16	7,507	0.17	7,507
Material deprivation (*ref.* not materially deprived)		0.06	7,489	0.07	7,500	0.12	7,500	0.07	7,483
Financial strain (*ref.* not reporting financial strain)		0.13	7,501	0.22	7,502	0.26	7,503	0.13	7,487
Material deprivation		0.25 (0.8)	7,489	0.33 (0.8)	7,500	0.47 (1.1)	7,500	0.3 (0.8)	7,483
Multidimensionally poor (1 or more dimensions)		0.27	7,485	0.33	7,497	0.37	7,498	0.26	7,477
Multidimensionally poor (2 or more dimensions)		0.09	7,485	0.11	7,497	0.14	7,498	0.09	7,477
ASQ_problem solving score (0-60)		46.1 (13.3)	7,094						
ASQ_gross motor score (0-60)		32.1 (16.7)	7,481						
ASQ_fine motor score (0-60)		51.5 (11.1)	7,277						
ASQ_communication score (0-60)		44.8 (11.4)	7,463						
ASQ_personal social score (0-60)		43.9 (11.8)	7,408						
COG_Picture Similarity (20-80)				52.6 (10.8)	7,356	58.3 (10.68)	7,452		
COG Naming Vocabulary (20-80)				50.7 (12.7)	7,153	55.1 (12.1)	7,437		
COG Drumcondra reading logit (45-135)								98.5 (15.2)	7,250
COG Selective attention test (0-80)								31.9 (9.30)	7,252
Parent's report	SDQ_emotional problems_parent report (0-10)			1.41 (1.42)	7,504	1.61 (1.73)	7,505	2.11 (2.08)	7,498
	SDQ_conduct problems (0-10)			2.20 (1.84)	7,503	1.54 (1.52)	7,505	1.17 (1.41)	7,499
	SDQ_hyperactivity problems (0-10)			3.26 (2.20)	7,502	3.43 (2.52)	7,504	3.25 (2.63)	7,499
	SDQ_peer problems (0-10)			1.22 (1.40)	7,504	1.05 (1.36)	7,504	1.14 (1.55)	7,499
	SDQ_total score (0-40)			8.08 (4.65)	7,502	7.63 (5.01)	7,504	7.67 (5.67)	7,498
Teacher's report	SDQ_emotional problems_teacher report (0-10)					1.35 (1.87)	7,071	1.58 (2.07)	6,856
	SDQ_conduct problems (0-10)					0.77 (1.37)	7,073	0.69 (1.40)	6,857
	SDQ_hyperactivity problems (0-10)					3.16 (2.88)	7,072	2.73 (2.75)	6,857

SDQ_peer problems (0-10)					1.03 (1.50)	7,070	0.96 (1.57)	6,857
SDQ_total score (0-40)					6.31 (5.45)	7,070	5.97 (5.79)	6,855
Parental investment								
Talking to baby (1-5)	4.5 (0.9)	7,506						
ABC or alphabet (0-7)			3.9 (22.4)	7,504				
Numbers or counting (0-7)			5.2 (2.0)	7,504				
Songs, poems or nursery rhymes (0-7)			5.2 (2.0)	7,503				
Paint, draw, colour or play-doh (0-7)			5.0 (2.0)	7,504				
Read to child (0-7)			5.5 (2.0)	7,504	4.5 (0.9)	7,505		
Play games (1-5)			4.3 (2.3)	7,501	4.1 (0.9)	7,506		
Visit library (1-5)					2.2 (1.1)	7,504		
Use computer in educational ways (1-5)					2.5 (1.3)	7,506		
Educational visits (1-5)					2.9 (0.7)	7,506		
Maternal stress								
Time & Energy (1-5)	3.1 (1.3)	7,501	2.3 (1.2)	7,425	2.3 (1.2)	7,408		
Main source (1-5)	1.9 (1.0)	7,501						
Time & flexibility (1-5)	3.0 (1.2)	7,496	1.5 (0.8)	7,426	1.4 (0.8)	7,408		
Financial burden (1-5)	2.2 (1.0)	7,492	2.1 (1.1)	7,424	1.9 (1.0)	7,406		
Responsibilities (1-5)	2.5 (1.1)	7,485	1.7 (0.9)	7,424	1.6 (0.9)	7,409		
Choice & control (1-5)	2.0 (0.9)	7,500	1.9 (1.0)	7,423	1.7 (0.9)	7,409		
Doing enough (1-5)			2.9 (1.2)	7,423	3.0 (1.3)	7,409		
Female child (*ref*. male)	0.49	7,507						
Mother has tertiary education (*ref.* upper secondary or less)	0.27	7,503	0.30	7,495	0.29	7,505		
Three or more children in the family (*ref:* one or two)	0.25	7,507	0.35	7,507	0.44	7,507		
Single parent family (*ref:* couple family)	0.16	7,507	0.17	7,507	0.16	7,507		

Source: Growing Up in Ireland ’08 Cohort. Longitudinal weights used.

Estimation

To account for the dynamic nature of child development, we draw on the value-added plus lagged inputs model of skill formation for both cognitive ability and behavioural functioning (Todd and Wolpin 2007). The child's cognitive (see Figure 1) and behavioural outcomes (see Figure 2), measured in each wave, are a function of previous outcomes and previous 'inputs' (i.e. parental investment in cognitively stimulating activities and maternal stress). Following Dickerson and Popli (2016), who modelled children's cognitive development between the ages of 3 and 7 in a dynamic structural equations framework using data from the UK Millennium Cohort Study, we use current multidimensional poverty (from here onwards: poverty, for simplicity) as a predictor of child outcomes in each wave. This allows us to disentangle the direct contemporaneous effects of poverty on child outcomes from the indirect effects accruing over time via the effects of poverty on parental investment and parental stress. Thus, cognitive ability (behaviour difficulties) at the age of 9 months is our baseline outcome, predicted only by household poverty at that time. From age 3 to age 9, however, child outcomes are predicted by prior outcomes, prior parental 'inputs,' and current poverty. However, to allow for persistence of poverty, we also include auto-regressive pathways from poverty in one period to poverty in the subsequent period.

Using the counterfactual approach to mediation analysis (see VanderWeele, 2015), poverty is the exposure or treatment, parental investment and parental stress are the mediators, and child cognitive ability and behaviour problems are the outcomes. In this causal framework, the direct effect of poverty is its 'impact' at a fixed level of the mediators. It is the expected difference in the outcome associated with a change in poverty level if parental investment/stress are the same at all levels of poverty. Meanwhile, the indirect effect is the effect of changes in poverty (or material well-being) that act solely through parental investment or stress.

However, in our dynamic 'lagged inputs' model, it is prior parental investment/stress that mediate prior poverty, while contemporaneous poverty has direct effects on children's outcomes. Thus, while the mediators of theoretical interest are parental investment and parenting stress, we have additional mediators in the model (prior outcomes and current poverty) to account for the cumulative nature of children's cognitive and behavioural development and for persistence in poverty over time. For example, outcomes at the age of 3 are a function of 1) the outcomes at age 9 months, which mediate the effect of poverty at that time, 2) current poverty, which mediates the effect of poverty at 9 months and 3) parental investment/stress at 9 months, which also mediate the effect of poverty in that period. If the direct contemporaneous effect of poverty is not statistically significantly different from zero, we would conclude that the effects of poverty are primarily via the mediating mechanisms, in line with Hypotheses 1 and 2. In other words, for children with similar levels of ability or behavioural problems, parental 'inputs' and poverty - all measured at an earlier age – there would be no differences in current ability/behaviour by current household poverty.

To interpret the estimates of this model in a causal framework, several assumptions need to be met. First, there should be no exposure-mediator interactions. This would mean that the direct effect of poverty on child outcomes is the same across all levels of parental investment/parenting stress. However, the model does not include a direct pathway from prior poverty to current outcomes, only indirect ones, while current poverty is directly associated with current outcomes, without mediators. Second, there should be no unmeasured confounders in the link between poverty and the mediators or between mediators and the outcomes. This assumption is investigated in the robustness checks.

Figure 1: Main hypothesised relations between poverty, parental investment and child cognitive ability (see Equations 1 and 3)

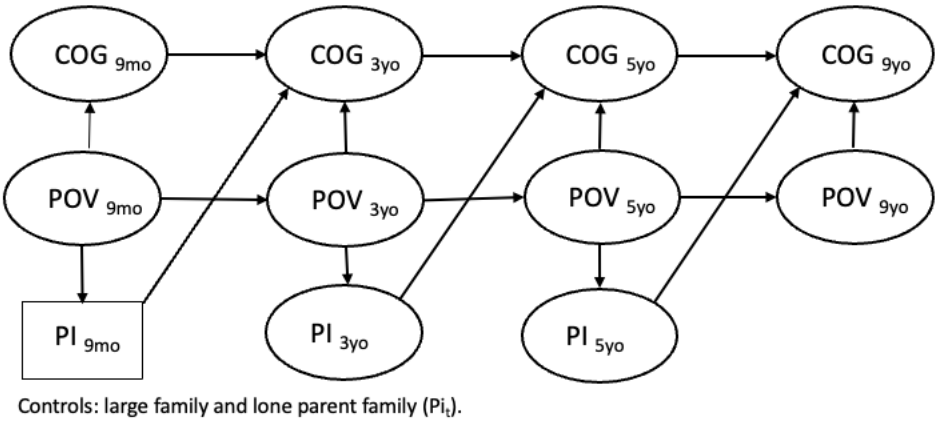
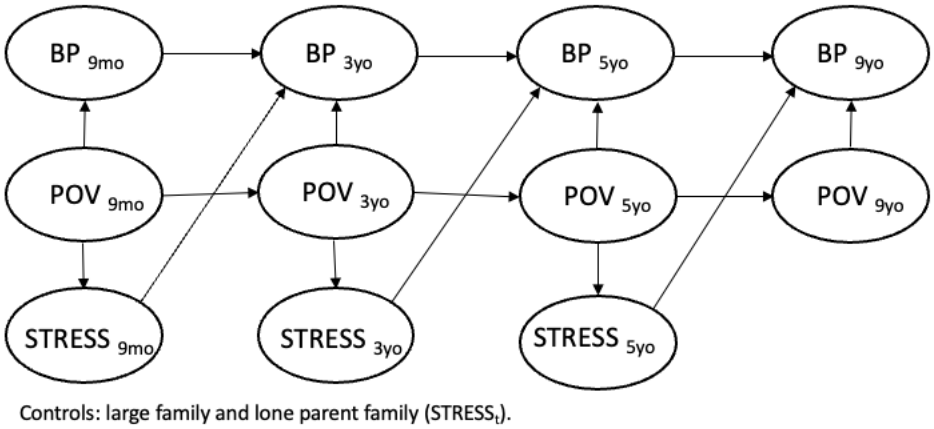


Figure 2: Main hypothesised relations between poverty, maternal stressors, and child behaviour problems (see Equations 2 and 4)



We model child outcomes, household poverty, parental investment, and maternal stress as latent (unobserved) variables that are represented by a set of manifested (observable) variables. Children's cognitive development is measured using ages and stages questionnaires (at 9 months, Wave 1), Naming Vocabulary and Picture Similarity from the British Ability Scales (age 3 and 5, Waves 2-3), and the Drumcondra Primary Reading Test-Revised and the Selective Attention Test (age 9, Wave 4). Child behaviour problems are measured using ages and stages questionnaires in Wave 1 and the four SDQ sub-scales in Waves 2-4. Note that higher ASQ scores refer to age-appropriate development, while higher SDQ scores refer to greater behaviour problems. For the items that are similar across any two subsequent waves,

we allow the error terms to be correlated (i.e. Naming Vocabulary scores at ages 3 and 5, Picture Similarity scores at ages 3 and 5; SDQ sub-scales at ages 3 and 5, and 5 and 9).

Poverty is measured using three binary variables in each wave: disposable household income (adjusted for household size and composition using the Irish equivalence scale) below 60% of the wave-specific median, material deprivation, and financial strain. Parental investment is measured using the frequency of parental engagement in age-appropriate cognitively stimulating activities with the child in Waves 1-3. Maternal stress is measured using 6 items of the parenting stressors sub-scale of the Parental Stress Scale (Berry and Jones 1995) in Waves 1-3.

We estimate a series of structural equation models (SEM) separately for latent cognitive ability (1) and behaviour problems (2) in Stata 17 using the maximum likelihood with missing values estimator. Instead of using modification indices to obtain a model with the best possible fit, we specify the hypothesised pathways and accept the results if the standardised root mean squared residual (SRMR) is below 0.08 (Hu and Bentler 1999). The SEM approach allows us to estimate multiple structural and measurement equations simultaneously and calculate both direct and indirect structural effects.

$$COG_t = \lambda_{11t} COG_{t-1} + \lambda_{12t} PI_{t-1} + \lambda_{13t} POV_t^C + \varepsilon_{1t} \quad (1)$$

$$BP_t = \lambda_{21t} BP_{t-1} + \lambda_{22t} STRESS_{t-1} + \lambda_{23t} POV_t^B + \varepsilon_{2t} \quad (2)$$

where,

- $COG_t (BP_t)$: Latent cognitive ability (or behaviour problems) of the child at time t;
- PI_{t-1} (or $STRESS_{t-1}$): Parental investment (or maternal stress) in the preceding wave;
- $POV_t^{C,B}$: multidimensional poverty;
- $\lambda_{t,}$: coefficients of time-varying predictors;

- ε_t: Error terms, assumed to be independent across children/families and over time.

Similarly, parental investment (maternal stress) is a latent variable associated with some covariates. These include time-varying household poverty and two family characteristics: whether there are three or more children in the household (including the study child) and whether the mother has a co-resident partner. Both large family status and lone parent status are associated with child poverty in Ireland (Maître *et al*. 2020) and they can also affect parental investment and maternal stress. The estimates of the effects of poverty are thus net of family structure, a potential confounder.

$$PI_t = \lambda_{3t} X_t^{PI} + \delta_{3t} \qquad (3)$$

$$STRESS_t = \lambda_{4t} X_t^{Stress} + \delta_{4t} \qquad (4)$$

Figures 1 and 2 illustrate the main hypothesized relations between predictors and outcomes embedded in the above equations. Cognitive ability (behaviour problems) are a function of current poverty, prior cognitive ability (behaviour problems), and prior parental investment (maternal stress). The latter are a function of current poverty. From Wave 2 onwards, poverty is a function of prior poverty status. This means that experiencing poverty in early childhood can affect later child outcomes both directly (i.e., concurrently) and indirectly via the effects on prior outcomes (and, thus, prior poverty) and prior home learning environment (maternal stress).

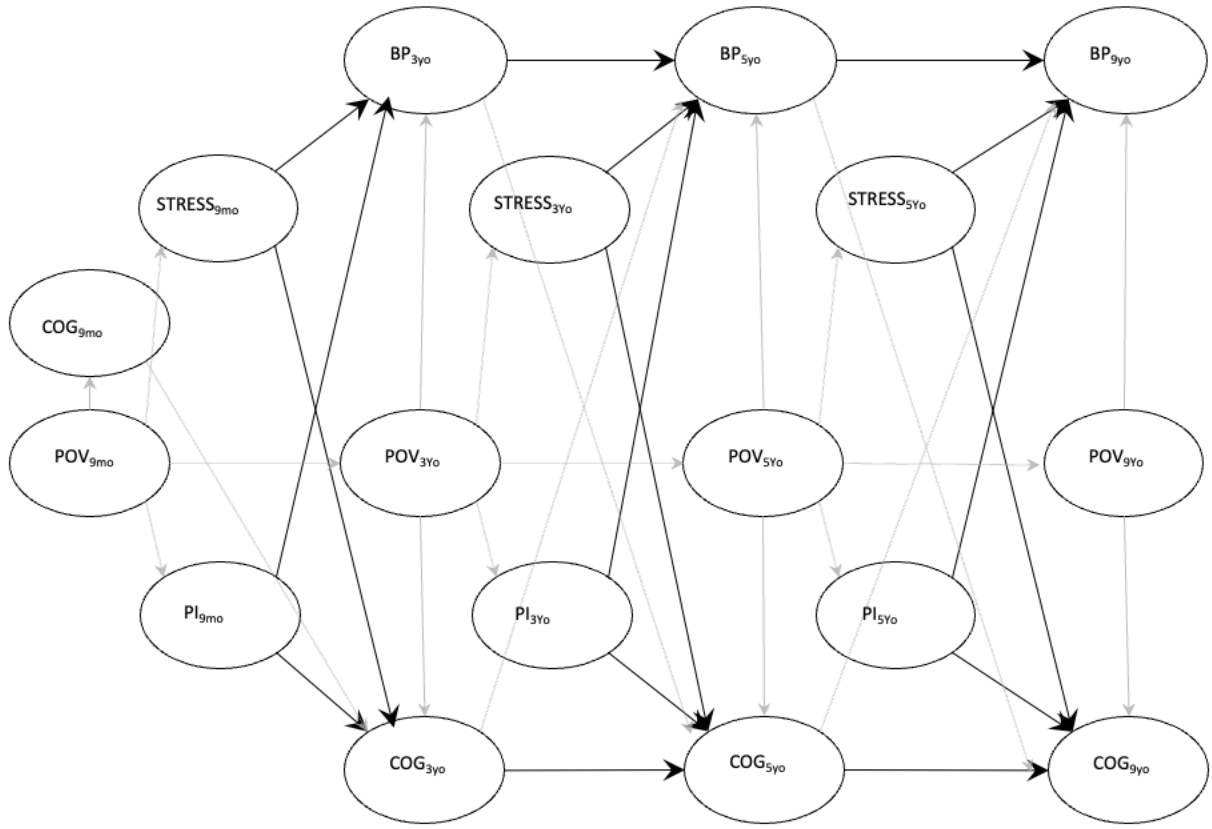
Finally, to address all four hypotheses simultaneously, we test a hybrid FIM+FSM model for cognitive ability and behaviour problems which includes prior maternal stress and home learning environment (Figure 3). This is a more complex model than the first two because it includes both child outcomes simultaneously and allows for the reciprocal cross-lagged

pathways between them. Cognitive ability at time *t* is now a function of not only cognitive ability at time *t-1* (as well as poverty at time *t*, parental investment at *t-1* and maternal stress at *t-1*), but also behavioural problems at *t-1*, and vice versa (see Equations 5 and 6). Since both cognitive ability and behavioural problems at Wave 1 are measured by developmental progress at 9 months (ASQ-2), it predicts these outcomes at age 3, and the cross-lagged portion of the model involves the period from age 3 to age 5 to age 9. Comparing the magnitude and direction of the reciprocal cross-lagged coefficients helps establish the relative strength of their effects on each other (Selig and Little 2012). Figure 3 represents this structural equation model graphically.

$$COG_t = \lambda_{11t}COG_{t-1} + \lambda_{12t}PI_{t-1} + \lambda_{13t}POV_t^C + \lambda_{14t}BP_{t-1} + \lambda_{15t}STRESS_{t-1} + \varepsilon_{1t} \quad (5)$$

$$BP_t = \lambda_{21t}BP_{t-1} + \lambda_{22t}STRESS_{t-1} + \lambda_{23t}POV_t^B + \lambda_{24t}COG_{t-1} + \lambda_{25t}PI_{t-1} + \varepsilon_{2t} \quad (6)$$

Figure 3: Main hypothesised relations between poverty, parental investment, maternal stressors, child cognitive ability and child behaviour problems (see Equations 5 and 6)



We also carry out a series of robustness checks. First, we check for dynamic complementarity of child outcomes and parental inputs/stress by allowing child outcomes at an earlier age to influence parental inputs/stress at a later age. Second, we re-estimate our main models separately by maternal educational status measured when the child was 9 months old (those without a tertiary degree vs those with a tertiary degree) to investigate if the pathways of influence are the same in both groups or if maternal education is an important moderating variable. Third, we check if the behaviour problems findings would differ if internalized and externalized symptoms were analysed separately. Fourth, we re-estimate the main models with controls for maternal education to assess the sensitivity of the coefficients to another potential confounder (in addition to family structure). We do not include maternal education in our main results to avoid over-controlling.

Data are available to apply via: https://www.growingup.ie/, and our replication package is available online (http://doi.org/10.5281/zenodo.8268737)

Results

Poverty duration and child outcomes at age 9

Figure 4 shows differences by income poverty duration in mean cognitive ability scores that are derived from two separate age-appropriate tests and are standardised to have a mean of 100 (SD = 15) at age 9. Children in households that never experienced two or more dimensions of poverty (i.e. low income, material deprivation or financial strain) have statistically significantly higher cognitive ability scores than those who experienced poverty in just one wave ('one-off'), two waves ('intermittent') or three or four waves ('persistent') from the age of 9 months onwards ($p < 0.001$). These are substantively large differences: children who were never in poverty score one-half of a standard deviation higher on the cognitive ability

scale than those in persistent poverty. However, there are no statistically significant differences in cognitive ability scores between those in one-off, persistent, or intermittent poverty.

Figure 4 Differences in child cognitive ability scores at age 9 by income poverty history

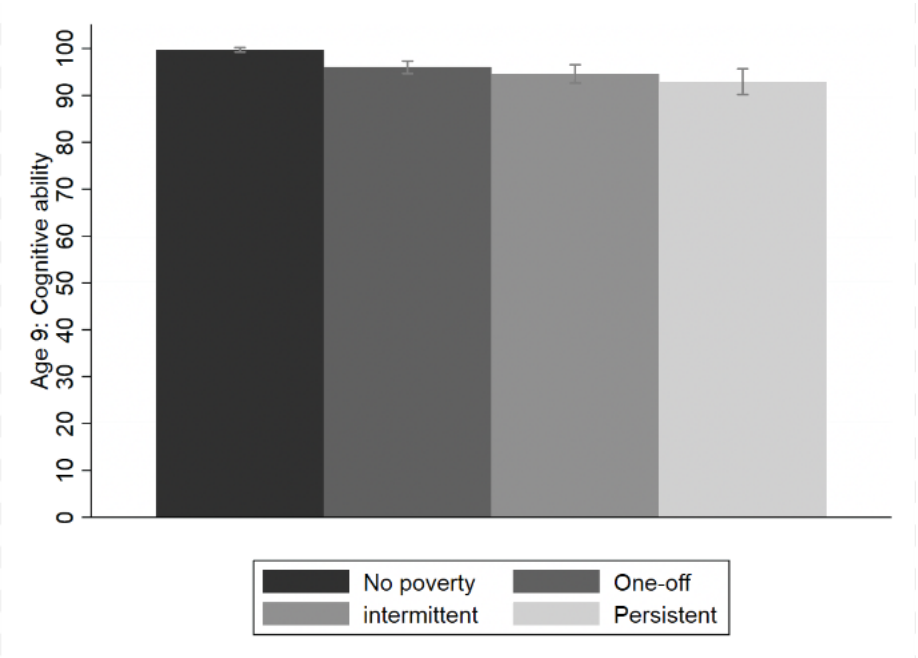
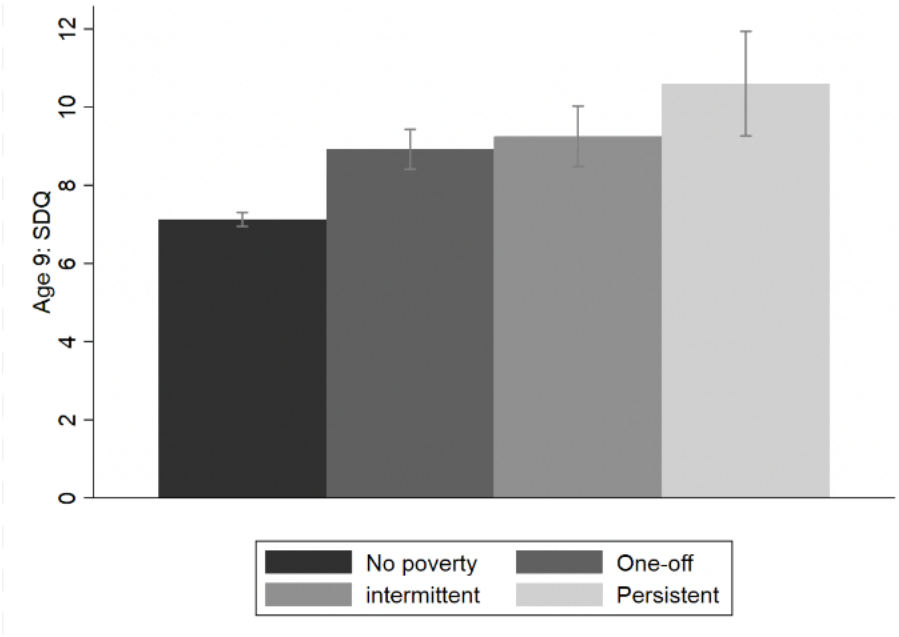


Figure 5 shows differences in mean SDQ scores by poverty duration. The SDQ score is a sum of the emotional, conduct, hyperactivity, and peer problems sub-scales, where higher scores indicate greater behaviour problems. Children who have never been in poverty have lower SDQ scores than their counterparts who experienced poverty at least once ($p < 0.001$). However, there are no statistically significant differences in SDQ scores among those who experienced poverty once or more than once.

Figure 5 Differences in child SDQ scores at age 9 by income poverty history



Poverty, home learning environment, maternal stress and child outcomes

Table 3 reports the standardised coefficients from a dynamic structural equation model of cognitive ability (see Equations 1 and 3, and Figure 1). It focuses on the family investment pathways between poverty and child cognitive development (see Hypothesis 1).

Everything else being equal, household poverty is statistically significantly negatively associated with the child's cognitive ability at the ages of 3, 5 and 9 years, but not at the age of 9 months. Children's cognitive ability is associated with their previous test scores: a 1 SD difference in cognitive ability scores at the age of 9 months is associated with 0.23 SD ($p < 0.001$) higher cognitive scores at age 3, on average; a 1 SD difference in cognitive ability scores at age 3 is associated with a 0.72 SD ($p < 0.001$) higher predicted score at age 5, and a 1 SD difference at age 5 is associated with a 0.84 SD ($p < 0.001$) difference at age 9.

Meanwhile, parental investment at an earlier age is positively associated with cognitive test scores at the ages of 5 and 9, but these effects are substantively small. Everything else being equal, a 1 SD difference in the parental investment score at age 3 is associated with a

0.05 SD ($p < 0.05$) higher predicted cognitive ability score at age 5, and a 1 SD difference in the parental investment score at age 5 is associated with a 0.09 SD ($p < 0.05$) higher predicted cognitive ability score at age 9.

Thus, poverty can influence current cognitive ability not only directly but also indirectly via the prior parental investment and cognitive ability pathways as well as due to poverty persistence over time. Controlling for large family and lone parent status, poverty is associated with lower parental investment scores at age 5 ($B = -0.28$; $p < 0.001$), but not at the earlier waves. The total (direct and indirect) effect of poverty on cognitive ability at age 9 is a substantial -0.30 SD ($p<0.001$) at age 9 months, -0.34 SD ($p < 0.001$) at age 3, and -0.17 SD ($p < 0.001$) at age 5. This is due to the direct effects of poverty on cognitive ability at ages 3, 5 and 9, indirect effects of poverty via the effect of parental investment at age 5 on cognitive ability at age 9 and strong path dependency in both poverty and cognitive ability over time.

Table 3 Standardised coefficients of latent predictors from a structural equation model of cognitive ability and parental investment (n = 7,507)

		Current wave						Previous wave	
		Cognitive ability		Parental investment		Poverty		Cognitive ability	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.007	0.029	-0.027	0.027	0.874***	0.022		
	Large family			-0.041**	0.016				
	Lone parent			0.018	0.024				
	Cognitive ability (ASQ)							0.229***	0.023
	Parental investment							0.032	0.020
Age 3	Poverty	-0.295***	0.026	-0.072	0.028	0.918***	0.020		
	Large family			-0.112***	0.019				
	Lone parent			0.057*	0.023				
	Cognitive ability							0.721***	0.021
	Parental investment							0.049*	0.020
Age 5	Poverty	-0.070**	0.024	-0.280***	0.033	0.874***	0.027		
	Large family			-0.217***	0.021				
	Lone parent			0.036	0.030				
	Cognitive ability							0.842***	0.049
	Parental investment							0.085*	0.032
Age 9	Poverty	-0.102***	0.030						

Coefficient of determination (CD) = .839. Standardised Root Mean Square Residual (SRMR) = .055. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on cognitive ability at 9 years: -0.299*** at 9 months; -0.340*** at 3 years; and -0.172*** at age 9.
***$p < .001$. **$p < .01$. *$p < .05$.

Table 4 shows the standardised coefficients from a dynamic structural equation model of behaviour problems (see Equations 2 and 4, and Figure 2), which focuses on the family stress pathways between poverty and children's behavioural development (Hypothesis 2). Poverty is associated with statistically significantly higher behaviour problems at ages 3, 5, and 9, everything else being equal. Poverty also predicts maternal stress when the child is 9 months, 3 years, and 5 years old, with standardised coefficients ranging from 0.21 SD to 0.28 SD ($p < 0.001$). In turn, maternal stress measured in the previous wave is associated with statistically significantly higher problem behaviour scores at ages 3, 5 and 9, with the largest association at age 3 ($B = 0.25$, $p < 0.001$). There is also substantial stability in behavioural problems over time. For example, a 1 SD difference in behaviour problem scores at age 3 is associated with a 0.74 SD higher predicted score at age 5 ($p < 0.001$), while a 1 SD difference at age 5 is associated with 0.72 SD higher scores at age 9 ($p < 0.001$), everything else being equal. The cumulative effects of poverty on behaviour problems at 9 years via prior problems and maternal stress, as well as path dependency in poverty and behaviour problems over time, is 0.26 SD ($p < 0.001$) for poverty experienced at 9 months, 0.26 SD ($p < 0.001$) at 3 years and 0.14 SD ($p < 0.01$) at 5 years.

Table 4 Standardised coefficients of latent predictors from a structural equation model of behaviour problems and maternal stress (N = 7,507)

		Current wave						Next wave	
		Behaviour problems		Maternal stress		Poverty		Behaviour problems	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.031	0.029	0.276***	0.030	0.859***	0.022		
	Large family			0.041	0.018				
	Lone parent			0.028	0.027				
	Behaviour problems (ASQ)							-0.153***	0.025
	Maternal stress							0.248***	0.024
Age 3	Poverty	0.224***	0.027	0.232***	0.029	0.920***	0.02		
	Large family			-0.182***	0.015				
	Lone parent			0.075**	0.024				
	Behaviour problems							0.742***	0.021
	Maternal stress							0.099***	0.02
Age 5	Poverty	0.082**	0.025	0.207***	0.031	0.859***	0.026		
	Large family			-0.167***	0.015				
	Lone parent			0.099***	0.024				
	Behaviour problems							0.718***	0.018
	Maternal stress							0.057**	0.020
Age 9	Poverty	0.074***	0.023						

Coefficient of determination (CD) =0.831. Standardised Root Mean Square Residual (SRMR) = .079. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on behaviour problems at 9 years: 0.262*** at 9 months; 0.260*** at 3 years; and 0.135*** at age 9.
***p<.001. **p<.01. *p<.05.

Table 5 reports the standardised coefficients from a hybrid model of cognitive ability and behaviour problems (see Hypothesis 3) that incorporates both the family investment and family stress pathways. It also allows the two child outcomes to predict each other over time (see Hypothesis 4). Poverty is directly associated with both cognitive ability and behaviour problems at ages 3, 5 and 9, with the coefficients comparable in size to those from the separate models of cognitive ability (Table 3) and behaviour problems (Table 4). Similarly, the auto-regressive paths for poverty, cognitive ability and behaviour problems are similar to those in the separate models. It is the added pathways that make the hybrid model different. Thus, everything else being equal, higher maternal stress when the child is 9 months old is associated with greater behaviour problems (but not cognitive ability) at age 3, while prior parental investment (i.e. the frequency of talking to the infant) is not a statistically significant predictor of either outcome. Since poverty predicts greater maternal stress when the child is 9 months old, maternal stress mediates the effects of poverty on behaviour problems at age 3. Similarly, poverty is associated with lower parental investment and greater maternal stress at age 3, but only maternal stress is then associated with greater behaviour problems at age 5. Parental investment at age 3 is not significantly associated with either child outcome at age 5. This is likely because both prior child outcomes are now controlled for simultaneously. Notably, behaviour problems at age 3 predict statistically significantly lower cognitive development at age 5 ($B = 0.09$, $p<0.01$). Thus, one of the pathways between poverty at age 3 and child outcomes at age 5 is via behaviour problems at age 3.

Further, behaviour problems at age 5 are associated with lower cognitive development at age 9 ($B = -0.22$, $p<0.001$), controlling for prior cognitive development, parental investment, and maternal stress, as well as current poverty. Similarly, cognitive ability at age 5 is associated with fewer behaviour problems at age 9 ($B = -0.08$, $p<0.001$), controlling for prior behaviour

problems, parental investment, and maternal stress, as well as current poverty. The cross-lagged coefficient of behaviour problems is larger in absolute terms than the reciprocal coefficient of cognitive ability, and a Wald test shows that the two coefficients are statistically significantly different from each other ($p<0.01$). This suggests that behaviour problems dominate the mutually reinforcing relationship between the two aspects of child development: behaviour problems are a better predictor of cognitive ability than vice versa.

Meanwhile, controlling for prior development outcomes and current poverty, parental investment at age 5 is associated with greater behaviour problems at age 9 ($B = 0.08$, $p<0.01$) and not with cognitive ability, while maternal stress is a significant predictor of both higher cognitive ability ($B = 0.13$, $p<0.001$) and greater behaviour problems ($B = 0.05$, $p<0.05$). These are substantively small associations, and some of them have counterintuitive signs. This may be due to the inclusion of the cross-lagged pathways between the two child outcomes, which already contain the effects of parental investment and maternal stress at the earlier ages.

Finally, the cumulative effects of poverty at the age of 9 months, 3 years, and 5 years on the age 9 outcomes are comparable to those in the separately estimated models, even though the pathways of influence are now more complicated. Poverty is still strongly related to child outcomes over time via the direct effects of current poverty on child outcomes and path dependency in both poverty and child outcomes over time. There are also indirect effects via the two child outcomes reinforcing each other as children grow older, even as the parental investment and maternal stress pathways are less pronounced.

Table 5 Standardised coefficients of latent predictors from a structural equation model of cognitive ability, behaviour problems, maternal stress and parental investment (N = 7,505)

		Current wave										Next wave			
		Cognitive ability		Behaviour problems		Parental investment		Maternal stress		Poverty		Cognitive ability		Behaviour problems	
		B	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.039	0.029	-0.039	0.029	-0.041	0.027	0.28***	0.018	0.871***	0.021				
	Large family					-0.038	0.016	0.00041	0.018						
	Lone parent					0.025	0.025	0.023	0.027						
	Cognitive and behavioural development (ASQ)											0.225***	0.023	-0.157***	0.024
	Parental investment											0.027	0.020	0.008	0.018
	Maternal stress											-0.016	-0.016	0.240***	0.025
Age 3	Poverty	-0.293***	-0.027	0.244***	0.027	-0.097**	0.029	0.24***	0.03	0.923***	0.020				
	Large family					-0.108***	0.018	-0.185***	0.015						
	Lone parent					0.066**	0.024	0.070**	0.024						
	Cognitive ability											0.707***	0.021	-0.035	0.023
	Behaviour problems											-0.085**	0.027	0.733***	0.021
	Parental investment											0.039	0.021	-0.001	0.02
	Maternal stress											0.037	0.021	0.099***	0.02
Age 5	Poverty	-0.059*	0.025	0.077**	0.026	-0.30***	0.033	0.21***	0.031	0.863***	0.026				
	Large family					-0.218***	0.021	-0.169***	0.015						
	Lone parent					0.05	0.030	0.094***	0.024						
	Cognitive ability											0.842***	0.048	-0.080***	0.022
	Behaviour problems											-0.223***	0.035	0.715***	0.02

	Parental investment					0.034	0.033	0.076**	0.027
	Maternal stress					0.125***	0.026	0.048*	0.02
Age 9	Poverty	-0.076*	0.032	0.074**	0.026				

Coefficient of determination (CD) =0.852. Standardised Root Mean Square Residual (SRMR) = .066. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on cognitive ability at 9 years: -0.324*** at 9 months; -0.342*** at 3 years; and -0.116*** at age 9. Total effects of poverty on behaviour problems at 9 years: 0.278*** at 9 months; 0.273*** at 3 years; and 0.111*** at age 9.
***p<.001. **p<.01. *p<.05.

Robustness checks

We checked for dynamic complementarity of child outcomes and parental inputs/stress by allowing child outcomes at an earlier age to influence parental inputs/stress at a later age. Table S1 in Supplemental Information reports the results of a structural equation model of cognitive ability identical to the one in Equation 1 but with an additional pathway from cognitive ability at age 3 to parental investment age at 5. This coefficient is positive and statistically significant: a 1SD difference in cognitive ability at age 3 is associated with 0.2 SD greater parental investment score at age 5 ($p<0.001$), everything else being equal. In the next period, parental investment at age 5 is no longer statistically significantly associated with cognitive ability at age 9. However, the total effects of earlier poverty on cognitive ability at age 9 are nearly identical to those in the main model.

Similarly, Table S2 shows that behavioural problems at age 3 are significantly associated with greater maternal stress at age 5, but the total effects of poverty at earlier ages on behavioural problems at age 9 are similar to the estimates in the main model. This alternative specification suggests that poverty at age 9 months is associated with greater maternal stress, which in turn is associated with greater child behavioural problems at age 3. These, in turn, are related to greater maternal stress at age 5. Meanwhile, poverty has a direct effect on behavioural problems at ages 3, 5 and 9. Overall, these alternative models indicate that the relationship between parental investment (stress) and cognitive (behavioural) development may be mutually reinforcing and at least in part triggered by poverty at an early age.

In a second series of checks, we re-estimated our main models allowing the coefficients to vary by maternal educational status (those without a tertiary degree vs those with a tertiary degree at Wave 1). Table S3 shows the results for cognitive ability. Although the findings are similar to those in the main model in Table 3, there are several differences to be noted. The effect of parental investment at age 9 months (i.e. frequency of talking to the infant) on

cognitive ability at age 3, the effect of poverty at age 3 on parental investment at age 3, and the effects of poverty on cognitive ability at ages 5 and 9, are all greater for children whose mothers are university educated. The total effects of poverty on cognitive ability at age 9 are then larger in higher educated families. Meanwhile, the effect of poverty at age 3 on behaviour problems are larger in higher educated families, even as the effect of poverty on maternal stress at ages 3 and 5 is larger for lower educated families (Table S4). The total effects of poverty on behaviour differences at age 9 are comparable for the two sub-groups.

To check if the associations between poverty and child outcomes may be confounded by other dimensions of family socio-economic status, we re-estimated our main models (Equations 1-4) with additional controls for maternal educational attainment (i.e. those without a tertiary degree vs those with a tertiary degree at Wave 1). Table S4 shows children whose mothers are tertiary educated have substantially higher cognitive ability scores, on average, at ages 3 years, 5 years, and 9 years ($p < 0.001$). Maternal education in associated with statistically significantly higher parental investment at ages 3 ($p < 0.05$) and 5 ($p < 0.001$). However, the direct contemporaneous effects of poverty are only slightly attenuated compared to the corresponding estimates in Table 3 and the total effects of poverty are only somewhat smaller. Meanwhile, Table S7 shows that children whose mothers are tertiary educated have lower behaviour problems scores at age 3 ($p < 0.001$), but there are no statistically significant associations at ages 5 or 9. Tertiary educated mothers have higher levels of parenting stress ($p < 0.001$) in all the waves. The direct and total effects of poverty on behaviour problems are somewhat attenuated compared to the corresponding estimates in table 4, but remain of the same sigh and statistical significance.

We also checked if the behaviour problems findings would differ if internalized and externalized symptoms were analysed separately. Tables S7 and S8 in Supplemental Information report the results of a specification equivalent to that in Table 4 separately for

internalised and externalised symptoms, respectively. Poverty is associated with higher internalised symptoms scores at ages 3 and 9, while prior maternal stress is associated with higher internalized symptoms at ages 3, 5 and 9. The cumulative effects of poverty for internalized symptoms at age 9 via maternal stress and prior symptoms are 0.25 SD ($p < 0.001$) for poverty experienced at 9 months, 0.26 SD ($p < 0.001$) at 3 years, and 0.13 SD at age 5.

Poverty is associated with higher externalized symptoms scores at ages 3 and 5, while prior maternal stress is associated with higher externalized symptoms at ages 3, 5 and 9. The total effects of poverty on externalized symptoms at age 9 via maternal stress and prior symptoms are 0.22 SD ($p < 0.001$) for poverty experienced at 9 months, 0.22 SD ($p < 0.001$) at 3 years, and 0.10 SD ($p < 0.001$) at 5 years. These results suggest that dividing behaviour problems into internalized and externalized symptoms does not alter the main findings, while producing less precisely estimated coefficients in dynamic SEM models.

Discussion

This study investigated the relationship between child poverty and child development, using a unique Irish longitudinal dataset for the period 2008-2017, when many households experienced at least one instance of economic hardship. Our key contributions are two-fold. First, we establish the differences in children's cognitive and behavioural outcomes at age 9 by the number of instances of multidimensional poverty since the age of 9 months. We demonstrate that even one instance of poverty is harmful to child development. Second, unlike other studies that documented similar patterns using longitudinal data from birth cohort studies in Ireland and the UK (Maître *et al*. 2020; Rees 2019), we investigate the theoretical mechanisms through which poverty affects child development over time. We focus on the family investment and family stress processes as well as the potentially mutually reinforcing relationships between children's cognitive and behavioural development outcomes. We are

contributing to the longitudinal studies literature that draws on both family investment and stress processes in explaining socio-economic differences in children's cognitive and behavioural outcomes in early to middle childhood (Layte 2017, 2022) and to the related body of evidence that operationalises poverty as not solely based on household income (Gershoff *et al*. 2007; Gibbons *et al*. 2023; Schenck-Fontaine and Panico 2019).

First we document substantial inequalities in Irish children's cognitive and behavioural outcomes by multidimensional poverty duration. Children with at least one spell in poverty (out of four interviews) since the age of 9 months have substantially worse cognitive and behavioural outcomes at age 9. Poverty is measured as household experience of two or more dimensions of economic hardship simultaneously (i.e., low income, financial strain, or material deprivation). We use this conservative definition of multidimensional poverty for descriptive statistics. In multivariate analyses, poverty is a latent factor based on the three indicators of economic hardship.

Overall, these results suggest that persistent multidimensional poverty is particularly harmful to children's outcomes, but even a one-off spell in poverty can matter. This is in line with findings in Maître *et al*. (2020), who documented similar patterns using data from Growing Up in Ireland, and Rees (2019), who found lower wellbeing in terms of cognitive ability, physical health, and emotional and behavioural difficulties among children with more extensive histories of poverty in the UK.

Second, we test hypotheses derived from the family investment and family stress literatures using dynamic structural equation models to understand these channels of influence. Although the links between poverty and adverse children's outcomes are well documented descriptively (Van Lancker and Vinck 2019), our study is among the few to analyse the specific channels through which poverty affects children's cognitive and behavioural development. In a series of models estimated separately for: 1) cognitive ability, poverty and parental

investment and 2) behaviour problems, poverty and maternal stress, we find that family investment processes – based on information about the cognitively stimulating activities that parents engage in with their young children – account for some but not all of the cumulative effects of childhood poverty on cognitive ability test scores. Similarly, family stress processes – manifested in maternal stress – play a key role in explaining the links between poverty and behaviour problems in early to middle childhood, but do not fully explain the relationship between poverty and child outcomes over time. These results only partially support our initial hypotheses 1 and 2 because our family investment and stress measures do not fully account for the association between poverty and child development outcomes. This could be because we included these measures in separate models.

In contrast, the more complex model, which includes both child development outcomes and both mediating channels simultaneously, sheds light on all four of our hypotheses. Here we find some evidence in support of a hybrid family investment and family stress model. Poverty is associated with lower parental investment and greater parental stress at ages 3 and 5. Controlling for prior cognitive ability and behaviour problems, prior maternal stress is associated with greater behavioural problems at age 5 but not with cognitive ability, while prior parental investment is no longer associated with either of the two child outcomes at that age.

The picture gets more complicated in the period between age 5 and age 9, when the two child outcomes already contain the effects of poverty, parental investment, and maternal stress at the earlier ages. Prior maternal stress is associated with greater behaviour problems at age 9 as well as with greater cognitive ability. This can be interpreted as follows: among the children with similar levels of poverty at age 9, cognitive and behavioural outcomes at age 5 as well as parental investment at age 5, those whose mothers experienced greater levels of parenting stress (when the children were 5) had higher cognitive ability scores at age 9. Although the temporal ordering of the measures helps preclude reverse causality, this may still indicate that greater

cognitive ability leads to greater parental anxiety. Meanwhile, although parental investment at age 5 is positively associated with cognitive ability at age 9, we also observe a small but statistically significant association between higher intensity of home learning activities at age 5 and greater behaviour problems at age 9. Since most children are already at school at age 5 (McGinnity *et al.* 2022), this may suggest a compensatory relationship: parents invest more in children who are more at risk of behaviour problems. Although further work is needed to focus specifically on the potentially compensatory effects of parental investment and stress processes, this is in line with Washbrook *et al.*'s (2014) finding that some of the income-mediating pathways can have opposing associations different child outcomes. Importantly, we find that behavioural problems are stronger predictors of cognitive ability than vice versa, suggesting that greater behaviour problems may impede children's ability to learn, everything else being equal, while greater cognitive ability is not necessarily a protective factor for the development of behaviour problems. Further, both parental investment and maternal stress are related to behavioural problems. This indicates that behavioural problems may mediate the effects of poverty and family processes on child cognitive development.

Overall, our hybrid model results contrast somewhat with Layte (2017) who found more conclusive evidence in support of a hybrid model using data from the first four sweeps (up to age 7) from the UK Millennium Cohort Study. Both the home learning environment and maternal psychological distress directly affected both child cognitive ability and behaviour problems, controlling for parental social class and household income. In contrast, we find that maternal stress plays a more important role as a mediator of poverty overall. Some of the differences in our findings may be due to different research questions, data, measures, and methods used. Importantly, Layte (2017) focused on social class rather than poverty or material well-being. More research is needed to contrast the roles of family investment and family processes in children's cognitive and behavioural development over time. Moreover, it would

be useful to have data on children's own perceptions of hardship and economic pressure, complementing parental reports. A recent adaptation of the standard FSM that relied on data from both parents and children showed that economic hardship can affect children more directly and immediately than via parental distress (Chzhen *et al*. 2021).

Our analysis has several limitations. First, although we used longitudinal weights designed to account for differential panel attrition and a maximum likelihood with missing values estimator to adjust for item non-response, our findings are based on nationally representative data for a specific cohort (i.e., those born in 2008 and resident in Ireland at the age of 9 months). These findings need to be replicated using longitudinal data for a different country, cohort, or period.

Second, we could only rely on the measures available in the GUI dataset. Thus, we do not have measures of child cognitive ability or behaviour problems at the ages of 9 months. We used ages and stages questionnaires as baseline measures for both outcomes, which is a valid measure of early developmental delays (Gollenberg *et al*. 2010). We showed that ASQ at 9 months is strongly predictive of both higher cognitive ability scores and lower behaviour problem scores at age 3. We also rely on parent-reported measures of children's behaviour problems, which could have been biased downward (i.e. towards fewer problems). Teacher-reported measures are available when the children are aged 5 and 9, but they have more missing values than parental reports. Similarly to other studies (A. Goodman *et al*. 2010), parent and teacher reports are moderately but statistically significantly ($p<0.001$) correlated for each sub-scale age ages 5 and 9 (see Tables S10-S11 in the Annex). It does not appear that parents tend to under-report their children's behaviour problems: teacher reports of SDQ sub-scales are lower, on average, than parental reports (see Table 2).

Third, our results may not necessarily be interpreted as causal, despite engaging with causal theories of child development and causal mediation frameworks. Our dynamic structural

equation models estimate outcomes between the ages of 9 months and 9 years, using key predictors from prior waves, but reverse causation in later years may still be a problem if parents adjust their home learning actions based on their perceptions of their child's cognitive ability, or if maternal mental health is affected by the child's behaviour difficulties. While Dickerson and Popli (2016) found no evidence of reverse causality in parental inputs and cognitive ability in a similar study using UK data, our robustness checks show that higher cognitive ability at age 3 is associated with greater parental investment at age 5. Similarly, greater behaviour problems at age 3 are associated with greater maternal stress at age 5. However, the cumulative effects of childhood poverty remain robust to alternative specifications of the intermediate pathways. Poverty at the earlier ages triggers a series of reactions that culminate in substantial cognitive and behavioural inequalities by age 9 via both family investment and family stress processes, with some unexplained direct effects of current poverty remaining.

Furthermore, we cannot discount the possibility of unmeasured confounders. We included family size and lone parent status in the baseline (age 9 months) equations because there are differences by family structure in poverty, parental investment/stress and child outcomes. When we further controlled for maternal education in sensitivity analyses, the results were qualitatively the same. However, there are other potential confounders that we cannot account for using our data, such as genetic information.

We also assume that there are no interactions with potential confounders. However, we have found some evidence for our dynamic structural equation models performing somewhat differently in for households with lower and higher educated mothers. When we re-estimated our main models (Figures 1-2) allowing all the coefficients to vary by maternal education (i.e. with or without a university degree), we observed that the total effects of poverty on cognitive ability are somewhat larger in higher educated families, with no sub-group differences

behaviour problems. Meanwhile, Mari and Keizer (2021) found larger effects of parental job loss on children's behaviour problems at age 5 among those with tertiary-educated mothers, with no sub-group differences for cognitive ability, using the same survey. This suggests that differences in material hardship may translate into greater inequalities in children's outcomes among higher educated families, who are at a lower risk of poverty overall. If education is a proxy for the non-income dimensions of socio-economic status, this implies a moderating relationship. Since socio-economic status is a complex concept that taps into different aspects of social position (Bradley and Corwyn 2002), further work is needed to disentangle the relationship between different aspects of household socio-economic status (i.e. material well-being, education and occupational social class), family inputs and child outcomes.

There are other avenues for further research. Given the complex dynamic nature of socio-economic inequalities in family processes and child development, sociologists could rely more on the causal mediation methods developed in epidemiology. For example, there are approaches for handling multiple mediators (VanderWeele and Vansteelandt 2014) and mediator-outcome confounding (Wodtke and Zhou 2020). A recent application of the latter in sociology is Mari and Keizer's (2021) analysis of parental job loss and children's outcomes. Furthermore, advances in genetics (e.g. polygenic scores) and sociogenomics (Mills and Tropf 2020) offer novel directions for the study of socio-economic inequalities in child development.

Concluding Remarks

Despite these limitations, a key strength of our study lies in analysing both cognitive and behavioural outcomes during an important developmental window from infancy (9 months) to middle childhood (9 years). We use data from a unique Irish study for the period 2008-2017, when many households experienced hardship due to the Great Recession and austerity policies. We show that experiencing poverty from age 3 is particularly harmful to both cognitive and behavioural development. This is due to indirect cumulative effects over time via family

processes (i.e., the parental investment in cognitively stimulating activities; parenting stress) and strong persistence in cognitive and behavioural development. This is consistent with an interdisciplinary body of work highlighting the early years as a key developmental window and calling for a special focus on the early years in anti-poverty policies (see Dickerson and Popli (2016)). However, we also find substantial direct effects of poverty on child outcomes at later ages, even after controlling for prior outcomes and prior parental 'inputs'. This means that public policies need to continue supporting families past the earlier ages. In fact, we do not observe any differences by household poverty in children's developmental milestones at age 9 months, but only from age 3 onwards.

Our findings have other potential policy implications. Since parental investment and parenting stress mediate the effects of poverty, interventions can be designed that improve their levels among the poor. Thus, poorer households need to be enabled to engage in cognitively stimulating activities with their children while experiencing less parenting stress. However, we also observed direct associations between poverty and children's outcomes even after adjusting for these mediators. This suggests that a more effective approach may be tackling poverty itself. Thus, rather than prioritising parent-focussed behavioural interventions, tax-benefit systems can redistribute incomes to reduce relative income poverty while accessible and affordable services can reduce financial strain and material deprivation. A better understanding of the family processes through which poverty affects children's outcomes is valuable without implying that efforts to improve disadvantaged children's outcomes must focus solely on these processes, while ignoring poverty and wider socio-economic inequality.

Thus our study contributes to the emerging literature that combines the family investment and stress processes in explaining socio-economic differences in children's outcomes (Layte 2017, 2022). It also speaks to the broader literature on child poverty and its consequences, highlighting the value of longitudinal birth cohort data. Although cross-

sectional studies highlight the factors associated with higher risks of poverty at a point in time, they cannot distinguish between groups who spend only a brief time in poverty and those who remain poor. Longitudinal studies demonstrate that while most income poverty is short-term, substantial minorities suffer from persistent poverty (Goodin *et al*. 1999; Headey 2008; Rees 2019). Persistent lack of income not only leads to debt (Lea *et al*. 1995) but also exacerbates long-term anxiety and stress (Rowlingson and McKay 2005). As children depend on their caregivers and are not responsible for their household circumstances, especially at younger ages, child poverty is both unfair and inefficient (Brooks-Gunn and Duncan 1997). It undermines meritocracy and equality of opportunity, standing in the way of all children reaching their full potential.

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Supplemental materials

Table S1 Standardised coefficients of latent predictors from a structural equation model of cognitive ability and parental investment (n = 7,507): alternative specification with dynamic complementarity

		Current wave						Next wave			
		Cognitive ability		Parental investment		Poverty		Cognitive ability		Parental investment	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.006	0.030	-0.026	0.027	0.875***	0.022				
	Large family			-0.041**	0.016						
	Lone parent			0.018	0.024						
	Cognitive ability (ASQ)							0.239***	0.024		
	Parental investment							0.036	0.020		
Age 3	Poverty	-0.291***	0.026	-0.069*	0.028	0.915***	0.020				
	Large family			-0.113***	0.018						
	Lone parent			0.056*	0.023						
	Cognitive ability							0.725***	0.021	0.202***	0.028
	Parental investment							0.043*	0.020		
Age 5	Poverty	-0.068**	0.024	-0.218***	0.033	0.877***	0.027				
	Large family			-0.209***	0.021						
	Lone parent			0.039	0.030						
	Cognitive ability							0.835***	0.049		
	Parental investment							0.062	0.033		
Age 9	Poverty	-0.111***	0.030								

Coefficient of determination (CD) = 0.839. Standardised Root Mean Square Residual (SRMR) = 0.054. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on cognitive ability at 9 years: -0.295*** at 9 months; -0.335*** at 3 years; and -0.167*** at age 9. ***$p < .001$. **$p < .01$. *$p < .05$.

Table S2 Standardised coefficients of latent predictors from a structural equation model of behaviour problems and maternal stress (n = 7,507): alternative specification with dynamic complementarity

		Current wave						Next wave			
		Behaviour problems		Maternal stress		Poverty		Behaviour problems		Maternal stress	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.028	0.030	0.265***	0.029	0.857***	0.023				
	Large family			0.004	0.017						
	Lone parent			0.036	0.027						
	Behaviour problems (ASQ)							-0.149***	0.023		
	Maternal stress							0.321***	0.025		
Age 3	Poverty	0.210***	0.029	0.218***	0.029	0.914***	0.020				
	Large family			-0.179***	0.015						
	Lone parent			0.079***	0.024						
	Behaviour problems							0.826***	0.022	0.480***	0.030
	Maternal stress							0.016	0.022		
Age 5	Poverty	0.054*	0.026	0.055	0.033	0.863***	0.026				
	Large family			-0.139***	0.015						
	Lone parent			0.068**	0.023						
	Behaviour problems							0.721***	0.021		
	Maternal stress							0.024	0.021		
Age 9	Poverty	0.081***	0.021								

Coefficient of determination (CD) = 0.828. Standardised Root Mean Square Residual (SRMR) = 0.071. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on behaviour problems at 9 years: 0.252*** at 9 months; 0.230*** at 3 years; and 0.110*** at age 9. ***$p < .001$. **$p < .01$. *$p < .05$.

Table S3 **Standardised coefficients of latent predictors from a structural equation model of cognitive ability and parental investment (n = 7,507): separately by maternal education**

			Current wave						Next wave	
		Maternal education	Cognitive ability		Parental investment		Poverty		Cognitive ability	
Wave			*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	non-degree	-0.043	0.035	-0.038	0.031	0.885***	0.025		
		degree	0.028	0.021	0.009	0.030	0.781***	0.045		
	Large family	non-degree			-0.038	0.020				
		degree			-0.056**	0.020				
	Lone parent	non-degree			0.021	0.028				
		degree			-0.012	0.031				
	Cognitive ability (ASQ)	non-degree							0.231***	0.029
		degree							0.238***	0.034
	Parental investment	non-degree							**0.032**	0.025
		degree							**0.076***	0.025
Age 3	Poverty	non-degree	-0.273***	0.032	**-0.052**	0.032	0.913***	0.024		
		degree	-0.163***	0.034	**-0.093****	0.027	0.938***	0.036		
	Large family	non-degree			-0.116***	0.021				
		degree			-0.100***	0.023				
	Lone parent	non-degree			**0.070****	0.027				
		degree			**-0.018**	0.035				
	Cognitive ability	non-degree							0.713***	0.026
		degree							0.728***	0.030
	Parental investment	non-degree							0.055*	0.026
		degree							0.040	0.029
Age 5	Poverty	non-degree	**-0.052**	0.028	**-0.215*****	0.037	0.882***	0.031		

	Large family	degree	**-0.125*** **	0.030	**-0.295*** **	0.037	0.872***	0.046			
		non-degree			**-0.276*** **	0.024					
	Lone family	degree			**-0.092** **	0.037					
		non-degree			0.034	0.034					
	Cognitive ability	degree			0.020	0.036					
		non-degree							0.844***	0.062	
	Parental investment	degree							0.905***	0.082	
		non-degree							0.102*	0.040	
Age 9	Poverty	degree							-0.016	0.047	
		non-degree	**-0.075***	0.036							
		degree	**-0.179*** **	0.053							

CD: 0.851 (non-degree) and 0.71 (degree). SRMR: 0.054 (non-degree) and 0.056 (degree).
Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on cognitive ability at 9 years: -0.261*** (non-degree) and -0.276*** (degree) at 9 months; -0.288*** (non-degree) and -0.359*** (degree) at 3 years; and -0.132*** and -0.265*** (degree) at 5 years. Statistically significant differences (at p<0.05) by maternal education are in bold. ***$p < .001$. **$p < .01$. *$p < .05$.

Table S4 **Standardised coefficients of latent predictors from a structural equation model of behaviour problems and maternal stress (n = 7,507): separately by maternal education**

			Current wave						Next wave	
			Behaviour problems		Maternal stress		Poverty		Behaviour problems	
Wave			*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	non-degree	-0.047	0.034	0.305***	0.034	0.871***	0.025		
		degree	0.027	0.021	0.128***	0.027	0.772***	0.042		
	Large family	non-degree			**-0.020**	0.021				
		degree			**0.084****	0.024				
	Lone parent	non-degree			0.028	0.030				
		degree			0.020	0.041				
	Behaviour problems (ASQ)	non-degree							-0.146***	0.030
		degree							-0.212***	0.031
	Maternal stress	non-degree							0.255***	0.030
		degree							0.230***	0.032
Age 3	Poverty	non-degree	**0.185****	0.032	**0.273****	0.030	0.919***	0.023		
		degree	**0.324****	0.028	**0.080****	0.030	0.926***	0.037		
	Large family	non-degree			-0.192***	0.018				
		degree			-0.163***	0.021				
	Lone parent	non-degree			0.070*	0.027				
		degree			0.100**	0.034				
	Behaviour problems	non-degree							0.746***	0.024
		degree							0.697***	0.028
	Maternal stress	non-degree							0.099***	0.025
		degree							0.117***	0.029
Age 5	Poverty	non-degree	0.081**	0.029	**0.258****	0.037	0.862***	0.029		
		degree	0.091*	0.028	**0.088****	0.034	0.856***	0.046		

	Large family	non-degree			**-0.191*** **	0.018		
		degree			**-0.125*** **	0.021		
	Lone parent	non-degree			**0.083** **	0.027		
		degree			**0.153*** **	0.034		
	Behaviour problems	non-degree					0.718***	0.021
		degree					0.695***	0.036
	Maternal stress	non-degree					0.041	0.024
		degree					0.124***	0.030
Age 9	Poverty	non-degree	0.071**	0.026				
		degree	0.083**	0.028				

CD: 0.84 (non-degree) and 0.73 (degree). SRMR: 0.079 (non-degree) and 0.082 (degree).
Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on cognitive ability at 9 years: 0.252*** (non-degree) and 0.241*** (degree) at 9 months; 0.238*** (non-degree) and 0.298*** (degree) at 3 years; and 0.130*** and 0.146*** (degree) at 5 years. Statistically significant differences (at p<0.05) by maternal education are in bold. ***$p < .001$. **$p < .01$. *$p < .05$.

Table S5 Standardised coefficients of latent predictors from a structural equation model of cognitive ability and parental investment (n = 7,507) controlled maternal degree

		Current wave				Previous wave			
		Cognitive ability		Parental investment		Poverty		Cognitive ability	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.023	0.030	-0.031	0.028	0.882***	0.022		
	Large family			-0.042**	0.016				
	Lone parent			0.016	0.024				
	Maternal degree			-0.020	0.129			0.104***	0.016
	Cognitive ability (ASQ)							0.228***	0.023
	Parental investment							0.034	0.020
Age 3	Poverty	-0.26***	0.027	-0.057	0.029	0.920***	0.020		
	Large family			-0.112***	0.018				
	Lone parent			0.058*	0.023				
	Maternal degree			0.037*	0.016			0.027	0.015
	Cognitive ability							0.719***	0.021
	Parental investment							0.051*	0.020
Age 5	Poverty	-0.061*	0.024	-0.230***	0.033	0.878***	0.027		
	Large family			-0.217***	0.021				
	Lone parent			0.043	0.030				
	Maternal degree			0.174***	0.018			0.173***	0.021
	Cognitive ability							0.837***	0.047
	Parental investment							0.063	0.032
Age 9	Poverty	-0.062*	0.030						

Coefficient of determination (CD) = .871. Standardised Root Mean Square Residual (SRMR) = .054. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on cognitive ability at 9 years: -0.239*** at 9 months; -0.267*** at 3 years; and -0.120*** at 5 years.
***$p < .001$. **$p < .01$. *$p < .05$.

Table S6 Standardised coefficients of latent predictors from a structural equation model of behaviour problems and maternal stress (N = 7,507) Controlled maternal degree

		Current wave						Next wave	
		Behaviour problems		Maternal stress		Poverty		Behaviour problems	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.027	0.029	0.299***	0.031	0.859***	0.022		
	Large family			0.006	0.018				
	Lone parent			0.033	0.027				
	Maternal degree			0.077***	0.015			-0.130***	0.015
	Behaviour problems (ASQ)							-0.157***	0.024
	Maternal stress							0.252***	0.024
Age 3	Poverty	0.188***	0.029	0.267***	0.031	0.920***	0.02		
	Large family			-0.180***	0.015				
	Lone parent			0.085***	0.024				
	Maternal degree			0.118***	0.015			-0.025	0.014
	Behaviour problems							0.737***	0.021
	Maternal stress							0.106***	0.021
Age 5	Poverty	0.076**	0.026	0.243***	0.032	0.859***	0.026		
	Large family			-0.169***	0.015				
	Lone parent			0.103***	0.024				
	Maternal degree			0.116***	0.015			-0.013	0.012
	Behaviour problems							0.716***	0.018
	Maternal stress							0.060**	0.020
Age 9	Poverty	0.0769**	0.023						

Coefficient of determination (CD) =0.847. Standardised Root Mean Square Residual (SRMR) = .084. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on behaviour problems at 9 years: 0.249*** at 9 months; 0.239*** at 3 years; and 0.129*** at 5 years.
***p<.001. **p<.01. *p<.05.

Table S7 Standardised coefficients of latent predictors from a structural equation model of internalising symptoms and maternal stress (n = 7,507)

		Current wave						Next wave	
		Internalising Behaviour problems		Maternal stress		Poverty		Internalising Behaviour problems	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.029	0.030	0.275***	0.03	0.856***	0.023		
	Large family			0.005	0.017				
	Lone parent			0.027	0.027				
	Behaviour problems (ASQ)							-0.127***	0.031
	Maternal stress							0.241***	0.028
Age 3	Poverty	0.222***	0.030	0.221***	0.029	0.921***	0.020		
	Large family			-0.181***	0.015				
	Lone parent			0.080***	0.023				
	Behaviour problems							0.788***	0.038
	Maternal stress							0.144***	0.026
Age 5	Poverty	0.032	0.034	0.196***	0.031	0.859***	0.026		
	Large family			-0.166***	0.015				
	Lone parent			0.102***	0.023				
	Behaviour problems							0.643***	0.029
	Maternal stress							0.096***	0.024
Age 9	Poverty	0.108***	0.028						

Coefficient of determination (CD) = 0.830. Standardised Root Mean Square Residual (SRMR) = 0.076. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on behaviour problems at 9 years: 0.254*** at 9 months; 0.255*** at 3 years; and 0.132*** at 5 years. ***$p < .001$. **$p < .01$. *$p < .05$.

Table S8 Standardised coefficients of latent predictors from a structural equation model of externalising symptoms and maternal stress (n = 7,507)

		Current wave						Next wave	
		Externalising Behaviour problems		Maternal stress		Poverty		Externalising Behaviour problems	
Wave		*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.031	0.030	0.275***	0.030	0.858***	0.023		
	Large family			0.0056	0.017				
	Lone parent			0.027	0.027				
	Behaviour problems							-0.151***	0.023
	Maternal stress							0.211***	0.025
Age 3	Poverty	0.192***	0.028	0.227***	0.030	0.918***	0.020		
	Large family			-0.181***	0.015				
	Lone parent			0.077**	0.024				
	Behaviour problems							0.757***	0.022
	Maternal stress							0.086***	0.020
Age 5	Poverty	0.075**	0.025	0.202***	0.031	0.861***	0.026		
	Large family			-0.166***	0.015				
	Lone parent			0.101***	0.024				
	Behaviour problems							0.754***	0.020
	Maternal stress							0.058**	0.019
Age 9	Poverty	0.037	0.025						

Coefficient of determination (CD) = 0.831. Standardised Root Mean Square Residual (SRMR) = 0.081. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on behaviour problems at 9 years: 0.222*** at 9 months; 0.217*** at 3 years; and 0.101*** at 5 years. ***$p < .001$. **$p < .01$. *$p < .05$.

Table S9 Standardised coefficients of latent predictors from a structural equation model of behaviour problems and maternal depression (n = 7,507)

		Current wave				Next wave			
		Behaviour problems		Maternal depression		Poverty		Behaviour problems	
		B	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age 9 months	Poverty	-0.027	0.030	0.327***	0.036	0.863***	0.022		
	Large family			-0.076***	0.017				
	Lone parent			0.073*	0.031				
	Behaviour problems (ASQ)							-0.161***	0.024
	Maternal depression							0.194***	0.025
Age 3	Poverty	0.231***	0.026	0.344***	0.034	0.922***	0.019		
	Large family			-0.045**	0.017				
	Lone parent			0.056*	0.026				
	Behaviour problems							0.759***	0.019
	Maternal depression							0.041	0.021
Age 5	Poverty	0.082**	0.026	0.344***	0.028	0.860***	0.026		
	Large family			-0.044**	0.016				
	Lone parent			0.085***	0.024				
	Behaviour problems							0.728***	0.018
	Maternal depression							0.063**	0.020
Age 9	Poverty	0.062*	0.023						

Coefficient of determination (CD) = 0.825. Standardised Root Mean Square Residual (SRMR) = 0.073. Estimates of control variables coefficients, factor variances, error variances, error covariances, intercept estimates and disturbances are omitted for clarity. Total effects of poverty on behaviour problems at 9 years: 0.264*** at 9 months; 0.262*** at 3 years; and 0.135*** at 5 years. ***$p < .001$. **$p < .01$. *$p < .05$.

Table S10 Correlation matrixes for teacher-reported and parent-reported behaviour problems (n = 7,507) at age 5

		Parent report					Teacher report				
		emotional problems	conduct problems	hyperactivity problems	peer problems	total score	emotional problems	conduct problems	hyperactivity problems	peer problems	total score
Parent report	emotional problems	1									
	conduct problems	0.335***	1								
	hyperactivity problems	0.312***	0.457***	1							
	peer problems	0.410***	0.325***	0.334***	1						
	total score	0.715***	0.683***	0.800***	0.664***	1					
Teacher report	emotional problems	**0.288*** **	0.124***	0.177***	0.237***	0.286***	1				
	conduct problems	0.080***	**0.273*** **	0.289***	0.199***	0.290***	0.238***	1			
	hyperactivity problems	0.131***	0.257***	**0.480*** **	0.225***	0.404***	0.308***	0.524***	1		
	peer problems	0.140***	0.156***	0.222***	**0.348*** **	0.291***	0.462***	0.417***	0.373***	1	
	total score	0.223***	0.276***	0.425***	0.335***	**0.446*** **	0.688***	0.690***	0.819***	0.717***	1

***$p < .001$. **$p < .01$. *$p < .05$.

Table S11 Correlation matrixes for teacher-reported and parent-reported behaviour problem (n = 7,507) at age 9

		Parent report					Teacher report				
		emotional problems	conduct problems	hyperactivity problems	peer problems	total score	emotional problems	conduct problems	hyperactivity problems	peer problems	total score
Parent report	emotional problems	1									
	conduct problems	0.266***	1								
	hyperactivity problems	0.220***	0.453***	1							
	peer problems	0.330***	0.263***	0.256***	1						
	total score	0.628***	0.703***	0.793***	0.599***	1					
Teacher report	emotional problems	**0.151*** **	0.052***	0.075***	0.117***	0.138***	1				
	conduct problems	0.010	**0.225*** **	0.224***	0.135***	0.224***	0.182***	1			
	hyperactivity problems	0.021	0.203***	**0.348*** **	0.167***	0.293***	0.184***	0.521***	1		
	peer problems	0.076***	0.133***	0.179***	**0.244*** **	0.225***	0.366***	0.407***	0.357***	1	
	total score	0.085***	0.219***	0.316***	0.229***	**0.320*** **	0.580***	0.703***	0.823***	0.681***	1

***$p < .001$. **$p < .01$. *$p < .05$.