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Gestational age and child development at age five in a population-based cohort of 97,989 Australian Aboriginal and non-Aboriginal children

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Short title Gestational age and child development in Australian children

Abstract

Background: Preterm birth and developmental vulnerability are more common in Australian Aboriginal compared with non-Aboriginal children. We quantified how gestational age relates to developmental vulnerability in both populations.

Methods: Perinatal datasets were linked to the Australian Early Development Census (AEDC), which collects data on five domains, including physical, social, emotional, language/cognitive, and general knowledge/communication development. We quantified the risk of developmental vulnerability on ≥1 domains at age 5, according to gestational age and Aboriginality, for 97,989 children born in New South Wales, Australia, who started school in 2009 or 2012.

Results: 7,079 children (7%) were Aboriginal. Compared with non-Aboriginal children, Aboriginal children were more likely to be preterm (5% versus 9%), and developmentally vulnerable on ≥1 domains (20% versus 36%). Overall, the proportion of developmentally vulnerable children decreased with increasing gestational age, from 44% at ≤27 weeks to 20% at 40 weeks. Aboriginal children had higher risks than non-Aboriginal children across the gestational age range, peaking among early term children (RD 19.0, 95% CI 16.3, 21.7; RR 1.91, 95% CI 1.77, 2.06). The relation of gestational age to developmental outcomes was the same in Aboriginal and non-Aboriginal children, and adjustment for socioeconomic disadvantage attenuated the risk differences and risk ratios across the gestational age range.

Conclusions: Although the relation of gestational age to developmental vulnerability was similar in Aboriginal and non-Aboriginal children, Aboriginal children had a higher risk of developmental vulnerability at all gestational ages, which was largely accounted for by socioeconomic disadvantage.

Keywords: Gestational age; Preterm birth; Early childhood development; Indigenous population; Linked administrative data.

Introduction

Birth before 39 weeks' gestation is a leading risk factor for adverse neonatal outcomes[1] and impaired development during early childhood and beyond.[2,3] By school age, children born preterm have an increased risk of developmental deficits on multiple domains.[4] The risk of adverse development is highest for extremely preterm babies, and declines with each additional week of gestational age at birth through to full term.[5–8] Recent evidence suggests that postterm babies, born after 41 weeks' gestation, also have an elevated risk of special educational needs[7] and developmental vulnerability,[9] broadly similar to children born at 37 weeks' gestation.

A social gradient in the prevalence of preterm birth has been observed in numerous settings[10] and using alternative measures of disadvantage.[11] There is also an association between disadvantage and early childhood development.[12] Accordingly, socioeconomic disadvantage potentially confounds the relationship between gestational age and child development. Socioeconomic disadvantage may also moderate the effect of gestational age on child development—deprivation during the early childhood years may exacerbate the effects of prematurity, while relative affluence may be protective.[1,13,14] These moderating effects may arise through differential access to resources[15] or parenting behaviours[16] that promote positive development.

In Australia, Aboriginal children are more likely to be born preterm,[17] and developmentally vulnerable at school entry,[18] compared with their non-Aboriginal peers. It is unknown, however, whether the relationship between gestational age and early childhood development is similar in both populations. Aboriginal children are more likely to experience disadvantage from the time they are in utero;[19] the effect of preterm birth on child development may therefore be more severe for Aboriginal compared with non-Aboriginal children due to the potential modifying effects of disadvantage during early childhood.[13,14] Combined with higher rates of preterm birth in Aboriginal children, this may explain some of the disparity in child development between Aboriginal and non-Aboriginal children, and inform targets for intervention to reduce the Aboriginal – non-Aboriginal development gap.

To better understand whether the association between gestational age and child development differs between Aboriginal and non-Aboriginal children, and to explore the contribution of socioeconomic disadvantage to this relationship, we used linked health and education data from population-level administrative datasets to quantify child development outcomes at age five, according to gestational age at birth, in Australian Aboriginal and non-Aboriginal children.

Methods

Data sources and study population

This study used the Seeding Success data resource, a population-based cohort of children who were born in New South Wales (NSW), Australia, and participated in the Australian Early Development Census (AEDC) in 2009 or 2012. The source data and characteristics of the cohort, have been described in detail elsewhere.[20,21] Briefly, AEDC data were linked to administrative datasets in NSW, including: Perinatal Data Collection (PDC), the Register of Births, Deaths and Marriages (RBDM) birth registrations, Admitted Patients Data Collection (APDC), and Public-School Enrolments.

The Seeding Success cohort (n=166,278) was restricted to singleton children without medically diagnosed special needs, and with available gestational age and AEDC data (n=151,088). The study population was further restricted to those enrolled in a NSW Public School in 2009 or 2012 (n=97,989), because socioeconomic measures were unavailable for children enrolled in non-government schools.

Gestational age and Aboriginality

Gestational age was recorded in the PDC as the number of completed weeks, using the best available clinical estimate based on last menstrual period, and early ultrasound, where available. Gestational age has previously been found to be recorded with a high degree of reliability in NSW perinatal data.[22] For descriptive statistics of the whole study population, outcomes were analysed by week of gestation, from 27 to 43 weeks, with children born prior to 28 weeks (n=123), or after 42 weeks (n=141) grouped as ≤27 weeks and ≥43 weeks, respectively. For analyses of Aboriginal and non-Aboriginal children, gestational age was recoded into six categories, because of small numbers of Aboriginal children at either extreme of the gestational age range. Gestational age categories included: early/moderate preterm (≤33 weeks), late preterm (34-36 weeks), early term (37-38 weeks), full term (39-40 weeks), late term (41 weeks) and postterm (≥42 weeks).[23]

Aboriginality was defined using multiple data sources to enhance Aboriginal identification, which is often under-reported in administrative datasets.[24] Children were classified as Aboriginal if the child or either parent was recorded as Aboriginal and/or Torres Strait Islander on any birth record from the PDC, RBDM or APDC, or their AEDC record at school age.

Early childhood development outcome

The outcome of interest was a binary indicator of developmental vulnerability on ≥1 domains measured by the AEDC. The AEDC is a nationwide census of Australian school starters implemented triennially since 2009, and includes a population measure of early childhood development on five domains: physical health and wellbeing; social competence; emotional maturity; language and cognitive skills; and communication and general knowledge.[25] The AEDC is completed in the second

term (May-July), for all children enrolled in the first year of school, by a teacher who has known the child for at least two months. Coverage is almost total in NSW, with 99.9% of school starters assessed in 2009 and 97.3% in 2012.[18] Children were classified as developmentally vulnerable if they scored in the lowest decile on one or more of the five AEDC domains, based on the 2009 thresholds.[26]

Explanatory variables

Potential explanatory variables were identified *a priori* using directed acyclic graphs (available on request) and included: child's sex, parity, maternal age at childbirth, maternal education, parental occupation, maternal region of birth, maternal partnership status at childbirth, private health insurance/patient status at childbirth, smoking during pregnancy, antenatal care attendance, maternal comorbidities during pregnancy (including pre-existing and gestational hypertension and/or diabetes), preschool attendance in the year before school, school starting age, and English as a Second Language (ESL). Area-level variables, assigned according to the mother's statistical local area of residence at the child's birth, included: geographical remoteness, measured by the Accessibility/Remoteness Index of Australia (ARIA+);[27] and area-level socioeconomic disadvantage, measured by the Australian Bureau of Statistics' Index of Relative Socioeconomic Advantage and Disadvantage.[28] Where available covariates were hypothesised to lie on the causal pathway between gestational age and development, they were excluded from the analysis (e.g. five minute Apgar score, admission to special care nursery/NICU at birth, and resuscitation at birth).

Missing data

Most variables used in the analysis had less than 3% missing data, apart from maternal education (8.5%), parental occupation (6.8%), and preschool attendance (6.5%) (Supplementary Table S1). Complete covariate information was available for 80% (n=82,089) of the study population. Aboriginal children with poor development were more likely to have incomplete data, therefore, multiple imputation was used to limit potential missing data bias. Imputations were derived using fully conditional specification, and each incomplete variable was modelled in turn using the outcome and covariates from the analysis model as predictors. The adjusted analyses presented here were performed by pooling estimates from the ten imputed datasets using standard rules.[29]

Statistical methods

We estimated the proportion of children with developmental vulnerability for the study population, with 95% confidence intervals, for each week of gestational age from 27 to 43 weeks. We then estimated the proportion of Aboriginal and non-Aboriginal children with developmental vulnerability for each gestational age category. To assess the independent associations between child development and both gestational age and Aboriginality, we fitted crude and adjusted logistic

regression models to estimate the risk difference and relative risk of developmental vulnerability within each gestational age category compared with children born at full term, and for Aboriginal compared with non-Aboriginal children. The risk estimates were calculated from the fitted logistic regression parameters, by aggregating individual probability estimates to derive estimates of risk for subgroups of interest.[30] This approach performs comparably to other common approaches to risk ratio estimation,[31] and avoided the common issue of non-converging log-binomial models.

To test whether the relationship between gestational age and child development differed statistically between Aboriginal and non-Aboriginal children, we refitted the model to include a set of dummy variables for the interaction between Aboriginality and gestational age. The fitted model parameters were used to estimate the risk difference and relative risk of developmental vulnerability for Aboriginal compared with non-Aboriginal children within each gestational age group. The presence of effect modification was assessed from the fully adjusted model on the additive scale by calculating the relative excess risk due to interaction (RERI),[32] and on the multiplicative scale, by examining the statistical significance of the interaction coefficients.

To quantify how much of the inequality in developmental vulnerability between Aboriginal and non-Aboriginal children could be explained by differences in measured socioeconomic, demographic and perinatal characteristics, the interaction model was fitted repeatedly, adding sets of covariates sequentially. Model 0 was unadjusted. Model 1 adjusted for family-level socioeconomic indicators, including low maternal education, low-skilled parental occupation and private health insurance/patient status. Model 2 included all remaining perinatal and demographic covariates from Table 1.

For all models, standard errors were calculated using the delta method, and were inflated to account for the clustering of similar children within schools. Analyses were carried out using Stata (version 12).[33]

Sensitivity analyses

To assess the impact of excluding children attending non-government schools from the main analysis, we compared the unadjusted association between gestational age and developmental vulnerability in the analysis sample and all children with complete exposure and outcome data. To assess the consistency of findings across different development domains, we examined the relationship between gestational age and developmental vulnerability by Aboriginality on the five AEDC domains. To assess the effect of multiple imputation, we compared the distribution of the study variables by Aboriginal status for children with complete covariate data and the imputed sample. Because the children with special needs are not assigned to an AEDC developmental vulnerability category, and gestational age may be associated with special needs, we conducted a

sensitivity analysis under a 'worst-case scenario' assumption whereby all children with special needs were assumed to be developmentally vulnerable.

Ethics approval

Ethical approval was obtained from the NSW Population Health Services and Research Ethics Committee (2014/04/523), the NSW Aboriginal Health and Medical Research Council Ethics Committee (1031/14) and the Australian National University Human Research Ethics Committee (2014/384).

Results

Study population

Of the total 97,989 children, 7,079 (7.2%) were Aboriginal. A higher proportion of Aboriginal children were born early preterm (0.3% versus 0.1%), moderate preterm (1.8% versus 1.0%), late preterm (6.5% versus 3.8%), and early term (22.2% versus 21.3%), compared with non-Aboriginal children (Table 1). Higher proportions of Aboriginal children had indicators of socioeconomic disadvantage compared with their non-Aboriginal counterparts, including low maternal education (19.9% versus 5.6%), low parental occupation level (59.3% versus 24.3%) and lower rates of private health insurance/patient status at the child's birth (6.6% versus 32.9%) (Table 1).

Gestational age, Aboriginality and child development outcomes

Overall, 20.8% (95% CI 20.6, 21.1) of children were developmentally vulnerable at age five. The proportion of developmentally vulnerable children was highest among those born ≤27 weeks' gestation, at 43.9% (95% CI 35.1, 52.1), decreasing with increasing gestational age to 19.8% (95% CI 19.4, 20.3) among children born at 40 weeks (Figure 1). Among children born at ≥43 weeks, 27.0% (95% CI: 19.6, 34.3) were developmentally vulnerable. The proportion of Aboriginal children who were developmentally vulnerable was 35.9% (95% CI: 34.8, 37.0) compared with 19.7% (95% CI: 19.4, 19.9) of non-Aboriginal children. A higher proportion of Aboriginal children were developmentally vulnerable across the gestational age range (Figure 2).

Modelling results

Compared to full term children, the adjusted risk difference for developmental vulnerability was 1.8 percentage points (95% CI 1.1, 2.4) for early term children, 3.9 percentage points (95% CI 2.6, 5.1) for late preterm children, and 7.5 percentage points (95% CI 5.1, 9.9) for early/moderate preterm children (Table 2). The adjusted relative risks, compared with full term children, were 1.09 (95% CI 1.05, 1.12) for early term children, 1.19 (95% CI 1.13, 1.26) for late preterm children, and

1.37 (95% CI 1.25, 1.49) for early/moderate preterm children, respectively. There was no difference in risk, in absolute or relative terms, between late or postterm children, compared with full term children.

The burden of developmental vulnerability between Aboriginal and non-Aboriginal children differed by 16.3 percentage points (95% CI 14.7, 17.8) in absolute terms, and was 83% higher (RR 1.83, 95% CI 1.74, 1.91) in relative terms (Table 2). After adjusting for differences in measured covariates, the Aboriginal to non-Aboriginal children risk difference was attenuated to 5.4 percentage points (95% CI, 4.3, 6.6), and the relative risk to 1.27 (95% CI 1.21, 1.32).

There was slight variation in the magnitude of the Aboriginal to non-Aboriginal risk differences and relative risks of developmental vulnerability across the gestational age range (Table 3). The smallest absolute difference was observed in postterm children (RD 12.5, 95% CI 3.8, 21.2; RR 1.62, 95% CI 1.17, 2.07), and the largest difference was among early term children (RD 19.0, 95% CI 16.3, 21.7; RR=1.91, 95% CI 1.77, 2.06) (Table 3; Model 0). Adjustment for family-level socioeconomic indicators attenuated the Aboriginal-to-non-Aboriginal risk differences and relative risks across the gestational age range. For example, for full term children, the unadjusted risk difference was 15.6 percentage points (95% CI 13.8, 17.4), reduced to 7.1 percentage points (95% CI 5.6, 8.5) after adjustment for family-level socioeconomic indicators; this equates to a 54% relative reduction (Table 3; Model 1). After adjusting for all available covariates, there were no interactions between gestational age and Aboriginality on the additive scale (assessed using the RERI statistic) or the multiplicative scale (assessed using the coefficient of the interaction term), indicating the association between gestational age and child development was similar in Aboriginal and non-Aboriginal children (Table 3; Model 2).

Sensitivity analyses

The relation of gestational age to developmental vulnerability was similar in the analysis sample (N=97,989) and the sample with complete outcome and exposure data (N=151,088) (Supplementary Figure S1). The pattern of association between gestational age and developmental vulnerability for Aboriginal and non-Aboriginal children was broadly similar on the five developmental domains (Supplementary Figure S2), and the aggregate outcome (i.e. vulnerable on ≥1 domains). Compared to the sample with complete covariate data, the imputed sample had a higher proportion of children with developmental vulnerability, low maternal education and low paternal occupation, especially among Aboriginal children (Supplementary Table S2). Accordingly, multiple imputation enabled us to include data for more vulnerable children in the analysis.

Because children with special needs did not have AEDC outcome data, 4,072 (4.3%) non-Aboriginal children and 531 (7.0%) Aboriginal children were excluded from the main analysis. When

children with special needs were included in the developmental vulnerability group, the proportion of children classified as vulnerable increased to 40.4% [95% CI: 39.3, 41.5] among Aboriginal children, and 23.1% [95% CI: 22.8, 23.4] among non-Aboriginal children, but, consistent with the main analysis, the relationship between gestational age and child development was similar in Aboriginal and non-Aboriginal children (Supplementary Figure S3).

Comment

Principal findings

In this contemporary population-based cohort of almost 100,000 Australian children, preterm children had a higher risk of developmental vulnerability, with increasing risks at earlier gestational ages. Although the association between gestational age and child development at age five was similar in Aboriginal and non-Aboriginal children, Aboriginal children had a higher risk of developmental vulnerability across the gestational age range. Within each gestational age category, adjustment for available socioeconomic, demographic and perinatal factors accounted for a substantial proportion of the absolute and relative inequalities between Aboriginal and non-Aboriginal children.

Interpretation

The general finding that each additional week of gestational age was associated with a decrease in the risk of developmental vulnerability from ≤27 weeks through to 40 weeks' gestation is consistent with a study of the same population that did not explore outcomes for Aboriginal children[5] and studies in Scotland and the USA that examined child outcomes beyond the perinatal period by week of gestational age among more than 100,000 children.[7,13] We also found that children born at 43 weeks' gestation had an elevated risk of developmental vulnerability, with similar risks compared to children born at 37 weeks' gestation, although the confidence intervals were wide, and overlapped with the estimate for children born at 40 weeks. A similar U-shaped pattern of risk in the full-term period between 37-43 weeks' gestation was found for developmental vulnerability at age 5 among more than 12,000 South Australian children,[9] and for special educational needs among more than 360,000 Scottish children.[7]

For the first time, this study quantifies at scale the relationship between gestational age and early childhood development in Aboriginal children, a disproportionately disadvantaged population group in Australia. Although it is well known that preterm birth is more common in Aboriginal compared with non-Aboriginal children,[17] this study shows that Aboriginal children have a higher risk of developmental vulnerability across the whole gestational age range. We also established that the overall relation of gestational age to child development is similar in Aboriginal and non-Aboriginal children. Aboriginal children were more likely than non-Aboriginal children to be disadvantaged, as

indicated by maternal schooling, parental occupation, and private health insurance/patient status. We have shown that differences in the distribution of these indicators of socioeconomic advantage/disadvantage account for a substantial proportion of the absolute and relative gap in child development outcomes between Aboriginal and non-Aboriginal children at all gestational ages. Although Aboriginal children are more likely to be born preterm, and to experience a disproportionate burden of developmental vulnerability, the absence of significant interaction terms in our study suggests that the relationship of gestational age to child development at age five is broadly similar in Aboriginal and non-Aboriginal children.

Strengths of the study

The strengths of this study include the high population coverage of the source data, and the large sample size, which enabled us to quantify outcomes for Aboriginal children, a small and vulnerable population group. Linkage of multiple cross-sectoral administrative datasets enabled enhanced identification of Aboriginal children compared with a single data source.[24]

Limitations of the data

We were limited to covariates available from the source data, which were collected primarily for administrative purposes, rather than research. Because there is likely to be residual confounding, adjusted risk estimates of the association between gestational age and child development in Aboriginal and non-Aboriginal children also include the effect of unmeasured covariates, including the intergenerational effects of discrimination, marginalisation and removal of children that are pertinent to Australian Aboriginal children and their families.[34] As key family-level socioeconomic variables were not available for children enrolled in non-government schools, the study population was restricted to the 70% of children who attended NSW Public Schools. However, sensitivity analyses illustrate that the relationship between gestational age and child development outcomes at age five were consistent in the study population and the broader population of children enrolled in both non-government and government schools who had complete exposure and outcome data. An additional limitation is that children with special needs were excluded from the main analysis because the AEDC is not validated for use in this population. This was potentially problematic because preterm birth is associated with an increased risk of special educational needs,[7] and Aboriginal children were disproportionately excluded from the analysis due to a higher prevalence of special needs. However, our sensitivity analysis, that added children with special needs to the group of children classified as developmentally vulnerable, showed a similar relationship between gestational age and child development outcomes in Aboriginal and non-Aboriginal children, and did not alter the qualitative conclusions of the study.

Conclusions

This study adds to growing evidence that, at a population level, increases of gestational age up to 39 weeks are associated with a reduced risk of adverse child development outcomes. This association is similar in both Aboriginal and non-Aboriginal children. Early preterm children are routinely monitored and supported during early childhood in Australia; our study suggests there may also be unmet developmental needs among late preterm and early term children.

Although the relationship between gestational age and early childhood development was similar for Aboriginal and non-Aboriginal children, Aboriginal children had an increased risk of developmental vulnerability by age five, regardless of gestational age. Our findings suggest that much of the absolute and relative gap in outcomes between Aboriginal and non-Aboriginal children across the gestational age range can be accounted for by the disproportionate burden of disadvantage experienced by Aboriginal children. Accordingly, policies that improve the social and economic conditions for disadvantaged children, including Aboriginal children, are likely to improve child development in these vulnerable populations.

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Figure legends

Figure 1. Percentage of children developmentally vulnerable on one or more AEDC domains, and number of births, by gestational age at birth.

Figure 2. Percentage of children developmentally vulnerable on one or more AEDC domains, by gestational age group and Aboriginality.

Supporting Information

Table S1. Number and percentage of missing observations for the study variables.

Table S2. Comparison of study variables by Aboriginal status for the sample with complete covariate data and the imputed sample.

Figure S1. Risk of developmental vulnerability by gestational age for the population of children with complete exposure and outcome data (N=151,088), the study population with exclusion criteria applied (N=97,989)

Figure S2. Percentage of children developmentally vulnerable on one or more AEDC domains, by gestational age group and Aboriginality for five developmental domains: physical health and wellbeing; social competence; emotional maturity; language and cognitive skills; and communication and general knowledge

Figure S3. Percentage of children developmentally vulnerable, or with medically diagnosed special needs, on one or more AEDC domains, by gestational age group and Aboriginality.

Table 1. Child, mother and area-level characteristics at birth and school age, by Aboriginality, for the imputed study population.

	Non-Aboriginal		Aboriginal		Total	
	n	(%)	n	(%)	n	(%)
Characteristics of child, mother and area of residence						
Child characteristics at birth						
n (%)	90,910	100.0	7,079	100.0	97,989	100.0
Gestational age group						
Early preterm (22-27 weeks)	102	0.1	21	0.3	123	0.1
Moderate preterm (28-33 weeks)	866	1.0	128	1.8	994	1.0
Late preterm (34-36 weeks)	3,469	3.8	463	6.5	3,932	4.0
Early term (37-38 weeks)	19,381	21.3	1,570	22.2	20,951	21.4
Full term (39-40 weeks)	49,714	54.7	3,731	52.7	53,445	54.5
Late term (41 weeks)	15,590	17.1	1,046	14.8	16,636	17.0
Postterm (≥42 weeks)	1,788	2.0	120	1.7	1,908	1.9
Male sex	46,185	50.8	3,475	49.1	49,660	50.7
Maternal characteristics at birth						
Parity						
0	37,654	41.4	2,385	33.7	40,040	40.9
1	31,637	34.8	1,978	27.9	33,614	34.3

2+	21,619	23.8	2,716	38.4	24,335	24.8
Maternal age at childbirth						
<20	3,087	3.4	1,218	17.2	4,305	4.4
20-24	13,385	14.7	2,181	30.8	15,566	15.9
25-29	25,140	27.7	1,766	24.9	26,906	27.5
30-34	30,221	33.2	1,277	18.0	31,498	32.1
35+	19,077	21.0	637	9.0	19,714	20.1
Mother born in Australia	64,932	71.4	6,716	94.9	71,648	73.1
Mother has a partner	75,755	83.3	3,338	47.2	79,093	80.7
Private patient/insurance	29,921	32.9	470	6.6	30,391	31.0
Smoking during pregnancy	12,882	14.2	3,415	48.2	16,297	16.6
Antenatal care in first 20 weeks	81,106	89.2	5,702	80.5	86,807	88.6
Maternal comorbidity[a]	9,740	10.7	672	9.5	10,412	10.6
Child characteristics at the start of school						
Attended preschool/childcare	67,007	73.7	4,953	70.0	71,960	73.4
English as a second language	16,455	18.1	231	3.3	16,686	17.0
School starting age						
<5 years	31,196	34.3	2,485	35.1	33,681	34.4

5-5.5 years	36,946	40.6	2,763	39.0	39,709	40.5
≥5.5 years	22,768	25.0	1,831	25.9	24,599	25.1
AEDC census year						
2009	43,315	47.6	3,190	45.1	46,505	47.5
2012	47,595	52.4	3,889	54.9	51,484	52.5
Maternal/family characteristics at the start of school						
Low maternal education (≤9 years school)	5,048	5.6	1,407	19.9	6,455	6.6
Low skilled parental occupation(s) (Grade 4/unemployed)	22,118	24.3	4,199	59.3	26,317	26.9
Area of residence						
Geographic remoteness[b]						
Major City	60,033	66.0	2,701	38.2	62,734	64.0
Inner Regional	22,951	25.2	2,462	34.8	25,413	25.9
Outer Regional	7,397	8.1	1,495	21.1	8,892	9.1
Remote/Very Remote	529	0.6	422	6.0	950	1.0
Area-level advantage/disadvantage[c]						
Q1 (Most disadvantaged)	7,885	8.7	1,558	22.0	9,443	9.6
Q2	9,656	10.6	1,330	18.8	10,987	11.2
Q3	31,305	34.4	2,950	41.7	34,255	35.0

Q4	19,321	21.3	877	12.4	20,198	20.6
Q5 (Most advantaged)	22,742	25.0	364	5.1	23,106	23.6

[a] Includes pre-existing and gestational-onset diabetes and hypertension

[b] Accessibility/Remoteness Index of Australia (ARIA+) based on mother's statistical local area of residence at the time of birth

[c] Socio-Economic Indices for Areas (SEIFA) Index of Relative Socio-economic Advantage and Disadvantage population quintiles based on mother's statistical local area of residence at the time of birth.

Table 2. Risk difference (RD) and relative risk (RR) of developmental vulnerability according to gestational age and Aboriginality

	Total Births	Developmental vulnerability/special needs				
		n (%)	RD (95% CI)	aRD[a] (95% CI)	RR (95% CI)	aRR[a] (95% CI)
Gestational Age						
Early/moderate preterm (≤33 weeks)	1117	362 (32.4)	12.6 (9.8, 15.3)	7.5 (5.1, 9.9)	1.63 (1.49, 1.77)	1.37 (1.25, 1.49)
Late preterm (34-36 weeks)	3932	1062 (27.0)	7.2 (5.7, 8.6)	3.9 (2.6, 5.1)	1.36 (1.29, 1.44)	1.19 (1.13, 1.26)
Early term (37-38 weeks)	20951	4654 (22.2)	2.4 (1.7, 3.0)	1.8 (1.1, 2.4)	1.12 (1.08, 1.15)	1.09 (1.05, 1.12)
Full term (39-40 weeks)	43199	362 (19.8)	Reference	Reference	Reference	Reference
Late term (41 weeks)	16636	3326 (20.0)	0.1 (-0.6, 0.8)	0.0 (-0.7, 0.7)	1.01 (0.97, 1.04)	1.00 (0.97, 1.03)
Postterm (≥42 weeks)	1908	397 (20.8)	1.0 (-1.0, 2.9)	0.5 (-1.3, 2.2)	1.05 (0.95, 1.14)	1.02 (0.93, 1.11)
Aboriginality						
non-Aboriginal	90910	17866 (19.7)	Reference	Reference	Reference	Reference
Aboriginal	7079	2543 (35.9)	16.3 (14.7, 17.8)	5.4 (4.3, 6.6)	1.83 (1.74, 1.91)	1.27 (1.21, 1.32)

RD=Risk difference; aRD=Adjusted risk difference; RR=Relative risk; aRR=Adjusted relative risk

[a]Adjusted models based on pooled estimates from 10 multiply imputed datasets, controlling for: mother's schooling, parent's occupation, Aboriginal status, child's sex, parity, maternal age, maternal country of birth, maternal partnership status, private insurance status, smoking during pregnancy, antenatal care in the first 20 weeks, maternal comorbidities (pre-existing or gestational-onset diabetes or hypertension), preschool attendance, school enrolment age, ESL status, geographic

Table 3. Absolute risk, risk difference and relative risk estimates from interaction models, comparing risk of developmental vulnerability for Aboriginal and non-Aboriginal children within each gestational age group.

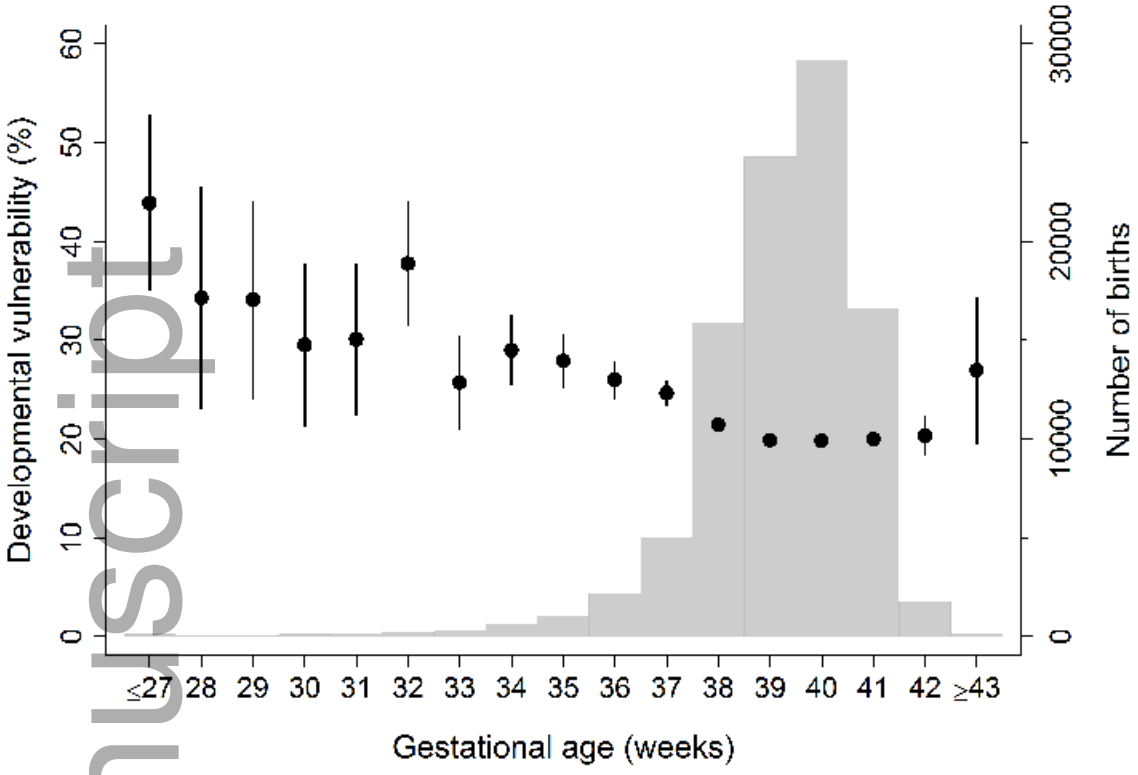
	Risk estimates				Tests of effect modification			
	non-Aboriginal risk (95% CI)	Aboriginal Risk (95% CI)	Risk Difference (95% CI)	Relative Risk (95% CI)	RERI[a]	P	Beta[b]	P
Model 0[c]								
Early/moderate preterm (≤33 weeks)	30.5 (27.5, 33.4)	45.0 (36.6, 53.4)	14.5 (5.6, 23.4)	1.48 (1.17, 1.78)	0.38	0.551	-0.19	0.308
Late preterm (34-36 weeks)	25.0 (23.4, 26.5)	42.1 (37.8, 46.5)	17.1 (12.6, 21.7)	1.69 (1.48, 1.89)	0.44	0.126	-0.04	0.720
Early term (37-38 weeks)	20.8 (20.0, 21.6)	39.8 (37.1, 42.5)	19.0 (16.3, 21.7)	1.91 (1.77, 2.06)	0.46	0.005	0.11	0.090
Full term (39-40 weeks)	18.8 (18.1, 19.4)	34.3 (32.5, 36.1)	15.6 (13.8, 17.4)	1.83 (1.72, 1.94)	Reference		Reference	
Late term (41 weeks)	19.2 (18.4, 20.0)	32.1 (29.1, 35.2)	12.9 (9.9, 16.0)	1.67 (1.51, 1.84)	-0.24	0.119	-0.13	0.098
Postterm (≥42 weeks)	20.0 (18.0, 22.1)	32.5 (23.9, 41.1)	12.5 (3.8, 21.2)	1.62 (1.17, 2.07)	-0.26	0.527	-0.16	0.426
Model 1[d]								

Early-moderate preterm (≤33 weeks)	28.4 (25.7, 31.2)	33.7 (26.3, 41.2)	5.3 (-2.6, 13.2)	1.19 (0.90, 1.47)	-0.02	0.936	-0.16	0.427
Late preterm (34-36 weeks)	24.5 (23.1, 26.0)	31.4 (27.6, 35.1)	6.8 (2.9, 10.8)	1.28 (1.11, 1.45)	0.06	0.734	-0.06	0.558
Early term (37-38 weeks)	21.7 (20.9, 22.4)	30.5 (28.2, 32.8)	8.8 (6.5, 11.1)	1.41 (1.30, 1.52)	0.19	0.086	0.06	0.323
Full term (39-40 weeks)	19.5 (18.9, 20.1)	26.6 (25.1, 28.1)	7.1 (5.6, 8.5)	1.36 (1.28, 1.44)	Reference		Reference	
Late term (41 weeks)	19.1 (18.4, 19.8)	24.9 (22.4, 27.4)	5.8 (3.3, 8.3)	1.31 (1.17, 1.44)	-0.10	0.339	-0.06	0.425
Postterm (≥42 weeks)	19.6 (17.7, 21.5)	25.3 (18.0, 32.6)	5.8 (-1.7, 13.2)	1.29 (0.91, 1.68)	-0.10	0.730	-0.07	0.739
Model 2[e]								
Early-moderate preterm (≤33 weeks)	27.4 (24.8, 29.9)	31.1 (24.3, 38.0)	3.8 (-3.5, 11.1)	1.14 (0.87, 1.41)	-0.03	0.939	-0.13	0.529
Late preterm (34-36 weeks)	23.5 (22.1, 24.9)	28.4 (24.9, 31.9)	4.9 (1.1, 8.6)	1.21 (1.04, 1.37)	0.03	0.885	-0.05	0.655
Early term (37-38 weeks)	21.4 (20.6, 22.1)	28.4 (26.3, 30.5)	7.1 (5.0, 9.2)	1.33 (1.23, 1.43)	0.19	0.068	0.09	0.175
Full term (39-40 weeks)	19.7 (19.2,	24.9 (23.5,	5.2 (3.8, 6.5)	1.26 (1.19,	Reference		Reference	

	20.3)	26.3)		1.33)				
	19.7 (19.0,	23.8 (21.4,		1.21 (1.08,				
Late term (41 weeks)	20.4)	26.3)	4.1 (1.6, 6.6)	1.34)	-0.09	0.425	-0.06	0.448
	20.2 (18.3,	24.3 (17.2,		1.20 (0.84,				
Postterm (≥42 weeks)	22.0)	31.4)	4.1 (-3.1, 11.4)	1.57)	-0.08	0.789	-0.07	0.770

[a] Relative Excess Risk of Interaction (test of interaction on the additive scale); [b] Coefficient for the interaction dummy variable (test of interaction on the multiplicative scale) [c] Model 0 is unadjusted

[d] Model 1 is adjusted for low maternal education, low parental occupation, and private insurance/patient status; [e] Model 2 is adjusted for all available covariates included in Table 1.



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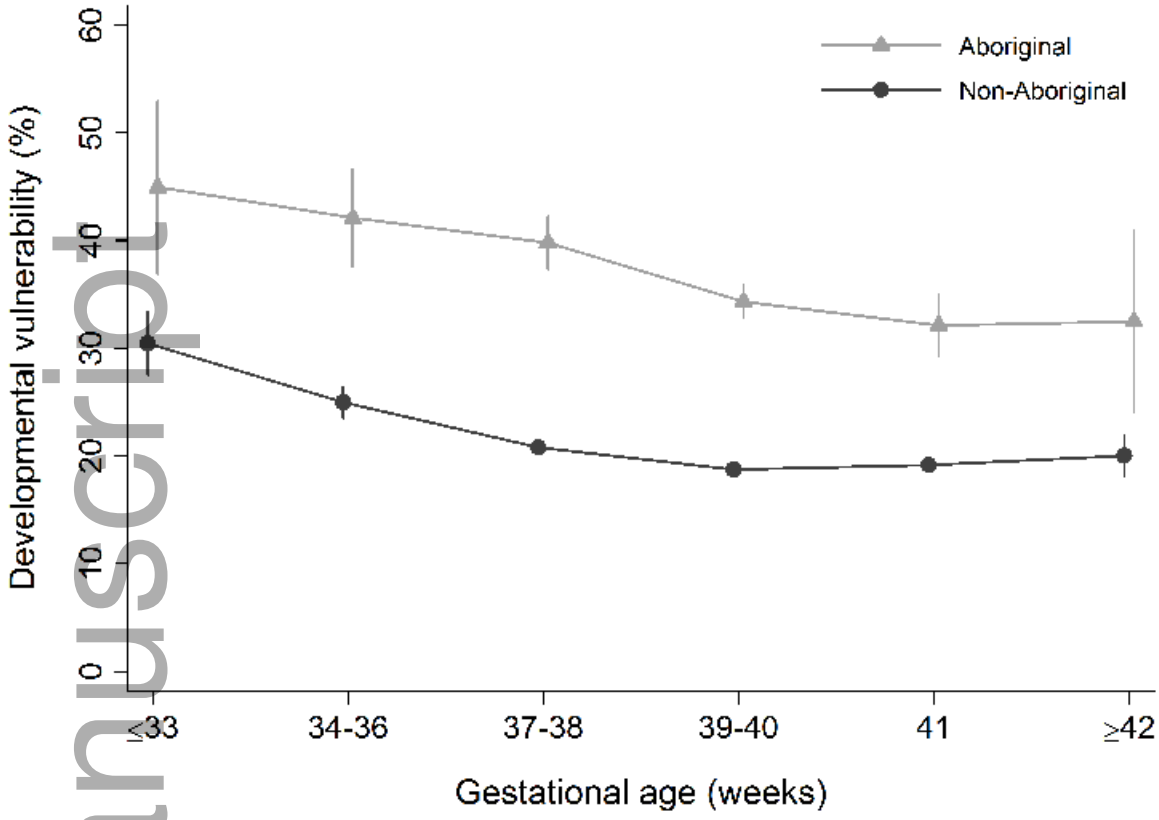

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