Risk Factors Associated With Language Delay in Preschool Children

Alexandra Galvin[1], Georgina Davis[1], Denise Neumann[1], Lisa Underwood[2], Elizabeth R. Peterson[1,2], Susan M. B. Morton[2,3], Karen E. Waldie[1,2]

Abstract

A variety of antenatal risk factors have been established as being detrimental to a child's developing language ability. Our aim was to examine the relationship between exposure to cumulative risk (CR), including antenatal maternal, perinatal, and maternal health characteristics, and children's preschool language ability. Analyses were comprised of interviews and observational data from 5,721 children and their mothers enrolled in the longitudinal *Growing up in New Zealand* cohort study. Language ability status was measured using the PPVT-III and DIBELS letter naming task (LNF) task at age 4.5 years. Results showed that CR was significantly associated with language status on both measures after controlling for multiple covariates. Improving maternal awareness and support during the perinatal period may reduce the number of risks a fetus is exposed to, which may aid early childhood language development.

Keywords: cohort, longitudinal, cognition, language, child, antenatal, perinatal, risk factors, cumulative risk

[1]School of Psychology, The University of Auckland, Auckland, New Zealand; [2]Center for Longitudinal Research – He Ara ki Mua, The University of Auckland, Auckland, New Zealand; [3]School of Population Health, The University of Auckland, Auckland, New Zealand.

Introduction

An understanding of words and letters lays the foundation for further learning, including reading and writing (Whitehurst & Lonigan, 1998), and has long-term effects on academic achievement, health, and future opportunities (Kaplan, Damphousse, & Kaplan, 1994; Masten et al., 2005; McCaul, Donaldson, Coladarci, & Davis, 1992; Obradovi , Burt, & Masten, 2009; Welsh, Nix, Blair, Bierman, & Nelson, 2010). The brain structure from birth to 5 years old provides the optimal time and conditions for language acquisition, with the peak period believed to occur around 16-18 months (Fox, Levitt, & Nelson, 2010; Phillips & Shonkoff, 2000; Werker & Tees, 2005). Phonological sensitivity, for example, was reported to have an 83% stability from the approximate ages of 4-6 years and 95% from the approximate ages of 7-9 years (Wagner et al., 1997).

Lower-ability language development is one of the most prevalent developmental challenges among preschool-aged children, and is often accompanied by a lifetime of social, emotional, academic, and economic challenges (Wake et al., 2012). Perhaps most troubling are associations between speech and language impairments and psychiatric disorders (Clegg, Hollis, Mawhood, & Rutter, 2005), including attention deficit problems, behavioural difficulties, and anxiety (Baker & Cantwell, 1987a, 1987b; Beitchman et al., 1986; Clegg et al., 2005; King, Jones, & Lasky,1982). Therefore, not only does lower-ability language have a negative effect on school life, it also has lasting connotations for a child's development into adulthood and future success. For the purpose of this study, language ability was assessed by measuring receptive language and early literacy.

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Perinatal Influences on Language Status

The development of language ability is determined by a multitude of biological and environmental factors, including gender (Halpern, 2012). In research on cognition and sex differences, it appears that while, overall, males and females are far more similar than they are different with respect to general intellect, there are nuances between the sexes with regard to the narrow abilities that make up general cognitive capacity (Hyde, 2005). As such, there is widely established evidence of a typical gendered variation throughout cognitive development, with preschool-aged girls developing verbal and language fluency, complex play, and planning skills (Barbu, Cabanes & Le Maner-Idrissi, 2011; Kramer, Delis, Kaplan, O'Donnell, & Prifitera, 1997; Unterrainer, Ruh, Loosli, Heinze, Rahm, & Keller, 2013) at an earlier age than their male counterparts. Thus, it is important to control for sex when investigating the development of language ability.

The effects of maternal alcohol consumption during pregnancy on a child's cognitive abilities, including language development, are well established (Davies et al., 2011; Lairoque, Kaminski, Dehaene, Subtil, Delfosse, & Querleu, 1995; Russell, Czarnecki, Cowan, McPherson, & Mudar, 1991). Thus, consumption of alcohol during pregnancy can result in a host of developmental abnormalities, with fetal alcohol spectrum disorder being the direct result of prenatal alcohol use. One study found that both alcohol consumption and preterm birth were associated with lower-ability language development (Peyre et al., 2014). Indeed, preterm delivery is also associated with lower-ability language status and communication impairments (Boyle et al., 2012; Stene-Larsen, Brandlisstuen, Lang, Landolt, Latal, & Vollrath, 2014; Zambrana, Vollrath, Sengpiel, Jacobsson, & Ystrom, 2015). Similarly, smoking cigarettes during pregnancy can induce a plethora of health problems for a mother and her unborn child (Abel, 1980). This is also the case for offspring brain growth in that prenatal smoking produces neurotoxic effects on the developing fetal brain (Ekblad, Korkeila, & Lehtonen, 2015).

Parity has been considered a predictor factor in a child's development. The firstborn child is overrepresented among Nobel Prize winners, tertiary education populations, and, on average, eldest children have higher academic and intelligence test scores than their later-born siblings (Adams, 1972; Altus, 1965; Arap-Maritim, 2009; Clark & Rice, 1982) even though the effects are small (Ernst & Angst, 2012). Cognitive ability may even be stratified ordinally among siblings, with first-borns outperforming second-born siblings, who outperform third-borns, and so on (Belmont & Marolla, 1973). Perhaps because a mother with multiple children has less time to focus on each child individually, resulting in a lack of necessary stimuli, children with two or more siblings are more likely to have delayed language ability (Halpern, Giugliani,Victora, Barros, & Horta, 2002; Quevedo et al., 2011). However, when factors such as family size and parental education are taken into account, parity no longer predicts cognitive ability (Damian & Roberts, 2015; Kanazawa, 2012; Rodgers, Cleveland, van den Oord, & Rowe, 2000).

Though the subject is widely debated, there is some evidence that children born as a result of fertility treatments, such as in-vitro fertilization (IVF), are at greater risk of cognitive delay (Sandin, Nygren, Iliadou, Hultman, & Reichenberg, 2013). Another form of reproductive technology, intracytoplasmic sperm injection (ICSI), has also been shown to put offspring at a higher risk of lower IQ scores compared to children conceived without assistance (Knoester et al., 2009). However, other studies have not found significant differences in cognition for children born via IVF or ICSI treatments compared to those conceived without assistance (Bay, 2014; Bay, Mortensen, & Kesmodel, 2014; Leslie, Gibson, McMahon, Cohen, Saunders, & Tennant, 2003).

There is a biological component to language learning (Rice, 2013; Tomblin, 2009; Vargha-Khadem, Watkins, Alcock, Fletcher, & Passingham, 1995), and, in addition, biology also interacts with the environment, making the role of parents and caregivers an important aspect of a child's language development (Hoff, 2006; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 199; Rowe, 2008). Because mothers largely constitute infants' social environment, mediating between children and their world to facilitate learning, they play a key role in their child's development (Bradley & Caldwell, 1984; Broen, 1972; Pan, Rowe, Singer, & Snow, 2005). For instance, delayed language and cognitive abilities are correlated with socioeconomic status (SES) in that children born into disadvantaged, low-SES families may not realise and fulfil their true potential (Davies, Crothers, & Hanna, 2010; Hart & Risley, 2003; Schady et al., 2015). The language ability gap between social classes is potentially due to lesser exposure to learning opportunities or materials and limited access to quality educational experiences (Willingham, 2012). Counter to a child from a less affluent background, advantaged children tend to have a relative abundance of resources and stimulating opportunities (Bradley & Corwyn, 2002).

Maternal Health Influences on Language Status

Mothers' mental health is a strong predictor of their children's mental health and cognition (Kim, Bale, & Epperson, 2015). Women are particularly vulnerable to adverse mental health during pregnancy (Waldie et al., 2015) and up to a year afterward (Underwood, Waldie, D'Souza, Peterson, & Morton, 2016). In particular, maternal stress, anxiety, and depression are common mental health issues in women of childbearing age (Lancaster, Gold, Flynn, Yoo, Marcus, & Davis, 2010; Woods, Melville, Guo, Fan, & Galvin, 2010). Laplante et al. (2004) found that toddlers whose mothers had been pregnant with them during a natural disaster displayed lower language development scores than standardized norms. Other studies have found that antenatal stress and anxiety can lead to changes in fetal brain structure and function as a result of reduced blood flow (Fisk & Glover, 1999; Lupien, McEwen, Gunnar, & Heim, 2009; Welberg & Seckl, 2001). For example, irregularities have been found in the orbito-frontal cortex, leading to impairments in working memory and a reduced ability to regulate behaviour and attention, which can result in attention deficit-hyperactivity disorder (ADHD) and externalising problems (Dieter, Emory, Johnson, & Raynor, 2008; Heron, O'Connor, Evans, Golding, Glover, & ALSPAC Study Team, 2004; Kinsella & Monk, 2009; Mennes, Stiers, Lagae, & Van den Bergh, 2006). Further, postnatal depression has been found to be detrimental to children's language learning due to poorer quality communication or fewer interactions between mother and child (Grace, Evindar, & Stewart, 2003; McLearn, Minkovitz, Strobino, Marks, & Hou, 2006; Rothbart, 2011; Saarni, Campos, Camra, & Witherington, 1998).

Other maternal factors that are related to offspring language include the planning of pregnancy (de La Rochebrochard & Joshi, 2013), body mass index scores (BMI), and nutrition status. For example, children of unplanned pregnancies have poorer verbal abilities (Carson, Kelly, Kurinczuk, Sacker, Redshaw, & Quigley, 2011) and perform worse on reading and math tasks than children whose mothers had planned their pregnancies (Joyce, Kaestner, & Korenman, 2000). Women whose pregnancies are unintended are more likely to engage in smoking, alcohol consumption, and illicit drug use, and less likely to take vitamins than mothers whose pregnancies were planned (Than, Honein, Watkins, Yoon, Daniel, & Correa, 2005). For example, Han, Nava-Ocampo, and Koren (2005) found that women with unintentional pregnancies were more likely to be exposed to cigarette smoke, X-rays, alcohol, and potentially harmful medications.

Maternal BMI classified as overweight or obese is associated with poor child cognitive outcomes (Daraki et al., 2017; Pugh et al., 2015). Further, maternal folate or folic acid intake during pregnancy has been strongly linked with irregularities in fetal brain development and greater risk of developing neural tube defects (De Wals et al., 2007; Roza, van Batenburg-Eddes, & Steegers, 2010) and behaviour problems (D'Souza, Waldie, Peterson, Underwood, & Morton, 2019). Understanding the effects of maternal health on child growth and development is essential. Hence, determining the relationship between maternal health, sociodemographic indicators, and early language development is the primary focus of this research.

With a growing number of longitudinal studies on health and development emerging, it has become possible to investigate more rigorously the extent to which vital influences such as prenatal and early-life factors impact developmental outcomes (Maccani & Marsit, 2009; Wang, Walker, Hong, Bartell, & Wang, 2013) and informing theory and practice within both the scientific community and health initiatives around the world (Poulton, Moffitt, & Silva, 2015). While the relationships between environmental conditions and language development require further investigation (Peterson & Pennington, 2015), we do know that unfavourable conditions during the gestational and perinatal periods negatively impact offspring development in multiple spheres (Liu et al., 2016).

Cumulative Risk and Language Ability

Though earlier research on this subject is limited, there has been some investigation into the relationship between cumulative risks (CR) and language ability. For example, Stanton-Chapman, Chapman, Kaiser, and Hancock (2004) looked at the impact of CR on language development in 3-year-old children from low-income families. Their CR model, which consisted of social and environmental risks present when the child was born, was significantly related to language development. Their findings showed that an increase in risks amplified the likelihood of lower-ability language status (Stanton-Chapman et al., 2004). Similarly, Burchinal, Roberts, Hooper, and Zeisel (2000) found an association between cumulative sociocultural and caregiving risks with language development throughout the first four years of African American children's lives. This study, focused on home environment, maternal IQ, and a mother's responsiveness to her child as components of CR, revealed that the probability of lower-ability language development increased alongside CR exposure (Burchinal et al., 2000).

Conversely, Sylvestre and Mérette (2010) found that CR had no significant impact on a child's language development, but that individual risk factors had a greater influence. Their longitudinal sample of children from 2 to 36 months old who had experienced parental neglect was more likely to have a language ability if they also had lower cognitive development, whereas the other psychological and biological risk factors were not significantly associated with language status when examined through a CR model (Sylvestre & Mérette, 2010).

Contradictory findings such as those cited above emphasize the need for further study on the relationship between CR and language development. In the current study, we utilised data from 6,822 *Growing up in New Zealand* study children and their families. We first catalogued risk factors that have been associated with delayed cognitive development: exposure to alcohol and cigarette smoke, maternal depression and/or anxiety during pregnancy, born with low birth weight, not being the first-born child, premature or overdue birth, mother not taking folate during the pregnancy, overweight or underweight maternal BMI, use of any fertility treatments, presence of any birth complications, and unplanned pregnancy.

We expected that children who are exposed to more risks are more likely to be classified as having lower-language ability than individuals exposed to fewer risks. As such, the current research fills the need for a longitudinal study that defines the cumulative contributions of certain gestational, perinatal, and postpartum risk factors of emergent lower-ability language development.

Methods

Participants and General Procedure

Participants consisted of expectant mothers and their children (N = 6,822; 52% male) enrolled in the *Growing up in New Zealand* (GUiNZ) longitudinal cohort study. The study focused on 5,721 children and their mothers who participated in our language ability assessment and provided personal information related to our CR index. This cohort is comprised of a socioeconomically and ethnically diverse sample of children that is broadly generalizable to current NZ births, coming from a geographical area that approximately mirrors one third of the New Zealand (NZ) birth population (Morton et al., 2012). Mothers were invited to participate if they were due to give birth between April 25, 2009, and March 25, 2010, and were residing in three bordering District Health Boards (DHBs) in the North Island of NZ: Auckland, Counties Manukau, and Waikato.

Data collection waves (DCWs) took place at various points in the child's development. Antenatal data collection occurred during the third trimester of pregnancy, with a face-to-face computer-assisted interview. Postnatal data collection was carried out nine months after childbirth, at ages 2 and 4.5 years old, using the same method as the antenatal data collection, as well as child observations at age 2 and 4.5 years.

Measures

DIBELS Letter Naming Fluency task. The Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Letter Naming Fluency (LNF) task was used at the 4.5-year DCW. The DIBELS LNF task is a standardised, individually administered test that indicates a child's early reading fluency (University of Oregon, 2019). It is designed for children entering primary school, who are 4.5–6 years of age.

The child of interest is presented with a page of upper- and lowercase letters, randomly ordered. The child has one minute to name as many letters as possible, providing the name of the letter rather than the sound it produces (Good & Kaminski, 2007). The child must read successively, across the page, pointing to each letter while saying its name. Children who cannot name any of the presented letters are considered at risk for developing literacy issues (Walsh, Price, & Gillingham, 1988). The DIBELS was an ideal measurement for the present study as it has been validated in a New Zealand longitudinal sample across primary school (Suggate, Schaughency, & Reese, 2012).

Peabody Picture Vocabulary Test (PPVT-III). An adapted version of the Peabody Picture Vocabulary Test (PPVT-III), developed by the Longitudinal Study of Australian Children (LSAC), was administered at 4.5 years to measure receptive language in English. The test involves an examiner revealing a series of images (four to a page) and reciting a word that corresponds to one of the images (Taylor et al., 2013). The child is tested on the ability to point to the correct image.

For the current study, PPVT-III scores were calculated by taking the total number of correct responses and submitting it to an item response theory factor analysis. The scores, which ranged from 0-40, were adjusted and converted to a z score. Children who scored one standard deviation below the mean were categorized as having lower-ability receptive language, and all other children were scored as not having lower ability. This is the standardized scoring technique for the task (Dunn & Dunn, 2007).

PPVT and DIBELS language ability outcome groups. In order to identify the children who were most at risk of developing late literacy, the PPVT and DIBELS scores were analysed separately. The DIBELS was completed by 5,409 (79%) children, whereas 5,533 children completed the PPVT task (81%) at 4.5 years of age. If the child was considered to have a lower-language ability on one or both measures, he or she was classified as having lower-language ability.

Because language ability was assessed only in English, the language ability of bilingual/multilingual children may be underestimated. Of those categorized here as lower ability, 52.5% spoke only English (n = 892) and 47.3% were bilingual or multilingual (n = 806). Within the higher-language ability group, 74.7% spoke only English, and 25.3% were bilingual or multilingual.

Though there is a discrepancy in the proportion of bilingual/multilingual children between groups, this is a multifaceted variable that cannot be easily controlled for. Because this is a complex subject, further investigation on the relationship between bilingual/multilingual status and language ability requires a separate study. However, all of the participating children were born in New Zealand, where English is the prominent language. It will be of interest to assess this association in future followup data collections and to directly test how multilingualism impacts cognitive development.

Cumulative risk variables. A cumulative risk (CR) index was developed for antenatal and perinatal predictor variables by (a) dichotomizing all predictor variables into 1 = risk or 0 = not at risk categories; and (b) adding all risk categories into a continuous CR variable. Multiple risk metrics are generally untenable due to low statistical power (Evans, Li, & Whipple, 2013).

Antenatal depression symptoms were assessed using the Edinburgh Postnatal Depression Scale (EPD; Cox, Holden, & Sagovsky, 1987), a 10-item scale designed to identify depressive symptoms during pregnancy and the postnatal period. Although the EPDS was designed for screening depression postnatally, it has been demonstrated to be a valid measure of depression in pregnant women (Gibson, McKenzie-McHarg, Shakespeare, Price, & Gray, 2009; Kozinszky & Dudasm, 2015; Murray & Cox, 1990). A cut-off of 13 was used to indicate clinically significant levels of depression.

Perceived maternal stress was measured using the abbreviated version (10 items) of the Perceived Stress Scale (PSS; Cohen, Karmack, & Mermelstein, 1983), which has been reported to have validity for use during pregnancy (Solivan, Xiong, Harville, & Buekens, 2015). Items on the PSS classify the level of stress to which participants assign daily activities. The maximum score for this measure is 40, with higher scores signifying greater levels of stress. Perceived stress scores at or above the median were considered as indicating a risk (Lamb et al., 2014).

Experiences of antenatal anxiety and panic attacks were assessed using modified questions from the New Zealand Health Survey (Ministry of Health, 2007). Women were asked if they had experienced anxiety or panic attacks before, during, or both before and during their current pregnancy. Those who indicated they had any anxiety and/or panic attacks during their pregnancy were classified as having antenatal anxiety.

Mothers were also asked about their alcohol consumption both before and during their current pregnancy throughout each trimester using questions derived from New Zealand's National Nutrition Survey (Russell et al., 1999); any alcohol consumption during the pregnancy was considered a risk.

Based on maternal self-report, the following were also considered risks: not having taken folate or folic acid as a supplement at any time during or before their pregnancy and presence of maternal smoking during pregnancy or second-hand smoke exposure during pregnancy. Finally, fertility awareness and weight loss, ovulation induction (with clomiphene citrate in the community or in an infertility clinic), tubal surgery, and IVF treatment or other specified fertility treatments were also assessed as risk factors.

Maternal BMI was assessed using self-reported height and weight pre-pregnancy against standard measures from the World Health Organisation (WHO), calculated as (weight (kg)/height (m2) (WHO, 2017). BMI measures were then categorically grouped with a BMI of ≤ 18.5 as underweight, ≥ 18.5 as normal, ≥ 25kg/m2 defined as overweight, and ≥ 30 kg/m2 as obese. Having maternal BMI classified as underweight, overweight, or obese was considered a risk.

Not being a firstborn child, presence of any birth complications, being premature (less than 37 weeks) or overdue (post-term was categorised above 41 weeks' gestation) were all risk factors. Having a high (>4000 grams) or low (<2500 grams) birth weight and if the pregnancy was unplanned were also categorised as risks.

With regard to frequency of risks, the highest number was 12 risks (out of a total of 14 possible risk factors); the lowest was zero risks (2.6% of the sample). Almost a third of participants reported being exposed to two or three risks (31.4%). A total of 61.1% of children were exposed to three or more risks. The risk categories were added for an overall CR variable.

In this context, the term *risk* is not necessarily a direct causative suggestion, but more loosely referred to as situations that have been correlated in research with putting certain individuals at a higher likelihood of poor cognitive outcomes. In order to be included in our analyses, individuals must have at least seven data points if they had a risk factor. If they had no risk factors, they needed to have a minimum of 10 data points in order to reduce bias. Based on these criteria, 62 individuals who did not meet the threshold were omitted from the analyses.

Control Variables

A range of variables previously found to be associated with language development were controlled for in the current study. Maternal variables measured at the antenatal DCW included mother's ethnicity (European, M ori, Pacific, Asian, Other), mother's education (no secondary school, secondary school/diploma/trade certificate, Bachelor's degree or higher), and mother's age when pregnant (≤ 30 years, or ≥ 31 years). Further control variables from the antenatal period included area-level deprivation (high, medium, and low) related to socioeconomic status and based on the New Zealand deprivation index (Salmond et al., 2007), and rurality (urban or rural). The analyses also controlled for child sex and age (in days) when assessed at the 4.5-year DCW.

Data Analysis

Following descriptive statistics, a hierarchical multivariable logistic regression was performed to ascertain the effect of CR on the likelihood of having lower-language ability, controlling for sociodemographic variables. All risk variables were included, with analyses adjusting for the seven sociodemographic covariates.

All statistical analyses were completed using IBM SPSS Statistics Version 25; statistical significance for the analyses was given at a *p* value of 0.05.

Results

Of the 6,822 individuals enrolled in the GUiNZ cohort, our study included the 5,721 for whom complete information was available on risk exposure as a function of language ability. Of this group, 5,533 children completed the PPVT, and 5,409 completed the DIBELS.

As shown in Table 1, mothers tended to be 31 years of age or older (52.3%), were predominantly European (57.5%), and had completed some form of education (93.7% had gained at least secondary school qualifications or higher). Area deprivation groups were similar, with around a third of participants coming from low (26.3%), medium (37.6%), or highly (36.1%) deprived areas; a majority of participants came from urban living areas (92.6%). Most women did not consume any alcohol (71.3%), smoke (90.2%), or expose themselves to second-hand smoke (93.4%) during pregnancy. Folate intake pre-pregnancy and/or during the first trimester was prevalent, with only 17% of women reporting taking no folate during the early stages of pregnancy. Fewer than half, 44.8%, of women in the study had BMIs that put them as being underweight, overweight, or obese. Regarding mental health, 11.5% of the women were identified as having antenatal depression symptoms, and 3.4% had doctor-diagnosed anxiety and panic attacks during their pregnancy. Fertility treatment was used to conceive a child by 10.3% of the women, and 61.9% of the women planned their pregnancy. With regard to birth factors, 34.3% of children were born via an assisted delivery, and 13.5% of children experienced birth complications. Over half the children were not firstborn, and 91.8% of the children were born at term with 78.8% at an appropriate birth weight.

A significant association was found between the PPVT and CR category, $X^2(14) = 77.68$, $p<.001$. The model for the DIBELS associated with CR was also significant, $X^2(14) = 391.41$, $p<.001$. Of the 5,533 children who took the PPVT, 1,202 (21.7%) were considered as having a lower-language ability. The DIBELS reflected that 1,010 (18.7%) of the total 5,409 were considered at lower ability. Of the individuals who partook in both assessments, 68.1% were within the higher-ability group for both tests, whereas 31.9% scored within the lower-ability group for one or both tests.

Logistic Regression

Table 2 shows the associations between covariates and CR variables and the language ability out-

Table 1
Descriptive Sociodemographic Covariates of Pregnant Women and Children and Perinatal Predictors Deriving Cumulative Risk Index

Variable		N	%
Mother Age			
	Younger[1]	2,727	47.7
	Older[2]	2,994	52.3
Child Age During 4.5 Year DCW			
	Younger[3]	2,818	49.3
	Older[4]	2,899	50.7
Ethnicity			
	European	3,240	57.5
	Māori	745	13.2
	Pacifica	715	12.7
	Asian	756	13.4
	MELAA, other, NZer[5]	179	3.2
Deprivation			
	Low	1,504	26.3
	Medium	2,148	37.6
	High	2,068	36.1
Education			
	No Secondary School Qualification	361	6.3
	Secondary School Qualification	1,290	22.6
	Diploma or Trade Certificate	1,743	30.5
	Bachelor's Degree	1,378	24.1
	Higher Degree	941	16.5
Child Gender			
	Boy	2,948	51.5
	Girl	2,773	48.5
Rurality			
	Urban	5,298	92.6
	Rural	423	7.4
Alcohol Consumption During Pregnancy			
	Yes	1,638	28.7
	No	4,077	71.3
Smoking During Pregnancy			
	Yes	512	9.8
	No	4,716	90.2
Prenatal Secondary Hand Smoke Exposure			
	Yes	346	6.6
	No	4,882	93.4
Antenatal Depression			
	Depression	592	11.5
	No Depression	4,570	88.5
Perceived Stress			
	Higher Stress	2,663	50.9
	Lower Stress	2,567	49.1

Table 1 (cont.)

Variable		N	%
Anxiety During Pregnancy			
	Anxiety	193	3.4
	No Anxiety	5,522	96.6
Fertility Treatment			
	Yes	366	10.3
	No	3,161	88.7
Maternal BMI			
	Underweight, Overweight or Obese	2,276	44.8
	Normal BMI	2,805	55.2
Folate During Pregnancy			
	No folate	887	17.0
	Pre-pregnancy and/or Trimester-One Intake	4,337	83.0
Delivery Type			
	Assisted Birth	1,956	34.3
	Spontaneous Vaginal	3,753	65.7
Parity			
	Firstborn	2,392	41.8
	Subsequent Born	3,329	58.2
Birth Complications			
	Yes	772	13.5
	No	4,949	86.5
Term			
	Term	5,247	91.8
	Pre- or Post-Term	471	8.2
Birth Weight			
	Appropriate	4,505	78.8
	Low or High	1,212	21.2
Pregnancy Planned			
	Yes	3,485	61.9
	No	2,144	38.1

[2] Mothers who were 30 years of age and/or younger while pregnant.
[3] Mothers who were 31 years of age and/or older while pregnant.
[4] Children who were younger than 4.5 years of age during this DCW.
[5] Children who were older than 4.5 years of age during this DCW.
[6] MELAA = Middle Eastern, Latin American, or African; NZer = New Zealander.

come at the 4.5 year DCW. Table 3 reflects he associations between covariates, CR, and the PPVT. Finally, Table 4 depicts the associations between covariates, CR, and the DIBELS.

The following covariates were significantly associated with language ability: child's age, mother's age, mother's ethnicity, gender, deprivation, and maternal education. The analysis also revealed that CR was significantly associated with language ability ($p = 0.014$) after controlling for the covariates.

Discussion

The aim of this study was to explore the relationship between mothers' CR factors and their child's language development. At 4.5 years of age, children were tested for English language ability using the PPVT-III and the DIBELS, and were either considered lower-ability in language development or higher-ability based on the two test results. A CR model comprised of 14 gestational, perinatal, and postpartum risk factors was created to assess

Table 2
Associations Between Covariates and Cumulative Risk Variable and Language Ability at Age 4.5 Years

Variable		*B* (SE)	OR (95% CI)
Mother Age*			
	Younger[6]	0.23 (0.07)	1.26 (1.10, 1.43)
	Older[7]		
Child Age During 4.5 Year DCW*			
	Younger[8]	-0.002 (0.001)	1.00 (1.00, 1.00)
	Older[9]		
Ethnicity*			
	European		
	Māori	1.02 (0.10)	2.77 (2.29, 3.37)
	Pacifica	1.46 (0.11)	4.30 (3.46, 5.31)
	Asian	0.88 (0.10)	2.42 (2.01, 2.92)
	MELAA, Other, NZer[10]	0.56 (0.18)	1.75 (1.23, 2.47)
Deprivation*			
	Low		
	Medium	0.42 (0.93)	1.52 (1.26, 1.82)
	High	-0.005 (0.09)	1.00 (0.84, 1.80)
Education*			
	No Secondary School Qualification	0.53 (0.15)	1.70 (1.27, 2.27)
	Secondary School Qualification	0.40 (1.00)	1.50 (1.23, 1.82)
	Diploma or Trade Certificate	0.44 (0.09)	1.56 (1.30, 1.86)
	Bachelor's Degree	-0.02 (0.11)	0.98 (0.79, 1.22)
	Higher Degree		
Child Gender*			
	Boy	0.42 (0.06)	1.53 (1.34, 1.73)
	Girl		
Rurality			
	Urban		
	Rural	0.20 (0.13)	1.22 (0.95, 1.56)
Cumulative Risk*			
(continuous)		0.07 (0.02)*	1.07 (1.03, 1.10)*

*Risk categories = $p < .05$.

[7] Mothers who were 30 years of age and/or younger while pregnant.
[8] Mothers who were 30 years of age and/or younger while pregnant.
[9] Children who were younger than 4.5 years of age during this DCW.
[10] Children who were older than 4.5 years of age during this DCW.
[11] MELAA = Middle Eastern, Latin American, or African; NZer = New Zealander.

Table 3
Associations Between Covariates and Cumulative Risk Variable and PPVT at Age 4.5 Years

Variable		*B* (SE)	OR (95% CI)
Mother Age*			
	Younger[11]	0.26 (0.08)	1.30 (1.12, 1.51)
	Older[12]		
Child Age During 4.5 Year DCW*			
	Younger[13]	-0.002 (0.001)	1.00 (1.00, 1.00)
	Older[14]		
Ethnicity*			
	European		
	Māori	1.07 (0.11)	2.92 (2.36, 3.61)
	Pacifica	1.65 (0.11)	5.21 (4.20, 6.48)
	Asian	1.42 (0.11)	4.15 (3.38, 5.10)
	MELAA, Other, NZer[15]	0.87 (0.20)	2.38 (1.63, 3.50)
Deprivation*			
	Low		
	Medium	0.49 (0.11)	1.64 (1.32, 2.03)
	High	0.10 (0.11)	1.11 (0.90, 1.37)
Education*			
	No Secondary School Qualification	0.59 (0.16)	1.81 (1.33, 2.46)
	Secondary School Qualification	0.50 (0.11)	1.66 (1.33, 2.06)
	Diploma or Trade Certificate	0.39 (0.11)	1.48 (1.20, 1.82)
	Bachelor's Degree	-0.05 (0.14)	0.95 (0.73, 1.25)
	Higher Degree		
Child Gender*			
	Boy	0.34 (0.07)	1.41 (1.22, 1.62)
	Girl		
Rurality			
	Urban		
	Rural	0.20 (0.13)	1.22 (0.95, 1.56)
Cumulative Risk* (continuous)		0.06 (0.02)*	1.06 (1.02, 1.10)*

*Risk categories = $p < .05$.

[12] Mothers who were 30 years of age and/or younger while pregnant.
[13] Mothers who were 30 years of age and/or younger while pregnant.
[14] Children who were younger than 4.5 years of age during this DCW.
[15] Children who were older than 4.5 years of age during this DCW.
[16] MELAA = Middle Eastern, Latin American, or African; NZer = New Zealander.

Table 4
Associations Between Covariates and Cumulative Risk Variable and DIBELS at Age 4.5 Years

Variable		*B* (SE)	OR (95% CI)
Mother Age*			
	Younger[16]	0.06 (0.08)	1.07 (0.91, 1.24)
	Older[17]		
Child Age During 4.5 Year DCW*			
	Younger[18]	-0.002 (0.001)	1.00 (1.00, 1.00)
	Older[19]		
Ethnicity*			
	European		
	Māori	0.84 (0.11)	2.32 (1.88, 2.87)
	Pacifica	0.96 (0.12)	2.60 (2.08, 3.26)
	Asian	-0.25 (0.14)	0.78 (0.59, 1.08)
	MELAA, Other, NZer[20]	0.22 (0.21)	1.24 (0.82, 1.89)
Deprivation*			
	Low		
	Medium	0.32 (0.11)	1.38 (1.11, 1.72)
	High	0.04 (0.10)	1.04 (0.85, 1.27)
Education*			
	No Secondary School Qualification	0.69 (0.16)	1.99 (1.45, 2.72)
	Secondary School Qualification	0.40 (0.12)	1.49 (1.18, 1.88)
	Diploma or Trade Certificate	0.51 (0.11)	1.66 (1.34, 2.06)
	Bachelor's Degree	-0.02 (0.14)	0.98 (0.74, 1.28)
	Higher Degree		
Child Gender*			
	Boy	0.37 (0.07)	1.45 (1.25, 1.68)
	Girl		
Rurality			
	Urban		
	Rural	0.33 (0.14)	1.38 (1.05, 1.82)
Cumulative Risk*			
(continuous)		0.07 (0.02)*	1.07 (1.03, 1.11)*

*Risk categories = $p < .05$.

[17] Mothers who were 30 years of age and/or younger while pregnant.
[18] Mothers who were 30 years of age and/or younger while pregnant.
[19] Children who were younger than 4.5 years of age during this DCW.
[20] Children who were older than 4.5 years of age during this DCW.
[21] MELAA = Middle Eastern, Latin American, or African; NZer = New Zealander.

the degree to which risk exposure affects language. Through logistic regression, the relation between CR and language status was analysed in 5,721 children and their mothers.

Our study revealed a high prevalence rate of lower-ability language status with almost a third (31.9%) of children presenting a lower language ability based on our criteria. Thus, the greater number of maternal risks children are exposed to, the more likely they are to experience delays in language development. All controlled covariates were significant except for rurality.

As expected, the number of maternal risks are strongly linked to a child's language ability. Prior research assessing the relationship between CR and language development with 3-year-olds of low-income families (Stanton-Chapman et al., 2004) found a relationship similar to that of our study. And like our study, the accumulation of risk factors increased the likelihood of delayed language development (Stanton-Chapman et al., 2004). Burchinal and colleagues (2000) also found that an increase in CR exposure led to an increase in lower language ability in children. However, Sylvestre and Mérette (2010) noted that CR had an insignificant impact on a neglected child's language development. Rather, these researchers found that individual risks explain language ability more concisely than a CR model. The children in all three of these studies were neglected by their parents or came from low-SES families. Our research differs as our CR model focuses on gestational, perinatal, and postpartum risk factors while controlling for sociodemographic covariates, such as deprivation, from a large and diverse group of mothers and children.

Despite conflicting results with regard to CR and language ability, past research on individual risks supports our findings. All risks included in our CR model were associated with cognitive development. Our study found that almost a third of mothers had consumed alcohol during pregnancy, which is an established risk factor for language and cognitive delays (Davies et al., 2011; Lairoque et al., 1995; Russell et al., 199). More than half of the children were not firstborns, a status associated with poorer cognitive ability (Belmont & Marolla, 1973). Almost half of mothers were underweight, overweight, or obese according to their BMI, a health concern associated with a child's lower-ability cognitive outcomes (Daraki et al., 2017; Pugh et al., 2015). Further, more than one third of the pregnancies were unplanned, a risk connected with lower verbal ability (Carson et al., 2011).

Though the mechanism behind language ability is relatively unknown, several of the risk factors included in this study are known to alter fetal development. For example, maternal perceived stress, which was experienced by a majority of mothers in this study, can negatively impact the intrauterine environment, leading to bio-behavioural abnormalities in newborns (Dieter et al., 2008). While there are no direct neural connections between mother and fetus (Dieter et al., 2008), the fetal environment is altered by maternal stress as there is a connection between maternal and fetal cortisol levels (Talge, Neal, & Glover, 2007), with an estimated 10-20% of maternal cortisol passing through to the fetus (Gitau, Cameron, Fisk, & Glover, 1998; Glover, Bergman, Sarkar, & O'Connor, 2009). Further, recent research from a longitudinal birth cohort found that adolescents carrying the TT genotype of the rs12193738 polymorphism on the KIAA0319 gene exposed to high maternal stress during pregnancy had significantly poorer reading abilities than offspring exposed to low maternal stress (D'Souza et al., 2016). Therefore, research now focuses on a pregnant mother's hypo-thalamic-pituitary-adrenal (HPA) axis as the underlying mechanism for long-term effects on a child's development (Talge et al., 2007). Nevertheless, more research regarding the mechanisms behind other risk factors is needed to determine the biological origins for language ability.

Strengths and Limitations

There are some important limitations to this study that must be taken into consideration when reviewing the findings. The antenatal data were collected late during the mother's pregnancy, making the results subject to potential bias in recalling information regarding pre- and early pregnancy. Also, as with many longitudinal studies, there are cases of missing data that relay a different sociodemographic distribution, which limits the overall generalisability of the results. Further, the CR approach limits risk intensity, making it impossible to determine the statistical interactions between risk factors (Evans et al., 2013). That is, when using the CR approach, risks are granted equal weight rather than each risk being viewed as having a unique effect, done in traditional multiple regression (Hall et al., 2010). This method is also subject to loss of information as individual measures are dichotomised, potentially creating an erroneous statistical relationship (Hall et al., 2010; MacCallum, Zhang, Preacher, & Rucker, 2002).

Another limitation is that we only measured English-language skills and did not control for multilingual status. The association between bilingualism/multilingualism and language ability is complex, and we acknowledge that some children may have ended up in our lower-ability category because of their non-monolingual status. However, all study members were born in New Zealand, where English is the predominant language. We intend to further explore the topic to better understand the effect multilingualism has on language ability.

Further, we did not account for any additional instruction or learning opportunities children might have been exposed to. However, at age 4.5, unless children are being taught by parents to recognise or write letters, they are unlikely to be learning letters on their own. It is possible, but if so, it would apply to a small minority.

Despite these limitations, there are also several strengths to the study. Previous research has mainly focused on the related risk factors of language ability in isolation, whereas the current study examined the effects of cumulative risk. Therefore, this multivariate analysis expands on our understanding of the relevance of both the antenatal environment and the perinatal events throughout early development. Additionally, the participants came from a large and diverse population. With 5,721 children and their mothers, the sample well represented a range of demographics, including ethnic minority and low-SES groups, making our results generalisable to children across New Zealand. Due to the up-to-date and detailed nature of the GUiNZ data, we were able to pinpoint a large variety of antenatal and perinatal risk factors associated with language development and control for a broad range of sociodemographic confounds.

Identification of controllable risk factors that may delay a child's early language ability can aid in the prevention and intervention of lower language ability. Findings support the improvement of education for new mothers on the dangers or risks, such as second-hand smoke exposure during pregnancy, and the importance of folate intake during the first trimester. The ongoing GUiNZ research has great potential to further investigate the long-term effects of CR on offspring language ability throughout development.

Conclusions

The extent of CR exposure has a significant impact on a child's language development. This study contributes to an understanding of CR's influence on pregnancy and language ability. Specifically, our findings emphasize the need for improving maternal education regarding modifiable factors such as smoking, taking vitamins, and keeping within a healthy weight gain during pregnancy. As a child's likelihood of having lower-ability language status increases after being exposed to more than three risks during and surrounding pregnancy, it is important that a mother understands the cumulative power of risks on a child's future language status.

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