Intergenerational transmission of human capital: what makes and breaks the cycle of advantage and disadvantage?

Children and Families Research Fund Round 7
Ministry of Social Development

ORANGA TAMARIKI
Ministry for Children

NEW ZEALAND POLICY RESEARCH INSTITUTE
TE KĀHUI RANGAHAU MANA TAURITE

NEW ZEALAND PRODUCTIVITY COMMISSION
Te Kōmihana Whai Hua o Aotearoa

Funder:
Ministry of Social Development

Fund:
Children and Families Research Fund Round 7

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Acknowledgements:

We thank the children and families who participate in the Growing Up in New Zealand (GUiNZ) study for sharing their information for the benefit of all New Zealanders. We thank members of the GUiNZ research team for their invaluable work interviewing participants and managing the data used in this report, including the GUiNZ Data Access team for prompt release of data output. We extend our gratitude to our external reviewers Dr Kate Prickett and Professor Matthew Roskruge for providing valuable feedback on draft findings and analysis. We thank Dr Jaimie Monk (Motu) for helpful methodological advice. This report was made possible with funding from the Ministry of Social Development, using GUiNZ data collected by the University of Auckland, and in accordance with the GUiNZ Data Access Protocol.

Disclaimer:

The views and interpretations in this report are those of the researchers and not the Ministry of Social Development.

Published

New Zealand Policy Research Institute, Auckland, New Zealand

ISBN (PDF): 978-1-99-101136-7

2024

Suggested citation: Iusitini, L., Plum, A., Pacheco, G., Copeland, V., & Timmins, J. (2024). *Intergenerational transmission of human capital: what makes and breaks the cycle of advantage and disadvantage?.* New Zealand Policy Research Institute, Auckland.

Executive summary

Using data from the longitudinal Growing Up in New Zealand (GUiNZ) study tracking the health and development of a cohort of children born in 2009-2010, we investigate the intergenerational transmission of human capital by studying the relationship between mothers' educational attainment and children's cognitive skills (vocabulary, reading, and overall cognitive skills at age 8 years).

Our research aims are to:

(1) quantify the strength of the relationship between mothers' highest educational qualification and children's cognitive skills (both in 'raw' terms and adjusted for a suite of potentially confounding) and explore potential mechanisms through which the two might be related;

(2) understand how differences in mothers' and children's characteristics – including mothers' parenting practices – contribute to differences in cognitive skills between children of higher-educated (degree-qualified) and lower-educated (without a degree) mothers;

(3) understand what breaks the intergenerational cycle of disadvantage by identifying factors linked to 'breaking the intergenerational mould' in human capital, that is, having a lower-educated mother yet scoring highly in cognitive tests.

We investigate these research aims using data collected from the GUiNZ cohort over childhood (including before birth from their pregnant mothers) and regression-based statistical methods.

We find that mothers' education is strongly linked to children's cognitive skills – the higher the mothers' educational attainment, the better children's cognitive skills are, on average. This link remains the case even when we take into account confounding maternal characteristics that are correlated with her educational attainment and when we control for fathers' educational attainment.

Some of the link appears to be mediated by a range of parenting behaviours and investments that act as channels or mechanisms through which her education influences her child's cognitive skills. Specifically, children tend to have better cognitive skills at age 8 years if their mother read to them frequently in the preschool years and had many books in the home. Children also tend to have better cognitive skills if their mother took folic acid supplementation during pregnancy and tend to have worse cognitive skills if they were exposed to a lot of television in infancy.

We find that gaps in cognitive skills between children of higher-educated and lower-educated mothers are mostly unexplained by mothers' and children's characteristics and mothers' parenting behaviours, but to the extent they are explained, differences in mothers' ethnicity, sole parenthood, neighbourhood socio-economic deprivation, and book reading to children stand out as key drivers of cognitive inequalities.

We find that children of lower-educated mothers have better chances of developing strong cognitive skills despite having a lower-educated mother (better chances of 'defying the odds' or breaking the intergenerational cycle of disadvantage) if their mother is of Asian ethnicity or an immigrant and is relatively sparing with praise and responsiveness in her parenting (the latter an unexpected finding that may reflect the detrimental effects of 'over-parenting' or 'helicopter parenting' on children's development).

On the other hand, children's chances of breaking the intergenerational cycle of disadvantage are hindered if they are born to a sole-parent mother living in a socio-economically deprived neighbourhood whose parenting is verbally and physically hostile or highly diffident and inconsistent. These children tend to find it difficult to develop strong cognitive skills and thus have lower chances of 'breaking the intergenerational mould'.

Public policy targeted at parents, expectant parents, and future parents should lift levels of educational attainment among the young before they have children, encourage frequent reading to children, increase awareness of the benefits to children's cognitive development of folic acid intake during pregnancy, promote the prudent use of screens with children, and encourage parenting practices that use reasoning with children and avoid harsh punishment and 'overparenting'. Future research could be directed at understanding exactly how Asian mothers in New Zealand promote their children's cognitive skills so successfully.

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1. Introduction

The aims of this study are to investigate how the human capital (or 'human capability') of mothers and their children are related, how differences in maternal and child characteristics contribute to inequalities in human capital, and how human capital is transmitted across generations in order to understand how to break the intergenerational cycle of disadvantage. Employing data from the longitudinal Growing Up in New Zealand (GUiNZ) study, we use mother's educational attainment and children's cognitive skills as proxies for their human capital. A tight link between the two would suggest a high degree of intergenerational transmission of human capital, which may indicate widespread inequality of opportunity if the transmission occurs primarily through environmental mechanisms denied to able children of lower-educated mothers. Identifying factors that are associated with children's cognitive skills is an important first step in identifying children at risk of atypical cognitive development. Gaining an understanding of the predictors of children's cognitive skills, the drivers of disparities in cognitive skills, and the factors that help break the intergenerational transmission of low cognitive skills can help inform prevention and early intervention efforts targeted at children at risk of cognitive dysfunction or developmental delay. Such insights can advance the goal of achieving equity in human capital outcomes among children in New Zealand. Understanding intergenerational transmission of human capital is also important for the long-term effectiveness of public policy related to child and family wellbeing, given that gaps in children's cognitive outcomes can be difficult to close once established.

New Zealand research has found children's cognitive skills are linked to their educational, labour market, and health outcomes later in life (Meehan et al., 2023; Fergusson, Horwood & Ridder, 2005). For example, using data from the Christchurch Health and Development Study, Fergusson, Horwood and Ridder (2005) find that children's IQ in middle childhood is significantly related to their annual personal income at age 25 and their educational attainment and duration of unemployment by age 25, even after controlling for confounding childhood measures of family socio-economic disadvantage, family instability, parental adjustment problems, child abuse, and child conduct problems. Thus, children's cognitive skills in childhood have important consequences for their future individual wellbeing and the collective wellbeing and wealth of New Zealand.

International research has found strong associations between children's cognitive or academic outcomes and maternal educational attainment (Carneiro, Meghir & Parey, 2013; Sirin, 2005; Reardon, 2011). We focus on mothers for two reasons. First, because, on average, they spend considerably more time caring for children than fathers in New Zealand (Gibb et al., 2013; Hennecke et al., 2022; Statistics New Zealand, 2013). Second, because of data considerations; compared to data on mothers, the 'partner' data from the Growing Up in New Zealand study is of considerably smaller sample size with worse attrition, and mothers are more likely to be living with the cohort child at each data collection wave (fathers are more likely to be absent) so are more likely to be the parent transmitting human capital to their child (Morton et al., 2017; Rusten et al.,

2019). However, recognising the role that fathers play in children's cognitive development, we supplement our main analyses with additional analyses that include father's educational attainment.

1.1. Research aims

We have three research aims:

(1) Quantify the strength of the relationship between mothers' educational attainment and children's cognitive skills at age 8 years (both in 'raw' or unadjusted terms and adjusted for a range of potentially confounding variables) and explore mechanisms (potential mediating variables) through which the two may be related.

(2) Understand how differences in mothers' and children's characteristics – including mothers' parenting practices – contribute to differences in cognitive skills between children of higher-educated and lower-educated mothers ('cognitive gaps').

(3) Understand what breaks the intergenerational cycle of disadvantage by identifying the maternal and child characteristics that are associated with 'breaking the intergenerational mould' in human capital, that is, having a lower-educated mother yet scoring highly in cognitive tests. In other words, we ask '*Among children of lower-educated mothers, what distinguishes those who 'defy the odds' by exhibiting relatively high cognitive skills?*'.

In short, Aim 1 quantifies the intergenerational transmission of human capital, Aim 2 examines what drives inequalities in human capital, and Aim 3 examines what helps break the intergenerational cycle of disadvantage in human capital.

Our study addresses all six outcomes of the Government's *Child and Youth Wellbeing Strategy*, as maternal education affects children across a range of domains, but it is particularly aligned with the 'Learning and Developing' outcome focused on children having "knowledge, skills and encouragement to achieve their potential" and on increasing equity of educational outcomes in New Zealand. The research is also underpinned by the Strategy's principles that "children and young people's wellbeing is interwoven with family and whānau wellbeing" and "early support is needed". It also examines two key indicators of human capability as measured by the Treasury's Living Standards Framework, namely adult educational attainment and children's cognitive skills (New Zealand Treasury, 2021).

1.2. Theoretical framework

We draw on Harding, Morris, and Hughes' (2015) theoretical framework for understanding the relationship between maternal education and children's cognitive skills and academic outcomes. In brief, the framework posits that a mother's educational attainment confers to her various forms of internalised 'capital' (human, cultural, social) that shape her parenting beliefs and practices which in turn influence her child's cognitive skills. In this framework, 'human capital' refers to mothers' knowledge and skills, which benefit her child directly

through her knowledge of how to provide enriching and developmentally-appropriate resources and learning experiences, as well as indirectly by giving her access to employment and income (especially a job that is well-paid and gives her flexibility to manage work and family commitments in ways that benefit her child). 'Cultural capital' refers to mothers' socially-sanctioned preferences and behaviours – the extent to which her ways of speaking and behaving and her cultural tastes align with those of the dominant culture which are rewarded in schools and other social institutions, such as her accent and vernacular. 'Social capital' refers to mothers' social networks which act as reference groups that set social norms for parenting behaviours to which she is induced to conform and relay information about how to optimise her child's development (for example, word-of-mouth information about enriching extracurricular activities or how to enrol in particular schools).

Mothers deploy these forms of capital and their associated parenting behaviours at multiple levels of the child's environment to promote the child's cognitive development. These range from the proximal effects of micro-level mother-child interactions (cognitively-stimulating one-on-one interactions such as talking to the child, reading to the child, helping with homework) to the more-distal effects of macro-level socio-economic contexts and circumstances (such as the neighbourhood in which the mother lives, the school she sends her child to, the friendships she keeps). These various mechanisms reinforce each other over time and across contexts, resulting in an intergenerational transmission of skills via both genetic/biological and environmental channels. This framework has informed the framing of our research questions, guided our choice of explanatory variables from the GUiNZ dataset, and informed our analysis and interpretation of findings.

1.3. Literature review

Previous studies of child cognitive development in New Zealand have drawn on two broad sources of data: (1) longitudinal cohort studies such as the GUiNZ study, the Christchurch Health and Development Study, and the Pacific Islands Families Study; (2) international surveys that include New Zealand children such as PISA (Programme for International Student Assessment which surveys 15-year-old students in many countries) and PIRLS (Progress in International Reading Literacy Study which surveys 10-year-old students).

Studies using data from the GUiNZ study and multivariable regression or structural equation models have found that preschool-aged children are at greater risk of cognitive delays or impairments – difficulties with language, literacy, or numeracy as measured by impaired expressive or receptive English vocabulary or low letter knowledge, counting ability, or writing ability – if their mother is young (Galvin et al., 2020), multilingual (Bird et al., 2023), of Māori or Pacific ethnicity (D'Souza et al., 2019; Thomas et al., 2019b; Galvin et al., 2020), has a low level of education (D'Souza et al., 2019; Galvin et al., 2020; Bird et al., 2023), lives in a socio-economically deprived neighbourhood (D'Souza et al., 2019; Thomas et al., 2019b; Bird et al., 2023), experienced antenatal anxiety (Neumann et al., 2019), experienced postnatal depression

(Bird et al., 2023), smoked pre-pregnancy (Neumann et al., 2019), and did not take folic acid supplements prenatally (D'Souza et al., 2019) or in the first trimester of pregnancy (Neumann et al., 2019). The risk of cognitive delays or impairments also increase as family socio-economic resources become more disadvantaged (combinations of household income, material hardship, home ownership, residential mobility, household overcrowding, parental employment, and neighbourhood deprivation) (Prickett et al., 2022) and as family dysfunction and violence become more pervasive (traumatic experiences of child abuse, parental substance use, parental mental illness, and parental relationship problems) (Walsh et al., 2019).

Conversely, analyses of GUiNZ data have found that children's cognitive skills at ages 2 and 4.5 years are *enhanced* when mothers talk and read frequently to their child at 9 months of age (Meissel et al., 2019; San San Khaw et al., 2020). Likewise, children's early vocabulary skills between 2.5 and 4 years are enhanced when fathers play and read frequently with their child at 9 months and 2 years of age (Hennecke et al., 2022). Mothers' frequent reading to children at 9 months tends to carry over to frequent reading at 2 years, which is linked to increases in the child's vocabulary at age 2, which in turn is linked to increases in their cognitive skills at age 4.5 (Meissel et al., 2019). The greater the frequency and quality of mother-child verbal interactions during the preschool years, the better are children's receptive vocabulary skills at age 4.5 (Bird et al., 2023). More frequent verbal interactions at age 4.5 are also linked to children having better literacy and numeracy skills and oral language and self-regulation skills at that age (Bird et al., 2024).

Analyses of GUiNZ data have also found that children have larger English vocabularies at age 2 if they are first-born, female, monolingual, live in a relatively affluent neighbourhood, and have a mother with a university degree (Reese et al., 2018) and have better inhibitory control (a measure of executive cognitive function) at age 4.5 if they are female, Asian, and second- or subsequent-born (Corkin et al., 2021) and their mother is highly educated, a non-smoker, and took folate in the first trimester (Buckley et al., 2020).

Studies using data from the Christchurch Health and Development Study and multivariable regression or structural equation models have found that the higher the educational attainment of the parents, the better children's reading skills in middle childhood (8 to 13 years) tend to be, with large effects that persist even when other variables correlated with parental education are held constant. When reading test scores are averaged across these ages, children of parents with no qualifications score -0.33 standard deviations below the mean, while children of degree-qualified parents score 0.60 standard deviations above the mean (Barker & Maloney, 2000). Children of Māori and Pacific parents (combined in Barker and Maloney's analysis due to relatively small sample sizes) have consistently lower reading skills, on average, than children of European parents (about -0.23 standard deviations below the mean), a gap which is entirely accounted for by other parental and school characteristics that are correlated with ethnicity (Barker & Maloney, 2000).

When the Christchurch cohort's cognitive skills in middle childhood were measured more broadly (verbal, reading, and mathematical skills), the same ethnic disparity was found and was similarly accounted for by differences in children's socio-economic backgrounds (Fergusson, Lloyd, & Horwood, 1991). Children's cognitive skills were also found to be unrelated to mothers' labour force participation once other maternal characteristics were taken into account (Horwood & Fergusson, 1999). [1]

There is a small amount of evidence pertaining specifically to Māori and Pacific children. Analysis of GUiNZ data has found that Māori children's cognitive skills at age 4.5 are not affected by family structure transitions over the preschool years (stability or instability in household living arrangements) but are at greater risk of impairment if the child has a mother who is young, lacks a university degree, lives in a deprived neighbourhood, and experiences material hardship (Kukutai et al., 2020). At age 2, children who can understand te reo Māori (81% of whom have Māori heritage) have larger vocabularies in te reo Māori if their mother has a university degree (Reese et al., 2018). [2] Results from the Pacific Islands Families Study have found that 2-year-old Pacific children are at greater risk of developmental delay across social, language, and cognitive skills if they were born at low birth weight and were breastfed for less than six weeks (Paterson et al., 2011). At age 6 years, Pacific children were found to be at greater risk of relatively poor receptive vocabulary skills if they were born small for gestational age and if their mother was born in the Pacific Islands, seldom read to them at age 1 year, and used relatively harsh discipline at age 2 years (Kim et al., 2019).

Turning to studies using PISA and PIRLS data, New Zealand children's cognitive skills (as measured by 2003 PISA test scores in reading, mathematics, science, and problem solving) are strongly related to parental educational attainment: the gap in test scores between children of university-educated parents and children of parents with no qualifications is between 0.75 and 0.90 standard deviations across the four test domains (Maré & Stillman, 2010). The gap in reading (0.83 standard deviations) is almost entirely explained by differences in student factors (attitudes to school, relationships with teachers, class size, etc., which account for 41% of the gap), family characteristics (family type, parents' employment status, parents' occupations, etc., 24% of the gap), home educational resources (books, computers, study space, etc., 20% of the gap), and school characteristics (private or public, gender mix, student-teacher ratio,

[1] Other studies using data from the Christchurch Health and Development Study have found that cognitive skills in middle childhood play a mediating role between childhood family background and life outcomes in adulthood. For example, children's cognitive skills mediate the link between family income over childhood and: failing to attain any qualifications and being NEET by age 21 (Maloney, 2004), educational attainment and income at age 30 (Gibb et al., 2012), and employment earnings between ages 30 and 40 (Iusitini, 2022).

[2] See also Neha et al. (2020) whose small-scale study of parent-child interaction and early learning outcomes among Māori preschool-aged children and their mothers found that, controlling for mothers' educational attainment, those mothers whose verbal interactions with their child involved shared reminiscing that was engaging and stimulating had children with better early academic skills (a composite of their literacy, numeracy, narrative, and self-regulation skills).

selectivity of enrolment, extent of streaming, resource and infrastructure levels, extent of behavioural problems, etc., 13% of the gap) (Maré & Stillman, 2010).

Analyses of 2000 PISA reading test scores have found that New Zealand children's reading skills are linked to parents' socio-economic status and about half of this link is due to higher-SES parents owning more household possessions and assets, educational resources and cultural works, and sending their children to particular schools (Marks, Cresswell, & Ainley, 2006). The gap in reading skills between Māori and New Zealand European children is 0.72 standard deviations, of which two-thirds is accounted for by family characteristics (especially Māori children having a lower perceived socio-economic status and English not being the main language spoken at home, 25% of the gap), student attitudes (especially lower enjoyment of reading among Māori, 15% of the gap), school characteristics (especially concentration of Māori children in low and middle decile schools, 15% of the gap), student activities (especially more time spent on computers among Māori, 9% of the gap), and student characteristics (age and sex differences, 3% of the gap) (Lock & Gibson, 2008).

Analysis of 2001 PIRLS reading test scores has found that New Zealand children's reading skills are enhanced when parents have many books in the home, have positive attitudes to reading, and frequently engage in literacy activities with their child in the preschool years (all these effects are stronger in New Zealand than all, or nearly all, of the 24 other countries analysed by Park (2008)). Parental attitudes to reading and number of books in the home jointly account for about 40% of the gap in reading skills between children of the highest-educated and lowest-educated parents (Park, 2008). [3]

Analysis of 2003 PISA reading test scores found that New Zealand children's reading skills are enhanced when students have many books in the home, a positive attitude to school, high expectations for their educational attainment, belong to a two-parent family, and have a mother who works part-time or is not in the labour force, while reading skills are undermined when students belong to a sole parent family and have a father who is unemployed or works part-time (Maré & Stillman, 2010).

In summary, the empirical evidence pertaining to New Zealand children indicates that cognitive development is associated with a multitude of factors spanning the child's experiences *in utero*, their outcomes at birth, where they grow up, how educated, healthy, and wealthy their parents are, who their parents are in socio-demographic terms, and the extent to which their parents engage them in cognitively-stimulating activities and other enriching aspects of their home environment.

[3] See also Martin et al. (2004) who use the same 2001 PIRLS data but for 33 countries and reach similar conclusions, notably that parental attitudes to reading distinguish high-skilled from low-skilled readers to a greater extent in New Zealand than all other countries analysed: "In every country, significantly greater percentages of the highest- than the lowest-achieving students had parents with favorable attitudes toward reading" and "[t]he difference was particularly striking in New Zealand" suggesting that "parents' viewpoints about the importance of reading as an enjoyable and worthwhile activity have a considerable impact on their children's success as readers".

In all previous studies utilising GUiNZ data cited above, maternal education is included only as a potential confounder (or left out), no studies have examined the predictors of cognitive outcomes at age 8 among the GUiNZ cohort,[4] the role of parenting practices has rarely been examined, and none have focused on how some children 'beat the odds' by exhibiting high levels of human capital despite having parents with lower levels of human capital. This study addresses these knowledge gaps by using GUiNZ data on cognitive test scores at age 8 years alongside information from the antenatal period and over early childhood to understand the relationship between mothers' education and children's cognitive outcomes.

2. Data

2.1. Data source

We use data from the longitudinal GUiNZ study which has been tracking the health and development of a cohort of children since before they were born (via their mothers who were recruited during pregnancy). GUiNZ enrolled 6,822 pregnant women which resulted in a cohort of 6,853 infants born between March 2009 and May 2010. To be eligible, pregnant women had to be resident within a geographical area where about one-third of the New Zealand population lives (covered by the three contiguous District Health Board regions of Auckland, Counties Manukau, and Waikato) and have an estimated delivery date between 25 April 2009 and 25 March 2010 (Morton et al., 2013).

Using a non-probability-based sampling approach, the GUiNZ cohort was recruited so as to be broadly generalisable to the population of New Zealand births at study inception. The cohort is ethnically and socio-economically diverse and demographically aligns with the national birth cohort over the period 2007 to 2010 (Morton et al., 2015). Ethical approval was obtained from the Ministry of Health Northern Y Regional Ethics Committee and written informed consent was obtained from all participating women for their own and their children's participation in the study. Consent to participate was also obtained from 4,401 of the mothers' partners (99% of whom described themselves as the biological father of the child).

The overarching aim of the GUiNZ study is to generate policy-relevant evidence, based on a diverse group of contemporary New Zealand children, in order to inform public policy directed at enhancing children's wellbeing. It specifically seeks to optimise children's developmental trajectories over the lifecourse across multiple aspects of their health and wellbeing. Commissioned by the Government in 2004 with the Ministry of Social Development as its lead government agency and primary funder, the GUiNZ study maintains close links with policymakers to facilitate timely translation of research findings into policy recommendations.

[4] Neumann et al. (2021a; 2021b) looked at cognitive outcomes among the GUiNZ cohort at age 8, but their focus is on the dimensional structure of the various cognitive tests administered at that age and at earlier ages, not their relationship to maternal education or any other family background characteristics.

Major data collection waves occurred during the antenatal period and when the child was aged 9 months, 2 years, 4.5 years (54 months), and 8 years. Each wave collects information across six interconnected domains: family and whānau, societal context and neighbourhoods, education, health and wellbeing, psychological and cognitive development, and culture and identity. The antenatal wave involved a face-to-face computer-assisted personal interview with the pregnant mother (usually conducted in her home in the last trimester of pregnancy). After birth, children's perinatal health records containing information on birth and immediate neonatal outcomes were linked to the GUiNZ dataset. The 8-year wave, completed over July 2017 to January 2019, involved data collection with the mother and child including questionnaires answered by the mother and interviews and direct observations with the child. As part of the latter 8-year child observation, children were administered a cognitive assessment. The current study analyses data from this cognitive assessment at age 8 alongside data from the child's perinatal records and from the maternal interviews at antenatal, 9 months, 2 years, and 4.5 years.

2.2. Variables

2.2.1. Outcome variables

In this study we focus on three cognitive outcomes measured among the GUiNZ cohort as part of the 8-year child observation: vocabulary skills, reading skills, and overall ('global') cognitive skills. These cognitive skills were assessed using the NIH Toolbox Cognition Battery, cognition being one of the four domains measured by the NIH Toolbox.[5] The Cognition Battery is a brief assessment tool designed for use in large-scale longitudinal and epidemiologic studies with individuals aged 3 to 85 years and was administered in English to the GUiNZ cohort at age 8 years. The Cognition Battery assesses five subdomains of cognition using seven different computerised tests, as shown in Table 1.

The Picture Vocabulary Test (hereafter, 'Vocabulary test') is a measure of general vocabulary knowledge. Participants hear a spoken word while viewing four pictures and then must choose the picture that best represents the word. The test does not require reading, writing or speaking so can be performed by individuals who are preliterate or illiterate. By removing the need for participants to read or write, the test removes "the literacy load for children who are developing literacy and for adults who struggle with reading and writing" (Gershon et al., 2013, p. 49). Participants are permitted as much time as necessary to complete their responses and average administration time is five minutes (see Gershon et al. (2013, p. 55) for an example item). Vocabulary comprehension is considered to be a strong measure of crystallised intelligence (those abilities that are highly dependent upon past learning experiences and are consistent across the lifespan) and is strongly associated with overall

[5] The NIH Toolbox – known more fully as the *National Institutes of Health Toolbox for the Assessment of Neurological and Behavioral Function* – assess four domains of functioning across the lifespan: cognitive, emotional, sensory and motor functioning. The NIH Toolbox Cognition Battery is the module used to assess the cognitive functioning domain.

cognitive functioning and success in school and work (Slotkin et al., 2012; Weintraub, Dikmen, et al., 2013).

Table 1. *NIH Toolbox Cognition Battery subdomains, tests, and constructs measured*

Cognition subdomain	NIH Toolbox Cognition Battery test	Construct measured
Executive function	Flanker Inhibitory Control and Attention Test	Inhibitory control and attention
	Dimensional Change Card Sort Test	Cognitive flexibility (switching/set shifting)
Working memory	List Sorting Working Memory Test	Working memory
Episodic memory	Picture Sequence Memory Test	Episodic memory
Processing speed	Pattern Comparison Processing Speed Test	Processing speed
Language	Picture Vocabulary Test	Vocabulary comprehension (receptive vocabulary)
	Oral Reading Recognition Test	Reading decoding

Source: Weintraub, Bauer, et al. (2013) and Weintraub, Dikmen, et al. (2013).

The Oral Reading Recognition Test (hereafter, 'Reading test') measures the ability to pronounce single printed words and/or to recognise letters. Participants are shown a letter or word on a computer screen and are asked to read it aloud. The examiner determines whether it was pronounced correctly by comparing the response to the pronunciation guide shown on a separate computer screen. Participants are permitted as much time as necessary to complete their responses and average administration time is four minutes (see Gershon et al. (2013, p. 57) for an example item). Weintraub et al. (2013, p. S56) note that "[s]ingle-word reading recognition tasks are strong predictors of health and cognitive outcomes across the lifespan".

In both the Vocabulary and Reading tests, ceiling and floor effects have been removed "through the inclusion of a large corpus of items, spanning the complete continuum of difficulty, from preemerging language through PhD-level materials" (Gershon et al., 2013, p. 65). The validity (convergent and discriminant validity when measured against existing gold standard instruments) and reliability (test-retest correlation) of both tests are sound (see Gershon et al., 2013).

In the GUiNZ study, the version of the Cognition Battery designed for use with 7 to 17-year-olds was administered to the cohort via the NIH Toolbox iPad app using standardised procedures. All Cognition Battery tests are scored automatically by the NIH Toolbox software and a range of scores are computed for each test. Both the Picture Vocabulary and Oral Reading Recognition tests are scored using Item Response Theory (a psychometric method of scoring tests) which generates a 'theta score' for each participant. Theta scores are similar to

z-scores (mean = 0 and standard deviation = 1) and represent "the relative overall ability or performance of the participant" (Slotkin et al., 2012, p. 5). Neumann et al. (2021b, p. 829) refer to these theta scores as "raw scores". For all tests, higher scores indicate higher levels of cognitive functioning.

In addition to scores for the seven individual tests listed in Table 1, the Cognition Battery also allows for the evaluation of higher-level cognitive functioning with 'composite scores' which assume that each of the individual tests measure one of two types of cognition – 'fluid intelligence' and 'crystallised intelligence' – and that scores on all tests can be combined into a 'total' composite summary score as a measure of overall cognitive functioning. The basis for the derivation of these composite scores is the two-component theory of the structure of human intelligence (see Akshoomoff et al., 2013). A validation study of the composite scores with US children aged 3 to 15 years found strong empirical support for the psychometric validity and reliability of the three composite scores (Akshoomoff et al., 2013). Fluid intelligence refers to the capacity for new learning and information processing in novel situations and is presumed to be especially influenced by biological processes. It is the ability to "solve problems, think and act quickly, and encode new episodic memories" and "play[s] an important role in adapting to novel situations in everyday life" (Akshoomoff et al., 2013, p. 120). Crystallised intelligence refers to cognitive abilities which are dependent upon past learning experiences and "represent an accumulation of verbal knowledge and skills, and thus are more heavily influenced by education and cultural exposure, particularly during childhood" (Akshoomoff et al., 2013, p. 120).

The three composite scores – Fluid, Crystallised, and Global Cognition – are created by grouping tests together that relate to each other and share theoretical and psychometric properties. The Fluid Cognition composite score is derived by averaging the normalised scores of the Flanker Inhibitory Control and Attention Test, the Dimensional Change Card Sort Test, the List Sorting Working Memory Test, the Picture Sequence Memory Test, and the Pattern Comparison Processing Speed Test, and then deriving standard scores based on the new distribution. The Crystallised Cognition composite score is derived by averaging the normalised scores on the two language tests (the Picture Vocabulary Test and the Oral Reading Recognition Test) and deriving standard scores based on the new distribution. The Global Cognition composite score is derived by averaging the Fluid and Crystallised composite scores and then deriving standard scores based on the new distribution.

We adjust the raw scores for each outcome in two ways. First, because the exact age at which children were administered the Cognition Battery as part of the 8-year child observation varied from approximately 7.9 to 9.7 years, we age-adjust the raw scores so that they do not reflect differences in age. Second, because each outcome is scored on a different numerical scale, we standardise the raw scores (subtract the mean and divide by the standard deviation) so that scores across all three outcomes are expressed on the same scale, namely, as 'number of standard deviations from the mean score'. Thus, the scores we analyse are both age-adjusted and standardised.

Why do we choose vocabulary skills, reading skills, and overall cognitive skills as the outcomes? Neumann et al. (2021b) find the psychometric underpinnings of the Cognition Battery (its dimensional structure) do not fit well the New Zealand data from the GUiNZ cohort in some key respects. Using confirmatory factor analysis to test the applicability of a one-factor model corresponding to a global cognition score, and a two-factor model corresponding to the fluid and crystallised cognition scores, they find model fit to be generally poor and factor reliability to be below the acceptable threshold. Using exploratory factor analysis, they find a three-factor model provides the best fit to the GUiNZ data, but factor reliability was unsatisfactory and measurement invariance of the three-factor model was patchy across child's neighbourhood deprivation and mother's ethnicity (however, measurement invariance *was* found across child gender). This means that "we can assume that the three cognitive dimensions have the same meaning to participants across gender in our cohort" but that "caution is needed if the three dimensions of cognition are used to compare cognitive performance across different groups stratified by ethnicity and SES [socio-economic status]" (Neumann et al., 2021b, pp. 831, 832).

Based on these findings, Neumann et al. (2021b, p. 832) recommend "using the NIH Toolbox…measures [i.e., the seven tests that comprise the Cognition Battery] individually in addition to considering the cognitive composites scores". The current study adheres to this recommendation by using scores on two individual tests (the Picture Vocabulary and Oral Reading Recognition tests) in addition to the Global Cognition score.

Why do we choose to focus on the two language-related tests of crystallised cognition? This is based on Neumann et al. (2021a) who find that a measure of expressive vocabulary administered at the earlier age of 2 years, and language-heavy indices of cognitive functioning at age 4.5 years (developed in their paper), are both significant predictors of cognitive outcomes at age 8, concluding that "early language development is important for later cognitive abilities" (Neumann et al., 2021a, p. 10). They also note that "early language impairments [are] often…associated with poorer behavioural, socio-emotional and academic outcomes later in life" (Neumann et al., 2021a, p. 10). Thus, the current study focuses on the two cognitive tests of language abilities (vocabulary and reading) at age 8 on the grounds that these tests are likely to be important predictors of cognitive, academic, and other developmental outcomes later in life. [6]

Are tests from the NIH Toolbox Cognition Battery culturally appropriate in the New Zealand context? The Cognition Battery was tested, validated, and normed on the US population and there has not been extensive study of its cross-cultural generalisability to populations outside the US (Tennant et al., 2022). As discussed above, Neumann et al. (2021b) find the Cognition Battery's dimensional structure (that is, two broad types of cognition that can be

[6] Our focus on reading skills is also motivated by New Zealand's comparatively large inequities in literacy achievement: results from international surveys show that the disparity between high and low reading performance among New Zealand children is one of the largest in the developed world, a gap that has persisted since the early 1990s (Prochnow, Tunmer, & Greaney, 2015).

combined into one overall measure of global cognition) does not apply to the GUiNZ cohort, and it remains unclear whether differences between the American and New Zealand dialects of English and other cultural differences may affect test performance among New Zealand children. Furthermore, tests that estimate the size of children's vocabulary in only one language (in the present case, English) underestimate bilingual children's vocabulary totalled across both languages spoken (see Reese et al., 2018). We discuss the issue of potential cultural biases in cognitive assessment in section 6.

2.2.2. Explanatory variables

We relate the cognitive outcomes to three sets of explanatory variables: the main predictor of interest (mother's educational attainment), a suite of potentially confounding variables measured contemporaneously to mother's education (characteristics of the mother or child that may be correlated with the mother's educational attainment and also influence the child's cognitive outcomes), and a suite of potentially mediating variables measured post-birth (mother's parenting behaviours and investments in her child that may act as channels or transmission mechanisms through which her education influences her child's cognitive outcomes).

Mother's educational attainment is measured as her highest educational qualification at the antenatal wave, derived and coded into five categories by GUiNZ researchers:

1 = No secondary school qualification
2 = Secondary school qualification/NCEA level 1 to 4
3 = Diploma or Trade certificate/NCEA level 5 to 6
4 = Bachelor's degree
5 = Higher degree

The potentially confounding variables, all measured antenatally or perinatally, are grouped into **mother's socio-demographic characteristics** (her age, self-prioritised ethnicity, native/migrant status, parity, rurality, household type, work and labour force status, neighbourhood socio-economic deprivation), **mother's lifestyle behaviours** (smoking behaviour during pregnancy, alcohol consumption during pregnancy, folate/folic acid intake in the first trimester of pregnancy), **mother's mental health** (depression status, anxiety/panic attacks status), and **child's birth characteristics** (child's sex, gestational age, and low birth weight status).

The potentially mediating variables, all measured postnatally, are **childcare** (the child's main care arrangement at age 9 months), **language spoken at home** (the language used most by the mother to talk to her child at 9 months), **books in the home** (the number of children's books in the home at 9 months), **television use** (mother's frequency of watching children's TV programmes with the child at 9 months, mother's frequency of having the TV on in the same room as the child at 9 months), **parent-child book reading** (mother's frequency of reading books to her child at 9 months, 2 years, and 4.5 years), and **parenting**

practices (mother's level of warm parenting, hostile parenting, and diffident parenting). See ***Appendix 1*** for details of how each variable was measured and coded.

Note that our analysis does not include measures of mother's household income or family wealth (the value of financial assets, property, etc. owned by the family). We initially included mother's household income at antenatal in our analyses, but statistical checks found that it caused multicollinearity issues (a problematic degree of interdependence between independent variables) due to its correlation with mother's educational attainment (Pearson's correlation coefficient = 0.38).[7] Such multicollinearity can render unreliable any inferences subsequently made about the relationship between mother's educational attainment and children's cognition in the general population. However, our analysis does include a measure of neighbourhood socio-economic deprivation – the *New Zealand Index of Deprivation 2006* which uses information on household income in its construction (Salmond et al., 2007) – and therefore captures an aspect of socio-economic status (albeit at the area level rather than individual level). GUiNZ does not collect information on family wealth.

Following Monk (2022), we use a Heckman correction (Heckman, 1979) to correct for bias due to differential attrition from the GUiNZ cohort by age 8 years. That is, we analyse a subset of GUiNZ children who are not representative of the full original cohort, so the Heckman correction adjusts for non-random selection into the 8-year child observation. We use an index of household crowding at the antenatal wave as an 'instrument' for such selection (that is, the household crowding index variable at antenatal is used as the 'exclusion restriction' variable, meaning it is included in the Heckman correction equation but not in the analytical models).

In order to consider the role played by father's educational attainment in children's cognitive development, we conduct a sensitivity analysis in which we include father's educational attainment at the antenatal wave as an additional covariate (which is coded identically to mother's educational attainment).

2.3. Sample selection

For each aim and each outcome, our analysis sample is of children with complete data on all variables included in the analysis (no imputation of missing data was performed) with random selection of one child from multiple births. Thus, to be included in the analysis, a child must have been followed-up at the 8-year child observation, completed the relevant test(s) from the NIH Toolbox Cognition

[7] With mother's household income included in the analyses, the variable measuring mother's highest educational attainment had variance inflation factor (VIF) values of around 7 to 8. While this is lower than the commonly-used VIF threshold of 10, it is higher than the threshold of 5 which is also commonly recommended (see Thompson et al. (2017)). Because this multicollinearity pertained to our main independent variable of interest, we applied the more conservative threshold of 5 which therefore required dropping mother's household income from the analysis. We also tried incorporating into the analysis mother's occupation before the birth of her first child but encountered the same multicollinearity problem, so it too was dropped.

Battery, and have complete data on mother's educational attainment and all the other explanatory variables. These selection criteria yield samples sizes of 4,080 children for the analysis of vocabulary skills, 3,858 for reading skills, and 3,739 for global cognitive skills. These samples are used in the Aim 1 and Aim 2 analyses, but a subset of each sample is used in the Aim 3 analysis. See the sample selection flowcharts in ***Appendix 2*** (Vocabulary sample), ***Appendix 3*** (Reading sample) and ***Appendix 4*** (Global Cognition sample) for details of how each analysis sample was determined.

Differential attrition from the GUiNZ cohort by the 8-year follow-up is documented in Morton et al. (2020, p. 36) who find that mothers of children who did not participate in the 8-year data collection wave were more likely to be younger, have fewer educational qualifications, live in a highly socio-economically deprived neighbourhood, and identify with an ethnicity other than European. This issue is explored further in section 6.

3. Method

3.1. Method for Aim 1

To investigate Aim 1, we use **box-and-whisker plots** to visually depict the relationship between maternal education and children's cognitive skills. We then use **linear regression** which is a statistical technique for quantifying the strength of the relationship between a scalar outcome variable and one or more explanatory variables. It predicts the value of the outcome variable based on the values of the explanatory variables by fitting a linear equation to the observed data. The statistical significance level is set at α=5%.

For each cognitive outcome, we estimate three models. The first (Model 1) predicts children's standardised test scores as a function of mother's educational attainment only (known as **simple linear regression** due to there being only one independent variable); the second (Model 2) predicts children's standardised test scores as a function of mother's educational attainment plus the potentially confounding variables (known as **multiple linear regression** due to there being two or more independent variables); and the third (Model 3) predicts children's standardised test scores as a function of mother's educational attainment plus the potentially confounding variables and the potentially mediating variables (**multiple linear regression**). Note that, for each cognitive outcome, the sample remains the same across models 1 to 3 (that is, the sample is held 'fixed' so that any changes in coefficients across models are not driven by changes in sample composition). All models also include the variable that corrects for attrition bias in the 8-year child observation data collection (the 'Inverse Mills ratio' which implements the Heckman correction). All the explanatory variables – described in section 2.2.2 above and detailed in Appendix 1 – are coded as 'dummy variables' (also called indicators or factor variables).

For each cognitive outcome, we conduct ethnic-specific analyses by repeating the linear regression analysis separately for children of Māori, Pacific, and Asian mothers (naturally, we exclude the 'mother's ethnicity' variable from these ethnic-specific models, and in the Māori-specific model we also exclude the

'mother's native/migrant status' variable because there are too few Māori mothers born overseas). We also conduct a sensitivity analysis in which we incorporate father's educational attainment at the antenatal wave as an additional covariate in Models 2 and 3. This reduces the samples to the subset of children whose fathers were interviewed antenatally. Unsurprisingly, this also has the effect of reducing the number of sole parent mothers in the samples to near zero, so we therefore exclude the 'household type' variable from these sensitivity analyses. Consequently, the sample sizes for these sensitivity analyses are 2,994 children for vocabulary skills, 2,834 for reading skills, and 2,749 for global cognitive skills.

3.2. Method for Aim 2

To investigate Aim 2, we use a **Kitagawa-Blinder-Oaxaca decomposition** which is a statistical technique for studying differences in average outcomes between groups, first developed by Kitagawa (1965) and later popularised by Oaxaca (1973) and Blinder (1973). It is most commonly used to study wage gaps but has also been used in the New Zealand context to examine group differences in cognitive or academic outcomes (see for example Cao and Maloney (2018), Lock and Gibson (2008), and Maré and Stillman (2010)). In these latter studies, the decomposition quantifies how much of the gap in cognitive outcomes between groups (defined by parental education and child ethnicity in these studies) can be statistically accounted for by group differences in measured characteristics that influence those outcomes, and how much cannot be accounted for by such differences or is left unmeasured in the decomposition. It takes the average difference in cognitive scores between two groups – the 'cognitive gap' – and apportions it into 'explained' and 'unexplained' components. The explained component is the portion of the cognitive gap that is *statistically attributable* to differences in the mean values of the cognition-influencing independent variables within the groups. The unexplained component is the remaining part of the cognitive gap that is not accounted for by differences in the independent variables but instead may be attributable to either (or some combination of): group differences in the effects of (or 'returns' to) the cognition-related characteristics included in the decomposition (in which case the unexplained component can be thought of as different rates at which children's family background characteristics are translated into cognitive test scores) or alternatively to factors that are not observed in the data (i.e., group differences in one or more determinants of children's cognitive skills that are not captured in the model).

We use the Kitagawa-Blinder-Oaxaca decomposition technique to decompose the gap in mean vocabulary, reading, and global cognition test scores between children of mothers with degrees (n=1,839 for Vocabulary, n=1,749 for Reading, n=1,706 for Global Cognition) and children of mothers without degrees (i.e., Diploma/Trade certificate or lower qualification; n=2,241 for Vocabulary, n=2,109 for Reading, n=2,033 for Global Cognition). We break down the explained component into the contribution made to the cognitive gap by each of the different groupings of characteristics (these groupings are mother's socio-demographic characteristics, mother's lifestyle characteristics during pregnancy,

mother's mental health, child's birth characteristics, main childcare arrangement, mother's language used at home, number of children's books in the home, mother's television use with child, mother's frequency of reading books to the child, and mother's parenting practices). To correct our estimates for attrition bias (i.e., sample selection bias arising from differential attrition out of the GUiNZ study by age 8), we again apply the Heckman correction procedure, which deducts the selection effects from the cognitive gap and then applies the decomposition technique to the adjusted gap.

To estimate the explained and unexplained components, we pose the counterfactual question, "*What would the difference in average cognitive scores be if children of mothers without degrees had the same characteristics as all children (of both degree-qualified and below-degree-qualified mothers) pooled together?*". That is, we use a pooled regression over both groups as the 'non-discriminatory benchmark'. This assumes that, in the absence of discrimination, the cognitive returns from the various characteristics that would prevail in the cohort would be some mixture of both groups' returns.

We are unable to conduct ethnic-specific analyses for Aim 2 because sample sizes of children of Māori, Pacific, and Asian mothers are too small for the requirements of the decomposition method.

3.3. Method for Aim 3

To investigate Aim 3, we use **binary logistic regression** which is a statistical technique for quantifying the strength of the relationship between a binary dependent variable (an outcome with only two categories) and a set of explanatory variables. It predicts the probability ('log odds') of the outcome based on the values of the explanatory variables by fitting a linear equation to the observed data. The outcome we model is scoring in the upper quartile (top 25%) of the *full sample* in Vocabulary/Reading/Global Cognition despite having a mother whose educational attainment is below degree level. We refer to this outcome as 'breaking the intergenerational mould' in human capital. This means the analysis for Aim 3 is restricted to those children of mothers with a Diploma/Trade certificate or lower qualification (n=2,241 for Vocabulary, n=2,109 for Reading, n=2,033 for Global Cognition).

We model children's odds of 'breaking the intergenerational mould' as a function of the same suite of potentially confounding and potentially mediating dummy variables (and the variable that corrects for attrition bias in the 8-year child observation data collection) used in the Aim 1 analysis.

As with Aim 2, we are unable to conduct ethnic-specific analyses because the numbers of children of Māori, Pacific, and Asian mothers who 'break the mould' are once again too small to meaningfully analyse with binary logistic regression. But we *are* able to conduct the sensitivity analysis that includes father's educational attainment as an additional covariate (which excludes the 'household type' explanatory variable, as done for Aim 1).

4. Results

4.1 Descriptive statistics

Of the full GUiNZ cohort of 6,853 children, a total of 4,837 participated in the NIH Toolbox Cognition Battery – from which we draw our three analytical samples – and 2,016 did not participate (were lost to follow-up). Table 2 displays socio-demographic characteristics of the full GUiNZ cohort of mothers and children at the antenatal wave, as well as a breakdown of these characteristics by whether or not the child participated in the NIH Toolbox Cognition Battery. The characteristics of the mothers and children who participated in the Cognition Battery closely resemble those of the mothers and children in our three analytical samples. Thus, any differences we find between the characteristics of children who did and did not participate in the Cognition Battery will also apply to our three analysis samples (and may even be slightly more prominent in them).

Among the full cohort, the highest qualification most commonly held by mothers was a Diploma or Trade Certificate (or equivalent NCEA level 5 or 6 qualification, 30.6%), followed by a secondary school qualification (or equivalent NCEA level 1 to 4 qualification, 23.7%), a Bachelor's degree (22.6%), a higher degree (Masters or PhD, 15.6%), and no school qualifications (7.1%).

At the antenatal wave, a majority of mothers were aged in their thirties or older (56.3%), born in New Zealand (64.3%), pregnant with their second or subsequent child (58.1%), and living in a two-parent household (65.5%) in an urban area (93.1%). Only a small proportion of mothers were sole parents (3.5%) at the antenatal wave. Just over half (53.2%) of mothers self-identified their main ethnicity as European, 13.9% as Māori, 14.5% as Pacific, 14.6% as Asian, and 3.5% as another ethnicity. A majority of mothers were employed (54.1%, of which most were full-time), 7.9% were unemployed, and 28.4% were not in the labour force. One-quarter of mothers were living in neighbourhoods of low socio-economic deprivation (deciles 1 to 3 of the *New Zealand Index of Deprivation 2006*), 36.6% were living in medium-deprivation neighbourhoods (deciles 4 to 7), and 38.5% were living in high-deprivation neighbourhoods (deciles 8 to 10). Mothers were mainly drawn from the Counties Manukau (36.7%) and Auckland (35.6%) District Health Board (DHB) areas, with the remaining 27.7% drawn from the Waikato DHB area. Children were roughly evenly split by sex (48.5% female).

Children who participated in the 8-year NIH Toolbox Cognition Battery – from which we draw our samples for the current analysis – were more likely to have mothers who were university-educated, older, European, born in New Zealand, employed, and living in two-parent households in low or medium deprivation neighbourhoods in the Auckland or Waikato DHB areas.

Conversely, children who did not participate in the 8-year NIH Toolbox Cognition Battery were more likely to have mothers who were lower-educated, younger, non-European (especially Pacific and Māori), born overseas, unemployed or not in the labour force, and living in households that were not of the conventional

Table 2. *Socio-demographic characteristics of mothers and children enrolled in GUiNZ study, in total and by follow-up at 8-year NIH Toolbox Cognition Battery*

Maternal and child characteristics	Total	By follow-up at 8-year NIH Toolbox Cognition Battery		
	Full GUiNZ cohort (%)	Participated (%)	Did not participate (%)	*p*-value from χ^2 test
Mother's highest educational qualification at antenatal				<0.001
No secondary school qualification	7.1	4.9	12.5	
Secondary school qualification/NCEA level 1 to 4	23.7	21.1	30.1	
Diploma or Trade certificate/NCEA level 5 to 6	30.6	29.9	32.2	
Bachelor's degree	22.6	26.1	14.3	
Higher degree	15.6	17.8	10.4	
Missing	0.3	0.2	0.5	
Mother's age at antenatal				<0.001
Less than 25 years	19.3	14.9	29.7	
25 to 29 years	24.4	23.4	26.7	
30 to 33 years	25.1	27.1	20.2	
34 years and over	31.2	34.4	23.4	
Mother's ethnicity at antenatal				<0.001
European	53.2	62.6	30.7	
Māori	13.9	11.3	19.9	
Pacific	14.5	9.5	26.6	
Asian	14.6	13.2	18.1	
Other ethnicity	3.5	3.2	4.3	
Missing	0.3	0.3	0.3	
Mother's native/migrant status at antenatal				<0.001
Born in New Zealand	64.3	68.5	54.1	
Migrated to New Zealand up to age 18 years	10.8	9.7	13.2	
Migrated to New Zealand after age 18 years	24.8	21.6	32.4	
Missing	0.2	0.2	0.2	
Mother's parity at antenatal				0.040
First-born	41.8	42.8	39.5	
Subsequent-born	58.1	57.1	60.4	
Missing	0.1	0.1	0.1	
Mother's rurality at antenatal				<0.001
Urban area	93.1	91.9	95.9	
Rural area	6.9	8.1	4.1	
Mother's household type at antenatal				<0.001
Two parents	65.5	70.6	53.3	
Parent(s) with others	30.9	26.4	41.8	
Sole parent	3.5	2.9	4.8	
Missing	0.1	0.1	0.1	
Mother's work and labour force status at antenatal				<0.001
Employed full-time	37.9	41.7	29.0	
Employed part-time	16.2	18.5	10.8	
Unemployed	7.9	5.9	12.8	
Not in the labour force	28.4	25.1	36.3	
Missing	9.5	8.8	11.1	
Mother's neighbourhood deprivation at antenatal				<0.001
Low	24.9	28.6	16.2	
Medium	36.6	39.8	28.7	
High	38.5	31.5	55.1	
Mother's District Health Board area at antenatal				<0.001
Auckland	35.6	37.0	32.2	
Counties Manukau	36.7	32.9	45.9	
Waikato	27.7	30.1	21.9	
Child's sex				0.290
Male	51.5	51.1	52.5	
Female	48.5	48.9	47.5	
Number of observations	**6,853**	**4,837**	**2,016**	

Notes: The children in our three analytical samples are drawn from the 4,837 children enumerated in the second column headed 'Participated' and closely resemble them in socio-demographic terms including their mothers' characteristics. In the interests of brevity, we eschew a table displaying three separate columns (and associated chi-squared test results) for each analytical sample. Any biases that exist between children in the 'Participated' and 'Did not participate' columns will apply equally (if not slightly more so) to our analytical samples.
Source: Authors' calculations from Growing Up in New Zealand dataset.

two-parent type in high deprivation neighbourhoods in the Counties Manukau DHB area. In short, children from socio-economically disadvantaged backgrounds are under-represented in the 8-year child observation meaning there has been biased attrition from the cohort (see section 6 and Morton et al. (2020) for further discussion of this attrition).

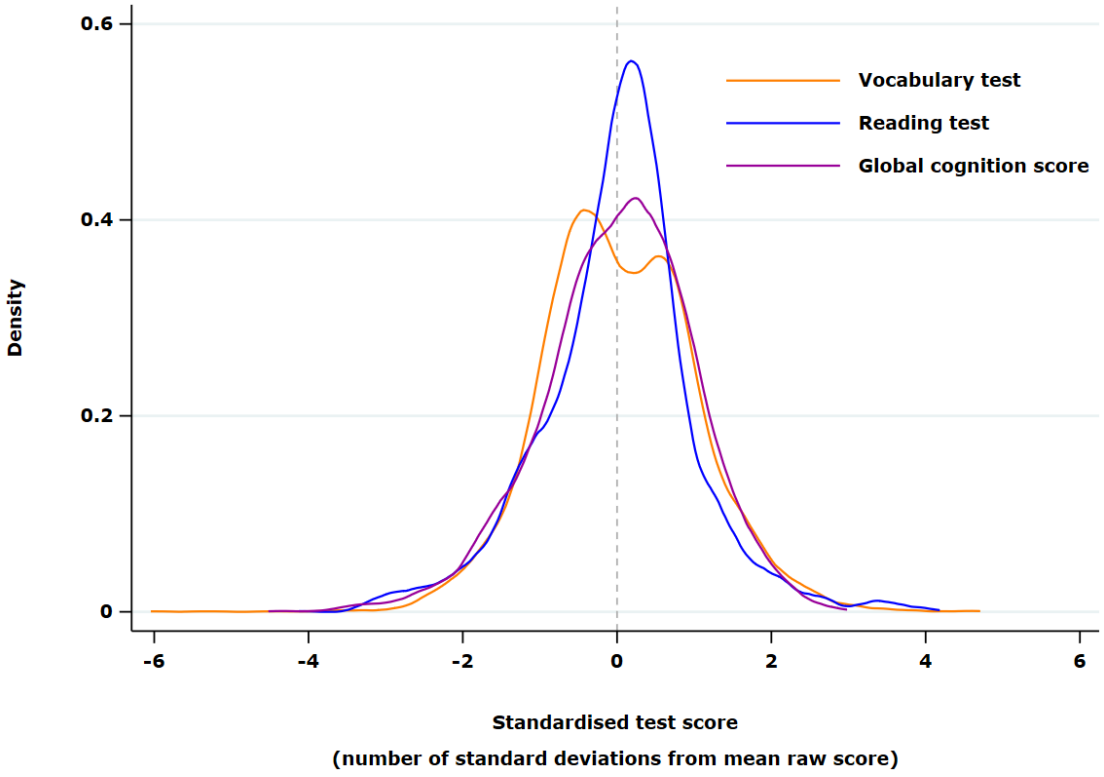
Table 3 presents descriptive statistics (central tendency and spread) of the outcome variables – Vocabulary, Reading, and Global Cognition scores – in both raw and standardised form. Figure 1 depicts the distribution of the standardised scores in which the underlying probability distribution of the test scores are represented by a continuous curve estimated with kernel density estimation, analogous to a histogram (recall that test scores have been standardised so they have a mean of zero and a standard deviation of 1).

Table 3. *Descriptive statistics of cognitive test scores (both raw scores and age-adjusted standardised scores) of 8-year-old GUiNZ children in each analytical sample*

		Raw score					Age-adjusted standardised score				
	n	Min.	Median	Max.	Mean	SD	Min.	Median	Max.	Mean	SD
Vocabulary Test	4,080	-9.91	-0.99	6.19	-0.87	1.45	-6.04	-0.02	4.71	0.03	0.99
Reading Test	3,858	-11.20	-1.20	9.99	-1.42	2.74	-4.13	0.08	4.18	0.01	0.99
Global Cognition	3,739	46.00	81.00	103.00	80.13	7.93	-4.52	0.08	2.98	0.02	0.99

Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 1. *Density plot of standardised scores on cognitive tests of 8-year-old GUiNZ children in each analytical sample*



Source: Authors' calculations from Growing Up in New Zealand dataset.

Table 3 shows that, for all three standardised cognitive outcomes, median scores fall quite close to mean scores, indicating distributions which are not heavily skewed, and Figure 1 shows that scores are distributed in a broadly even way about the mean (except vocabulary scores which have a bimodal distribution and a negative skew or left-tail).

Table 4 presents the distributions of all the explanatory variables included in the analysis, by each cognitive outcome (Vocabulary sample, Reading sample, and Global Cognition sample). Mother's socio-demographic characteristics are similar to those of the wider set of mothers whose children participated in the NIH Toolbox Cognition Battery (shown in Table 2). With respect to other maternal characteristics, Table 4 shows that minorities of mothers smoked cigarettes during pregnancy (about 8%), did not take folate (an essential vitamin) or folic acid (synthetic version used in foods and supplements) in the first trimester of pregnancy (about 13%), had significant antenatal depressive symptoms (about 10%), and suffered from anxiety or panic attacks (about 3%). A larger proportion (30%) drank alcohol during pregnancy. Small proportions of children were born preterm (5%) and at low birth weight (4%).

Turning to the postnatal potential mediators, at age 9 months most children were being cared for primarily by their parent or other informal caregiver (83%, the remaining 17% were in early childhood education, either centre-based or home-based), had a mother who mainly spoke to them in English (85%), had over 20 books in the home (65%), watched children's television programmes with their mother less than once a day (75%), and just under half (46%) had television on in the background more than once a day. Mothers' reading to children was relatively infrequent at 9 months (less than daily was most common at 45%), peaked at 2 years (more than once a day was most common at 44%), then declined at 4.5 years (once a day was most common at 45%). Mothers' scores on three scales of parenting practices at 4.5 years – 'warm parenting' (warm, affectionate, and responsive), 'hostile parenting' (verbally and physically hostile/punitive), and 'diffident parenting' (unconfident, inconsistent, and lacking in disciplinary follow-through) – were grouped into three roughly equal-sized bins, where 'low' refers to relatively infrequent use of those parenting practices and 'high' refers to relatively frequent use of those parenting practices (the distribution of scores meant bins of exactly equal size could not be derived).

Table 4. *Distribution of explanatory variables for each cognitive test sample drawn from 8-year-old GUiNZ cohort*

Type of explanatory variable	Category	Variable	Vocabulary sample (%)	Reading sample (%)	Global cognition sample (%)
Main predictor	**Mother's educational attainment**	Mother's highest educational qualification at antenatal			
		No secondary school qualification	4.3	4.0	3.9
		Secondary school qualification	20.5	20.5	20.5
		Diploma or Trade certificate	30.2	30.2	30.0
		Bachelor's degree	26.4	26.4	26.4
		Higher degree	18.7	18.9	19.2
Antenatal and perinatal potential confounders	**Mother's socio-demographic characteristics**	Mother's age at antenatal			
		Less than 25 years	14.6	14.4	14.3
		25 to 29 years	23.7	23.4	23.5
		30 to 33 years	27.5	27.8	28.0
		34 years and over	34.2	34.4	34.2
		Mother's ethnicity at antenatal			
		European	64.9	65.0	65.1
		Māori	11.3	11.1	10.9
		Pacific	8.5	8.3	8.4
		Asian	12.3	12.4	12.6
		Other ethnicity	3.1	3.2	3.1
		Mother's native/migrant status at antenatal			
		Born in New Zealand	70.0	69.6	69.5
		Migrated to New Zealand up to age 18 years	9.3	9.3	9.3
		Migrated to New Zealand after age 18 years	20.6	21.1	21.3
		Mother's parity at antenatal			
		First-born	43.1	43.2	43.4
		Subsequent-born	56.9	56.8	56.6
		Mother's rurality at antenatal			
		Urban area	91.5	91.4	91.4
		Rural area	8.5	8.6	8.6
		Mother's household type at antenatal			
		Two parents	72.0	72.4	72.5
		Parent(s) with family or non-family	25.5	25.3	25.2
		Sole parent	2.5	2.3	2.3
		Mother's work and labour force status at antenatal			
		Employed full-time	46.2	46.6	46.9
		Employed part-time	20.9	20.9	20.9
		Unemployed	6.1	5.9	5.8
		Not in the labour force	26.8	26.7	26.5
		Mother's neighbourhood socioeconomic deprivation at antenatal			
		Low	29.2	29.4	29.5
		Medium	40.3	40.7	40.8
		High	30.5	29.9	29.8
	Mother's lifestyle behaviours	Mother's smoking behaviour during pregnancy at antenatal			
		Did not smoke	92.0	92.2	92.4
		Smoked	8.0	7.8	7.6
		Mother's alcohol consumption during pregnancy at antenatal			
		Did not drink alcohol	70.5	70.3	70.5
		Drank alcohol	29.5	29.7	29.5
		Mother's folate intake during first trimester at antenatal			
		Took folate	86.5	86.8	87.0
		No folate	13.5	13.2	13.0
	Mother's mental health	Mother's depression status at antenatal			
		Not depressed	89.9	90.0	90.0
		Depressed	10.1	10.0	10.0
		Mother anxiety/panic attacks status at antenatal			
		No anxiety	96.5	96.6	96.5
		Anxious	3.5	3.4	3.5

Table 4 (continued). *Distribution of explanatory variables for each cognitive test sample drawn from 8-year-old GUiNZ cohort*

Type of explanatory variable	Category	Variable	Vocabulary sample (%)	Reading sample (%)	Global cognition sample (%)
Antenatal and perinatal potential confounders	**Child's birth characteristics**	Child's sex			
		Male	51.1	50.8	50.5
		Female	48.9	49.2	49.5
		Child's gestational age			
		Term (≥37 weeks)	94.7	94.8	94.8
		Preterm (<37 weeks)	5.3	5.2	5.2
		Child's low birth weight status			
		Not low birth weight (≥2500 grams)	96.2	96.1	96.1
		Low birth weight (<2500 grams)	3.8	3.9	3.9
Post-birth potential mediators	**Childcare**	Child's main care arrangement at 9 months			
		Early childhood education	17.2	17.2	17.4
		Parental care or informal care	82.8	82.8	82.6
	Language at home	Mother's language used most to talk to child at 9 months			
		English	84.8	84.7	84.6
		Other language	15.2	15.3	15.4
	Books in home	Number of children's books in home at 9 months			
		5 or fewer books	8.7	8.8	8.8
		6 to 20 books	26.0	25.8	26.0
		21 or more books	65.3	65.3	65.2
	Television use	Mother's frequency of watching children's TV with child at 9 months			
		Less than once a day	74.4	74.6	74.5
		Once a day	16.1	16.0	16.1
		More than once a day	9.5	9.4	9.4
		Mother's frequency of having TV on in same room as child at 9 months			
		Less than once a day	24.8	25.2	25.3
		Once a day	28.8	28.7	28.8
		More than once a day	46.3	46.2	45.9
	Book reading	Mother's frequency of reading books to child at 9 months			
		Less than once a day	45.3	45.1	44.9
		Once a day	36.1	36.2	36.3
		More than once a day	18.7	18.7	18.8
		Mother's frequency of reading books to child at 2 years			
		Less than once a day	27.9	27.8	27.4
		Once a day	28.7	28.5	28.6
		More than once a day	43.4	43.7	43.9
		Mother's frequency of reading books to child at 4.5 years			
		Less than once a day	36.1	35.9	35.8
		Once a day	45.1	45.0	45.0
		More than once a day	18.8	19.0	19.1
	Parenting practices	Mother's warm parenting at 4.5 years			
		Low warm parenting	37.0	37.0	37.1
		Medium warm parenting	37.3	37.6	37.4
		High warm parenting	25.7	25.3	25.4
		Mother's hostile parenting at 4.5 years			
		Low hostile parenting	28.9	29.0	29.0
		Medium hostile parenting	32.8	32.9	32.9
		High hostile parenting	38.2	38.1	38.0
		Mother's diffident parenting at 4.5 years			
		Low diffident parenting	33.8	34.2	34.4
		Medium diffident parenting	31.5	31.4	31.3
		High diffident parenting	34.7	34.4	34.4
Number of observations			**4,080**	**3,858**	**3,739**

Source: Authors' calculations from Growing Up in New Zealand dataset.

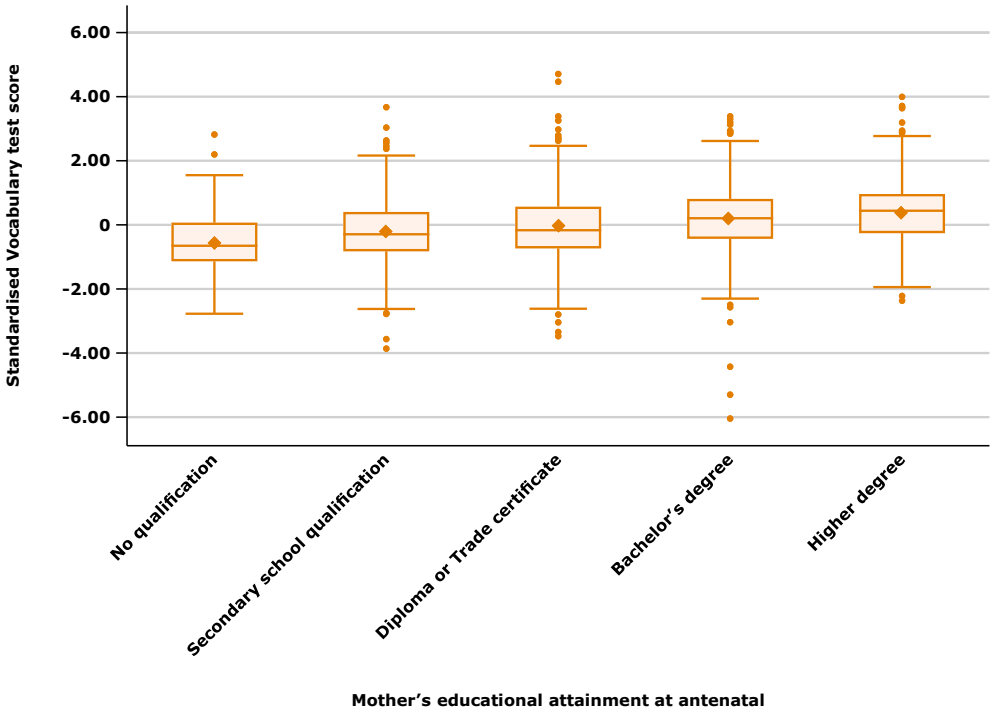
4.2. Results for Aim 1 (quantifying intergenerational transmission of human capital)

4.2.1 Main results

We begin by describing the 'raw' (unadjusted) relationship between mother's educational attainment at antenatal and children's cognitive skills at age 8 years. Figure 2 (Vocabulary), Figure 3 (Reading), and Figure 4 (Global Cognition) are box-and-whisker plots depicting the distribution of standardised test scores by levels of maternal education (mean tests scores – represented by diamonds – have been overlaid). While there is much variability at each level of maternal education, the overall tendency is a positive relationship or social gradient: as mothers' educational attainment increases, children tend to have better cognitive skills. The gradient is less pronounced in reading skills than in vocabulary and global cognitive skills.

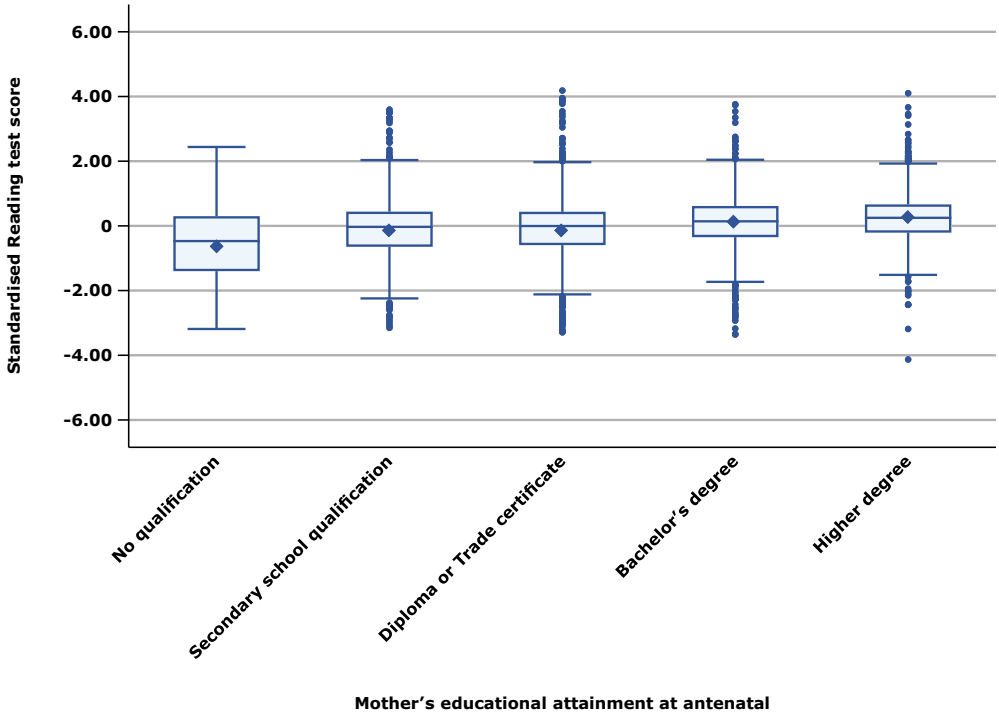
On average, children of mothers with no qualifications score roughly 0.6 standard deviations below the mean score on vocabulary, reading, and global cognition. Children of mothers with a Diploma or Trade certificate score about 0.1 standard deviations below the mean score on all three outcomes. Children of mothers with a higher degree (Masters or PhD) score about 0.4 standard deviations above the mean in vocabulary, 0.2 standard deviations above the mean in reading, and 0.3 standard deviations above the mean in global cognition.

Figure 2. *Box-and-whisker plot of standardised Vocabulary test scores of 8-year-old GUiNZ children by levels of maternal educational attainment*



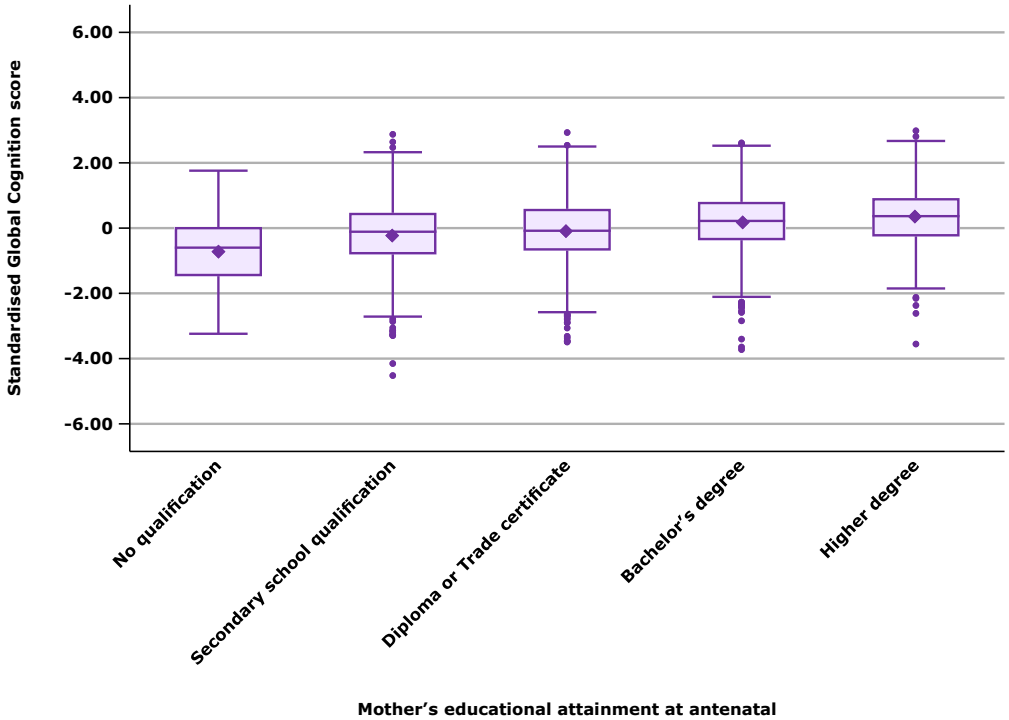
Notes: Diamond symbols represent mean test scores.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 3. *Box-and-whisker plot of standardised Reading test scores of 8-year-old GUiNZ children by levels of maternal educational attainment*



Notes: Diamond symbols represent mean test scores.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 4. *Box-and-whisker plot of standardised Global Cognition scores of 8-year-old GUiNZ children by levels of maternal educational attainment*



Notes: Diamond symbols represent mean test scores.
Source: Authors' calculations from Growing Up in New Zealand dataset.

As background context for the ethnic-specific analyses, we also present box-and-whisker plots of the distribution of standardised test scores by mothers' ethnicity. See ***Appendix 5*** (Vocabulary), ***Appendix 6*** (Reading), and ***Appendix 7*** (Global Cognition). These show that vocabulary skills are highest among children of European mothers while reading skills and global cognitive skills are highest among children of Asian mothers.

Turning to our regression results for vocabulary skills, the simple linear regression results (Model 1 in ***Appendix 8***) indicate that only children of mothers with higher degrees have *significantly* higher vocabulary test scores (+0.39 standard deviations) than children of mothers with no qualifications. Thus, maternal education only significantly improves children's vocabulary if it is an advanced level of attainment; lower levels of attainment confer no significant advantage to children's vocabulary compared to having no qualifications.

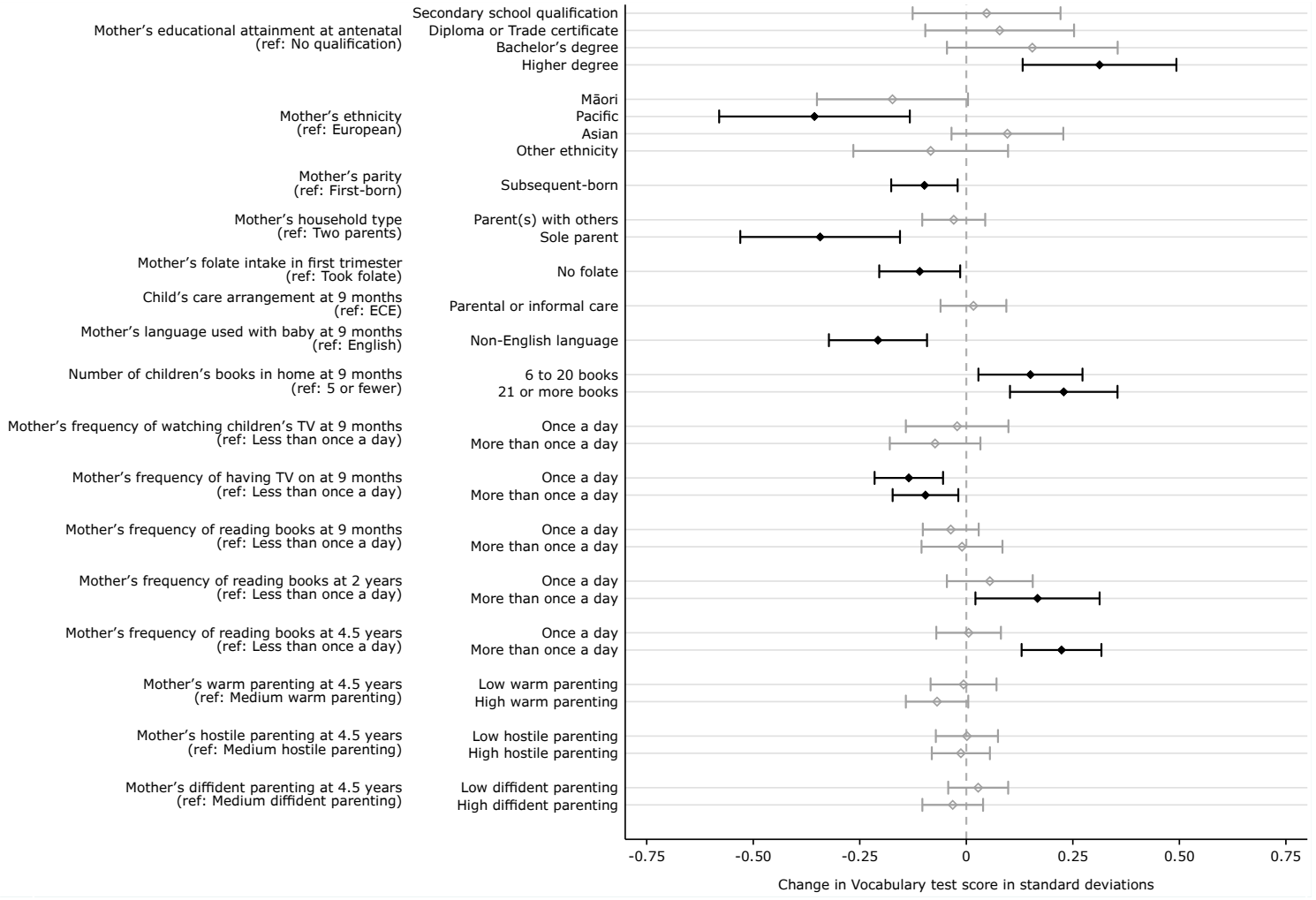
When potentially confounding variables are taken into account (Model 2 in ***Appendix 8***), the effect of a higher degree *increases* to 0.48 standard deviations, suggesting that mothers with higher degrees tend to have other characteristics that are associated with *decreases* in children's vocabulary, notably a higher proportion of Asian mothers who mainly speak languages other than English to their child (recalling that the vocabulary test is administered in English).

The results for Model 3, which includes all the potentially confounding and mediating variables, are displayed in Figure 5. Owing to the large number of explanatory variables, to improve readability Figure 5 does not show the constant, the inverse Mills ratio, and any non-significant potential confounders (that is, it displays the regression results for the main predictor of interest and all potential mediators – whether statistically significant or not – plus those potential confounders that reach statistical significance).

Figure 5 shows that having a mother with a higher degree is associated with an increase in vocabulary scores of 0.31 standard deviations compared to having a mother with no qualifications. Comparing these effects to those from Model 2 suggests the positive effect of having a mother with a higher degree on children's vocabulary is partly due to her parenting behaviours and investments in her child, notably, more children's books in her home, more frequent reading to her the child in the preschool years, and less frequent television use. We now discuss the role played by these mediators, and the confounding variables, on children's vocabulary skills.

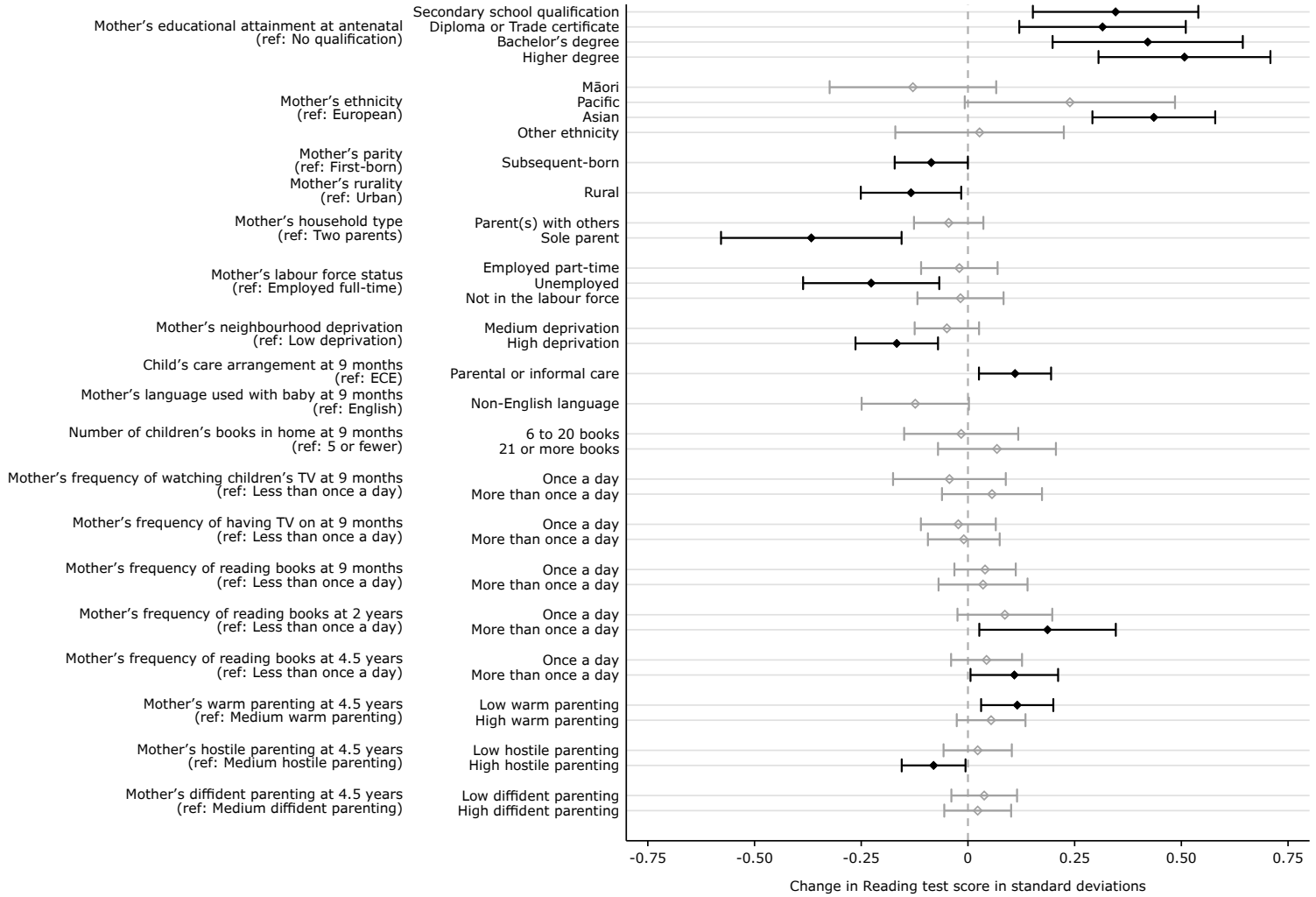
We find that vocabulary skills are significantly higher among children who had six to 20, and 21 or more, children's books in their home at 9 months (compared to having five or fewer books) and who have a mother who read to them more than once a day at ages 2 years and 4.5 years (compared to less than once a day).

Figure 5. *Plot of multiple linear regression results for Vocabulary skills among 8-year-old GUiNZ children*



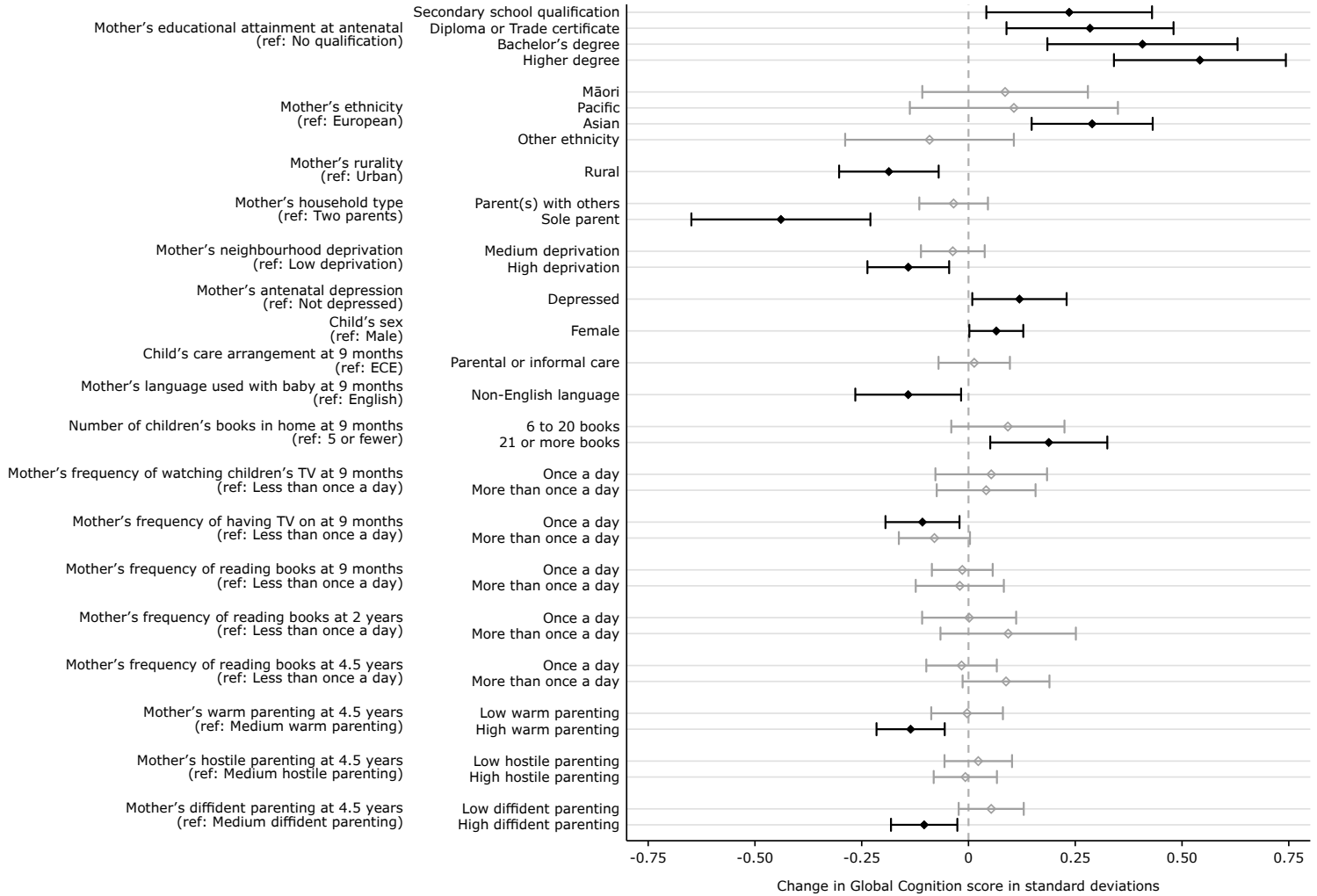
Notes: The plot displays the expected change in children's standardised vocabulary test score between the dummy variable listed in the column to the right compared to the reference category noted on the left (holding all other explanatory variables constant). Estimates in bold are statistically significant at the 5% level or better. For brevity, the plot does not show the constant, the inverse Mills ratio (the variable that corrects for attrition bias), and potential confounders that were statistically insignificant (these were mother's age, mother's native/migrant status, mother's rurality, mother's work and labour force status, mother's neighbourhood deprivation, mother's antenatal smoking, mother's antenatal alcohol consumption, mother's antenatal depression, mother's antenatal anxiety, child's sex, child's gestational age, and child's birth weight status). Sample size is n=4,080 and R^2=0.190.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 6. *Plot of multiple linear regression results for Reading skills among 8-year-old GUiNZ children*



Notes: The plot displays the expected change in children's standardised reading test score between the dummy variable listed in the column to the right compared to the reference category noted on the left (holding all other explanatory variables constant). Estimates in bold are statistically significant at the 5% level or better. For brevity, the plot does not show the constant, the inverse Mills ratio (the variable that corrects for attrition bias), and potential confounders that were statistically insignificant (these were mother's age, mother's native/migrant status, mother's antenatal smoking, mother's antenatal alcohol consumption, mother's folate intake in the first trimester, mother's antenatal depression, mother's antenatal anxiety, child's sex, child's gestational age, and child's birth weight status). Sample size is n=3,858 and R^2=0.084.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 7. *Plot of multiple linear regression results for Global Cognition skills among 8-year-old GUiNZ children*



Notes: The plot displays the expected change in children's standardised global cognition score between the dummy variable listed in the column to the right compared to the reference category noted on the left (holding all other explanatory variables constant). Estimates in bold are statistically significant at the 5% level or better. For brevity, the plot does not show the constant, the inverse Mills ratio (the variable that corrects for attrition bias), and potential confounders that were statistically insignificant (these were mother's age, mother's native/migrant status, mother's parity, mother's antenatal smoking, mother's antenatal alcohol consumption, mother's folate intake in the first trimester, mother's antenatal anxiety, child's gestational age, and child's birth weight status). Sample size is n=3,739 and R^2=0.118.
Source: Authors' calculations from Growing Up in New Zealand dataset.

On the other hand, vocabulary skills are significantly *lower* among children who are second- or subsequent-born (compared to first-born) with a mother of Māori or Pacific ethnicity (compared to European) who was a sole parent (compared to a two-parent household), did not take folate in the first trimester of pregnancy (compared to taking folate), mainly spoke a language other than English to the child at 9 months (compared to speaking English), and who had the television on once a day or more at 9 months (compared to less than once a day). The largest (absolute) effect sizes are for having a mother of Pacific ethnicity (-0.36 standard deviations), having a sole parent mother (-0.34 standard deviations), having a mother with a higher degree (+0.31 standard deviations), and having more than 20 books in the home (+0.23 standard deviations).

For reading skills, the simple linear regression results (Model 1 in ***Appendix 9***) indicate that children of mothers with all levels of qualifications have significantly higher reading test scores than children of mothers with no qualifications (ranging from +0.52 standard deviations from having a mother with a Diploma/Trade certificate to +0.88 standard deviations from having a mother with a higher degree). The higher the mother's education, the higher are children's reading skills on average, with the exception of mothers with a Diploma or Trade certificate whose children have lower reading scores than children of mothers with secondary school qualifications (but not significantly so).

When potentially confounding variables are taken into account (Model 2 in ***Appendix 9***), the effect of mother's education decreases across the board, suggesting that the positive effect of maternal education on children's reading skills is partly because mothers with qualifications tend to possess other characteristics that are also associated with better reading skills among children (notably, higher proportions of European and Asian mothers and lower proportions of sole parent and unemployed mothers living in high-deprivation neighbourhoods as maternal education increases).

The results for Model 3 are displayed in Figure 6 (again, non-significant confounders are not shown in the figure). Figure 6 shows that all levels of maternal education remain significantly associated with vocabulary scores compared to having a mother with no qualifications (ranging from +0.32 standard deviations from having a mother with a Diploma or Trade certificate to +0.51 standard deviations from having a mother with a higher degree). Comparing these effects to those from Model 2 suggests that the positive effect of mother's education on children's reading skills is partly due to several significant mediating variables, notably more frequent reading to children in the preschool years, more parental or other informal caregiving at age 9 months, and less frequent warm parenting. We now discuss the role played by these mediators, and the confounding variables, on children's reading skills.

We find that reading skills are significantly higher among children in parental or informal childcare at age 9 months (compared to early childhood education) who have mothers of Asian ethnicity (compared to European) that read to them more than once a day at ages 2 years and 4.5 years (compared to less than once a day) and scored relatively low on warm parenting at age 4.5 years (parenting

that is less frequently warm, affectionate, and responsive, compared to a medium score).

We find reading skills are significantly *lower* among children who are second- or subsequent-born (compared to first-born) with a mother who was unemployed (compared to full-time employed), a sole parent (compared to a two-parent household), living in a high deprivation neighbourhood (compared to a low-deprivation neighbourhood), living in a rural area (compared to an urban area), and scored relatively high on hostile parenting at age 4.5 years (parenting that is frequently verbally and physically hostile/punitive, compared to a medium score). The largest effect sizes are for having a mother with a higher degree (+0.51 standard deviations), having a mother of Asian ethnicity (+0.44 standard deviations), having a mother with a Bachelor's degree (+0.42 standard deviations), and living in a sole parent household (-0.37 standard deviations).

For global cognitive skills, the simple linear regression results (Model 1 in ***Appendix 10***) indicate that children of mothers with all levels of qualifications have significantly higher global cognition scores than children of mothers with no qualifications. Indeed, there is a gradient between the two: the higher the mother's education, the higher are children's global cognitive skills on average, ranging from +0.44 standard deviations from having a mother with a secondary school qualification up to +0.87 standard deviations from having a mother with a higher degree.

When potentially confounding variables are taken into account (Model 2 in ***Appendix 10***), the effect of mother's education decreases across the board, suggesting that the positive effect of maternal education on children's global cognitive skills is partly because mothers with qualifications tend to possess other characteristics that are also associated with higher overall cognitive skills among children (notably, a lower likelihood of being a sole parent, being unemployed, and living in a high-deprivation neighbourhood as maternal education increases).

The results for Model 3 are displayed in Figure 7, which shows that all levels of maternal educational attainment remain significantly associated with higher global cognition scores compared to having a mother with no qualifications (ranging from +0.24 standard deviations from having a mother with a secondary school qualification to +0.54 standard deviations from having a mother with a higher degree). Comparing these effects to those from Model 2 suggests that the positive effect of mother's education on children's cognitive skills is partly due to several significant mediating variables, notably more books in the home, less frequent television use, lower proportions of mothers who spoke languages other than English to their child, and lower proportions who are highly warm or highly diffident in their parenting. We now discuss these mediating channels and the effects of confounding variables.

We find that global cognitive skills are significantly higher among children of female sex (compared to males) with more than 20 books in the home (compared to five or fewer) and with mothers of Asian ethnicity (compared to European) who were antenatally depressed (compared to not depressed).

We find that children's global cognitive skills are significantly lower among children born to sole parent mothers (compared to mothers in a two-parent household) living in high deprivation neighbourhoods (compared to low-deprivation neighbourhoods) in rural areas (compared to urban areas) who spoke a language other than English to their child at 9 months (compared to speaking English), had the TV on once a day at 9 months (compared to less than once a day), and who are highly warm and highly diffident in their parenting (compared to medium levels).

The largest effect sizes are for having a mother with a higher degree (+0.54 standard deviations), having a sole parent mother (-0.44 standard deviations), having a mother with a Bachelor's degree (+0.41 standard deviations), and having a mother of Asian ethnicity (+0.29 standard deviations).

4.2.2 Ethnic-specific results

We repeated the linear regression analysis separately for children of Māori, Pacific, and Asian mothers. Tabulated regression results are presented in ***Appendix 11*** (Vocabulary), ***Appendix 12*** (Reading), and ***Appendix 13*** (Global Cognition). Due to the small sample sizes of each ethnicity, few results reach the level of statistical significance and thus the ethnic-specific results should be interpreted with caution.

Among children of Māori mothers, we find vocabulary and reading skills are not significantly related to mother's educational attainment in raw terms or adjusted for confounders and mediators. But global cognitive skills *are* significantly related to mother's educational attainment in raw terms, however once confounders are taken into account, only children of mothers with a secondary school qualification have significantly higher global cognitive skills than children of mothers with no qualifications (and this becomes non-significant in Model 3 when mediators are included).

For children of Māori mothers, we also find vocabulary skills are significantly lower among those born preterm; reading skills are significantly lower among those who are second- or subsequent-born; and reading skills are significantly *higher* among those whose mothers scored low or high in warm parenting compared to medium scores (a result that is difficult to interpret). No statistically significant confounding or mediating results are found in the Global Cognition analysis.

Among children of Pacific mothers, we find vocabulary, reading, and global cognitive skills are all significantly related to mother's educational attainment in raw terms, but once confounders are taken into account, only having a mother with a higher degree confers benefits to reading and global cognitive skills (effects which persist even in Model 3 when mediators are included).

For children of Pacific mothers, we also find vocabulary skills are significantly lower for those whose mothers were living in a high-deprivation neighbourhood; reading skills are significantly lower among those whose mother was not living in a two-parent household, smoked during pregnancy, and mainly spoke to her child in a non-English language at 9 months; reading skills are significantly

higher among females and those with highly warm mothers; global cognitive skills are significantly lower among those born at low birth weight to a sole parent who smoked during pregnancy and mainly spoke to her child in a non-English language at 9 months; and global cognitive skills are significantly higher among children of mothers with a higher degree.

Among children of Asian mothers, we find reading and global cognitive skills are not significantly related to mother's educational attainment in raw terms. Having a mother with a higher degree *is* associated with significantly better vocabulary skills in raw terms, but this becomes non-significant once confounders are taken into account.

For children of Asian mothers, we also find that vocabulary skills are significantly lower among those whose mothers had the TV on once a day at age 9 months (compared to less than once a day); reading skills are significantly lower among those born to mothers living in a high-deprivation neighbourhood; reading skills are significantly higher among those whose mothers were employed part-time (compared to full-time); global cognitive skills are significantly lower among those born to mothers living in a high-deprivation neighbourhood and who had the TV on once a day at 9 months; and global cognitive skills are significantly higher among those who had more than 20 books in the home (compared to five or fewer).

4.2.3 Sensitivity analysis results

When father's educational attainment at antenatal is incorporated into the analyses, we find that it is significantly positively associated with children's vocabulary, reading, and global cognitive skills, over and above the influence of mother's education and controlling for all confounding (Model 2) and confounding plus mediating variables (Model 3). We also find that the effects of mother's education on children's cognitive skills decrease across all levels of maternal education, suggesting that, in the main analyses, the mother's education variable was also capturing the effects of father's education (indeed there is a positive correlation of about 0.40 between mothers' and fathers' educational attainment).

When controlling for potential confounders only (Model 2), compared to children of fathers with no qualifications, children of fathers with qualifications have vocabulary skills that are between +0.18 and +0.34 standard deviations higher, reading skills that are between +0.17 and +0.43 standard deviations higher, and global cognitive skills that are between +0.24 and +0.56 standard deviations higher. When potential mediators (of mother's education) are also held constant (Model 3), these effects decrease but remain statistically significant (except for father's pre-degree qualifications in relation to children's vocabulary skills). For example, compared to children of fathers with no qualifications, children of fathers with a Bachelor's degree have vocabulary, reading, and global cognitive skills that are +0.23, +0.35, +0.42 standard deviations higher, respectively, while children of fathers with a higher degree have vocabulary, reading, and global cognitive skills that are +0.25, +0.37, and +0.48 standard deviations

higher, respectively. Tabulated regression results are presented in ***Appendix 14*** (Vocabulary), ***Appendix 15*** (Reading), and ***Appendix 16*** (Global Cognition).

Father's education tends to have effect sizes that are somewhat smaller than mother's education (based on Model 2, which is the appropriate model for making such as comparison), except for children's vocabulary skills where fathers of all education levels have significant effects, while only mothers with a higher degree have a significant effect (which is larger in size than fathers with a higher degree).

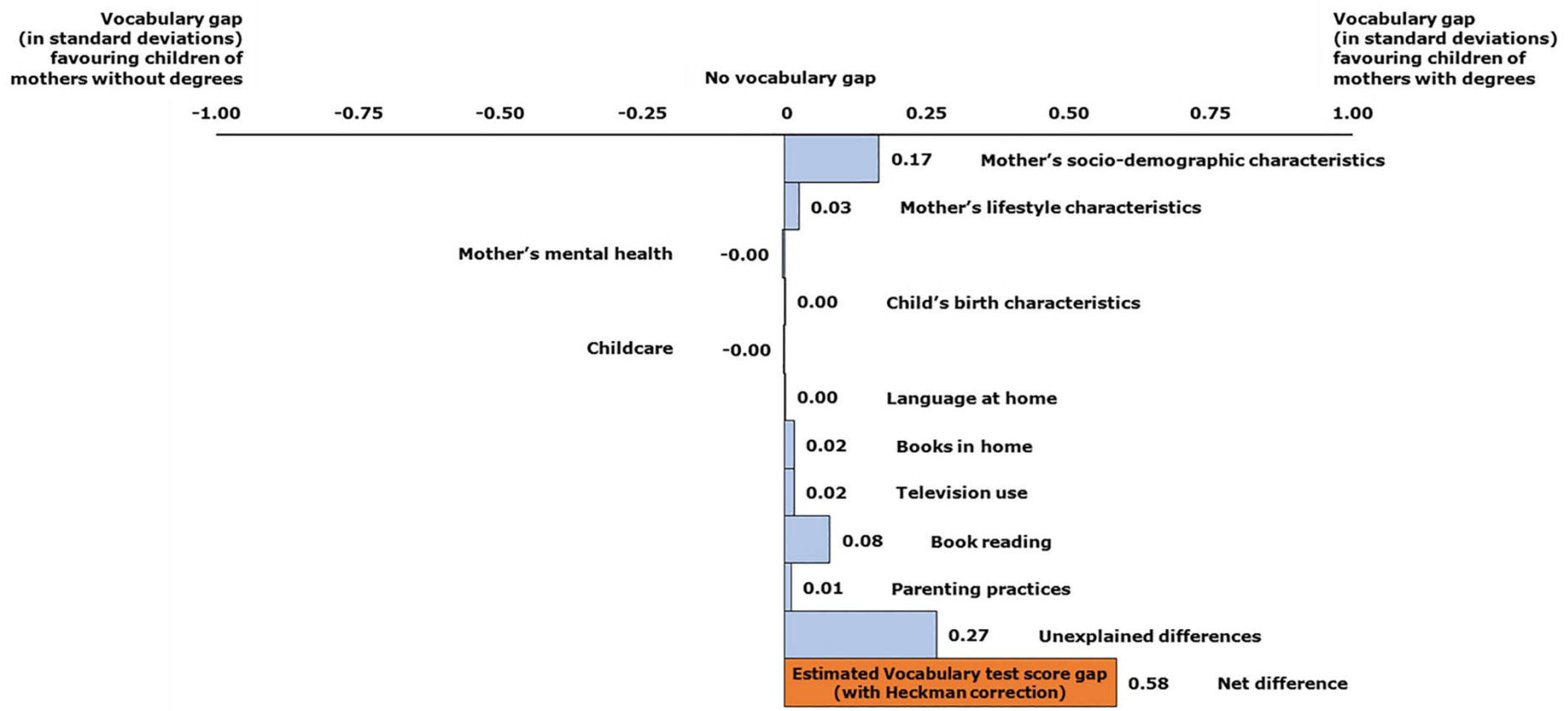
The inclusion of father's education has the effect of nullifying previously-significant results and rendering other variables statistically significant that were not so before. Changes between the results of the main and sensitivity analyses are difficult to interpret given the change in sample composition between the two. The subset of mothers with partners who participated in the antenatal data collection wave are likely to systematically differ in their characteristics from those of the wider set of mothers included in the main analyses in ways that matter to children's cognitive development (for example, as previously noted and as expected, there are considerably fewer sole-parent mothers among the partnered subset).

With this caveat in mind, we nevertheless note that even with the addition of father's education, the positive impacts on children's vocabulary skills of mother's education, number of books in the home, and mother's frequent reading to children at ages 2 and 4.5 years, and the negative impact of frequent television use at 9 months, all remain significant. Likewise, the positive impacts on children's reading skills of mother's education, frequent reading to children at age 4.5, and infrequent warm parenting, and the negative impact of highly hostile parenting, all remain significant. And the positive impacts on children's global cognitive skills of having a mother with a degree and having many books in the home, and the negative impacts of frequent television use at 9 months and highly diffident parenting, all remain significant.

4.3. Results for Aim 2 (understanding drivers of inequalities in human capital)

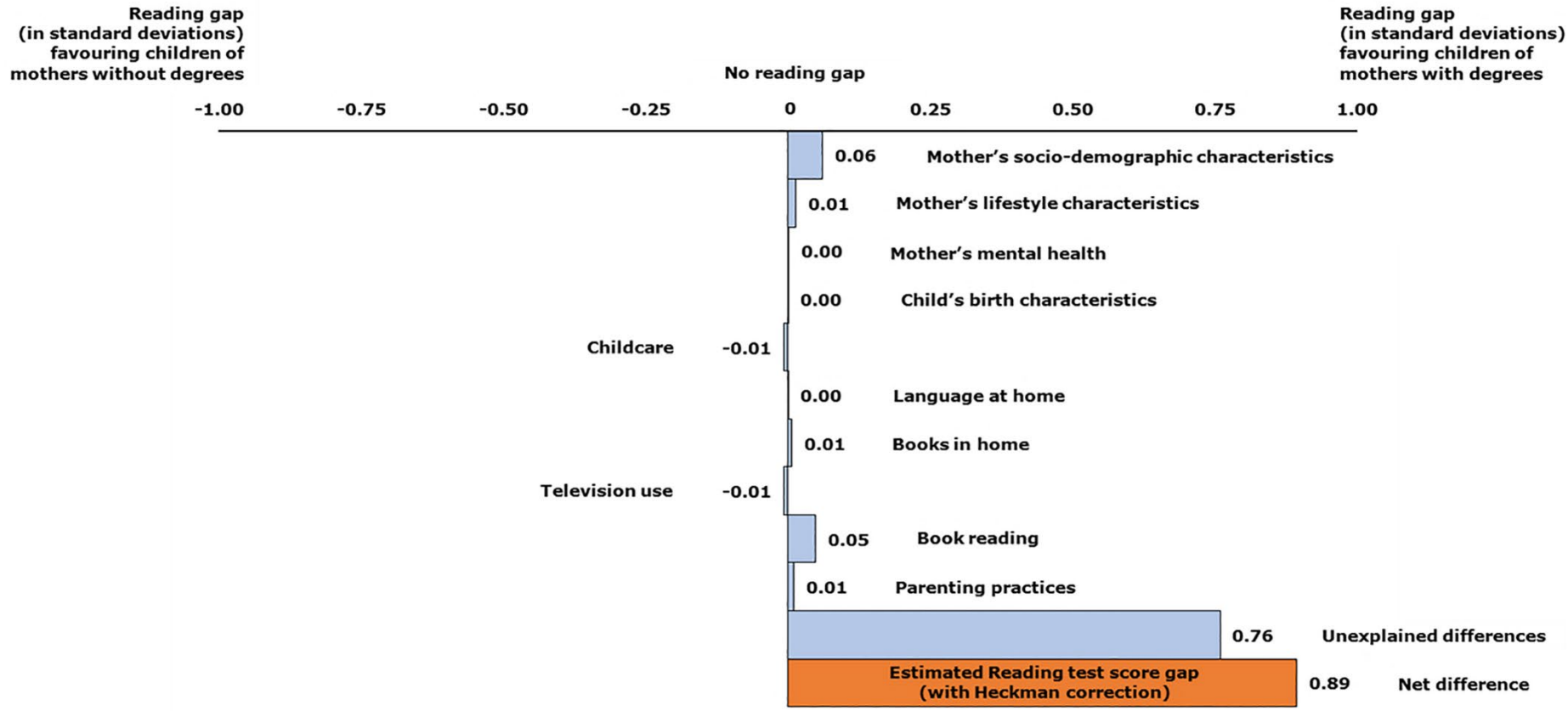
We now turn to the results from our Aim 2 analysis of the gap in cognitive skills between children of mothers with degree qualifications and those without degrees. Contrasting the characteristics of these mothers and children may shed light on which factors contribute the most to cognitive inequalities. After correcting for bias arising from differential attrition, we find the gap in mean cognitive test scores between children of mothers with and without degrees is 0.58 standard deviations for vocabulary skills, 0.89 standard deviations for reading skills, and 0.86 standard deviations for global cognitive skills. What accounts for these gaps? Figures 8, 9, and 10 depict the results from our Kitagawa-Blinder-Oaxaca decompositions of the gap in mean test scores for Vocabulary, Reading, and Global Cognition, respectively. The full decomposition results are presented in ***Appendix 17***.

Figure 8. *Chart of Kitagawa-Blinder-Oaxaca decomposition of gap in Vocabulary test scores between 8-year-old GUiNZ children of mothers with and without degree qualifications*



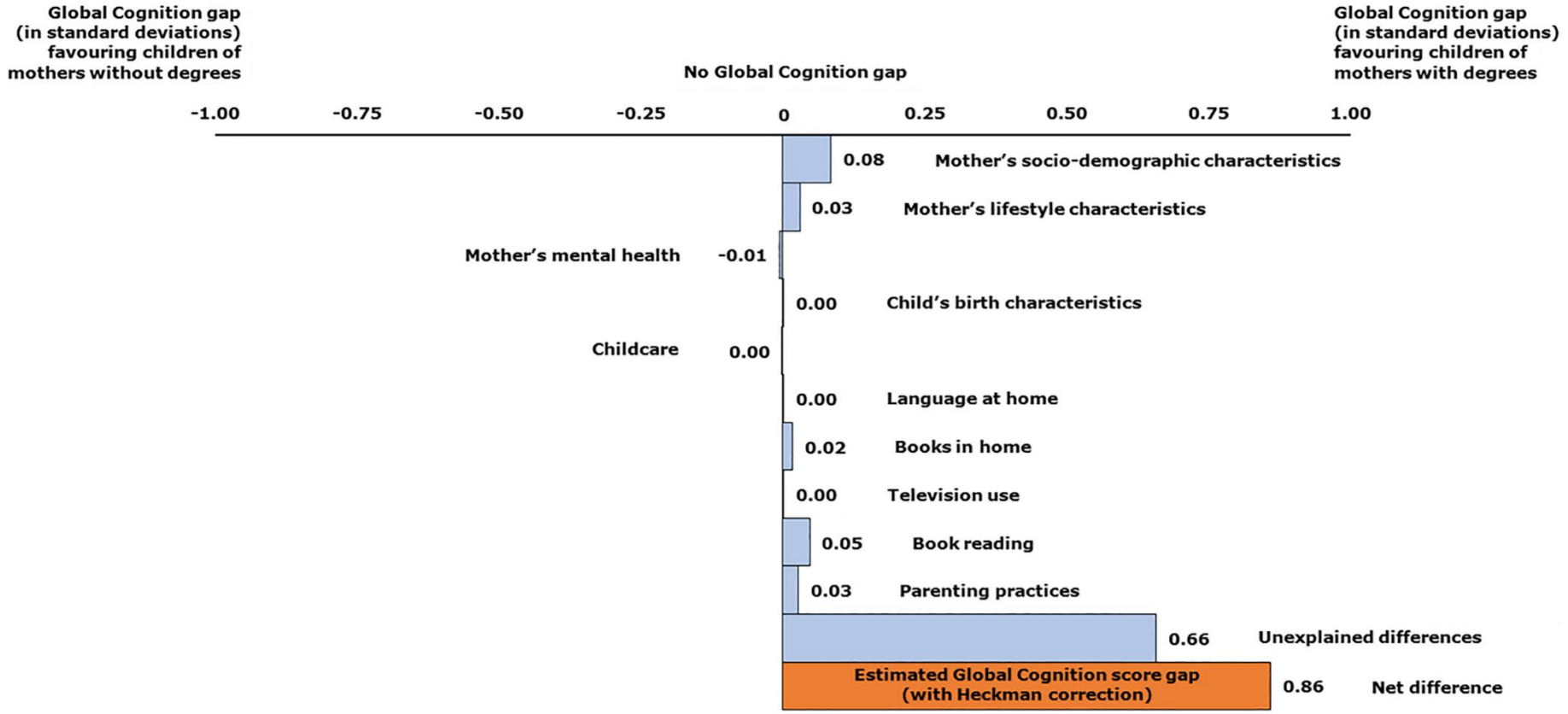
Notes: The chart displays a decomposition of the gap in standardised Vocabulary test score between children of mothers with a degree and children of mothers without a degree, adjusted for selection bias from differential attrition from the GUiNZ cohort (a 'Heckman correction'). The gap (represented by the orange bar at the bottom) is decomposed into the various sets of explanatory variables represented by the blue bars. All bars are measured in standard deviations from the mean test score. Bars on the positive side of the axis represent differences in maternal and child characteristics that generate a vocabulary gap favouring children of degree-qualified mothers. Bars on the negative side of the axis represent differences that generate a gap favouring children of below-degree-qualified mothers.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 9. *Chart of Kitagawa-Blinder-Oaxaca decomposition of gap in Reading test scores between 8-year-old GUiNZ children of mothers with and without degree qualifications*



Notes: The chart displays a decomposition of the gap in standardised Reading test score between children of mothers with a degree and children of mothers without a degree, adjusted for selection bias from differential attrition from the GUiNZ cohort (a 'Heckman correction'). The gap (represented by the orange bar at the bottom) is decomposed into the various sets of explanatory variables represented by the blue bars. All bars are measured in standard deviations from the mean test score. Bars on the positive side of the axis represent differences in maternal and child characteristics that generate a reading gap favouring children of degree-qualified mothers. Bars on the negative side of the axis represent differences that generate a gap favouring children of below-degree-qualified mothers.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 10. *Chart of Kitagawa-Blinder-Oaxaca decomposition of gap in Global Cognition scores between 8-year-old GUiNZ children of mothers with and without degree qualifications*



Notes: The chart displays a decomposition of the gap in standardised Global Cognition score between children of mothers with a degree and children of mothers without a degree, adjusted for selection bias from differential attrition from the GUiNZ cohort (a 'Heckman correction'). The gap (represented by the orange bar at the bottom) is decomposed into the various sets of explanatory variables represented by the blue bars. All bars are measured in standard deviations from the mean test score. Bars on the positive side of the axis represent differences in maternal and child characteristics that generate a global cognitive gap favouring children of degree-qualified mothers. Bars on the negative side of the axis represent differences that generate a gap favouring children of below-degree-qualified mothers.
Source: Authors' calculations from Growing Up in New Zealand dataset.

For the gap in Vocabulary test scores, we find that differences in the socio-demographic characteristics of mothers with and without degrees makes the largest explanatory contribution to the vocabulary gap among their children (0.17 standard deviations of the 0.58 standard deviation gap, which is 29% of the gap), mostly due to higher proportions of Pacific, Māori, and sole parent mothers who lived in high-deprivation neighbourhoods being in the lower-educated group of mothers. Differences in how often mothers read books to their children account for 14% of the vocabulary gap. Differences in mothers' lifestyle behaviours, books in the home, television use, and parenting practices make small contributions to the vocabulary gap (between 2% and 5% each).

Differences in mothers' mental health, children's birth characteristics, childcare arrangements, and mothers' language used at home account for almost none of the gap. This leaves 46% of the vocabulary gap unexplained by the variables included in the decomposition.

For the gap in Reading test scores, we find that differences in mothers' socio-demographic characteristics make the largest explanatory contribution to the reading gap among their children (0.06 standard deviations of the 0.89 standard deviation gap, which is 7% of the gap), mostly due to higher proportions of Māori, sole parent, and unemployed mothers who lived in high-deprivation neighbourhoods being in the lower-educated group. Differences in how often mothers read books to their children account for 6% of the reading gap. All other differences make trivial or zero contributions to the reading gap (they are also statistically insignificant except for childcare), leaving the vast majority (85%) of the reading gap unexplained by the variables included in the decomposition.

For the gap in Global Cognition scores, we find once again that differences in mothers' socio-demographic characteristics make the largest explanatory contribution to the global cognition gap (0.08 standard deviations of the 0.86 standard deviation gap, which is 10% of the gap), mostly due to higher proportions of sole parent mothers who lived in high-deprivation neighbourhoods being in the lower-educated group and higher proportions of Asian and European mothers who lived in low-deprivation neighbourhoods being in the higher-educated group.[8] Differences in how often mothers read books to their children account for 6% of the global cognition gap. Differences in mothers' lifestyle behaviours, books in the home, and parenting practices make small contributions to the global cognition gap (between 2% and 3%). Differences in mothers' mental health, children's birth characteristics, childcare arrangements, mothers' language used at home, and mothers' television use account for none of the gap, leaving 77% of the global cognition gap unexplained by the variables included in the decomposition.

[8] Similarly, Bird et al. (2024, p. 264), who use GUiNZ data to test whether maternal socio-demographic characteristics, child socio-demographic characteristics, and maternal parenting behaviours predict four early learning outcomes at age 4.5 years (composite measures of literacy and numeracy skills, oral language and self-regulation skills, behavioural difficulties, and interpersonal and motor skills), find that maternal socio-demographic characteristics account for the largest proportion of variance in early learning outcomes, which "may reflect socio-economic and ethnic inequalities in early learning outcomes".

In summary, cognitive gaps are mostly unexplained by the variables included in our analysis (especially so for the reading and global cognition gaps) which may be because other important inputs to children's cognitive skills – such as the role of fathers, grandparents, schools, and genetic factors – are not captured in our analysis. To the extent the gaps are explained, mothers' ethnicity, household type (notably, sole parenthood), neighbourhood deprivation, and book reading stand out as key drivers of cognitive inequalities between children of higher-educated and lower-educated mothers.

4.4. Results for Aim 3 (understanding drivers of breaking the intergenerational mould in human capital)

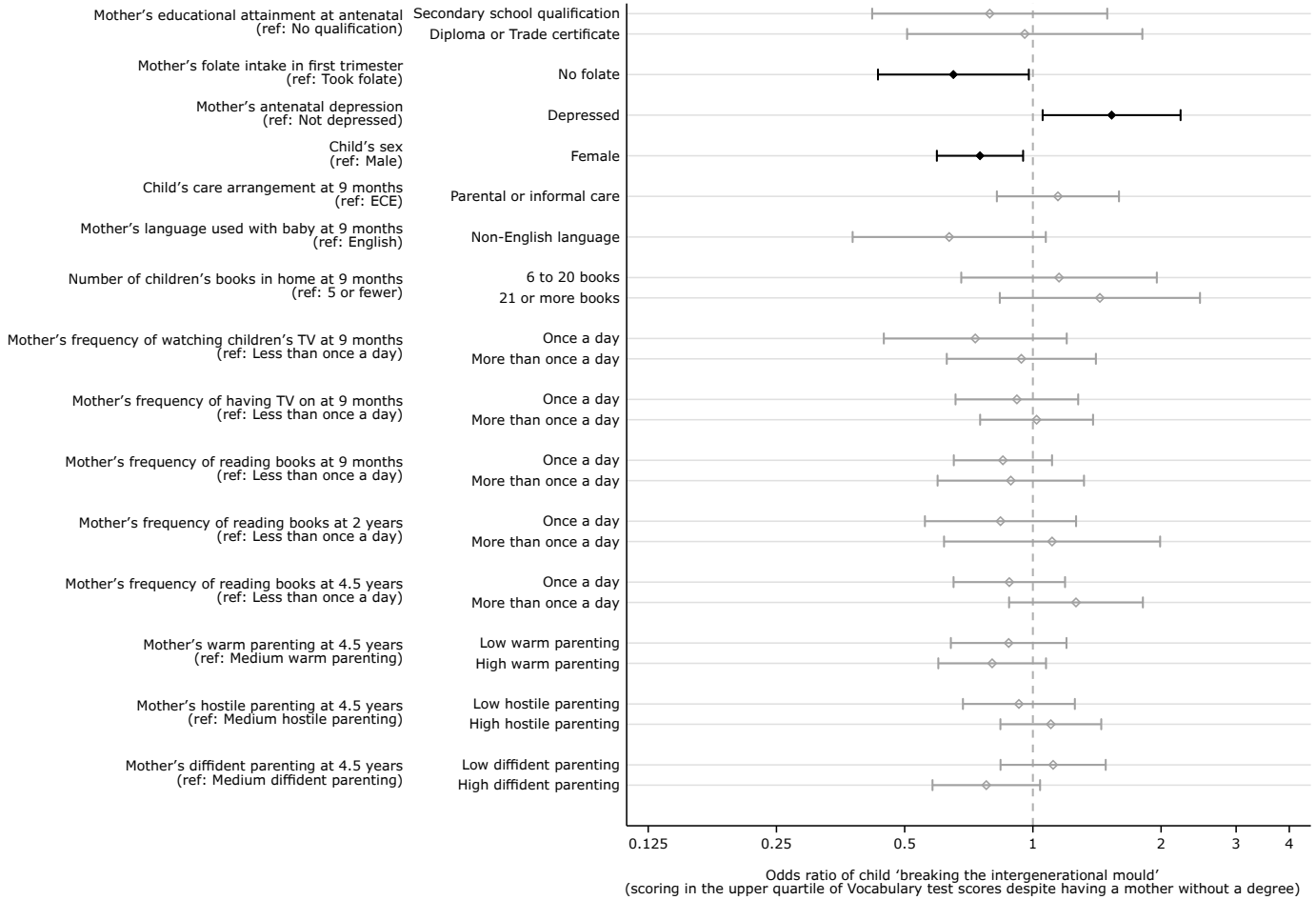
4.4.1 Main results

Turning to the Aim 3 analysis of 'breaking the intergenerational mould' in human capital, Figures 11, 12, and 13 present the results of the binary logistic regressions which estimate the odds of children of mothers without degrees scoring in the upper quartile (top 25% of the full sample) of vocabulary skills, reading skills, and global cognitive skills, respectively, given all the explanatory variables (that is, Model 3 results). The results are reported as odds ratios (ORs) – the odds of breaking the mould given some characteristic (e.g., mother drank alcohol in pregnancy, mother is Asian) compared to the odds of breaking the mould in the absence of that characteristic (e.g., mother did not drink alcohol during pregnancy) or compared to the reference characteristic (e.g., mother is European). Note that in Figures 11, 12, and 13, the x-axis is on a logarithmic scale and non-significant confounders are not shown. See ***Appendix 18*** for the full regression results for both Model 2 (potential confounders only) and Model 3 (potential confounders and potential mediators).

For vocabulary skills (Figure 11), we find that having a mother who was antenatally depressed significantly *increases* children's odds of breaking the mould (OR=1.53) compared to having a mother who was not depressed. We also find that the chances of breaking the mould in vocabulary skills are significantly lower among female children (OR=0.75) and children of mothers who did not take folate (OR=0.65). Because these latter variables have only two categories, we can say that the chances of breaking the intergenerational mould in vocabulary skills are *higher* among boys and children of mothers who took folate.

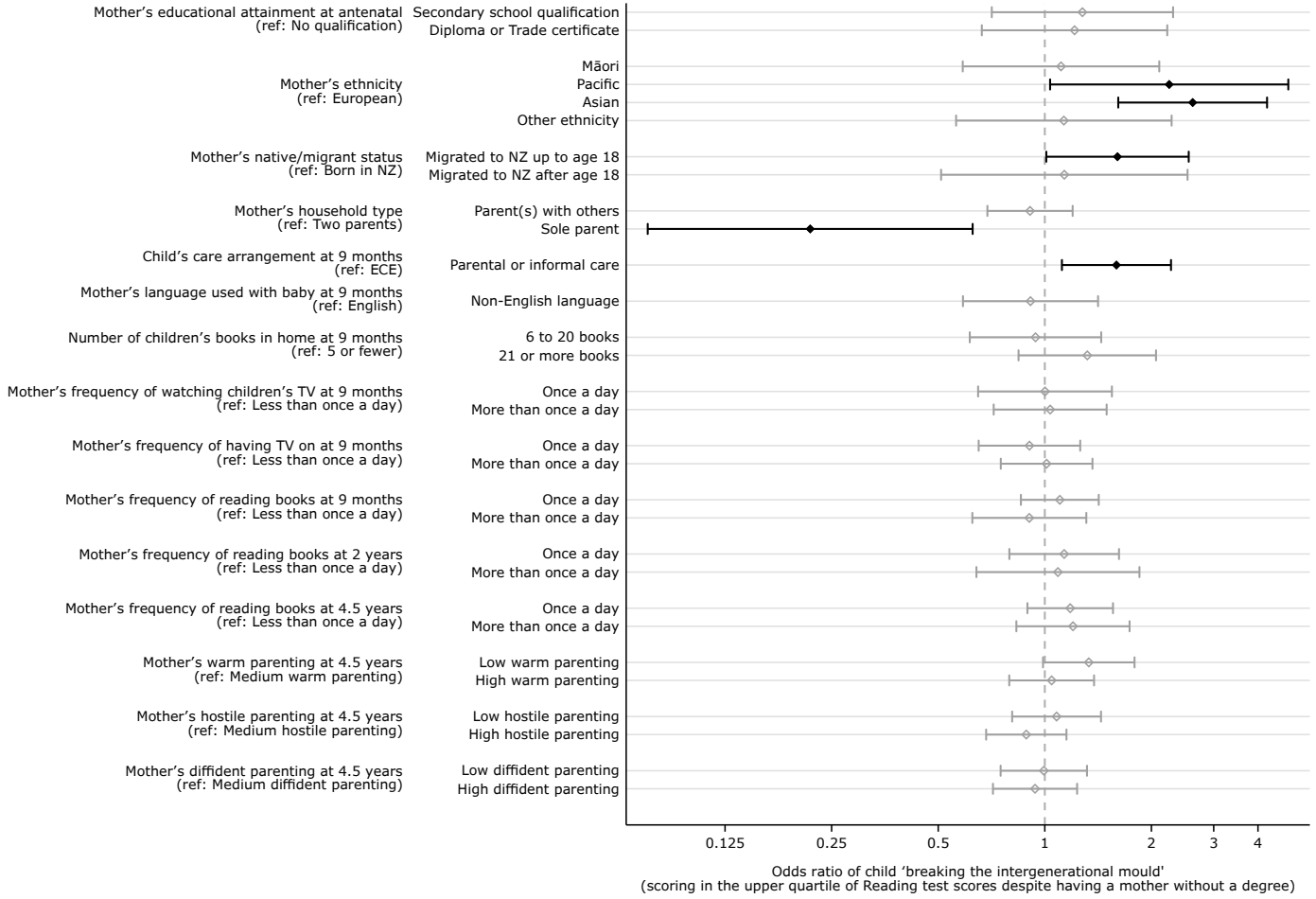
For reading skills (Figure 12), we find that the odds of breaking the mould are significantly higher among children of Pacific mothers (OR=2.25) and Asian mothers (OR=2.62) compared to children of European mothers, children of mothers who migrated to New Zealand up to the age of 18 years (OR=1.60) compared to children of New Zealand-born mothers, and children who were primarily in parental or informal care at age 9 months (OR=1.59) compared to children who were in early childhood education. The odds of breaking the mould in reading skills were significantly lower among children born to sole parent mothers (OR=0.22) compared to children born into a two-parent household.

Figure 11. *Plot of binary logistic regression results for 'breaking the intergenerational mould' in vocabulary skills among 8-year-old GUiNZ children*



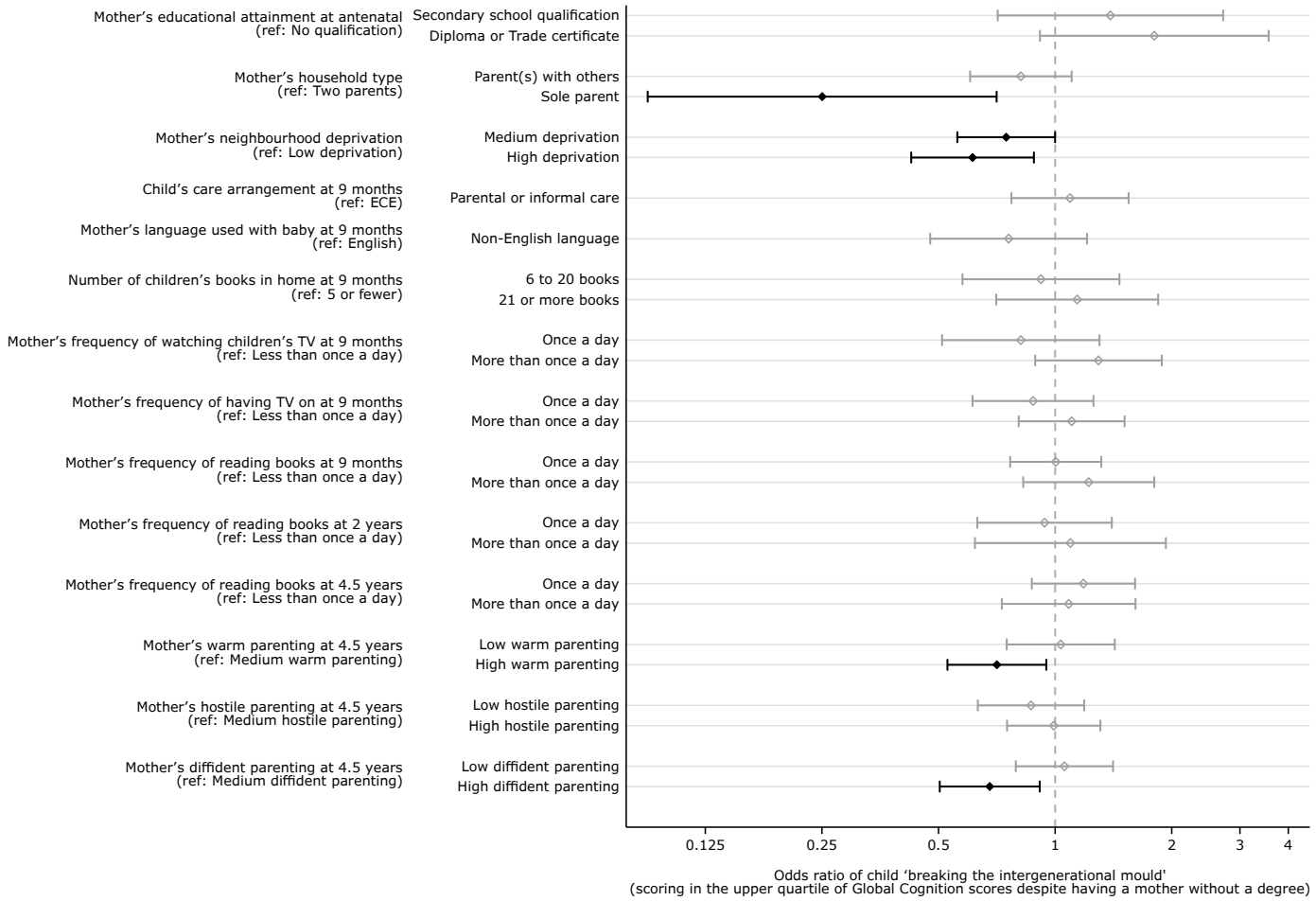
Notes: The plot displays the ratio of the odds of 'breaking the intergenerational mould' (scoring in the upper quartile of the full sample despite having a mother without a degree) for a child who has the characteristic listed in the column to the right compared to the odds of breaking the mould for a child who is in the reference category noted on the left (holding all other explanatory variables constant). The x-axis is on a logarithmic scale. Estimates in bold are statistically significant at the 5% level or better. For brevity, the plot does not show the constant, the inverse Mills ratio (the variable that corrects for attrition bias), and potential confounders that were statistically insignificant (these were mother's age, mother's ethnicity, mother's native/migrant status, mother's parity, mother's rurality, mother's household type, mother's work and labour force status, mother's neighbourhood deprivation, mother's antenatal smoking, mother's antenatal alcohol consumption, mother's antenatal anxiety, child's gestational age, and child's birth weight status). Sample size is n=2,241 and pseudo R^2=0.089.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Figure 12. *Plot of binary logistic regression results for 'breaking the intergenerational mould' in reading skills among 8-year-old GUiNZ children*



Notes: The plot displays the ratio of the odds of 'breaking the intergenerational mould' (scoring in the upper quartile of the full sample despite having a mother without a degree) for a child who has the characteristic listed in the column to the right compared to the odds of breaking the mould for a child who is in the reference category noted on the left (holding all other explanatory variables constant). The x-axis is on a logarithmic scale. Estimates in bold are statistically significant at the 5% level or better. For brevity, the plot does not show the constant, the inverse Mills ratio (the variable that corrects for attrition bias), and potential confounders that were statistically insignificant (these were mother's age, mother's parity, mother's rurality, mother's work and labour force status, mother's neighbourhood deprivation, mother's antenatal smoking, mother's antenatal alcohol consumption, mother's folate intake in the first trimester, mother's antenatal depression, mother's antenatal anxiety, child's sex, child's gestational age, and child's birth weight status). Sample size is n=2,109 and pseudo R^2=0.042.
Source: Authors' calculations from Growing Up in New Zealand data

Figure 13. *Plot of binary logistic regression results for 'breaking the intergenerational mould' in global cognitive skills among 8-year-old GUiNZ children*



Notes: The plot displays the ratio of the odds of 'breaking the intergenerational mould' (scoring in the upper quartile of the full sample despite having a mother without a degree) for a child who has the characteristic listed in the column to the right compared to the odds of breaking the mould for a child who is in the reference category noted on the left (holding all other explanatory variables constant). The x-axis is on a logarithmic scale. Estimates in bold are statistically significant at the 5% level or better. For brevity, the plot does not show the constant, the inverse Mills ratio (the variable that corrects for attrition bias), and potential confounders that were statistically insignificant (these were mother's age, mother's ethnicity, mother's native/migrant status, mother's parity, mother's rurality, mother's work and labour force status, mother's antenatal smoking, mother's antenatal alcohol consumption, mother's folate intake in the first trimester, mother's antenatal depression, mother's antenatal anxiety, child's sex, child's gestational age, and child's birth weight status). Sample size is n=2,033 and R^2=0.048.
Source: Authors' calculations from Growing Up in New Zealand dataset.

For global cognitive skills (Figure 13), we find that the odds of breaking the mould are significantly lower among children born to sole parent mothers (OR=0.25) who were living in medium deprivation (OR=0.75) or high deprivation (OR=0.61) neighbourhoods compared to low deprivation neighbourhoods, and who are highly warm (OR=0.71) and highly diffident (OR=0.68) in their parenting compared to medium levels.

4.4.2 Sensitivity analysis results

When father's educational attainment at antenatal is incorporated into the Aim 3 analyses, we find it promotes breaking the mould in human capital with respect to children's vocabulary and global cognitive skills, but not their reading skills. Mother's own educational attainment up to Diploma or Trade certificate remains not significantly related to children's chances of breaking the mould. Thus, mothers without degrees increase the chances of their children developing strong vocabulary and global cognitive skills if they partner with someone who has qualifications (results show all levels of paternal educational attainment promote breaking the mould compared to fathers with no qualifications, with the exception of fathers having a Diploma/Trade certificate which does not significantly promote strong vocabulary skills). A full tabulation of the binary logistic regression results with father's education included are presented in ***Appendix 19***.

As for the Aim 2 sensitivity analyses, the inclusion of father's educational attainment leads to some changes in which particular variables are significantly associated with breaking the mould, but such changes may be driven by differences in sample composition. With this caution in mind, we nevertheless note that even with the addition of father's education, the positive impact of having a mother who took folate on children's chances of breaking the mould in vocabulary skills (scoring highly in vocabulary despite having a lower-educated mother) remains significant. Likewise, the positive impact of being in parental or other informal care at 9 months on children's chances of breaking the mould in reading skills (scoring highly in reading despite having a lower-educated mother) remains significant.

In summary, children are more likely to break the intergenerational transmission of relative disadvantage in human capital if they are a boy, if their mother is of Asian ethnicity (or Māori ethnicity for global cognition), if their mother immigrated to New Zealand as a child, if their mother took folic acid in pregnancy, if their father has educational qualifications of any kind, and if at age 9 months they were primarily being cared for by their parent (or grandparent or other informal arrangement). Being born to a sole parent mother living in a high-deprivation neighbourhood act as brakes on children's chances of breaking the mould. Low levels of warm parenting appear to help children break the mould in reading skills, while highly warm or highly diffident parenting hinder children's chances of breaking the mould in overall cognition.

4.5. Summary of research findings

Taking all our results across all three research aims together, some common patterns emerge based on factors that are repeatedly linked to cognitive outcomes. We summarise our key findings below based on these patterns.

Parental education matters a lot to children's cognitive outcomes:

- Mothers' education is strongly related to children's cognitive skills at age 8 years (although only a higher degree confers advantages to children's vocabulary skills). Having a mother with a higher degree is particularly beneficial to Pacific children's cognitive skills.

- Fathers' education is also strongly related to children's cognitive skills, even when mothers' education is taken into account (although, as with mothers, only a Bachelor's or higher degree confer advantages to children's vocabulary skills). Fathers' education is linked to children breaking the intergenerational mould in vocabulary and global cognitive skills (having strong skills despite a lower-educated mother) but not reading skills.

Maternal education is associated with other socio-demographic characteristics (ethnicity, sole parenthood, neighbourhood deprivation) and these also influence children's cognitive skills:

- Children of Asian mothers have the highest reading and global cognitive test scores of the five main ethnic groups and have greater chances of breaking the mould in reading skills (strong reading skills despite a lower-educated mother) than children of European mothers. A greater proportion of Asians among higher-educated mothers compared to lower-educated mothers account for some of the cognitive inequalities between their children.

- Given their socio-economic disadvantages including lower levels of paternal education, children of Pacific mothers perform remarkably well in reading (second-highest scores behind children of Asian mothers) and have greater chances of breaking the mould in reading skills than children of European mothers. However, they have the lowest vocabulary and global cognitive skills of all ethnic groups (impaired even further if they were born to a mother living in a highly deprived neighbourhood) and differences in the proportions of Pacific mothers between higher-educated and lower-educated mothers account for some of the gap in vocabulary skills between their children.

- The vocabulary and reading skills of children of Māori mothers are lower than those of children of European mothers, but not significantly so once mediating variables are controlled for (notably parent-child reading and books in the home). This suggests Māori disparities in these cognitive outcomes can be reduced with policy initiatives focused on literacy

activities in the home that are culturally appropriate for Māori parents (both current and future parents).

- Children born to sole parent mothers have poorer outcomes across all three cognitive skills (especially children of Pacific sole parents) and lower chances of breaking the mould in human capital compared to children of mothers in two-parent households. Differences in the proportions of sole parents between higher-educated and lower-educated mothers play a role in generating cognitive inequalities between their children.

- Children born to mothers living in highly socio-economically deprived neighbourhoods have poorer reading and global cognitive skills (especially so for children of Asian mothers) and lower chances of breaking the mould in global cognition than children born to mothers living in low-deprivation neighbourhoods. Differences in neighbourhood deprivation between higher-educated and lower-educated mothers play a role in generating cognitive inequalities between their children. These results are likely to be driven in part by differences in average family income between neighbourhoods of different deprivation levels.

The more educated a mother is, the more likely she is to take folic acid supplements during pregnancy, which is linked to better vocabulary skills among children:

- Children of mothers who did not take folate/folic acid during pregnancy have poorer vocabulary skills and lower chances of breaking the mould in vocabulary than children of mothers who did take folate.

More educated mothers have more books in the home which is linked to better cognitive skills among their children:

- Children with many books in the home have better vocabulary and global cognitive skills than children with few books in the home. Differences in the number of books in the home between higher-educated and lower-educated mothers play a small role in generating inequalities in vocabulary and global cognitive skills between their children.

More educated mothers read more frequently to their children which enhances their children's cognitive skills:

- Children whose mothers frequently read to them in the preschool years (especially at age 4.5) have better vocabulary and reading skills than children whose mothers seldom read to them. Differences in the frequency of reading to children between higher-educated and lower-educated mothers play a role in generating cognitive inequalities between their children.

Less educated mothers use television more frequently which undermines their children's cognitive skills:

- Children whose mothers frequently had the television on when they were infants have worse vocabulary and global cognition skills (especially so for children of Asian mothers).

Maternal education is related to parenting practices which influence children's cognitive skills:

- Children of mothers who scored relatively low in warm parenting (less frequently warm, affectionate, and responsive by comparison with other parents) have better reading skills (especially among children of Māori mothers) and greater chances of breaking the mould in reading skills than children of mothers with a medium level of warm parenting. Degree-qualified mothers are more likely to fall into the 'low' warm parenting category compared to mothers without a degree.

- Children of mothers who score highly on warm parenting (frequently warm, affectionate, and responsive) have worse global cognitive skills[9] and lower chances of breaking the mould in global cognition than children of mothers with a medium level of warm parenting.

- Children of mothers who score highly on hostile parenting (frequently verbally and physically hostile/punitive) have worse reading skills than children of mothers with a medium level of hostile parenting. The more educated a mother is, the less likely she is to engage in hostile parenting.

- Children of mothers who score highly on diffident parenting (frequently unconfident, inconsistent, and lacking in disciplinary follow-through) have worse global cognitive skills and lower chances of breaking the mould in global cognition than children of mothers with a medium level of diffident parenting. The more educated a mother is, the less likely she is to engage in diffident parenting.

[9] The opposite applies among children of Māori and Pacific mothers with respect to their reading skills; having a mother who is highly warm significantly *enhances* reading skills. Note that among children of Māori mothers, both low and high warm parenting enhance reading skills compared to a medium level of warm parenting.

5. Policy implications

Our findings have a number of implications for public policy related to child development and family wellbeing. They suggest where policy should be focused to reduce disparities in cognitive outcomes, weaken intergenerational transmission of disadvantage, and enhance social mobility and equality of opportunity. Broadly, policy should focus on prevention and early intervention aimed at pregnant women and their partners, couples considering having children, and future parents in their youth before they start forming families. For example, the findings from this study could be incorporated into educational programmes delivered as part of maternity services and/or pregnancy and parenting education ('antenatal') classes. We outline our specific policy recommendations below.

Policy should encourage frequent reading to children and the value of books

Frequent reading to children during the preschool years enhances both their vocabulary and reading skills and plays a role in driving cognitive inequalities by maternal education level. The importance of reading to children from an early age to their cognitive development should be promoted in educational programmes and services aimed at parents and expectant parents (including antenatal classes and the Ministry of Education's Early Intervention Service and Incredible Years programme) via resources (such as the Ministry of Education's *Much More than Words* booklet), promotional campaigns, and on digital platforms such as parenting apps and websites popular with parents. In addition, guidelines should be developed by the Ministry of Health containing evidence-based recommendations for parent-child book reading as part of optimal child development, as is done for children's screen time, physical activity, and food and nutrition.

Which parents should such educational resources and campaigns be aimed at? Analysis of the 4.5-year GUiNZ data found that children are read to more frequently if their mother is of European ethnicity, lives in an affluent neighbourhood, and has a managerial or professional occupation (Thomas et al., 2019a; 2019b). Thus, policy support should be directed at Māori and Pacific parents and caregivers living in socio-economically disadvantaged areas.

The importance of reading to preschool children is also relevant to the early childhood education sector and its curriculum. Early childhood teachers should be given guidance and support on how to identify children with emergent literacy skills that are delayed or impaired and on how best to intervene to support children's cognitive development including how to tailor or differentiate support depending on the child's current level of literacy skills and competencies (see McLachlan & Arrow, 2015).

Policy aimed at current and future parents should emphasise the value of books to children's cognitive development and make access to books easy. This could include the resourcing and promotion of libraries as recreational destinations attractive to all families and beneficial to children. A survey of New Zealanders

found that respondents who grew up in a home with hundreds of books went on to complete 2.8 years more education, on average, than those who grew up in a home with no books, controlling for parents' education and other socio-economic characteristics, supporting findings from the current study that books in the home make an independent contribution to children's cognitive skills over and above parents' education (Evans et al., 2010). [10]

Policy should increase awareness of the benefits to children of folic acid intake

Not taking folate or folic acid supplements (known to reduce the risk of neural tube defects) during the first trimester of pregnancy undermines the development of children's vocabulary skills. The Ministry of Health has guidelines for folic acid supplementation and these should be updated to reflect the increasing evidence from the GUiNZ study that failure to take folic acid increases the risk of cognitive delays in children; in addition to the current study, this has been found in Neumann et al. (2019), D'Souza et al. (2019), and Buckley et al. (2020). Reducing barriers to accessing folic acid supplements – including cost – should be investigated and weighed against the potential benefits of increased uptake. While it is now mandatory in New Zealand for non-organic wheat flour (used in making bread) to be fortified with folic acid, the use of folic acid supplements is still recommended for women of childbearing age in order to ensure intake is at an adequate level.

Policy should promote prudent use of screens with children

Frequently having television on in the presence of infants (but not the frequency of watching children's television programmes with them) undermines the development of their vocabulary and overall cognitive skills. This may be because parents tend to speak fewer words to their children when screens are used in ways that are non-educational, non-interactive, and displace parent-child communication and interaction such as talk and play (see Wilkinson et al., 2021). A survey of New Zealand preschool children aged 3 to 5 years found that the more time they spent watching television and using electronic media, the less they engaged in shared reading and stimulating interactions with their parents, which in turn was linked to lower language skills and a less-close bond with their parent (Gath et al., 2023). Among the GUiNZ cohort, mothers who watched television frequently also read to their preschool children less often (Thomas et al., 2019a) and by age 8 years children with above-average passive screen time also engaged less frequently in reading for pleasure (Boyask et al., 2024). Furthermore, 2-year-old children with excessive screen time or television exposure are at greater risk of behavioural problems at that age (Monk, 2022), poor health outcomes at age 4.5 including obesity and hyperactivity (Stewart et al., 2019), and inability to delay gratification at age 4.5 (Corkin et al., 2021).

[10] This effect size compares with a gain of 1.9 years of completed education among respondents of university-educated parents compared to respondents of primary-school-educated parents, which suggests a 'scholarly family culture' – of which home library size is a proxy – is more important to children's educational attainment than parents' qualifications per se (Evans et al., 2010).

It is important to note that the content or 'quality' of television programming, as well as the context in which screen use occurs (e.g., with or without parental involvement), are also important for children's cognitive development. For example, educational television programmes that present literacy- or numeracy-related content in an interactive way may be beneficial to children's cognition (see Wilkinson et al., 2021). However, the GUiNZ study did not collect information at age 9 months on the content of television programmes that infants were exposed to (beyond the specific question about children's programmes), only on the frequency of television use.

Yet the 'quantity' of television viewing matters to the extent that it displaces parent-child conversation, physical activity and play, in-person social interaction with other children, and other developmentally beneficial activities. The Ministry of Health's (2017) *Active play guidelines* (which recommend no screen time for under-two-year-olds and less than one hour per day for children aged two years or older) should be updated to reflect the risks of excessive screen use to cognitive development. Pregnancy and parenting programmes and child wellbeing services (such as Well Child Tamariki Ora visits including the B4 School Check) should also emphasise the importance of using screens interactively and as a learning or bonding opportunity through parental co-viewing as well as balancing screen time with other family activities.

Policy should encourage parents to use reasoning and avoid harsh discipline and 'overparenting'

Parenting practices are related to the development of reading and overall cognitive skills but not vocabulary skills. Verbally and physically punitive parenting – which declines as maternal education increases – undermines the development of children's reading skills. Parenting that is diffident and lacking in disciplinary follow-through – which also declines as maternal education increases – undermines children's overall cognitive skills. Both types of parenting lower the chances of children 'defying the intergenerational odds' through developing strong cognitive skills despite having a lower-educated mother. Analysis of GUiNZ 4.5-year data has also found that verbally hostile parenting increases the risk of hyperactivity problems among children and permissive/diffident parenting and corporal punishment undermine children's inhibitory control (Corkin et al., 2021). Parenting education courses and public awareness campaigns should promote the use of reasoning and the application of consistent rules with children (instead of harsh punishment and inconsistency) as being the type of behavioural control that is most optimal for child development.

Perhaps surprisingly, parenting that has a relatively low frequency of warmth, affection, and responsiveness is linked to *better* reading skills among children [11]

[11] This finding contrasts with findings from Barker and Maloney (2000) who investigate the drivers of children's reading skills in middle childhood using data from the Christchurch Health and Development Study and find that mother's emotional responsiveness when the child was aged 3 – the degree to which she praised her child, involved her child in conversation, and displayed positive emotion to her child – is positively related to children's reading skills over ages 8 to 13 years (that is, higher maternal responsiveness is associated with higher reading ability among children).

and *higher* chances of children 'breaking the intergenerational mould' with respect to reading skills. Note that it is *relatively* low, which does not mean warmth and responsiveness are near-absent among these parents (in an absolute sense they may be common behaviours for these parents), but rather that they are lower than average by comparison with other parents in the GUiNZ cohort. 'Low' warm parenting is more common among GUiNZ mothers with degree qualifications than those without degrees. This result is driven in particular by differences in responses to the item "*I am responsive to {child's} feelings and needs*" (response options are on a frequency scale ranging from '*Never*' to '*Always*'). Of mothers with no qualifications, 64% responded '*Always*' to this item, whereas only 43% of mothers with a higher degree responded '*Always*'.

It is possible for parents to be *too* responsive to their children and too willing to protect them from difficulties or challenges in life, preventing the development of independence, responsibility, and self-efficacy (sometimes called 'overparenting' or 'helicopter parenting'; see Locke, Campbell, & Kavanagh, 2012). Turner et al. (2023) find that parents who fit an 'authoritative' parenting style (which includes high levels of warmth and responsiveness) endorse greater use of helicopter parenting. This type of intensive, over-protective parenting sees the child's needs placed at the centre of the parent's life who shields the child from experiencing disappointment and discourages the child's achievement of age-appropriate milestones that foster their autonomy. Such over-protection may also extend to not encouraging children to do their own independent reading for pleasure or may have the effect of undermining children's self-efficacy in reading. Parenting education courses and public awareness campaigns should warn of the risks to children's development of overcontrolling parenting that inhibits children's independence and autonomy.

Policy should target Pacific parents and consider further research on Asian parenting and parents who struggle with reading

Compared to children of European mothers, children of Pacific mothers have significantly lower vocabulary skills. Policy should be aimed at supporting Pacific parents/caregivers. Sole parent mothers also stand out as a group requiring focused support.

Policy should consider commissioning further research directed at understanding exactly how Asian mothers in New Zealand significantly promote their children's reading and overall cognitive skills (including by Asian mothers without degree qualifications whose children have greater chances than other children of 'breaking the intergenerational mould' with respect to reading skills).[12] There is some evidence that the effects of socioeconomic background on educational achievement are weaker among Asian students compared to other students in New Zealand (Hernandez, 2019; Meehan et al., 2019). Further research should be directed at understanding why this is the case, including whether parenting

[12] Analyses of GUiNZ data have found that, compared to mothers of other ethnicities, Asian mothers report more frequent teaching of literacy and numeracy skills (Meissel et al., 2019) and more frequent verbal interactions (Bird et al., 2023) with their 4.5-year-old child.

practices or parenting strategies used by Asian parents play a role in mitigating socioeconomic disadvantage. While there exists a body of research on parenting among Asian parents including 'tiger parenting' (see Ng and Wang (2019) and Juang et al. (2013)), this is mostly focused on Asian American parents and there is little research on Asian parents in New Zealand. [13]

Given that some mothers with low education or from culturally or linguistically diverse backgrounds may themselves lack the ability to read to their child (or read in English), further research is needed on preschool interventions that could assist these families such as whether children's audiobooks are an effective substitute for parental reading (Singh & Alexander, 2022).

In summary, this study has shown large gaps in children's cognitive skills by parents' educational attainment and points to important areas for policy development aimed at overcoming these inequities. While higher parental educational attainment is linked to better cognitive skills among children, it is not necessarily desirable or feasible for public policy to attempt to have every person attend tertiary education. Improving parents' awareness and understanding of specific inputs that are important to children's cognitive development – such as reading to children, taking folic acid in pregnancy, and using screens wisely – can occur without changing the qualifications that parents hold. Yet lifting educational attainment among the general population is likely to yield intergenerational benefits for a wide range of child well-being outcomes (not just children's cognition but also their socio-emotional development, their health, their academic achievement, etc.). Recent evidence finds it is particularly important to children's developmental outcomes for increases in educational attainment to occur among young people *before they start having children*, as further education attained after the birth of children may not improve children's skills (Augustine & Negraia, 2018). Thus, for public policy to be effective in the long-term, it must focus on lifting educational attainment among *future parents* to achieve intergenerational gains and improve equity in children's human capital.

6. Limitations

There are a number of limitations to this study. First, our results are correlational and therefore do not imply cause-and-effect relationships between explanatory variables and cognitive outcomes.

Second, not all inputs to children's cognitive development could be captured in the analysis. In particular, the roles played by children's genetics, peers, and schools in the formation of their cognitive skills is not explored (partly due to limitations in data availability). Relatedly, due to multicollinearity issues, our analyses did not include a direct measure of family or household income, so the maternal education effects or other parental effects we find may be partly driven by income effects.

[13] For exceptions, see Zhang et al. (2014) and Yao (2015). The studies noted in footnote 13 above, as well as Monk (2022), analyse ethnic differences in parenting but are not focused specifically on Asian parenting.

Third, we did not conduct a formal mediation analysis so we cannot be certain that the mediating variables we discuss are in fact acting as pathways through which maternal education influences children's cognitive outcomes.

Fourth, most of the explanatory variables were collected via maternal self-report which can be subject to various forms of response bias, notably recall bias (e.g., a mother forgets how often she reads to her child) and social desirability bias (e.g., a mother reports that she did not drink alcohol during pregnancy when in fact she did because she wants to appear in a more favourable light to the interviewer).

Fifth, we used complete-case analysis or 'listwise deletion' (no imputation of missing data was conducted) which reduced statistical power and thus our ability to make inferences about the general population of 8-year-old children in New Zealand.

Sixth, the differential attrition documented in section 4.1 and in Morton et al. (2020) revealed that socio-economically disadvantaged children were less likely to participate in the 8-year NIH Toolbox Cognition Battery. While we have attempted to mitigate this issue by using a Heckman correction which adjusts results for selection bias, our results may still be affected by differential loss to follow-up among the GUiNZ cohort. To the extent this is the case, our results are likely to be conservative estimates of differences between 8-year-olds in the general population because the greatest attrition has occurred in the groups most likely to have poorer outcomes overall (see Morton et al., 2020).

Finally, as previously mentioned in section 2.2.1, the NIH Toolbox Cognition Battery was developed and normed in the US and it is not clear whether this introduces cultural biases that disadvantage New Zealand children, especially non-European children. [14] Cognitive and neuropsychological test performance of groups other than those on which they have been standardised can be affected by cultural biases, with respect to both test content and administration procedures. This may be especially so for tests that rely heavily on cultural knowledge and experience such as vocabulary tests administered in the English language. Differences in test scores between culturally/linguistically dominant and non-dominant groups (such as ethnic minorities or children whose first language is not English) may be attributable to such cultural biases or to more distal socio-economic inequalities rather than to ethnicity or cultural background per se (Casaletto et al., 2015). Such concerns motivated our ethnic-specific analyses for Aim 1.

In the New Zealand context, Haitana et al. (2010, p. 29) assessed the cultural bias of the Peabody Picture Vocabulary Test (a measure of receptive vocabulary in English) with a sample of Māori children and concluded that the test is "largely an appropriate measure to use with Māori children" but those attending Māori-medium schools were linguistically disadvantaged and some items were biased towards American culture (e.g., items for which the target word was 'Porcupine'

[14] In addition, as discussed in section 2.2.1, Neumann et al. (2021b) find the dimensional structure that underpins the NIH Toolbox Cognition Battery does not hold among the GUiNZ cohort.

and ‘Raccoon’ – animals not commonly seen in New Zealand).[15] Ogden et al. (1997, p. 9) assessed the cultural bias of seven neuropsychological tests with a sample of young Māori men and found that while they scored within the average range on four of the seven tests administered, their scores on the Vocabulary subtest of the Wechsler Adult Intelligence Scale were one standard deviation below the mean, partly due to “culturally-biased scoring of some words” (e.g., a majority of participants defined the word ‘domestic’ as ‘an argument between a man and a woman’, reflecting common usage within the New Zealand context but scored as incorrect in the test).

[15] It is common for psychologists working with New Zealand children to adapt cognitive tests that have been developed in American English to New Zealand English by changing specific words, such as ‘diaper’ to ‘nappy’ and ‘faucet’ to ‘tap’ (Ross-McAlpine et al., 2018; Reese & Read, 2000).

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Appendix 1: *Description of variables*

Type of variable	Category	Variable	Coding	DCW	Specific collection	GUiNZ variable name(s)	Notes
Outcome	**Child's cognitive skills**	Picture Vocabulary Test score (age-adjusted and standardised)	Continuous score	DCW8	8-year child observation	PVT_THETA_Y8CONIH	Measured with the NIH Toolbox Cognition Battery. Age-adjusted using test date (PVT_DATEFIN_Y8CONIH) and date of birth (cdob_w6) variables. See section 2.2.1 for bibliographic details.
		Oral Reading Recognition Test score (age-adjusted and standardised)	Continuous score	DCW8	8-year child observation	ORR_THETA_Y8CONIH	Measured with the NIH Toolbox Cognition Battery. Age-adjusted using test date (ORR_DATEFIN_Y8CONIH) and date of birth (cdob_w6) variables. See section 2.2.1 for bibliographic details.
		Global composite cognition score (age-adjusted and standardised)	Continuous score	DCW8	8-year child observation	COGTOTALCOM_UNR_Y8CONIH	Measured with the NIH Toolbox Cognition Battery. Age-adjusted using test date (PVT_DATEFIN_Y8CONIH) and date of birth (cdob_w6) variables. See section 2.2.1 for bibliographic details.
Predictor	**Mother's educational attainment**	Mother's highest educational qualification at antenatal	1 = No secondary school qualification; 2 = Secondary school qualification/NCEA level 1 to 4; 3 = Diploma or Trade certificate/NCEA level 5 to 6; 4 = Bachelor's degree; 5 = Higher degree	DCW0	Antenatal mother	EDALL_AM	
Antenatal and perinatal potential confounders	**Mother's socio-demographic characteristics**	Mother's age	1 = Less than 25 years; 2 = 25 to 29 years; 3 = 30 to 33 years; 4 = 34 years or older	DCW0	Antenatal mother	AGE_AM	
		Mother's ethnicity	1 = European; 2 = Māori; 3 = Pacific; 4 = Asian; 5 = Other ethnicity	DCW0	Antenatal mother	SELF_PROETH_AM	Mother's ethnicity is self-prioritised.
		Mother's native/migrant status	1 = Born in New Zealand; 2 = Migrated to New Zealand up to age 18 years; 3 = Migrated to New Zealand after age 18 years	DCW0	Antenatal mother	OL1_AM, AGETONZ_AM	
		Mother's parity	1 = First-born; 2 = Subsequent-born	DCW0	Antenatal mother	CHILD_AM	
		Mother's rurality	1 = Urban area; 2 = Rural area	DCW0	Antenatal mother	RURALITY_AM	
		Mother's household type	1 = Two parents; 2 = Parent(s) with other family or non-family; 3 = Sole parent	DCW0	Antenatal mother	HHST_AM	
		Mother's work and labour force status	1 = Employed full-time; 2 = Employed part-time; 3 = Unemployed; 4 = Not in the labour force	DCW0	Antenatal mother	LFS_AM, LFSHR_AM	
		Mother's neighbourhood socio-economic deprivation	1 = Low deprivation (deciles 1 to 3); 2 = Medium deprivation (deciles 4 to 7); 3 = High deprivation (deciles 8 to 10)	DCW0	Antenatal mother	NZDEPGP_AM	Measured with the New Zealand Index of Deprivation 2006 (NZDep 2006) (Salmond et al., 2007).
	Mother's lifestyle behaviours	Mother's smoking behaviour during pregnancy	0 = Did not smoke; 1 = Smoked	DCW0	Antenatal mother	SM4_AM	
		Mother's alcohol consumption during pregnancy	0 = Did not drink alcohol; 1 = Drank alcohol	DCW0	Antenatal mother	ALC2_AM, ALC3_AM	
		Mother's folate or folic acid intake in first trimester	1 = Took folate; 2 = No folate	DCW0	Antenatal mother	VM2_AM	
	Mother's mental health	Mother's depression status	0 = Not depressed; 1 = Depressed	DCW0	Antenatal mother	EDI_AM	Measured with the Edinburgh Postnatal Depression Scale (Cox et al., 1987) using a cut-off score of 13 or more.
		Mother's anxiety/panic attacks status	0 = No anxiety; 1 = Anxious	DCW0	Antenatal mother	GH9_AM	
	Child's birth characteristics	Child's sex	1 = Male; 2 = Female	DCW1	9-month child	GENDER_PDL	
		Child's gestational age	1 = Term (≥37 weeks); 2 = Preterm (<37 weeks)	DCW1	9-month child	TERM_PDL	
		Child's low birth weight status	0 = Not low (≥2,500 grams); 1 = Low birth weight (<2,500 grams)	DCW1	9-month child	BW3GRPS_PDL	

Appendix 1 (continued): Description of variables

Type of variable	Category	Variable	Coding	DCW	Specific collection	GUiNZ variable name(s)	Notes
Post-birth potential mediating variables	**Childcare**	Child's main care arrangement	1 = Early childhood education; 2 = Parental or informal care	DCW1	9-month mother	cc1_m9m, cc3h_m9m, cc4h_m9m, ncc5_m9m	Coding based on Thomas et al. (2019a).
	Language at home	Mother's language used most to talk to child	1 = English; 2 = Non-English language	DCW1	9-month mother	nln6_m9m	
	Books in home	Number of children's books in home	1 = 5 or fewer books; 2 = 6 to 20 books; 3 = 21 or more books	DCW1	9-month mother	h14_m9m	
	Television use	Mother's frequency of watching children's TV programmes with child	1 = Less than once a day; 2 = Once a day; 3 = More than once a day	DCW1	9-month mother	h12_m9m	
		Mother's frequency of having TV on in same room as child	1 = Less than once a day; 2 = Once a day; 3 = More than once a day	DCW1	9-month mother	h13_m9m	
	Book reading	Mother's frequency of reading books to child at 9 months	1 = Less than once a day; 2 = Once a day; 3 = More than once a day	DCW1	9-month mother	pc5_m9m	
		Mother's frequency of reading books to child at 2 years	1 = Less than once a day; 2 = Once a day; 3 = More than once a day	DCW2	2-year mother	pc5_y2m	
		Mother's frequency of reading books to child at 4.5 years	1 = Less than once a day; 2 = Once a day; 3 = More than once a day	DCW5	54-month child	pc5_m54cm	
	Parenting practices	Mother's warm parenting	1 = Low warm parenting; 2 = Medium warm parenting; 3 = High warm parenting	DCW5	54-month child	par7_m54cm-par14_m54cm	Measured with items from the Parenting Practices Questionnaire (Robinson et al., 1995) with scores grouped into three approximately equal-sized bins.
		Mother's hostile parenting	1 = Low hostile parenting; 2 = Medium hostile parenting; 3 = High hostile parenting	DCW5	54-month child	par15_m54cm-par22_m54cm	Measured with items from the Parenting Practices Questionnaire (Robinson et al., 1995) with scores grouped into three approximately equal-sized bins.
		Mother's diffident parenting	1 = Low diffident parenting; 2 = Medium diffident parenting; 3 = High diffident parenting	DCW5	54-month child	par23_m54cm-par27_m54cm	Measured with items from the Parenting Practices Questionnaire (Robinson et al., 1995) with scores grouped into three approximately equal-sized bins.
Heckman exclusion restriction variable	**Household crowding**	Household crowding index	Continuous score (range 0.14 to 8.00)	DCW0	Antenatal mother	CROWDING_AM	

References:

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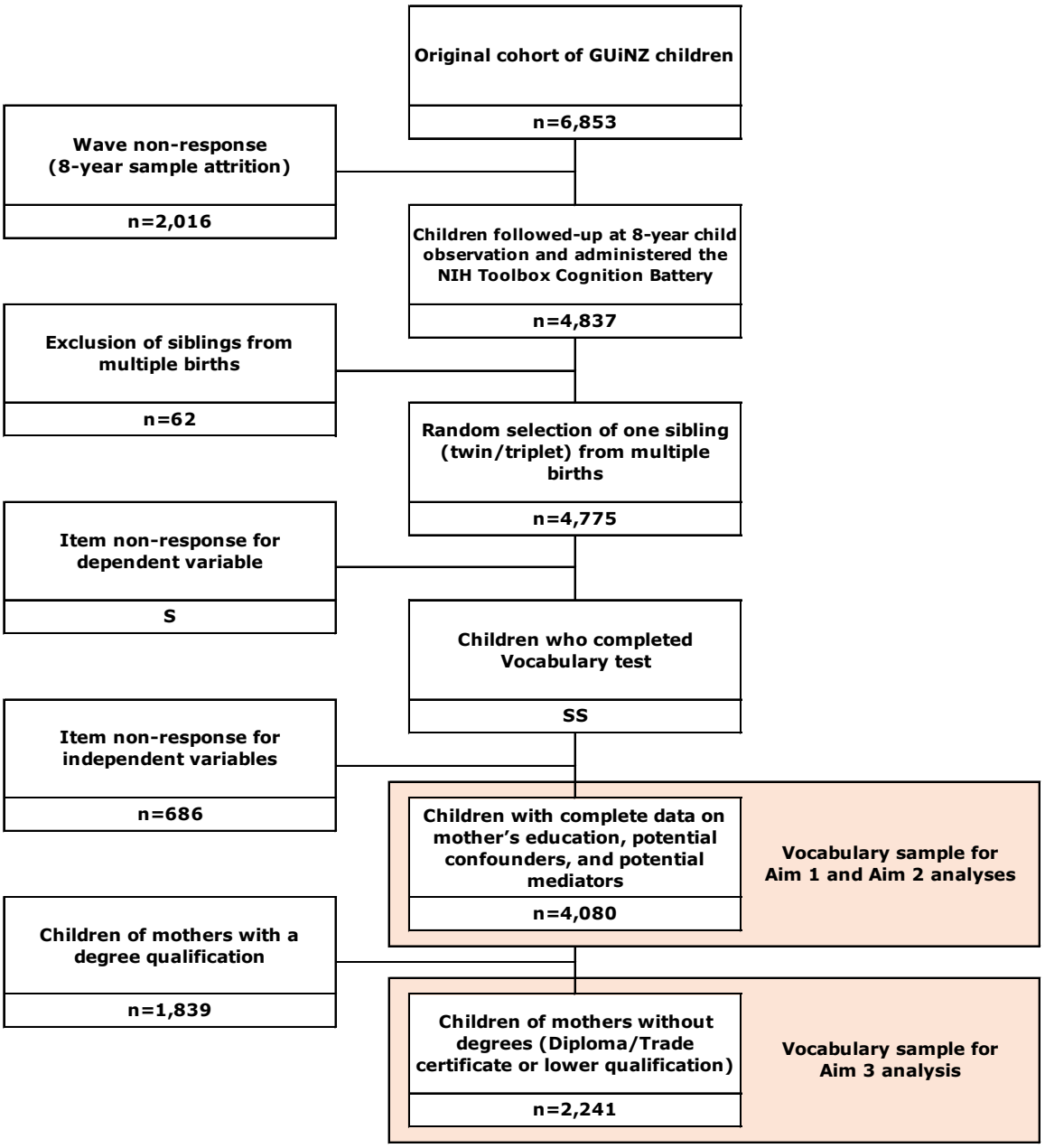
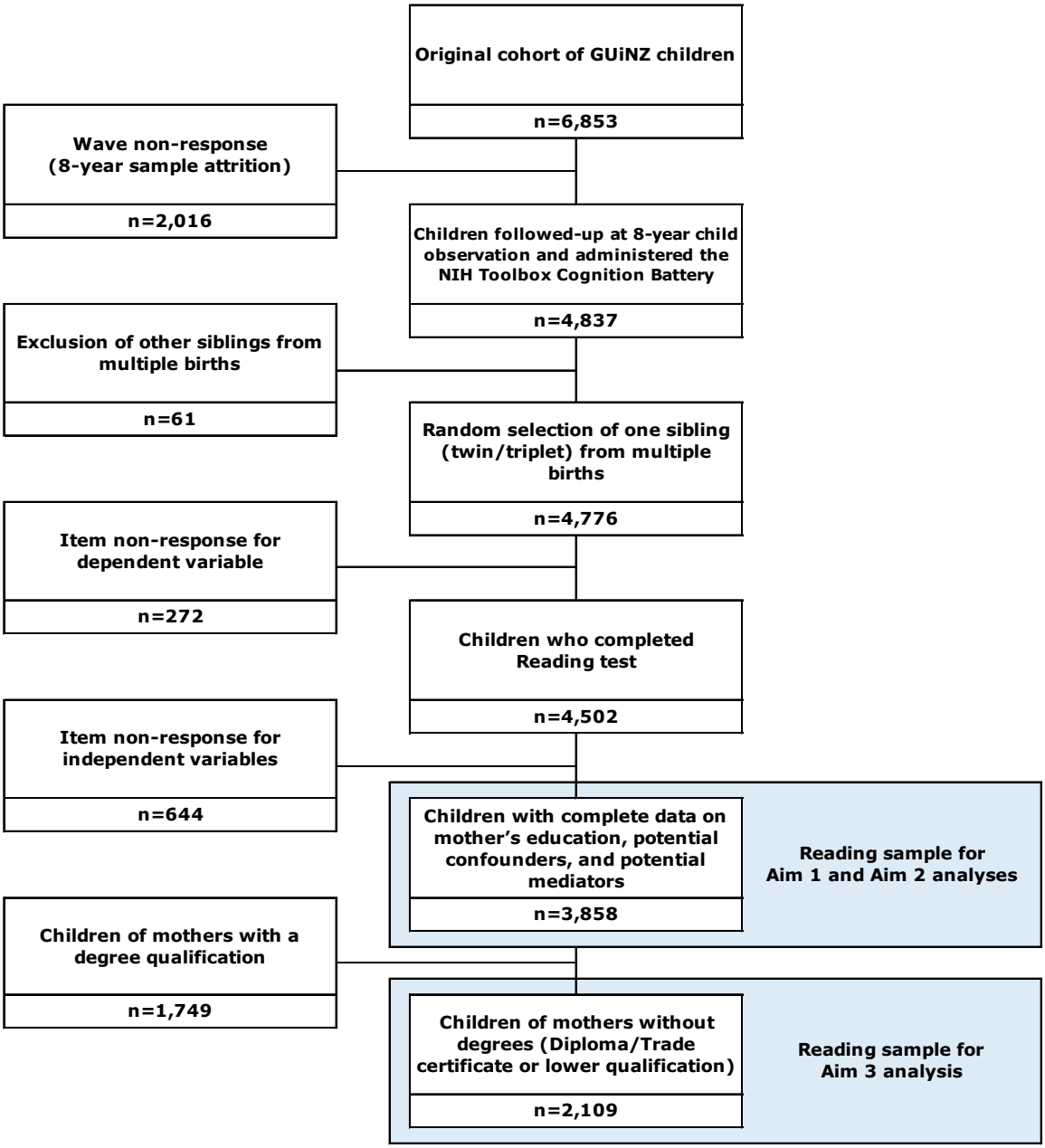
Appendix 2: *Sample selection flowchart – Vocabulary sample*



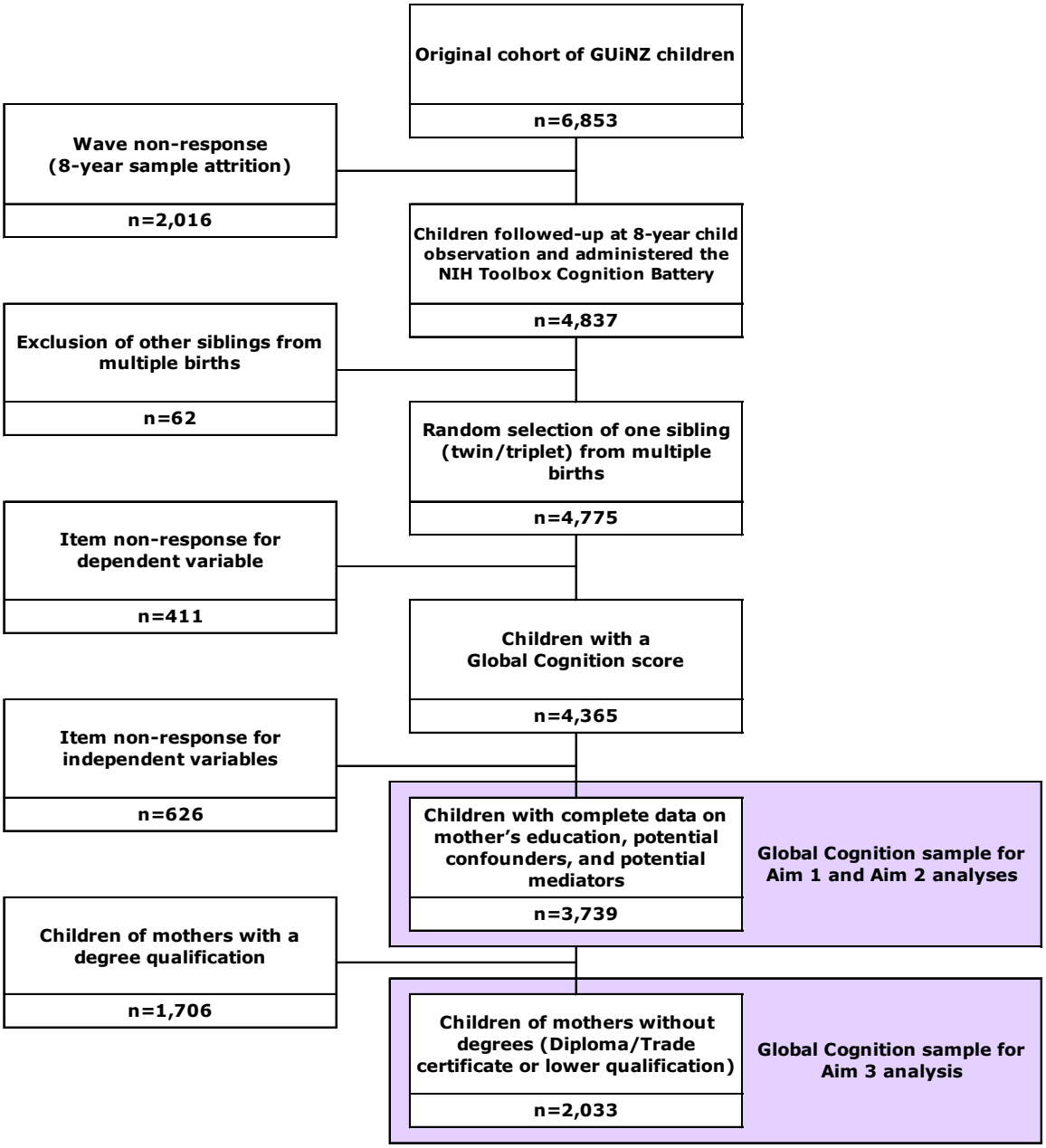
Notes: S = suppressed due to cell size less than 10. SS = secondary suppression so that suppressed cell cannot be recalculated.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 3: *Sample selection flowchart – Reading sample*



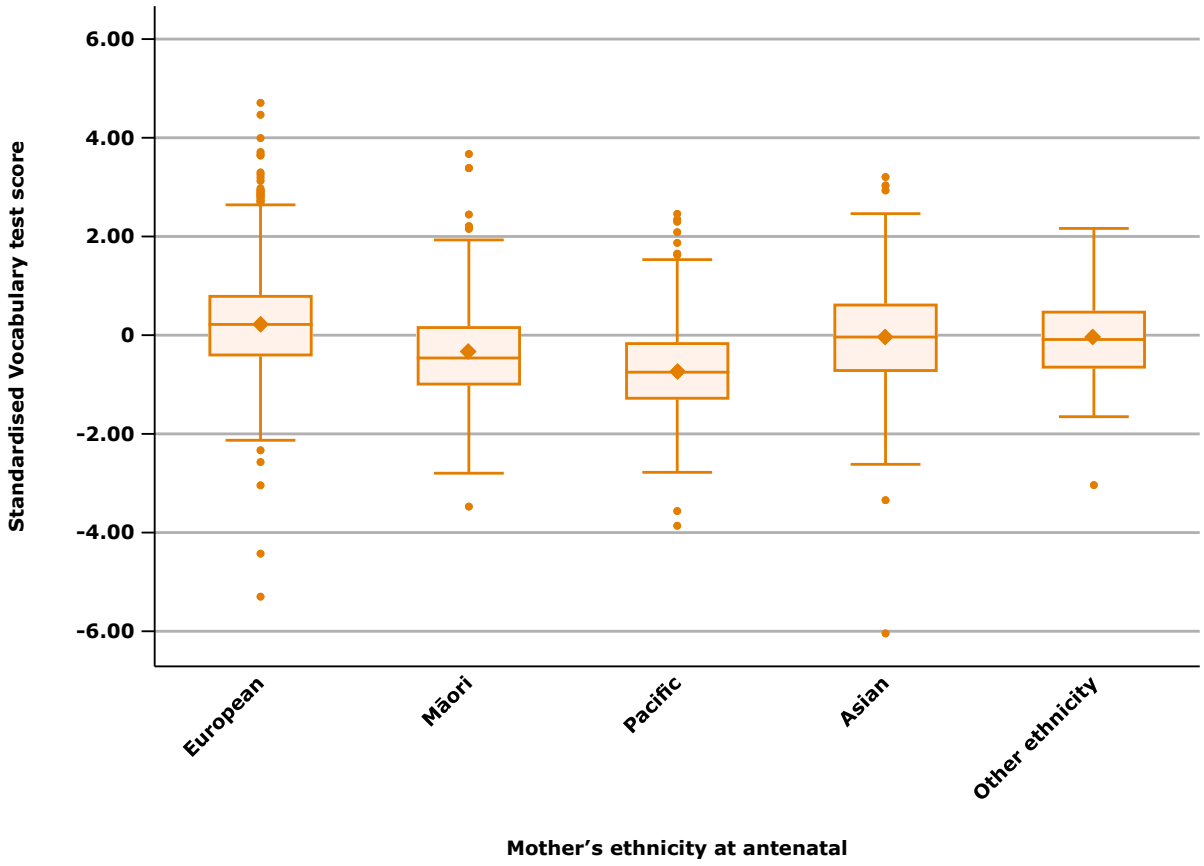
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 4: *Sample selection flowchart – Global Cognition sample*



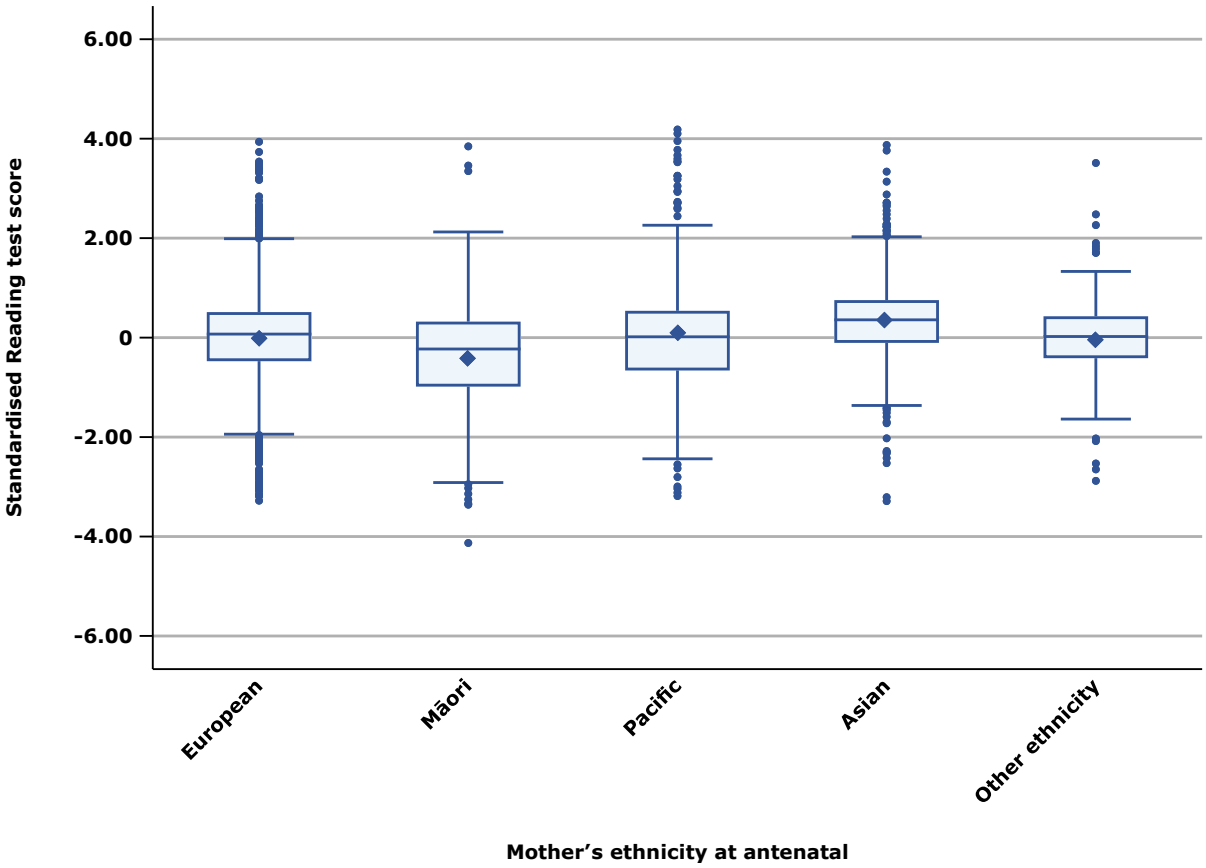
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 5: *Box-and-whisker plot of standardised Vocabulary test scores of 8-year-old GUiNZ children by mothers' ethnicity*



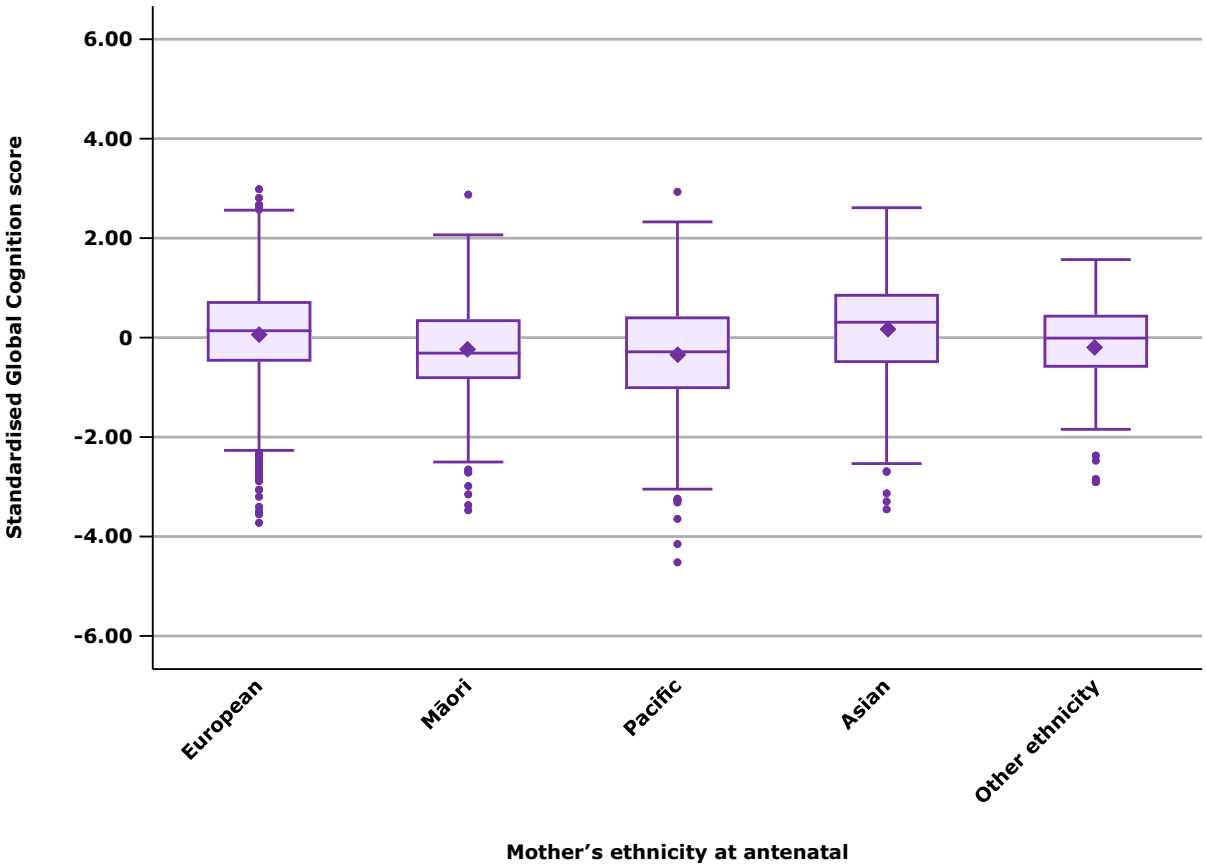
Notes: Diamond symbols represent mean test scores.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 6: *Box-and-whisker plot of standardised Reading test scores of 8-year-old GUiNZ children by mothers' ethnicity*



Notes: Diamond symbols represent mean test scores.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 7: *Box-and-whisker plot of standardised Global Cognitive scores of 8-year-old GUiNZ children by mothers' ethnicity*



Notes: Diamond symbols represent mean test scores.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 8: *Aim 1 linear regression results – vocabulary skills*

Variable	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)						
Secondary school qualification	0.132	(0.082)	0.105	(0.088)	0.048	(0.089)
Diploma or Trade certificate	0.135	(0.084)	0.160	(0.092)	0.078	(0.089)
Bachelor's degree	0.124	(0.103)	0.319 *	(0.127)	0.155	(0.102)
Higher degree	0.394 ***	(0.101)	0.483 ***	(0.110)	0.313 ***	(0.092)
Mother's age (ref. Less than 25 years)						
25 to 29 years			0.069	(0.073)	-0.017	(0.069)
30 to 33 years			0.119	(0.091)	-0.003	(0.076)
34 years or older			0.193	(0.103)	0.049	(0.086)
Mother's ethnicity (ref. European)						
Māori			-0.365 **	(0.116)	-0.173	(0.090)
Pacific			-0.641 ***	(0.134)	-0.356 **	(0.114)
Asian			-0.192 *	(0.083)	0.096	(0.067)
Other ethnicity			-0.234 *	(0.116)	-0.084	(0.093)
Mother's native/migrant status (ref. Born in New Zealand)						
Migrated to New Zealand up to age 18			0.015	(0.067)	0.081	(0.063)
Migrated to New Zealand after age 18			-0.077	(0.119)	0.143	(0.113)
Mother's parity (ref. First-born)						
Subsequent-born			-0.129 ***	(0.038)	-0.098 *	(0.040)
Mother's rurality (ref. Urban)						
Rural			0.025	(0.058)	-0.001	(0.055)
Mother's household type (ref. Two parents)						
Parent(s) with others			-0.074	(0.039)	-0.030	(0.038)
Sole parent			-0.382 ***	(0.097)	-0.343 ***	(0.096)
Mother's labour force status (ref. Employed full-time)						
Employed part-time			-0.004	(0.041)	-0.006	(0.042)
Unemployed			-0.123	(0.079)	-0.085	(0.074)
Not in the labour force			-0.086	(0.048)	-0.057	(0.047)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)						
Medium deprivation			-0.006	(0.036)	-0.001	(0.035)
High deprivation			-0.124 *	(0.048)	-0.079	(0.045)
Mother's antenatal smoking (ref. Did not smoke)						
Smoked			-0.070	(0.066)	-0.027	(0.060)
Mother's antenatal alcohol consumption (ref. No alcohol)						
Drank alcohol			-0.031	(0.033)	-0.012	(0.033)
Mother's folate intake in first trimester (ref. Took folate)						
No folate			-0.164 **	(0.052)	-0.109 *	(0.048)
Mother's antenatal depression (ref. Not depressed)						
Depressed			0.039	(0.051)	0.076	(0.052)
Mother's antenatal anxiety (ref. No anxiety)						
Anxious			-0.054	(0.080)	-0.059	(0.081)
Child's sex (ref. Male)						
Female			0.024	(0.029)	0.008	(0.030)
Child's gestational age (ref. Term)						
Preterm			0.025	(0.076)	-0.005	(0.084)
Child's birth weight status (ref. Not low)						
Low birth weight			-0.147	(0.094)	-0.114	(0.096)
Child's care arrangement at 9 months (ref. Early childhood education)						
Parental or informal care					0.017	(0.039)
Mother's language used with baby at 9 months (ref. English)						
Non-English language					-0.207 ***	(0.059)
Number of children's book in home at 9 months (ref. Five or fewer)						
6 to 20 books					0.150 *	(0.062)
21 or more books					0.229 ***	(0.064)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)						
Once a day					-0.021	(0.061)
More than once a day					-0.073	(0.054)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)						
Once a day					-0.135 ***	(0.041)
More than once a day					-0.096 *	(0.039)
Mother's frequency of reading books at 9 months (ref. Less than once a day)						
Once a day					-0.036	(0.033)
More than once a day					-0.010	(0.048)
Mother's frequency of reading books at 2 years (ref. Less than once a day)						
Once a day					0.055	(0.051)
More than once a day					0.167 *	(0.074)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)						
Once a day					0.005	(0.039)
More than once a day					0.223 ***	(0.048)
Mother's warm parenting at 4.5 years (ref. Medium)						
Low warm parenting					-0.006	(0.039)
High warm parenting					-0.069	(0.037)
Mother's hostile parenting at 4.5 years (ref. Medium)						
Low hostile parenting					0.001	(0.037)
High hostile parenting					-0.013	(0.035)
Mother's diffident parenting at 4.5 years (ref. Medium)						
Low diffident parenting					0.028	(0.036)
High diffident parenting					-0.032	(0.036)
Inverse Mills ratio	-4.759 ***	(0.508)	0.309	(1.427)	-1.243	(1.398)
Constant	1.084 ***	(0.189)	-0.059	(0.382)	0.107	(0.403)
R^2	0.090		0.156		0.190	
Number of observations	4,080		4,080		4,080	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Notes: S.E. = standard error.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 9: *Aim 1 linear regression results - reading skills*

Variable	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	**S.E.**	**Coefficient**	**S.E.**	**Coefficient**	**S.E.**
Mother's educational attainment (ref. No qualification)						
Secondary school qualification	0.537 ***	(0.089)	0.378 ***	(0.097)	0.346 ***	(0.099)
Diploma or Trade certificate	0.520 ***	(0.091)	0.361 ***	(0.101)	0.315 **	(0.099)
Bachelor's degree	0.761 ***	(0.111)	0.543 ***	(0.139)	0.421 ***	(0.114)
Higher degree	0.879 ***	(0.109)	0.627 ***	(0.120)	0.507 ***	(0.103)
Mother's age (ref. Less than 25 years)						
25 to 29 years			0.047	(0.079)	0.009	(0.075)
30 to 33 years			0.117	(0.099)	0.044	(0.083)
34 years or older			0.117	(0.111)	0.034	(0.095)
Mother's ethnicity (ref. European)						
Māori			-0.268 *	(0.126)	-0.129	(0.100)
Pacific			0.092	(0.146)	0.239	(0.126)
Asian			0.223 *	(0.090)	0.435 ***	(0.073)
Other ethnicity			-0.106	(0.125)	0.027	(0.101)
Mother's native/migrant status (ref. Born in New Zealand)						
Migrated to New Zealand up to age 18			0.086	(0.073)	0.126	(0.070)
Migrated to New Zealand after age 18			-0.066	(0.129)	0.034	(0.124)
Mother's parity (ref. First-born)						
Subsequent-born			-0.102 *	(0.041)	-0.086 *	(0.044)
Mother's rurality (ref. Urban)						
Rural			-0.111	(0.063)	-0.133 *	(0.060)
Mother's household type (ref. Two parents)						
Parent(s) with others			-0.065	(0.042)	-0.045	(0.041)
Sole parent			-0.357 ***	(0.108)	-0.367 ***	(0.108)
Mother's labour force status (ref. Employed full-time)						
Employed part-time			0.015	(0.044)	-0.020	(0.046)
Unemployed			-0.223 **	(0.086)	-0.227 **	(0.081)
Not in the labour force			-0.003	(0.052)	-0.017	(0.051)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)						
Medium deprivation			-0.052	(0.039)	-0.049	(0.038)
High deprivation			-0.194 ***	(0.052)	-0.167 ***	(0.049)
Mother's antenatal smoking (ref. Did not smoke)						
Smoked			-0.077	(0.072)	-0.051	(0.066)
Mother's antenatal alcohol consumption (ref. No alcohol)						
Drank alcohol			-0.064	(0.035)	-0.053	(0.036)
Mother's folate intake in first trimester (ref. Took folate)						
No folate			-0.070	(0.056)	-0.041	(0.053)
Mother's antenatal depression (ref. Not depressed)						
Depressed			-0.035	(0.055)	-0.023	(0.057)
Mother's antenatal anxiety (ref. No anxiety)						
Anxious			-0.042	(0.087)	-0.022	(0.089)
Child's sex (ref. Male)						
Female			0.046	(0.031)	0.040	(0.033)
Child's gestational age (ref. Term)						
Preterm			-0.018	(0.084)	0.010	(0.093)
Child's birth weight status (ref. Not low)						
Low birth weight			-0.134	(0.102)	-0.122	(0.104)
Child's care arrangement at 9 months (ref. Early childhood education)						
Parental or informal care					0.110 *	(0.043)
Mother's language used with baby at 9 months (ref. English)						
Non-English language					-0.123	(0.064)
Number of children's book in home at 9 months (ref. Five or fewer)						
6 to 20 books					-0.016	(0.068)
21 or more books					0.068	(0.070)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)						
Once a day					-0.043	(0.067)
More than once a day					0.056	(0.060)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)						
Once a day					-0.023	(0.045)
More than once a day					-0.010	(0.043)
Mother's frequency of reading books at 9 months (ref. Less than once a day)						
Once a day					0.040	(0.037)
More than once a day					0.035	(0.053)
Mother's frequency of reading books at 2 years (ref. Less than once a day)						
Once a day					0.087	(0.057)
More than once a day					0.187 *	(0.082)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)						
Once a day					0.044	(0.042)
More than once a day					0.109 *	(0.052)
Mother's warm parenting at 4.5 years (ref. Medium)						
Low warm parenting					0.115 **	(0.043)
High warm parenting					0.054	(0.041)
Mother's hostile parenting at 4.5 years (ref. Medium)						
Low hostile parenting					0.023	(0.041)
High hostile parenting					-0.080 *	(0.038)
Mother's diffident parenting at 4.5 years (ref. Medium)						
Low diffident parenting					0.038	(0.039)
High diffident parenting					0.023	(0.040)
Inverse Mills ratio	0.533	(0.538)	1.611	(1.549)	1.067	(1.534)
Constant	-0.762 ***	(0.202)	-0.693	(0.414)	-0.819	(0.443)
R^2	0.031		0.069		0.084	
Number of observations	3,858		3,858		3,858	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Notes: S.E. = standard error.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 10: *Aim 1 linear regression results - global cognitive skills*

Variable	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)						
Secondary school qualification	0.438 ***	(0.090)	0.330 ***	(0.098)	0.236 *	(0.099)
Diploma or Trade certificate	0.498 ***	(0.092)	0.405 ***	(0.101)	0.285 **	(0.100)
Bachelor's degree	0.720 ***	(0.111)	0.628 ***	(0.139)	0.407 ***	(0.114)
Higher degree	0.874 ***	(0.109)	0.733 ***	(0.120)	0.542 ***	(0.103)
Mother's age (ref. Less than 25 years)						
25 to 29 years			0.055	(0.079)	-0.062	(0.075)
30 to 33 years			0.080	(0.098)	-0.082	(0.083)
34 years or older			0.111	(0.111)	-0.084	(0.094)
Mother's ethnicity (ref. European)						
Māori			-0.149	(0.126)	0.086	(0.099)
Pacific			-0.216	(0.145)	0.106	(0.124)
Asian			0.051	(0.089)	0.290 ***	(0.072)
Other ethnicity			-0.259 *	(0.125)	-0.091	(0.101)
Mother's native/migrant status (ref. Born in New Zealand)						
Migrated to New Zealand up to age 18			0.047	(0.072)	0.134	(0.069)
Migrated to New Zealand after age 18			-0.050	(0.128)	0.225	(0.122)
Mother's parity (ref. First-born)						
Subsequent-born			0.005	(0.041)	0.012	(0.043)
Mother's rurality (ref. Urban)						
Rural			-0.142 *	(0.062)	-0.186 **	(0.059)
Mother's household type (ref. Two parents)						
Parent(s) with others			-0.076	(0.041)	-0.035	(0.041)
Sole parent			-0.495 ***	(0.107)	-0.439 ***	(0.107)
Mother's labour force status (ref. Employed full-time)						
Employed part-time			-0.022	(0.044)	-0.021	(0.045)
Unemployed			-0.190 *	(0.085)	-0.126	(0.081)
Not in the labour force			-0.060	(0.052)	-0.007	(0.051)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)						
Medium deprivation			-0.036	(0.038)	-0.037	(0.038)
High deprivation			-0.200 ***	(0.052)	-0.141 **	(0.049)
Mother's antenatal smoking (ref. Did not smoke)						
Smoked			-0.170 *	(0.072)	-0.107	(0.066)
Mother's antenatal alcohol consumption (ref. No alcohol)						
Drank alcohol			-0.025	(0.035)	-0.005	(0.036)
Mother's folate intake in first trimester (ref. Took folate)						
No folate			-0.102	(0.056)	-0.060	(0.053)
Mother's antenatal depression (ref. Not depressed)						
Depressed			0.074	(0.055)	0.119 *	(0.056)
Mother's antenatal anxiety (ref. No anxiety)						
Anxious			-0.059	(0.085)	-0.062	(0.087)
Child's sex (ref. Male)						
Female			0.088 **	(0.031)	0.065 *	(0.032)
Child's gestational age (ref. Term)						
Preterm			-0.054	(0.083)	-0.089	(0.092)
Child's birth weight status (ref. Not low)						
Low birth weight			-0.249 *	(0.101)	-0.189	(0.103)
Child's care arrangement at 9 months (ref. Early childhood education)						
Parental or informal care					0.013	(0.043)
Mother's language used with baby at 9 months (ref. English)						
Non-English language					-0.141 *	(0.063)
Number of children's book in home at 9 months (ref. Five or fewer)						
6 to 20 books					0.092	(0.068)
21 or more books					0.188 **	(0.070)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)						
Once a day					0.053	(0.067)
More than once a day					0.041	(0.059)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)						
Once a day					-0.108 *	(0.044)
More than once a day					-0.080	(0.042)
Mother's frequency of reading books at 9 months (ref. Less than once a day)						
Once a day					-0.014	(0.036)
More than once a day					-0.020	(0.053)
Mother's frequency of reading books at 2 years (ref. Less than once a day)						
Once a day					0.002	(0.056)
More than once a day					0.093	(0.081)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)						
Once a day					-0.016	(0.042)
More than once a day					0.088	(0.052)
Mother's warm parenting at 4.5 years (ref. Medium)						
Low warm parenting					-0.003	(0.043)
High warm parenting					-0.135 ***	(0.041)
Mother's hostile parenting at 4.5 years (ref. Medium)						
Low hostile parenting					0.023	(0.040)
High hostile parenting					-0.007	(0.038)
Mother's diffident parenting at 4.5 years (ref. Medium)						
Low diffident parenting					0.053	(0.039)
High diffident parenting					-0.104 **	(0.040)
Inverse Mills ratio	-1.096 *	(0.533)	1.004	(1.539)	-1.598	(1.518)
Constant	-0.295	(0.200)	-0.599	(0.412)	-0.039	(0.439)
R^2	0.062		0.096		0.118	
Number of observations	3,739		3,739		3,739	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Notes: S.E. = standard error.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 11: *Aim 1 ethnic-specific linear regression results - vocabulary skills*

Variable	Children of Māori mothers						Children of Pacific mothers						Children of Asian mothers					
	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)																		
Secondary school qualification	0.192	(0.155)	0.029	(0.181)	-0.066	(0.189)	0.104	(0.180)	0.113	(0.201)	0.107	(0.220)	1.283	(0.720)	1.387	(0.874)	1.202	(0.887)
Diploma or Trade certificate	0.032	(0.157)	-0.130	(0.191)	-0.181	(0.189)	0.346	(0.191)	0.278	(0.210)	0.226	(0.227)	1.149	(0.720)	1.240	(0.882)	1.058	(0.890)
Bachelor's degree	-0.154	(0.235)	-0.494	(0.332)	-0.345	(0.256)	0.312	(0.274)	0.173	(0.329)	0.047	(0.303)	1.396	(0.730)	1.400	(0.924)	1.205	(0.907)
Higher degree	0.089	(0.275)	-0.019	(0.297)	0.180	(0.258)	0.919 **	(0.332)	0.717	(0.368)	0.646	(0.344)	1.491 *	(0.730)	1.518	(0.898)	1.325	(0.887)
Mother's age (ref. Less than 25 years)																		
25 to 29 years			-0.264	(0.184)	-0.310	(0.181)			0.017	(0.188)	-0.092	(0.200)			-0.017	(0.241)	-0.056	(0.228)
30 to 33 years			-0.185	(0.246)	-0.142	(0.217)			-0.173	(0.247)	-0.188	(0.253)			-0.070	(0.300)	-0.108	(0.250)
34 years or older			-0.434	(0.274)	-0.352	(0.237)			-0.054	(0.250)	-0.167	(0.261)			0.097	(0.345)	-0.007	(0.295)
Mother's native/migrant status (ref. Born in New Zealand)[a]																		
Migrated to New Zealand up to age 18			n/a	n/a	n/a	n/a			-0.110	(0.160)	-0.052	(0.173)			-0.160	(0.259)	-0.075	(0.245)
Migrated to New Zealand after age 18			n/a	n/a	n/a	n/a			-0.158	(0.272)	-0.028	(0.312)			-0.007	(0.440)	0.177	(0.393)
Mother's parity (ref. First-born)																		
Subsequent-born			-0.012	(0.120)	-0.053	(0.123)			-0.101	(0.130)	-0.088	(0.144)			-0.033	(0.111)	-0.138	(0.123)
Mother's rurality (ref. Urban)																		
Rural			-0.002	(0.207)	-0.001	(0.199)			-0.514	(0.497)	-0.616	(0.504)			-0.038	(0.596)	-0.077	(0.613)
Mother's household type (ref. Two parents)																		
Parent(s) with others			0.035	(0.102)	0.018	(0.103)			-0.015	(0.118)	-0.004	(0.122)			-0.023	(0.101)	0.047	(0.103)
Sole parent			0.067	(0.203)	0.104	(0.208)			-0.264	(0.244)	-0.265	(0.253)			-0.816	(0.503)	-0.945	(0.506)
Mother's labour force status (ref. Employed full-time)																		
Employed part-time			0.091	(0.139)	0.164	(0.148)			0.112	(0.189)	0.061	(0.193)			-0.089	(0.149)	-0.067	(0.152)
Unemployed			0.263	(0.214)	0.210	(0.199)			0.095	(0.207)	0.088	(0.206)			-0.169	(0.237)	-0.185	(0.220)
Not in the labour force			0.229	(0.147)	0.206	(0.143)			-0.033	(0.157)	-0.055	(0.155)			-0.075	(0.148)	-0.062	(0.143)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)																		
Medium deprivation			-0.275	(0.151)	-0.278	(0.155)			-0.150	(0.253)	-0.137	(0.260)			-0.070	(0.123)	-0.050	(0.123)
High deprivation			-0.139	(0.164)	-0.142	(0.161)			-0.593 *	(0.239)	-0.519 *	(0.246)			-0.100	(0.152)	-0.095	(0.145)
Mother's antenatal smoking (ref. Did not smoke)																		
Smoked			0.111	(0.137)	0.058	(0.122)			-0.144	(0.167)	-0.102	(0.163)			1.233	(0.875)	1.322	(0.875)
Mother's antenatal alcohol consumption (ref. No alcohol)																		
Drank alcohol			-0.091	(0.096)	-0.053	(0.099)			-0.011	(0.130)	-0.037	(0.137)			0.022	(0.168)	-0.010	(0.174)
Mother's folate intake in first trimester (ref. Took folate)																		
No folate			-0.068	(0.130)	-0.161	(0.112)			-0.123	(0.121)	-0.113	(0.118)			-0.192	(0.147)	-0.142	(0.136)
Mother's antenatal depression (ref. Not depressed)																		
Depressed			0.091	(0.129)	0.152	(0.135)			-0.041	(0.124)	0.023	(0.130)			-0.057	(0.159)	-0.011	(0.167)
Mother's antenatal anxiety (ref. No anxiety)																		
Anxious			-0.036	(0.243)	-0.172	(0.255)			-0.062	(0.360)	-0.116	(0.370)			0.256	(0.365)	0.080	(0.372)
Child's sex (ref. Male)																		
Female			0.068	(0.089)	0.036	(0.095)			0.010	(0.103)	0.010	(0.107)			0.135	(0.091)	0.075	(0.096)
Child's gestational age (ref. Term)																		
Preterm			-0.320	(0.291)	-0.646 *	(0.313)			0.171	(0.283)	0.246	(0.308)			0.032	(0.235)	-0.001	(0.268)
Child's birth weight status (ref. Not low)																		
Low birth weight			0.062	(0.346)	0.115	(0.354)			-0.665	(0.345)	-0.698	(0.356)			-0.137	(0.235)	-0.114	(0.252)
Child's care arrangement at 9 months (ref. Early childhood education)																		
Parental or informal care					-0.134	(0.113)					-0.077	(0.186)					-0.028	(0.158)
Mother's language used with baby at 9 months (ref. English)																		
Non-English language					-0.362	(0.211)					-0.097	(0.135)					0.013	(0.124)
Number of children's book in home at 9 months (ref. Five or fewer)																		
6 to 20 books					-0.184	(0.172)					0.129	(0.158)					0.128	(0.145)
21 or more books					-0.008	(0.172)					0.248	(0.164)					0.273	(0.166)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)																		
Once a day					0.243	(0.178)					-0.011	(0.198)					0.115	(0.183)
More than once a day					0.120	(0.155)					-0.276	(0.143)					0.025	(0.143)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)																		
Once a day					-0.084	(0.150)					-0.238	(0.173)					-0.323 *	(0.140)
More than once a day					-0.173	(0.126)					-0.246	(0.150)					-0.110	(0.125)
Mother's frequency of reading books at 9 months (ref. Less than once a day)																		
Once a day					-0.113	(0.109)					0.018	(0.123)					0.063	(0.110)
More than once a day					-0.100	(0.165)					0.043	(0.169)					0.008	(0.178)
Mother's frequency of reading books at 2 years (ref. Less than once a day)																		
Once a day					-0.074	(0.145)					0.029	(0.148)					-0.033	(0.152)
More than once a day					-0.290	(0.222)					0.248	(0.242)					0.134	(0.245)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)																		
Once a day					0.059	(0.116)					-0.043	(0.136)					-0.073	(0.113)
More than once a day					0.166	(0.187)					0.133	(0.199)					0.299	(0.172)
Mother's warm parenting at 4.5 years (ref. Medium)																		
Low warm parenting					-0.073	(0.122)					0.136	(0.144)					-0.096	(0.142)
High warm parenting					0.066	(0.118)					0.015	(0.132)					-0.054	(0.111)
Mother's hostile parenting at 4.5 years (ref. Medium)																		
Low hostile parenting					-0.045	(0.137)					-0.136	(0.164)					0.039	(0.119)
High hostile parenting					0.115	(0.108)					-0.029	(0.133)					0.141	(0.118)
Mother's diffident parenting at 4.5 years (ref. Medium)																		
Low diffident parenting					0.097	(0.121)					-0.045	(0.145)					-0.004	(0.120)
High diffident parenting					0.080	(0.116)					-0.206	(0.137)					-0.161	(0.114)
Inverse Mills ratio	-6.005 ***	(1.384)	-11.792 **	(4.509)	-11.205 **	(4.077)	-0.442	(1.461)	-0.542	(4.771)	0.276	(4.848)	-1.897	(1.352)	-3.018	(5.015)	-3.296	(4.442)
Constant	1.284 **	(0.492)	3.536 *	(1.464)	3.216 *	(1.344)	-0.847	(0.542)	0.027	(1.642)	-0.006	(1.636)	-0.867	(0.842)	-0.364	(1.726)	-0.369	(1.536)
R^2	0.078		0.132		0.181		0.049		0.147		0.218		0.042		0.093		0.153	
Number of observations	459		459		459		345		345		345		503		503		503	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$

Notes: S.E. = standard error. [a] Mother's native/migrant status was not included in the Māori-specific analysis due to too few Māori mothers being born overseas.

Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 12: *Aim 1 ethnic-specific linear regression results - reading skills*

Variable	Children of Māori mothers						Children of Pacific mothers						Children of Asian mothers					
	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)																		
Secondary school qualification	0.364	(0.193)	0.425	(0.224)	0.267	(0.233)	0.584 *	(0.261)	0.420	(0.286)	0.508	(0.315)	1.303	(0.930)	0.897	(0.954)	0.935	(0.976)
Diploma or Trade certificate	0.294	(0.194)	0.363	(0.236)	0.212	(0.234)	0.555 *	(0.275)	0.344	(0.300)	0.480	(0.327)	1.192	(0.931)	0.823	(0.955)	0.915	(0.975)
Bachelor's degree	0.175	(0.290)	0.234	(0.407)	-0.023	(0.316)	0.606	(0.386)	0.499	(0.456)	0.504	(0.431)	1.468	(0.940)	1.113	(0.986)	1.103	(0.988)
Higher degree	0.260	(0.339)	0.333	(0.363)	0.225	(0.312)	1.406 **	(0.461)	1.147 *	(0.508)	1.297 **	(0.480)	1.367	(0.940)	0.977	(0.967)	1.037	(0.972)
Mother's age (ref. Less than 25 years)																		
25 to 29 years			0.137	(0.227)	0.023	(0.220)			-0.146	(0.259)	-0.015	(0.272)			-0.045	(0.224)	-0.135	(0.215)
30 to 33 years			0.359	(0.302)	0.154	(0.265)			-0.405	(0.339)	-0.409	(0.346)			-0.036	(0.277)	-0.159	(0.235)
34 years or older			0.081	(0.337)	-0.071	(0.291)			-0.235	(0.343)	-0.169	(0.355)			0.050	(0.318)	-0.084	(0.277)
Mother's native/migrant status (ref. Born in New Zealand)[a]																		
Migrated to New Zealand up to age 18			n/a	n/a	n/a	n/a			0.100	(0.221)	0.158	(0.239)			-0.118	(0.246)	-0.021	(0.237)
Migrated to New Zealand after age 18			n/a	n/a	n/a	n/a			-0.007	(0.373)	0.100	(0.427)			-0.091	(0.407)	0.169	(0.372)
Mother's parity (ref. First-born)																		
Subsequent-born			-0.310 *	(0.150)	-0.330 *	(0.152)			-0.173	(0.178)	-0.135	(0.199)			0.102	(0.102)	0.142	(0.116)
Mother's rurality (ref. Urban)																		
Rural			0.357	(0.253)	0.266	(0.240)			-0.424	(0.669)	-0.224	(0.677)			-0.938	(0.541)	-0.963	(0.563)
Mother's household type (ref. Two parents)																		
Parent(s) with others			-0.188	(0.128)	-0.208	(0.126)			-0.383 *	(0.163)	-0.406 *	(0.168)			0.086	(0.094)	0.110	(0.096)
Sole parent			-0.253	(0.243)	-0.238	(0.247)			-0.821 *	(0.354)	-0.849 *	(0.367)			-0.545	(0.678)	-0.696	(0.695)
Mother's labour force status (ref. Employed full-time)																		
Employed part-time			0.140	(0.171)	0.098	(0.180)			-0.071	(0.262)	-0.153	(0.265)			0.347 *	(0.139)	0.346 *	(0.143)
Unemployed			-0.365	(0.262)	-0.330	(0.242)			-0.228	(0.285)	-0.247	(0.286)			-0.208	(0.221)	-0.130	(0.208)
Not in the labour force			0.068	(0.180)	0.051	(0.175)			-0.292	(0.218)	-0.239	(0.216)			0.019	(0.137)	0.101	(0.133)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)																		
Medium deprivation			-0.219	(0.185)	-0.266	(0.189)			-0.528	(0.350)	-0.478	(0.358)			-0.082	(0.114)	-0.112	(0.116)
High deprivation			-0.275	(0.202)	-0.225	(0.197)			-0.317	(0.333)	-0.288	(0.339)			-0.345 *	(0.140)	-0.360 **	(0.135)
Mother's antenatal smoking (ref. Did not smoke)																		
Smoked			0.130	(0.170)	0.192	(0.149)			-0.718 **	(0.229)	-0.837 ***	(0.224)			1.132	(0.940)	1.055	(0.951)
Mother's antenatal alcohol consumption (ref. No alcohol)																		
Drank alcohol			-0.137	(0.117)	-0.086	(0.120)			-0.152	(0.182)	-0.210	(0.190)			-0.069	(0.157)	-0.025	(0.163)
Mother's folate intake in first trimester (ref. Took folate)																		
No folate			-0.004	(0.161)	0.018	(0.137)			0.005	(0.168)	0.150	(0.163)			-0.145	(0.137)	-0.117	(0.129)
Mother's antenatal depression (ref. Not depressed)																		
Depressed			-0.194	(0.158)	-0.175	(0.162)			-0.221	(0.171)	-0.286	(0.179)			0.098	(0.148)	0.153	(0.158)
Mother's antenatal anxiety (ref. No anxiety)																		
Anxious			0.338	(0.288)	0.409	(0.300)			0.442	(0.519)	0.530	(0.537)			0.110	(0.332)	0.170	(0.341)
Child's sex (ref. Male)																		
Female			0.101	(0.110)	0.124	(0.116)			0.347 *	(0.143)	0.324 *	(0.149)			0.169 *	(0.085)	0.116	(0.090)
Child's gestational age (ref. Term)																		
Preterm			0.128	(0.380)	0.200	(0.397)			0.050	(0.380)	0.079	(0.409)			-0.315	(0.220)	-0.350	(0.252)
Child's birth weight status (ref. Not low)																		
Low birth weight			-0.440	(0.423)	-0.539	(0.429)			-0.326	(0.474)	-0.313	(0.482)			0.181	(0.223)	0.278	(0.239)
Child's care arrangement at 9 months (ref. Early childhood education)																		
Parental or informal care					0.121	(0.137)					0.140	(0.253)					0.153	(0.148)
Mother's language used with baby at 9 months (ref. English)																		
Non-English language					-0.183	(0.259)					-0.541 **	(0.184)					0.042	(0.117)
Number of children's book in home at 9 months (ref. Five or fewer)																		
6 to 20 books					-0.356	(0.207)					0.055	(0.218)					-0.156	(0.137)
21 or more books					-0.099	(0.207)					0.136	(0.226)					-0.149	(0.156)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)																		
Once a day					0.033	(0.219)					-0.054	(0.269)					0.103	(0.172)
More than once a day					0.282	(0.191)					-0.047	(0.198)					0.041	(0.136)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)																		
Once a day					0.024	(0.180)					-0.148	(0.239)					-0.205	(0.130)
More than once a day					-0.010	(0.151)					0.254	(0.205)					0.068	(0.116)
Mother's frequency of reading books at 9 months (ref. Less than once a day)																		
Once a day					0.153	(0.132)					-0.023	(0.172)					0.032	(0.103)
More than once a day					0.085	(0.200)					-0.007	(0.232)					-0.133	(0.169)
Mother's frequency of reading books at 2 years (ref. Less than once a day)																		
Once a day					0.042	(0.177)					0.189	(0.204)					-0.095	(0.143)
More than once a day					0.295	(0.269)					0.420	(0.334)					-0.071	(0.230)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)																		
Once a day					0.015	(0.138)					0.245	(0.188)					-0.056	(0.106)
More than once a day					0.069	(0.222)					0.025	(0.281)					0.288	(0.161)
Mother's warm parenting at 4.5 years (ref. Medium)																		
Low warm parenting					0.361 *	(0.149)					0.348	(0.197)					0.154	(0.135)
High warm parenting					0.299 *	(0.144)					0.409 *	(0.184)					0.007	(0.104)
Mother's hostile parenting at 4.5 years (ref. Medium)																		
Low hostile parenting					-0.115	(0.164)					0.181	(0.229)					0.125	(0.111)
High hostile parenting					-0.136	(0.132)					0.174	(0.183)					0.040	(0.110)
Mother's diffident parenting at 4.5 years (ref. Medium)																		
Low diffident parenting					0.269	(0.146)					-0.083	(0.201)					-0.090	(0.112)
High diffident parenting					0.153	(0.143)					0.100	(0.190)					-0.196	(0.107)
Inverse Mills ratio	-1.057	(1.701)	1.146	(5.522)	-1.445	(5.014)	0.169	(2.007)	1.748	(6.521)	3.301	(6.638)	-0.703	(1.264)	0.731	(4.599)	-2.719	(4.163)
Constant	-0.323	(0.605)	-0.673	(1.791)	-0.110	(1.655)	-0.585	(0.752)	0.080	(2.240)	-1.304	(2.244)	-0.816	(1.028)	-0.754	(1.655)	-0.114	(1.531)
R^2	0.015		0.092		0.168		0.039		0.160		0.241		0.025		0.098		0.146	
Number of observations	427		427		427		322		322		322		480		480		480	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$

Notes: [a] Mother's native/migrant status was not included in the Māori-specific analysis due to too few Māori mothers being born overseas. S.E. = standard error.

Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 13: *Aim 1 ethnic-specific linear regression results – global cognitive skills*

Variable	Children of Māori mothers						Children of Pacific mothers						Children of Asian mothers Model 3					
	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)																		
Secondary school qualification	0.563 ***	(0.169)	0.460 *	(0.200)	0.381	(0.211)	0.377	(0.231)	0.368	(0.252)	0.407	(0.279)	0.886	(1.032)	0.338	(1.056)	0.262	(1.079)
Diploma or Trade certificate	0.488 **	(0.169)	0.347	(0.210)	0.292	(0.212)	0.542 *	(0.243)	0.416	(0.264)	0.371	(0.288)	0.812	(1.033)	0.289	(1.057)	0.276	(1.077)
Bachelor's degree	0.581 *	(0.251)	0.221	(0.361)	0.213	(0.287)	0.418	(0.339)	0.369	(0.399)	0.350	(0.378)	1.176	(1.044)	0.481	(1.092)	0.510	(1.092)
Higher degree	0.696 *	(0.292)	0.461	(0.320)	0.484	(0.278)	1.202 **	(0.404)	1.115 *	(0.445)	1.139 **	(0.423)	1.125	(1.042)	0.520	(1.070)	0.549	(1.075)
Mother's age (ref. Less than 25 years)																		
25 to 29 years			-0.017	(0.201)	-0.067	(0.198)			-0.223	(0.226)	-0.237	(0.239)			-0.261	(0.251)	-0.169	(0.242)
30 to 33 years			-0.031	(0.268)	-0.054	(0.240)			-0.389	(0.295)	-0.430	(0.303)			-0.397	(0.311)	-0.275	(0.264)
34 years or older			-0.158	(0.297)	-0.151	(0.262)			-0.396	(0.298)	-0.439	(0.312)			-0.347	(0.356)	-0.243	(0.311)
Mother's native/migrant status (ref. Born in New Zealand)[a]																		
Migrated to New Zealand up to age 18			n/a	n/a	n/a	n/a			-0.058	(0.192)	0.060	(0.210)			0.072	(0.273)	0.096	(0.262)
Migrated to New Zealand after age 18			n/a	n/a	n/a	n/a			0.030	(0.326)	0.353	(0.374)			0.385	(0.455)	0.395	(0.415)
Mother's parity (ref. First-born)																		
Subsequent-born			-0.013	(0.133)	-0.055	(0.135)			0.022	(0.155)	-0.036	(0.175)			0.121	(0.113)	-0.093	(0.129)
Mother's rurality (ref. Urban)																		
Rural			-0.165	(0.224)	-0.179	(0.213)			0.265	(0.578)	0.194	(0.591)			-0.419	(0.598)	-0.346	(0.622)
Mother's household type (ref. Two parents)																		
Parent(s) with others			-0.095	(0.112)	-0.092	(0.113)			-0.257	(0.142)	-0.291	(0.148)			0.119	(0.105)	0.153	(0.108)
Sole parent			-0.101	(0.213)	-0.034	(0.220)			-1.083 ***	(0.323)	-1.120 **	(0.338)			-1.305	(0.750)	-1.303	(0.769)
Mother's labour force status (ref. Employed full-time)																		
Employed part-time			0.195	(0.150)	0.246	(0.160)			0.230	(0.226)	0.240	(0.233)			0.127	(0.155)	0.179	(0.159)
Unemployed			0.214	(0.231)	0.209	(0.219)			-0.068	(0.248)	-0.135	(0.251)			-0.188	(0.247)	-0.259	(0.233)
Not in the labour force			0.187	(0.160)	0.178	(0.159)			-0.150	(0.190)	-0.069	(0.191)			-0.017	(0.153)	-0.005	(0.149)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)																		
Medium deprivation			-0.167	(0.165)	-0.187	(0.170)			-0.385	(0.302)	-0.472	(0.314)			-0.212	(0.127)	-0.159	(0.129)
High deprivation			-0.227	(0.180)	-0.241	(0.177)			-0.398	(0.288)	-0.425	(0.296)			-0.361 *	(0.157)	-0.375 *	(0.150)
Mother's antenatal smoking (ref. Did not smoke)																		
Smoked			-0.021	(0.151)	-0.002	(0.133)			-0.535 **	(0.205)	-0.525 **	(0.202)			1.741	(1.039)	1.510	(1.050)
Mother's antenatal alcohol consumption (ref. No alcohol)																		
Drank alcohol			-0.044	(0.104)	-0.003	(0.108)			-0.042	(0.159)	-0.076	(0.171)			0.036	(0.174)	0.000	(0.181)
Mother's folate intake in first trimester (ref. Took folate)																		
No folate			0.192	(0.142)	0.181	(0.122)			0.031	(0.146)	0.105	(0.144)			-0.129	(0.154)	-0.137	(0.145)
Mother's antenatal depression (ref. Not depressed)																		
Depressed			-0.053	(0.138)	0.031	(0.144)			0.057	(0.151)	0.118	(0.161)			0.146	(0.169)	0.151	(0.180)
Mother's antenatal anxiety (ref. No anxiety)																		
Anxious			0.306	(0.249)	0.356	(0.263)			0.070	(0.448)	-0.055	(0.469)			-0.132	(0.367)	-0.294	(0.377)
Child's sex (ref. Male)																		
Female			0.095	(0.097)	0.105	(0.105)			0.070	(0.125)	0.043	(0.132)			0.229 *	(0.095)	0.173	(0.101)
Child's gestational age (ref. Term)																		
Preterm			-0.092	(0.329)	-0.179	(0.349)			-0.013	(0.345)	-0.034	(0.377)			-0.287	(0.243)	-0.240	(0.279)
Child's birth weight status (ref. Not low)																		
Low birth weight			-0.031	(0.367)	-0.110	(0.376)			-1.032 *	(0.411)	-1.122 **	(0.426)			-0.005	(0.247)	-0.035	(0.265)
Child's care arrangement at 9 months (ref. Early childhood education)																		
Parental or informal care					-0.229	(0.123)					-0.102	(0.226)					0.050	(0.165)
Mother's language used with baby at 9 months (ref. English)																		
Non-English language					-0.202	(0.227)					-0.442 **	(0.163)					-0.057	(0.129)
Number of children's book in home at 9 months (ref. Five or fewer)																		
6 to 20 books					-0.108	(0.186)					-0.053	(0.197)					0.171	(0.153)
21 or more books					0.120	(0.186)					0.220	(0.203)					0.345 *	(0.175)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)																		
Once a day					0.213	(0.197)					0.184	(0.237)					0.169	(0.192)
More than once a day					-0.026	(0.168)					-0.060	(0.177)					0.170	(0.153)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)																		
Once a day					-0.035	(0.161)					-0.387	(0.213)					-0.297 *	(0.145)
More than once a day					-0.041	(0.137)					-0.204	(0.185)					-0.059	(0.129)
Mother's frequency of reading books at 9 months (ref. Less than once a day)																		
Once a day					-0.039	(0.118)					-0.063	(0.154)					0.037	(0.115)
More than once a day					0.202	(0.181)					0.076	(0.203)					-0.019	(0.189)
Mother's frequency of reading books at 2 years (ref. Less than once a day)																		
Once a day					-0.093	(0.159)					-0.022	(0.182)					-0.160	(0.159)
More than once a day					-0.006	(0.243)					0.068	(0.293)					-0.205	(0.255)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)																		
Once a day					-0.006	(0.126)					0.080	(0.167)					-0.126	(0.118)
More than once a day					0.177	(0.195)					-0.245	(0.248)					0.229	(0.178)
Mother's warm parenting at 4.5 years (ref. Medium)																		
Low warm parenting					-0.012	(0.134)					-0.117	(0.175)					-0.022	(0.150)
High warm parenting					-0.046	(0.131)					-0.109	(0.163)					-0.106	(0.117)
Mother's hostile parenting at 4.5 years (ref. Medium)																		
Low hostile parenting					0.108	(0.148)					-0.094	(0.203)					-0.013	(0.124)
High hostile parenting					0.027	(0.117)					0.028	(0.163)					0.078	(0.123)
Mother's diffident parenting at 4.5 years (ref. Medium)																		
Low diffident parenting					0.187	(0.130)					-0.034	(0.178)					0.012	(0.125)
High diffident parenting					0.009	(0.127)					-0.169	(0.168)					-0.169	(0.119)
Inverse Mills ratio	-1.573	(1.479)	-6.098	(4.865)	-5.616	(4.511)	-1.232	(1.769)	-2.616	(5.701)	-1.953	(5.813)	-1.902	(1.419)	-5.840	(5.144)	-3.844	(4.659)
Constant	-0.298	(0.525)	1.349	(1.581)	1.087	(1.499)	-0.400	(0.664)	1.075	(1.956)	1.269	(1.964)	-0.330	(1.143)	1.529	(1.844)	0.755	(1.703)
R^2	0.063		0.113		0.176		0.056		0.186		0.249		0.051		0.130		0.178	
Number of observations	407		407		407		313		313		313		470		470		470	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$

Notes: [a] Mother's native/migrant status was not included in the Māori-specific analysis due to too few Māori mothers being born overseas. S.E. = standard error.

Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 14: *Aim 1 sensitivity analysis linear regression results – vocabulary skills*

Variable	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)						
Secondary school qualification	0.067	(0.111)	0.090	(0.130)	0.020	(0.115)
Diploma or Trade certificate	0.062	(0.113)	0.124	(0.128)	0.041	(0.112)
Bachelor's degree	0.027	(0.133)	0.248	(0.168)	0.101	(0.120)
Higher degree	0.321 *	(0.131)	0.430 **	(0.145)	0.285 *	(0.117)
Father's educational attainment (ref. No qualification)						
Secondary school qualification			0.221 **	(0.080)	0.156	(0.080)
Diploma or Trade certificate			0.176 *	(0.077)	0.143	(0.075)
Bachelor's degree			0.312 ***	(0.090)	0.229 **	(0.085)
Higher degree			0.336 ***	(0.087)	0.250 **	(0.085)
Mother's age (ref. Less than 25 years)						
25 to 29 years			0.040	(0.099)	-0.055	(0.070)
30 to 33 years			0.074	(0.124)	-0.036	(0.073)
34 years or older			0.127	(0.148)	-0.014	(0.082)
Mother's ethnicity (ref. European)						
Māori			-0.272	(0.154)	-0.086	(0.084)
Pacific			-0.624 **	(0.204)	-0.323 **	(0.111)
Asian			-0.222	(0.116)	0.036	(0.076)
Other ethnicity			-0.204	(0.145)	-0.092	(0.099)
Mother's native/migrant status (ref. Born in New Zealand)						
Migrated to New Zealand up to age 18			0.085	(0.099)	0.166 *	(0.076)
Migrated to New Zealand after age 18			-0.012	(0.193)	0.219 *	(0.106)
Mother's parity (ref. First-born)						
Subsequent-born			-0.072	(0.051)	-0.034	(0.046)
Mother's rurality (ref. Urban)						
Rural			0.069	(0.065)	0.030	(0.062)
Mother's labour force status (ref. Employed full-time)						
Employed part-time			-0.027	(0.048)	-0.006	(0.048)
Unemployed			-0.031	(0.098)	-0.023	(0.084)
Not in the labour force			-0.150 *	(0.060)	-0.119 *	(0.050)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)						
Medium deprivation			-0.010	(0.046)	-0.019	(0.042)
High deprivation			-0.097	(0.050)	-0.073	(0.047)
Mother's antenatal smoking (ref. Did not smoke)						
Smoked			0.036	(0.094)	0.062	(0.079)
Mother's antenatal alcohol consumption (ref. No alcohol)						
Drank alcohol			-0.042	(0.038)	-0.012	(0.038)
Mother's folate intake in first trimester (ref. Took folate)						
No folate			-0.144 *	(0.064)	-0.087	(0.062)
Mother's antenatal depression (ref. Not depressed)						
Depressed			0.022	(0.070)	0.091	(0.066)
Mother's antenatal anxiety (ref. No anxiety)						
Anxious			-0.067	(0.097)	-0.059	(0.095)
Child's sex (ref. Male)						
Female			0.022	(0.034)	0.016	(0.034)
Child's gestational age (ref. Term)						
Preterm			0.031	(0.091)	-0.039	(0.094)
Child's birth weight status (ref. Not low)						
Low birth weight			-0.116	(0.110)	-0.092	(0.100)
Child's care arrangement at 9 months (ref. Early childhood education)						
Parental or informal care					0.038	(0.044)
Mother's language used with baby at 9 months (ref. English)						
Non-English language					-0.118	(0.072)
Number of children's book in home at 9 months (ref. Five or fewer)						
6 to 20 books					0.284 ***	(0.073)
21 or more books					0.315 ***	(0.077)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)						
Once a day					-0.008	(0.064)
More than once a day					-0.069	(0.068)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)						
Once a day					-0.157 ***	(0.045)
More than once a day					-0.098 *	(0.045)
Mother's frequency of reading books at 9 months (ref. Less than once a day)						
Once a day					0.003	(0.039)
More than once a day					0.008	(0.051)
Mother's frequency of reading books at 2 years (ref. Less than once a day)						
Once a day					0.039	(0.049)
More than once a day					0.158 **	(0.056)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)						
Once a day					0.037	(0.046)
More than once a day					0.273 ***	(0.055)
Mother's warm parenting at 4.5 years (ref. Medium)						
Low warm parenting					0.014	(0.039)
High warm parenting					-0.047	(0.045)
Mother's hostile parenting at 4.5 years (ref. Medium)						
Low hostile parenting					-0.004	(0.043)
High hostile parenting					-0.001	(0.040)
Mother's diffident parenting at 4.5 years (ref. Medium)						
Low diffident parenting					0.008	(0.041)
High diffident parenting					-0.029	(0.042)
Inverse Mills ratio	-4.653 ***	(0.614)	-0.310	(1.902)	-1.873	(1.026)
Constant	1.186 ***	(0.234)	-0.119	(0.505)	-0.098	(0.315)
R^2	0.079		0.133		0.175	
Number of observations	2,994		2,994		2,994	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Notes: The variable 'Mother's household type' is not included as there were too few sole-parent mothers in the sample when father's educational attainment is included.
S.E. = standard error.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 15: *Aim 1 sensitivity analysis linear regression results – reading skills*

Variable	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)						
Secondary school qualification	0.446 ***	(0.121)	0.396 **	(0.142)	0.290 *	(0.128)
Diploma or Trade certificate	0.464 ***	(0.124)	0.392 **	(0.140)	0.278 *	(0.126)
Bachelor's degree	0.664 ***	(0.144)	0.545 **	(0.181)	0.326 *	(0.134)
Higher degree	0.804 ***	(0.141)	0.610 ***	(0.157)	0.437 ***	(0.131)
Father's educational attainment (ref. No qualification)						
Secondary school qualification			0.314 ***	(0.087)	0.278 **	(0.088)
Diploma or Trade certificate			0.170 *	(0.083)	0.167 *	(0.082)
Bachelor's degree			0.422 ***	(0.096)	0.352 ***	(0.093)
Higher degree			0.428 ***	(0.093)	0.365 ***	(0.093)
Mother's age (ref. Less than 25 years)						
25 to 29 years			0.059	(0.105)	-0.060	(0.076)
30 to 33 years			0.121	(0.131)	-0.050	(0.079)
34 years or older			0.167	(0.156)	-0.053	(0.089)
Mother's ethnicity (ref. European)						
Māori			-0.324 *	(0.164)	-0.058	(0.091)
Pacific			-0.012	(0.219)	0.353 **	(0.121)
Asian			0.164	(0.122)	0.453 ***	(0.082)
Other ethnicity			-0.083	(0.153)	0.127	(0.105)
Mother's native/migrant status (ref. Born in New Zealand)						
Migrated to New Zealand up to age 18			-0.036	(0.106)	0.087	(0.082)
Migrated to New Zealand after age 18			-0.243	(0.205)	0.066	(0.114)
Mother's parity (ref. First-born)						
Subsequent-born			-0.099	(0.054)	-0.048	(0.049)
Mother's rurality (ref. Urban)						
Rural			-0.059	(0.069)	-0.096	(0.066)
Mother's labour force status (ref. Employed full-time)						
Employed part-time			-0.032	(0.051)	-0.036	(0.052)
Unemployed			-0.112	(0.105)	-0.064	(0.091)
Not in the labour force			-0.046	(0.064)	-0.008	(0.054)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)						
Medium deprivation			0.008	(0.049)	-0.014	(0.045)
High deprivation			-0.172 **	(0.053)	-0.131 *	(0.051)
Mother's antenatal smoking (ref. Did not smoke)						
Smoked			0.023	(0.101)	0.099	(0.086)
Mother's antenatal alcohol consumption (ref. No alcohol)						
Drank alcohol			-0.059	(0.040)	-0.059	(0.040)
Mother's folate intake in first trimester (ref. Took folate)						
No folate			-0.054	(0.068)	-0.014	(0.067)
Mother's antenatal depression (ref. Not depressed)						
Depressed			0.059	(0.075)	0.126	(0.072)
Mother's antenatal anxiety (ref. No anxiety)						
Anxious			-0.163	(0.104)	-0.121	(0.103)
Child's sex (ref. Male)						
Female			0.035	(0.036)	0.018	(0.036)
Child's gestational age (ref. Term)						
Preterm			-0.018	(0.098)	-0.039	(0.103)
Child's birth weight status (ref. Not low)						
Low birth weight			-0.139	(0.117)	-0.072	(0.108)
Child's care arrangement at 9 months (ref. Early childhood education)						
Parental or informal care					0.087	(0.048)
Mother's language used with baby at 9 months (ref. English)						
Non-English language					-0.136	(0.077)
Number of children's book in home at 9 months (ref. Five or fewer)						
6 to 20 books					0.059	(0.078)
21 or more books					0.119	(0.082)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)						
Once a day					0.027	(0.069)
More than once a day					0.000	(0.074)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)						
Once a day					-0.023	(0.048)
More than once a day					-0.035	(0.048)
Mother's frequency of reading books at 9 months (ref. Less than once a day)						
Once a day					0.046	(0.042)
More than once a day					0.047	(0.055)
Mother's frequency of reading books at 2 years (ref. Less than once a day)						
Once a day					0.072	(0.053)
More than once a day					0.116	(0.060)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)						
Once a day					0.075	(0.049)
More than once a day					0.124 *	(0.059)
Mother's warm parenting at 4.5 years (ref. Medium)						
Low warm parenting					0.099 *	(0.041)
High warm parenting					0.056	(0.049)
Mother's hostile parenting at 4.5 years (ref. Medium)						
Low hostile parenting					0.025	(0.046)
High hostile parenting					-0.113 **	(0.044)
Mother's diffident parenting at 4.5 years (ref. Medium)						
Low diffident parenting					0.046	(0.044)
High diffident parenting					0.015	(0.046)
Inverse Mills ratio	0.532	(0.644)	2.499	(2.020)	-0.019	(1.106)
Constant	-0.677	(0.248)	-1.161 *	(0.536)	-0.824 *	(0.340)
R^2	0.025		0.067		0.085	
Number of observations	2,834		2,834		2,834	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Notes: The variable 'Mother's household type' is not included as there were too few sole-parent mothers in the sample when father's educational attainment is included.
S.E. = standard error.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 16: *Aim 1 sensitivity analysis linear regression results – global cognitive skills*

Variable	Model 1 (Mother's education only)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Mother's educational attainment (ref. No qualification)						
Secondary school qualification	0.350 **	(0.124)	0.330 *	(0.143)	0.195	(0.129)
Diploma or Trade certificate	0.361 **	(0.126)	0.342 *	(0.141)	0.195	(0.127)
Bachelor's degree	0.552 ***	(0.146)	0.535 **	(0.182)	0.291 *	(0.135)
Higher degree	0.730 ***	(0.143)	0.621 ***	(0.157)	0.424 **	(0.132)
Father's educational attainment (ref. No qualification)						
Secondary school qualification			0.342 ***	(0.087)	0.279 **	(0.087)
Diploma or Trade certificate			0.244 **	(0.083)	0.226 **	(0.082)
Bachelor's degree			0.510 ***	(0.097)	0.415 ***	(0.093)
Higher degree			0.557 ***	(0.093)	0.482 ***	(0.092)
Mother's age (ref. Less than 25 years)						
25 to 29 years			0.040	(0.105)	-0.101	(0.076)
30 to 33 years			0.007	(0.131)	-0.173 *	(0.079)
34 years or older			0.059	(0.156)	-0.180 *	(0.088)
Mother's ethnicity (ref. European)						
Māori			-0.102	(0.165)	0.173	(0.090)
Pacific			-0.259	(0.219)	0.155	(0.120)
Asian			0.002	(0.122)	0.269 ***	(0.081)
Other ethnicity			-0.212	(0.153)	-0.027	(0.105)
Mother's native/migrant status (ref. Born in New Zealand)						
Migrated to New Zealand up to age 18			0.066	(0.105)	0.202 *	(0.082)
Migrated to New Zealand after age 18			-0.112	(0.205)	0.244 *	(0.113)
Mother's parity (ref. First-born)						
Subsequent-born			0.038	(0.054)	0.066	(0.049)
Mother's rurality (ref. Urban)						
Rural			-0.118	(0.069)	-0.173 **	(0.066)
Mother's labour force status (ref. Employed full-time)						
Employed part-time			-0.074	(0.051)	-0.045	(0.051)
Unemployed			-0.102	(0.106)	-0.053	(0.092)
Not in the labour force			-0.137 *	(0.064)	-0.064	(0.054)
Mother's neighbourhood socioeconomic deprivation (ref. Low deprivation)						
Medium deprivation			-0.012	(0.048)	-0.044	(0.045)
High deprivation			-0.179 ***	(0.053)	-0.145 **	(0.051)
Mother's antenatal smoking (ref. Did not smoke)						
Smoked			-0.024	(0.101)	0.036	(0.086)
Mother's antenatal alcohol consumption (ref. No alcohol)						
Drank alcohol			-0.023	(0.040)	-0.007	(0.040)
Mother's folate intake in first trimester (ref. Took folate)						
No folate			-0.088	(0.068)	-0.045	(0.067)
Mother's antenatal depression (ref. Not depressed)						
Depressed			0.092	(0.075)	0.183 **	(0.071)
Mother's antenatal anxiety (ref. No anxiety)						
Anxious			-0.082	(0.102)	-0.056	(0.101)
Child's sex (ref. Male)						
Female			0.095 **	(0.036)	0.071 *	(0.036)
Child's gestational age (ref. Term)						
Preterm			-0.052	(0.097)	-0.130	(0.101)
Child's birth weight status (ref. Not low)						
Low birth weight			-0.254 *	(0.116)	-0.204	(0.106)
Child's care arrangement at 9 months (ref. Early childhood education)						
Parental or informal care					0.010	(0.047)
Mother's language used with baby at 9 months (ref. English)						
Non-English language					-0.084	(0.076)
Number of children's book in home at 9 months (ref. Five or fewer)						
6 to 20 books					0.191 *	(0.078)
21 or more books					0.242 **	(0.082)
Mother's frequency of watching children's TV at 9 months (ref. Less than once a day)						
Once a day					0.092	(0.069)
More than once a day					0.045	(0.074)
Mother's frequency of having TV on at 9 months (ref. Less than once a day)						
Once a day					-0.113 *	(0.048)
More than once a day					-0.082	(0.048)
Mother's frequency of reading books at 9 months (ref. Less than once a day)						
Once a day					-0.005	(0.042)
More than once a day					-0.014	(0.054)
Mother's frequency of reading books at 2 years (ref. Less than once a day)						
Once a day					0.008	(0.053)
More than once a day					0.113	(0.060)
Mother's frequency of reading books at 4.5 years (ref. Less than once a day)						
Once a day					0.040	(0.049)
More than once a day					0.127 *	(0.059)
Mother's warm parenting at 4.5 years (ref. Medium)						
Low warm parenting					0.056	(0.041)
High warm parenting					-0.067	(0.048)
Mother's hostile parenting at 4.5 years (ref. Medium)						
Low hostile parenting					0.001	(0.046)
High hostile parenting					-0.025	(0.043)
Mother's diffident parenting at 4.5 years (ref. Medium)						
Low diffident parenting					0.066	(0.044)
High diffident parenting					-0.093 *	(0.046)
Inverse Mills ratio	-1.250	(0.642)	1.268	(2.021)	-1.847	(1.098)
Constant	-0.089	(0.248)	-0.907	(0.536)	-0.354	(0.339)
R^2	0.049		0.091		0.115	
Number of observations	2,749		2,749		2,749	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Notes: The variable 'Mother's household type' is not included as there were too few sole-parent mothers in the sample when father's educational attainment is included. S.E. = standard error.
Source: Authors' calculations from Growing Up in New Zealand dataset

Appendix 17: *Aim 2 Kitagawa-Blinder-Oaxaca decomposition results*

	Vocabulary gap			Reading gap			Global Cognition gap		
	Portion of gap (standard deviations)	**S.E.**	**Percentage of gap (%)**	**Portion of gap (standard deviations)**	**S.E.**	**Percentage of gap (%)**	**Portion of gap (standard deviations)**	**S.E.**	**Percentage of gap (%)**
Mean test score of children of mothers with degrees (Heckman corrected)	0.621	(0.328)		0.502	(0.322)		0.722 *	(0.343)	
Mean test score of children of mothers without degrees (Heckman corrected)	0.037	(0.328)		-0.393	(0.395)		-0.137	(0.368)	
Cognitive gap (in standard deviations)	0.584	(0.464)		0.894	(0.510)		0.859	(0.503)	
Decomposition of cognitive gap:									
Mother's sociodemographic characteristics	0.167 ***	(0.023)	28.5	0.061 *	(0.025)	6.8	0.084 ***	(0.023)	9.8
Mother's lifestyle behaviours	0.026 **	(0.010)	4.4	0.015	(0.012)	1.7	0.030 *	(0.012)	3.5
Mother's mental health	-0.004	(0.004)	-0.6	0.002	(0.004)	0.2	-0.006	(0.004)	-0.7
Child's birth characteristics	0.001	(0.001)	0.1	0.000	(0.001)	0.0	0.001	(0.002)	0.1
Childcare	0.000	(0.002)	-0.1	-0.006 *	(0.003)	-0.7	0.000	(0.002)	0.0
Language at home	0.001	(0.002)	0.2	0.001	(0.001)	0.1	0.001	(0.002)	0.1
Books in home	0.017 ***	(0.005)	2.9	0.007	(0.005)	0.8	0.016 **	(0.005)	1.9
Television use	0.018 *	(0.007)	3.0	-0.004	(0.008)	-0.5	0.002	(0.007)	0.2
Book reading	0.080 ***	(0.013)	13.8	0.049 ***	(0.013)	5.5	0.047 ***	(0.013)	5.5
Parenting practices	0.012 *	(0.006)	2.1	0.011	(0.007)	1.3	0.027 ***	(0.007)	3.2
Total explained	0.317 ***	(0.032)	54.2	0.135 ***	(0.034)	15.1	0.201 ***	(0.033)	23.4
Unexplained	0.267	(0.462)	45.8	0.760	(0.505)	84.9	0.657	(0.499)	76.6

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Notes: S.E. = standard error.
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 18: *Aim 3 binary logistic regression results*

Variable	Vocabulary				Reading				Global cognition			
	Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Mother's educational attainment												
No qualification	1.00		1.00		1.00		1.00		1.00		1.00	
Secondary school qualification	1.24	(0.66, 2.34)	0.79	(0.42, 1.49)	1.55	(0.86, 2.79)	1.28	(0.71, 2.30)	1.56	(0.83, 2.94)	1.39	(0.71, 2.71)
Diploma or Trade certificate	1.67	(0.86, 3.25)	0.96	(0.51, 1.81)	1.53	(0.83, 2.84)	1.21	(0.66, 2.22)	2.12 *	(1.10, 4.11)	1.80	(0.91, 3.56)
Mother's age												
Less than 25 years	1.00		1.00		1.00		1.00		1.00		1.00	
25 to 29 years	1.54	(0.87, 2.72)	0.92	(0.54, 1.56)	1.10	(0.69, 1.76)	0.88	(0.56, 1.38)	1.14	(0.66, 1.96)	1.00	(0.60, 1.68)
30 to 33 years	1.85	(0.90, 3.80)	0.94	(0.52, 1.71)	0.99	(0.55, 1.78)	0.73	(0.44, 1.22)	1.22	(0.61, 2.44)	1.02	(0.58, 1.80)
34 years or older	2.19	(0.97, 4.93)	0.97	(0.49, 1.91)	1.16	(0.60, 2.26)	0.81	(0.45, 1.45)	1.46	(0.66, 3.21)	1.17	(0.60, 2.25)
Mother's ethnicity												
European	1.00		1.00		1.00		1.00		1.00		1.00	
Māori	0.25 **	(0.10, 0.61)	0.61	(0.29, 1.25)	0.68	(0.31, 1.49)	1.11	(0.59, 2.11)	0.74	(0.30, 1.81)	1.00	(0.49, 2.01)
Pacific	0.13 ***	(0.05, 0.39)	0.42	(0.17, 1.05)	1.27	(0.52, 3.11)	2.25 *	(1.03, 4.87)	0.57	(0.21, 1.57)	0.81	(0.35, 1.87)
Asian	0.55	(0.29, 1.04)	1.18	(0.69, 2.02)	1.98 *	(1.12, 3.50)	2.62 ***	(1.61, 4.24)	0.98	(0.52, 1.83)	1.63	(0.96, 2.79)
Other ethnicity	0.39 *	(0.16, 0.95)	0.75	(0.37, 1.52)	0.79	(0.35, 1.80)	1.13	(0.56, 2.28)	0.42	(0.16, 1.09)	0.57	(0.27, 1.24)
Mother's native/migrant status												
Born in New Zealand	1.00		1.00		1.00		1.00		1.00		1.00	
Migrated to New Zealand up to age 18	1.13	(0.68, 1.88)	1.61	(0.97, 2.69)	1.26	(0.80, 2.00)	1.60 *	(1.01, 2.55)	1.46	(0.87, 2.45)	1.65	(0.99, 2.73)
Migrated to New Zealand after age 18	0.64	(0.26, 1.59)	2.00	(0.84, 4.78)	0.73	(0.34, 1.61)	1.14	(0.51, 2.53)	0.88	(0.35, 2.19)	1.18	(0.49, 2.84)
Mother's parity												
First-born	1.00		1.00		1.00		1.00		1.00		1.00	
Subsequent-born	0.77	(0.57, 1.03)	0.85	(0.62, 1.17)	0.95	(0.72, 1.25)	0.92	(0.68, 1.23)	1.10	(0.81, 1.48)	1.07	(0.78, 1.47)
Mother's rurality												
Urban	1.00		1.00		1.00		1.00		1.00		1.00	
Rural	1.29	(0.85, 1.96)	1.02	(0.67, 1.53)	0.80	(0.52, 1.25)	0.72	(0.47, 1.12)	1.10	(0.70, 1.72)	1.04	(0.68, 1.59)
Mother's household type												
Two parents	1.00		1.00		1.00		1.00		1.00		1.00	
Parent(s) with others	0.96	(0.73, 1.28)	1.12	(0.84, 1.50)	0.86	(0.66, 1.13)	0.91	(0.69, 1.20)	0.78	(0.58, 1.06)	0.82	(0.60, 1.10)
Sole parent	0.52	(0.22, 1.22)	0.63	(0.26, 1.52)	0.22 **	(0.08, 0.64)	0.22 **	(0.08, 0.63)	0.25 **	(0.09, 0.71)	0.25 **	(0.09, 0.71)
Mother's labour force status												
Employed full-time	1.00		1.00		1.00		1.00		1.00		1.00	
Employed part-time	0.93	(0.69, 1.26)	0.93	(0.68, 1.29)	1.27	(0.93, 1.72)	1.16	(0.84, 1.59)	1.04	(0.76, 1.43)	0.99	(0.71, 1.38)
Unemployed	0.57	(0.31, 1.05)	0.80	(0.46, 1.42)	0.92	(0.54, 1.57)	0.93	(0.56, 1.55)	0.60	(0.33, 1.10)	0.63	(0.35, 1.13)
Not in the labour force	0.63 *	(0.43, 0.92)	0.80	(0.55, 1.16)	1.14	(0.81, 1.60)	1.14	(0.81, 1.61)	0.81	(0.56, 1.18)	0.84	(0.58, 1.22)
Mother's neighbourhood socioeconomic deprivation												
Low deprivation	1.00		1.00		1.00		1.00		1.00		1.00	
Medium deprivation	1.28	(0.97, 1.68)	1.22	(0.92, 1.62)	0.87	(0.65, 1.15)	0.85	(0.64, 1.14)	0.76	(0.57, 1.01)	0.75 *	(0.56, 1.00)
High deprivation	0.91	(0.62, 1.32)	1.09	(0.76, 1.57)	0.85	(0.60, 1.20)	0.93	(0.66, 1.31)	0.59 **	(0.41, 0.86)	0.61 **	(0.43, 0.88)
Mother's antenatal smoking												
Did not smoke	1.00		1.00		1.00		1.00		1.00		1.00	
Smoked	0.89	(0.56, 1.40)	1.15	(0.74, 1.76)	1.14	(0.76, 1.72)	1.25	(0.84, 1.85)	0.90	(0.57, 1.43)	0.98	(0.64, 1.51)
Mother's antenatal alcohol consumption												
No alcohol	1.00		1.00		1.00		1.00		1.00		1.00	
Drank	0.83	(0.65, 1.07)	0.89	(0.68, 1.15)	0.91	(0.71, 1.16)	0.93	(0.72, 1.20)	0.80	(0.61, 1.04)	0.81	(0.61, 1.07)
Mother's folate intake in first trimester												
Took folate	1.00		1.00		1.00		1.00		1.00		1.00	
No folate	0.55 **	(0.37, 0.83)	0.65 *	(0.43, 0.98)	0.79	(0.57, 1.09)	0.84	(0.61, 1.15)	1.02	(0.70, 1.48)	1.09	(0.77, 1.54)
Mother's antenatal depression												
Not depressed	1.00		1.00		1.00		1.00		1.00		1.00	
Depressed	1.31	(0.92, 1.87)	1.53 *	(1.05, 2.22)	0.76	(0.54, 1.09)	0.82	(0.57, 1.19)	1.15	(0.80, 1.64)	1.17	(0.81, 1.69)
Mother's antenatal anxiety												
No anxiety	1.00		1.00		1.00		1.00		1.00		1.00	
Anxious	0.83	(0.47, 1.48)	0.80	(0.44, 1.47)	1.15	(0.66, 2.01)	1.13	(0.64, 2.01)	0.69	(0.36, 1.31)	0.72	(0.37, 1.39)
Child's sex												
Male	1.00		1.00		1.00		1.00		1.00		1.00	
Female	0.81	(0.65, 1.01)	0.75 *	(0.60, 0.95)	0.96	(0.78, 1.19)	0.93	(0.75, 1.17)	0.87	(0.69, 1.10)	0.87	(0.69, 1.11)
Child's gestational age												
Term	1.00		1.00		1.00		1.00		1.00		1.00	
Preterm	1.51	(0.90, 2.53)	1.25	(0.69, 2.27)	0.79	(0.43, 1.44)	0.74	(0.39, 1.40)	1.06	(0.57, 1.96)	1.14	(0.58, 2.23)
Child's birth weight status												
Not low	1.00		1.00		1.00		1.00		1.00		1.00	
Low birth weight	0.54	(0.27, 1.09)	0.70	(0.34, 1.47)	0.90	(0.45, 1.79)	1.04	(0.52, 2.07)	0.78	(0.37, 1.67)	0.79	(0.36, 1.71)
Child's care arrangement at 9 months												
Early childhood education			1.00				1.00				1.00	
Parental or informal care			1.15	(0.82, 1.59)			1.59 *	(1.12, 2.27)			1.09	(0.77, 1.55)
Mother's language used with baby at 9 months												
English			1.00				1.00				1.00	
Non-English language			0.64	(0.38, 1.07)			0.91	(0.59, 1.41)			0.76	(0.48, 1.21)
Number of children's book in home at 9 months												
Five or fewer			1.00				1.00				1.00	
6 to 20 books			1.15	(0.68, 1.95)			0.94	(0.61, 1.44)			0.92	(0.58, 1.47)
21 or more books			1.44	(0.84, 2.47)			1.32	(0.84, 2.06)			1.14	(0.70, 1.84)
Mother's frequency of watching children's TV at 9 months												
Less than once a day			1.00				1.00				1.00	
Once a day			0.73	(0.45, 1.20)			1.00	(0.65, 1.55)			0.82	(0.51, 1.30)
More than once a day			0.94	(0.63, 1.41)			1.04	(0.72, 1.50)			1.29	(0.89, 1.89)
Mother's frequency of having TV on at 9 months												
Less than once a day			1.00				1.00				1.00	
Once a day			0.92	(0.66, 1.28)			0.90	(0.65, 1.26)			0.88	(0.61, 1.26)
More than once a day			1.02	(0.75, 1.38)			1.01	(0.75, 1.36)			1.10	(0.81, 1.51)
Mother's frequency of reading books at 9 months												
Less than once a day			1.00				1.00				1.00	
Once a day			0.85	(0.65, 1.11)			1.10	(0.86, 1.42)			1.00	(0.77, 1.32)
More than once a day			0.89	(0.60, 1.32)			0.90	(0.62, 1.31)			1.22	(0.83, 1.80)
Mother's frequency of reading books at 2 years												
Less than once a day			1.00				1.00				1.00	
Once a day			0.84	(0.56, 1.26)			1.13	(0.79, 1.62)			0.94	(0.63, 1.40)
More than once a day			1.11	(0.62, 1.99)			1.09	(0.64, 1.85)			1.09	(0.62, 1.93)
Mother's frequency of reading books at 4.5 years												
Less than once a day			1.00				1.00				1.00	
Once a day			0.88	(0.65, 1.19)			1.18	(0.89, 1.56)			1.18	(0.87, 1.61)
More than once a day			1.26	(0.88, 1.81)			1.20	(0.83, 1.74)			1.08	(0.73, 1.61)
Mother's warm parenting at 4.5 years												
Medium warm parenting			1.00				1.00				1.00	
Low warm parenting			0.88	(0.64, 1.20)			1.33	(0.99, 1.79)			1.03	(0.75, 1.43)
High warm parenting			0.80	(0.60, 1.07)			1.05	(0.79, 1.38)			0.71 *	(0.53, 0.95)
Mother's hostile parenting at 4.5 years												
Medium hostile parenting			1.00				1.00				1.00	
Low hostile parenting			0.93	(0.69, 1.25)			1.08	(0.81, 1.44)			0.87	(0.63, 1.19)
High hostile parenting			1.10	(0.84, 1.45)			0.89	(0.68, 1.15)			0.99	(0.75, 1.31)
Mother's diffident parenting at 4.5 years												
Medium diffident parenting			1.00				1.00				1.00	
Low diffident parenting			1.12	(0.84, 1.48)			0.99	(0.75, 1.32)			1.06	(0.79, 1.41)
High diffident parenting			0.78	(0.58, 1.04)			0.94	(0.71, 1.23)			0.68 *	(0.50, 0.91)
Inverse Mills ratio	1110.52	(0.02, 70076127.34)	0.01	(0.00, 366.08)	12.26	(0.00, 160116.86)	0.11	(0.00, 1762.54)	62.81	0.00, 4101329.22	6.91	(0.00, 261432.92)
Constant	0.04 *	(0.00, 0.89)	0.91	(0.04, 21.83)	0.11	(0.01, 1.47)	0.18	(0.01, 2.86)	0.07	(0.00, 1.29)	0.14	(0.01, 2.94)
Pseudo R^2	0.07		0.09		0.03		0.04		0.03		0.05	
Number of observations	2,241		2,241		2,109		2,109		2,033		2,033	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Source: Authors' calculations from Growing Up in New Zealand dataset.

Appendix 19: *Aim 3 sensitivity analysis binary logistic regression results*

Variable	Vocabulary				Reading				Global cognition			
	Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)		Model 2 (Mother's education + potential confounders)		Model 3 (Mother's education + confounders + mediators)	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Mother's educational attainment												
No qualification	1.00		1.00		1.00		1.00		1.00		1.00	
Secondary school qualification	1.28	(0.53, 3.11)	0.63	(0.30, 1.33)	1.88	(0.80, 4.41)	1.00	(0.47, 2.10)	1.93	(0.79, 4.72)	1.09	(0.47, 2.52)
Diploma or Trade certificate	1.74	(0.73, 4.14)	0.85	(0.41, 1.76)	1.85	(0.80, 4.3)	0.99	(0.47, 2.07)	2.28	(0.93, 5.57)	1.26	(0.55, 2.88)
Father's educational attainment												
No qualification	1.00		1.00		1.00		1.00		1.00		1.00	
Secondary school qualification	2.78 **	(1.47, 5.25)	2.38 **	(1.25, 4.53)	1.86 *	(1.07, 3.23)	1.64	(0.93, 2.89)	3.57 ***	(1.74, 7.30)	3.22 **	(1.52, 6.80)
Diploma or Trade certificate	2.02 *	(1.10, 3.72)	1.99 *	(1.08, 3.67)	1.15	(0.68, 1.95)	1.20	(0.70, 2.06)	2.33 *	(1.17, 4.64)	2.41 *	(1.19, 4.91)
Bachelor's degree	2.73 *	(1.27, 5.87)	1.95	(0.94, 4.04)	1.66	(0.84, 3.30)	1.28	(0.65, 2.50)	3.21 **	(1.40, 7.38)	2.42 *	(1.05, 5.58)
Higher degree	3.13 **	(1.46, 6.70)	2.54 *	(1.18, 5.47)	1.67	(0.83, 3.33)	1.49	(0.74, 2.99)	3.13 **	(1.34, 7.31)	2.80 *	(1.17, 6.68)
Mother's age												
Less than 25 years	1.00		1.00		1.00		1.00		1.00		1.00	
25 to 29 years	1.49	(0.71, 3.15)	0.76	(0.45, 1.29)	1.41	(0.75, 2.64)	0.77	(0.49, 1.22)	1.28	(0.62, 2.66)	0.73	(0.43, 1.24)
30 to 33 years	1.87	(0.74, 4.71)	0.82	(0.47, 1.44)	1.47	(0.67, 3.25)	0.67	(0.40, 1.12)	1.36	(0.54, 3.46)	0.68	(0.39, 1.21)
34 years or older	2.31	(0.75, 7.13)	0.77	(0.41, 1.44)	1.96	(0.76, 5.06)	0.67	(0.37, 1.21)	1.84	(0.61, 5.60)	0.72	(0.38, 1.35)
Mother's ethnicity												
European	1.00		1.00		1.00		1.00		1.00		1.00	
Māori	0.20 **	(0.06, 0.63)	0.64	(0.31, 1.32)	0.47	(0.16, 1.36)	1.61	(0.85, 3.06)	0.79	(0.25, 2.56)	2.32 *	(1.19, 4.54)
Pacific	0.08 **	(0.02, 0.43)	0.40	(0.15, 1.10)	0.42	(0.10, 1.69)	2.09	(0.91, 4.80)	0.33	(0.07, 1.47)	1.26	(0.51, 3.13)
Asian	0.47	(0.19, 1.12)	1.12	(0.57, 2.19)	1.50	(0.68, 3.34)	3.03 ***	(1.65, 5.59)	0.66	(0.27, 1.63)	1.32	(0.69, 2.52)
Other ethnicity	0.35	(0.11, 1.06)	0.80	(0.38, 1.66)	0.59	(0.21, 1.69)	1.37	(0.64, 2.95)	0.38	(0.12, 1.18)	0.81	(0.38, 1.73)
Mother's native/migrant status												
Born in New Zealand	1.00		1.00		1.00		1.00		1.00		1.00	
Migrated to New Zealand up to age 18	0.96	(0.46, 2.04)	1.91	(1.00, 3.66)	0.91	(0.45, 1.83)	2.07 *	(1.11, 3.84)	1.59	(0.74, 3.42)	2.97 ***	(1.60, 5.54)
Migrated to New Zealand after age 18	0.40	(0.10, 1.66)	2.01	(0.87, 4.67)	0.28	(0.08, 1.00)	1.35	(0.57, 3.20)	0.50	(0.12, 2.06)	1.91	(0.81, 4.51)
Mother's parity												
First-born	1.00		1.00		1.00		1.00		1.00		1.00	
Subsequent-born	0.83	(0.56, 1.22)	1.15	(0.79, 1.67)	0.86	(0.59, 1.24)	1.08	(0.75, 1.55)	1.08	(0.73, 1.62)	1.41	(0.97, 2.06)
Mother's rurality												
Urban	1.00		1.00		1.00		1.00		1.00		1.00	
Rural	1.54	(0.95, 2.49)	1.17	(0.73, 1.88)	0.73	(0.42, 1.28)	0.57 *	(0.33, 0.99)	1.07	(0.62, 1.84)	0.87	(0.52, 1.47)
Mother's labour force status												
Employed full-time	1.00		1.00		1.00		1.00		1.00		1.00	
Employed part-time	0.81	(0.56, 1.16)	0.89	(0.61, 1.30)	1.09	(0.75, 1.59)	1.11	(0.76, 1.62)	0.91	(0.62, 1.32)	0.95	(0.64, 1.41)
Unemployed	0.59	(0.28, 1.25)	0.79	(0.41, 1.54)	1.25	(0.63, 2.48)	1.56	(0.88, 2.75)	0.67	(0.32, 1.42)	0.85	(0.43, 1.68)
Not in the labour force	0.51 **	(0.32, 0.82)	0.69	(0.46, 1.03)	1.04	(0.67, 1.61)	1.26	(0.86, 1.85)	0.63	(0.39, 1.02)	0.79	(0.52, 1.19)
Mother's neighbourhood socioeconomic deprivation												
Low deprivation	1.00		1.00		1.00		1.00		1.00		1.00	
Medium deprivation	1.33	(0.92, 1.92)	1.11	(0.78, 1.56)	1.01	(0.70, 1.46)	0.85	(0.59, 1.23)	0.82	(0.56, 1.19)	0.69	(0.48, 1.01)
High deprivation	1.01	(0.69, 1.50)	1.06	(0.71, 1.57)	0.80	(0.55, 1.18)	0.89	(0.60, 1.32)	0.58 **	(0.39, 0.88)	0.61 *	(0.41, 0.92)
Mother's antenatal smoking												
Did not smoke	1.00		1.00		1.00		1.00		1.00		1.00	
Smoked	1.00	(0.53, 1.87)	1.36	(0.80, 2.31)	1.09	(0.61, 1.96)	1.47	(0.89, 2.42)	0.87	(0.46, 1.66)	1.16	(0.67, 1.99)
Mother's antenatal alcohol consumption												
No alcohol	1.00		1.00		1.00		1.00		1.00		1.00	
Drank	0.91	(0.67, 1.24)	0.95	(0.69, 1.29)	0.81	(0.60, 1.12)	0.80	(0.58, 1.11)	0.85	(0.62, 1.19)	0.90	(0.65, 1.26)
Mother's folate intake in first trimester												
Took folate	1.00		1.00		1.00		1.00		1.00		1.00	
No folate	0.50 *	(0.29, 0.87)	0.54 *	(0.31, 0.93)	0.81	(0.53, 1.23)	0.91	(0.60, 1.39)	1.21	(0.77, 1.90)	1.30	(0.83, 2.03)
Mother's antenatal depression												
Not depressed	1.00		1.00		1.00		1.00		1.00		1.00	
Depressed	1.03	(0.64, 1.67)	1.47	(0.91, 2.36)	0.72	(0.45, 1.16)	1.03	(0.63, 1.66)	1.02	(0.62, 1.66)	1.36	(0.84, 2.23)
Mother's antenatal anxiety												
No anxiety	1.00		1.00		1.00		1.00		1.00		1.00	
Anxious	0.77	(0.38, 1.57)	0.86	(0.43, 1.75)	0.69	(0.32, 1.49)	0.78	(0.36, 1.71)	0.60	(0.27, 1.36)	0.62	(0.27, 1.40)
Child's sex												
Male	1.00		1.00		1.00		1.00		1.00		1.00	
Female	0.80	(0.61, 1.05)	0.75 *	(0.57, 0.98)	0.93	(0.71, 1.21)	0.86	(0.66, 1.14)	0.79	(0.59, 1.05)	0.72 *	(0.54, 0.96)
Child's gestational age												
Term	1.00		1.00		1.00		1.00		1.00		1.00	
Preterm	2.01 *	(1.07, 3.79)	1.45	(0.72, 2.90)	0.80	(0.40, 1.62)	0.59	(0.28, 1.22)	1.58	(0.77, 3.23)	1.22	(0.56, 2.66)
Child's birth weight status												
Not low	1.00		1.00		1.00		1.00		1.00		1.00	
Low birth weight	0.42	(0.18, 1.02)	0.55	(0.25, 1.24)	0.87	(0.40, 1.88)	1.23	(0.60, 2.51)	0.64	(0.26, 1.55)	0.81	(0.34, 1.89)
Child's care arrangement at 9 months												
Early childhood education			1.00				1.00				1.00	
Parental or informal care			1.11	(0.75, 1.65)			1.79 **	(1.16, 2.77)			1.09	(0.73, 1.65)
Mother's language used with baby at 9 months												
English			1.00				1.00				1.00	
Non-English language			0.76	(0.39, 1.46)			0.79	(0.45, 1.41)			0.95	(0.52, 1.74)
Number of children's book in home at 9 months												
Five or fewer			1.00				1.00				1.00	
6 to 20 books			1.12	(0.60, 2.10)			1.13	(0.67, 1.92)			1.03	(0.58, 1.80)
21 or more books			1.02	(0.53, 1.96)			1.26	(0.72, 2.23)			1.05	(0.58, 1.88)
Mother's frequency of watching children's TV at 9 months												
Less than once a day			1.00				1.00				1.00	
Once a day			0.62	(0.36, 1.08)			1.11	(0.68, 1.81)			0.86	(0.50, 1.47)
More than once a day			1.10	(0.67, 1.80)			1.11	(0.67, 1.82)			1.61	(0.98, 2.65)
Mother's frequency of having TV on at 9 months												
Less than once a day			1.00				1.00				1.00	
Once a day			0.87	(0.59, 1.29)			0.97	(0.67, 1.42)			0.93	(0.62, 1.39)
More than once a day			1.02	(0.71, 1.46)			0.96	(0.67, 1.36)			0.98	(0.67, 1.41)
Mother's frequency of reading books at 9 months												
Less than once a day			1.00				1.00				1.00	
Once a day			0.99	(0.72, 1.36)			1.05	(0.76, 1.44)			1.24	(0.89, 1.74)
More than once a day			0.99	(0.65, 1.51)			0.91	(0.60, 1.39)			1.37	(0.89, 2.10)
Mother's frequency of reading books at 2 years												
Less than once a day			1.00				1.00				1.00	
Once a day			0.80	(0.54, 1.20)			1.05	(0.73, 1.52)			0.78	(0.52, 1.17)
More than once a day			1.04	(0.67, 1.60)			0.96	(0.62, 1.49)			0.86	(0.55, 1.34)
Mother's frequency of reading books at 4.5 years												
Less than once a day			1.00				1.00				1.00	
Once a day			1.04	(0.72, 1.49)			1.31	(0.91, 1.87)			1.41	(0.95, 2.08)
More than once a day			1.51	(0.99, 2.31)			1.43	(0.92, 2.23)			1.24	(0.77, 1.99)
Mother's warm parenting at 4.5 years												
Medium warm parenting			1.00				1.00				1.00	
Low warm parenting			0.99	(0.72, 1.37)			1.60 **	(1.16, 2.21)			1.10	(0.78, 1.56)
High warm parenting			0.79	(0.55, 1.15)			1.17	(0.82, 1.66)			0.76	(0.53, 1.10)
Mother's hostile parenting at 4.5 years												
Medium hostile parenting			1.00				1.00				1.00	
Low hostile parenting			0.81	(0.56, 1.16)			0.97	(0.68, 1.38)			0.82	(0.56, 1.20)
High hostile parenting			1.02	(0.73, 1.41)			0.80	(0.58, 1.10)			1.10	(0.78, 1.54)
Mother's diffident parenting at 4.5 years												
Medium diffident parenting			1.00				1.00				1.00	
Low diffident parenting			1.17	(0.83, 1.65)			1.07	(0.76, 1.51)			1.31	(0.92, 1.87)
High diffident parenting			0.91	(0.64, 1.30)			1.02	(0.72, 1.44)			0.82	(0.57, 1.20)
Inverse Mills ratio	24826.95	(0.01, 43248527354.13)	0.00	(0.00, 18.61)	16821.08	(0.05, 6030780044.89)	0.00	(0.00, 10.37)	5769.45	(0.00, 10704333885.76)	0.01	(0.00, 21.96)
Constant	0.01 *	(0.00, 0.58)	0.62	(0.05, 8.15)	0.01 *	(0.00, 0.47)	0.25	(0.02, 2.73)	0.01 *	(0.00, 0.43)	0.22	(0.02, 2.64)
Pseudo R^2	0.07		0.09		0.03		0.05		0.04		0.06	
Number of observations	1,475		1,475		1,385		1,385		1,333		1,333	

Symbols: * $p<0.05$ ** $p<0.01$ *** $p<0.001$
Source: Authors' calculations from Growing Up in New Zealand dataset.