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ORIGINAL ARTICLE

Impact of perinatal health and socio-demographic factors on school education outcomes: A population study of Indigenous and non-Indigenous children in the Northern Territory

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Aim: This study investigated the association between early-life risk factors and school education outcomes.

Methods: This is an historical cohort study of 7601 children (61% were Indigenous) born in the Northern Territory between 1999 and 2004. Information was linked, for each child on: perinatal health, student enrolment and National Assessment Program – Literacy and Numeracy (NAPLAN) Year 3 results. Logistic regression was used to estimate the association between selected risk factors and a NAPLAN result 'below' the national minimum standard (NMS) in reading and numeracy.

Results: Indigenous children had much higher odds, than non-Indigenous children, of a result below the NMS for both reading (odds ratio (OR): 8.58, 95% confidence interval (CI): 7.55–9.74)) and numeracy (OR: 11.52, 95% CI: 9.94–13.35). When adjusted for all other variables, the increased odds were attenuated for both reading (OR: 2.89, 95% CI: 2.46–3.40) and numeracy (OR: 3.19, 95% CI: 2.65–3.84). Common risk factors for Indigenous and non-Indigenous children included higher birth order, maternal smoking in pregnancy and being a boy. There were gradients of decreasing risk with increasing education level of primary care giver and increasing maternal age. Among Indigenous children only, risks increased when living in remote areas, with younger age (<8 years) and low birthweight.

Conclusions: The study highlights that many of the risk factors associated with poor education outcomes among Indigenous children are shared with the general population. The results inform a targeted, cross-agency response to address modifiable early-life risk factors for educational disadvantage. Data linkage, using existing administrative datasets, provides a useful addition to methods that identify priority areas for prevention and early intervention.

Key words: educational measurement; Indigenous population; Northern Territory; perinatal care; socio-economic factor.

What is already known on this topic

1 A growing literature shows that both birth and socio-demographic factors, in early life, influence subsequent education outcomes.
2 Indigenous children, in many parts of Australia, have poor education outcomes.

What this paper adds

1 Many early life risk factors for later educational disadvantage are similar for Indigenous and non-Indigenous children.
2 The results inform a cross-agency response to address early life risk factors associated with educational disadvantage among Indigenous children.

Getting a good education and doing well in school are widely acknowledged as essential preparations for future success in life. Past studies have reported that birth characteristics, including gestational age and birthweight, have a substantial influence on subsequent education outcomes.[1,2] Studies have also demonstrated the effects of socio-demographic factors, including gender, maternal age, maternal education and poverty on education outcomes[1,3,4] and that different types of developmental problems are influenced differently by socio-demographic and perinatal characteristics.[1,5] Understanding the relative contribution of these and other factors to children's education outcomes is important to inform the targeting of services that support children and their families to overcome early childhood disadvantage.[6]

In the Northern Territory (NT) there are arguably two distinct populations of children, each with very different outcomes. Non-Indigenous children make up 55.9% of NT children aged 5–14 years and have health and education outcomes similar to the rest of Australia,[7] while the balance are Indigenous children (44.1%) who have much poorer health[8] and education outcomes.[9,10] Given the current policy efforts to improve Indigenous education outcomes, it is critical that service delivery and resource allocation are based on reliable evidence and a

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systematic understanding of the complex interplay between the individual, environmental and social forces that shape these outcomes.

National Assessment Program – Literacy and Numeracy (NAPLAN) tests commenced in 2008 and provided nationwide information for individual children in Years 3, 5, 7 and 9. NAPLAN data have recently become available for research and, to date, one study has used NAPLAN data when examining how well an Early Development Instrument predicts a child's later literacy and numeracy achievement.[11] In the NAPLAN 2012 national report Indigenous students in the NT performed much worse than in other jurisdictions, with 60% of Year 3 NT Indigenous students scoring below the national minimum standard (NMS), and worse outcomes (78%) among Indigenous children attending bush (very remote) schools.[12]

The aim of our study was to investigate the association of perinatal and socio-demographic factors with educational attainment in NAPLAN Year 3 reading and numeracy tests among both NT Indigenous and non-Indigenous children. To our knowledge, this is the first study to use data linkage to link perinatal, student enrolment and NAPLAN datasets at population level. Of particular importance is that this is the first study to provide detailed information on these associations for Indigenous children.

Methods

Data sources

Unit record level information for individuals, from three administrative datasets: perinatal health, government school student information and NAPLAN assessment were probabilistically linked to create an anonymous linkage key unique for individuals within the datasets.[13] Probabilistic linkage involves the calculation of probability weights for potential matches among individuals in different datasets and are estimated given all the observed agreements and disagreements of the values of identifying variables.[14] Identifiable datasets, with the addition of the unique linkage keys, were returned to the respective data custodians who then collated de-identified research datasets that contained content information and unique linkage keys. The separation of 'identifiable data' and 'content data' maintains confidentiality in linkable research datasets. The perinatal dataset contained antenatal and birthing information for all births occurring in the NT. Student information included demographic and social characteristics for the child and parents. The NAPLAN dataset contained individual results for students in Years 3, 5, 7 and 9 from 2008 to 2012.

Subjects

The perinatal dataset included a total of 17 584 records for liveborn children, born to NT resident mothers, between 1st July 1999 and 30th June 2004. From perinatal data, 7601 children (4603 Indigenous and 2998 non-Indigenous) were successfully linked to school student information and NAPLAN Year 3 results. The majority of children in Year 3 were aged 8 years. The linked study cohort represented 43% of the corresponding NT birth cohort, or approximately 65% of Indigenous and 30% of non-Indigenous children. There were five sources for loss to follow-up. First, there was a high level of migration among non-Indigenous children, in this case occurring between birth and the NAPLAN Year 3 assessment. Migration of non-Indigenous children is largely responsible for the difference in distribution, by Indigenous status, between the birth cohort and linked study cohort. A second source of loss to follow-up was that the linked study cohort only included children enrolled in NT government schools, whereas approximately 30% of NT children attended non-government schools, were home-schooled or were otherwise not enrolled in public schools.[15] A proportion of children would have been absent during NAPLAN assessments and a small number would have died. Finally, linkage may have been incomplete, for some individuals, for a range of reasons including changes in name or recording errors in identifying variables.

Outcome measures

NAPLAN data provide achievement level information for Year 3 students in five areas – numeracy, reading, writing, spelling and grammar. The NMS, for each area, is the benchmark for the basic level of knowledge and understanding needed to function at that year level. Of the five NAPLAN areas, reading and numeracy results were selected as outcome measures on the basis of their reported consistency through time and their demonstrated utility in the previous study.[11]

Explanatory variables

Explanatory variables were selected on the basis of previous studies that described the association of specific risk factors with education outcomes. Variables available from the perinatal dataset were: gestational age,[1,2,5,16–18] birthweight,[2,16–19] Apgar scores at 5 min,[5,17,18] maternal age,[1,2,5,16–19] child gender,[1–3,5] parity,[2,5,16,17,20] maternal smoking[2,18,19] and alcohol consumption.[2,18–20] Variables selected from student information data were: maternal education,[1,2,16,20] Indigenous status,[3,4,18] age of child[17] and remoteness of residence.[18] The selected variables overlapped with indicators of progress in early child development within the Australian government's 'Close the Gap' initiatives, including birthweight, maternal age (teenage pregnancy) and maternal smoking and alcohol consumption, and with the more general emphasis on social disadvantage.[19] Risk factors identified in the literature but not available for this study were marital status and family income.[2,4,5]

Student information did not specify 'maternal education' but included fields for the school education level of both 'Parent 1' and 'Parent 2', in which 'Parent 1' was the primary care giver and was typically the child's biological mother but may be another carer including the father, guardian or grandparent. 'Parent 2' was usually the biological father but could be another adult responsible for the child. NAPLAN data provided age of child at the time of assessment. Information on 'remoteness of residence' was categorised into one of three levels of relative remoteness applicable to the NT using the Australian Standard Geographical Classification 2006.[21] Plurality of birth was included as an explanatory variable to control for multiple births.

Statistical analysis

Logistic regression was used to examine the association between potential risk factors and NAPLAN results. The analyses were first undertaken at univariate level, and then all variables were incorporated in a multivariate logistic regression model. Unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were estimated for an outcome 'below' the NMS for literacy or numeracy. Models were undertaken for Indigenous and non-Indigenous children combined and separately. Analyses were conducted using Stata version 12 (Stata Corporation, College Station, TX, USA).

The number of children available for analysis varied with missing variable-level data. Most explanatory variables in the linked dataset had less than 1% missing values. Variables with more than 1% missing data were maternal smoking status (12.8%), maternal alcohol consumption status (16.1%) and primary care giver school education level (37.1%). There was also a proportion of children who were eligible for NAPLAN but with missing results in either reading (12.6%) or numeracy (13.1%). We accounted for missing data using multiple imputation by chained equations. This approach, under the assumption of missing at random and conditional on all other variables, uses multiple multivariate imputations to estimate missing values from the information available in other explanatory variables. A set of 20 imputation datasets was generated and used for all explanatory variable based models with results combined. Multinomial logistic regression was used for ordinal and categorical variables.

Ethics

The study protocol was approved by the Human Research Ethics Committee of NT Department of Health and Menzies School of Health Research (HR-10-1458) and Central Australian Human Research Ethics Committee (2010-09-06).

Results

A comparison of the distribution of demographic and risk factor variables for the linked study cohort and all NT births to NT resident women, between 1st July 1999 and 30th June 2004, is presented in Table 1. The groups were similar for many variables, including gestational age, Apgar score and sex; however, the increased representation of Indigenous children in the study cohort is evident in greater proportions of: younger mothers, children with low birthweight and children from very remote areas, as well as greater proportion of later birth order, and greater proportion of self-reported maternal smoking and alcohol consumption during pregnancy.

The proportion of children, in the study cohort, with a result below the NMS for reading was 38.2% for all children, with 54.9% and 12.5% for Indigenous and non-Indigenous children, respectively. The corresponding results for numeracy were 34.3% for all children, and 51.1% and 8.5% for Indigenous and non-Indigenous children, respectively. The results from logistic regression with and without imputation for missing values were similar. The results, with imputation, for all children combined and separately for Indigenous children and non-Indigenous children are presented in Tables 2–4.

Table 1 Comparison of demographic and risk factor distributions for the linked study cohort with all children born in the NT to NT resident women, 1999–2004

	Linked dataset		All NT births	
	Number	%	Number	%
Age of mother at the time of the birth				
<18	762	10.0	1279	7.3
18–19	736	9.7	1300	7.4
20–24	1922	25.3	3898	22.2
25–29	1909	25.1	4744	27.0
30–34	1465	19.3	4177	23.8
>35	807	10.6	2186	12.4
Total	7601	100.0	17584	100.0
Estimated gestational age, in completed weeks				
<34	234	3.1	536	3.0
34–36	593	7.8	1246	7.1
≥37	6774	89.1	15802	89.9
Total	7601	100.0	17584	100.0
Apgar 5 (numerical score of baby's condition, 5 min after birth)				
≥7	7403	97.4	17108	97.3
<7	198	2.6	476	2.7
Total	7601	100.0	17584	100.0
Birthweight (grams)				
≥2500	6825	89.8	16049	91.3
<2500	776	10.2	1535	8.7
Total	7601	100.0	17584	100.0
Sex				
Girl	3704	48.7	8496	48.3
Boy	3897	51.3	9088	51.7
Total	7601	100.0	17584	100.0
Remoteness				
Outer regional area	3146	41.4	8583	48.8
Remote area	1449	19.1	3642	20.7
Very remote area	3006	39.5	5359	30.5
Total	7601	100.0	17584	100.0
Parity (total number of previous births for the mother)				
0	2728	35.9	6902	39.3
1	2085	27.4	5156	29.3
>1	2788	36.7	5526	31.4
Total	7601	100.0	17584	100.0
Mother's alcohol consumption during pregnancy				
No	6698	88.1	15732	89.5
Yes	903	11.9	1852	10.5
Total	7601	100.0	17584	100.0
Mother's smoking status during pregnancy				
No	4692	61.7	12085	68.7
Yes	2909	38.3	5499	31.3
Total	7601	100.0	17584	100.0

An Indigenous child had 8.6 times greater unadjusted odds (OR: 8.58, 95% CI: 7.55–9.74) than a non-Indigenous child of a NAPLAN result below the NMS for reading and 11.5 times time greater unadjusted odds for numeracy (OR: 11.52, 95% CI: 9.94–13.35) (Table 2). When adjusted for all other variables, the increased odds for Indigenous children were attenuated, though

Table 2 Unadjusted and adjusted odds ratios of reading and numeracy results below the national minimum standard for NAPLAN Year 3 test (n = 7601)

	Reading					Numeracy				
	No. below/no. at & above	Unadjusted OR	95% CI	Adjusted OR†	95% CI	No. below/no. at & above	Unadjusted OR	95% CI	Adjusted OR†	95% CI
Indigenous status										
Non-Indigenous child	374/2624	1.00‡		1.00		255/2743	1.00		1.00	
Indigenous child	2526/2077	8.58	7.55–9.74	2.89	2.46–3.40	2352/2251	11.52	9.94–13.35	3.19	2.65–3.84
Age at assessment										
<8	383/527	1.25	1.08–1.45	1.22	1.02–1.45	383/527	1.43	1.23–1.66	1.47	1.21–1.79
8	2285/3881	1.00		1.00		2013/4153	1.00		1.00	
>8	232/293	1.30	1.07–1.57	0.87	0.69–1.09	211/314	1.31	1.06–1.61	0.85	0.66–1.09
Estimated gestational age, in completed weeks										
<34	112/122	1.68	1.28–2.22	1.32	0.88–1.98	102/132	1.64	1.24–2.18	1.06	0.70–1.60
34–36	319/274	1.91	1.60–2.28	1.28	1.00–1.64	286/307	1.90	1.59–2.27	1.11	0.87–1.42
≥37	2469/4305	1.00		1.00		2219/4555	1.00		1.00	
Apgar 5 (numerical score of baby's condition, 5 min after birth)										
≥7	2801/4602	1.00		1.00		2515/4888	1.00		1.00	
<7	99/99	1.67	1.22–2.27	1.23	0.84–1.79	92/106	1.73	1.28–2.34	1.27	0.87–1.86
Birthweight (gms)										
≥2500	2499/4326	1.00		1.00		2243/4584	1.00		1.00	
<2500	401/375	1.78	1.52–2.09	1.22	0.94–1.59	364/410	1.93	1.64–2.26	1.49	1.14–1.93
Sex										
Girl	1292/2412	1.00		1.00		1152/2552	1.00		1.00	
Boy	1608/2289	1.29	1.17–1.42	1.37	1.22–1.54	1455/2442	1.30	1.18–1.44	1.41	1.24–1.60
Age of mother at the time of the birth										
<18	495/267	3.58	2.97–4.33	1.86	1.45–2.37	458/304	3.69	3.07–4.44	1.94	1.50–2.51
18–19	377/359	2.09	1.74–2.51	1.23	0.98–1.55	366/370	2.41	1.99–2.90	1.50	1.18–1.90
20–24	824/1098	1.43	1.25–1.64	1.15	0.98–1.36	755/1167	1.46	1.26–1.68	1.22	1.02–1.46
25–29	644/1265	1.00		1.00		570/1339	1.00		1.00	
30–34	392/1073	0.70	0.60–0.81	0.90	0.75–1.09	324/1141	0.68	0.57–0.80	0.89	0.73–1.10
>35	168/639	0.48	0.39–0.59	0.70	0.55–0.89	134/673	0.46	0.37–0.58	0.69	0.53–0.90
Remoteness										
Outer regional area	588/2558	1.00		1.00		432/2711	1.00		1.00	
Remote area	401/1048	1.73	1.49–2.01	1.11	0.94–1.31	335/1113	1.94	1.64–2.29	1.19	0.99–1.43
Very remote area	1911/1095	7.67	6.76–8.70	2.70	2.30–3.16	1840/1170	10.30	8.94–11.86	3.43	2.91–4.04
Primary care giver school education level										
Year 9 or less	1424/801	8.80	7.43–10.43	2.68	2.20–3.26	1346/890	10.59	8.77–12.79	2.86	2.27–3.60
Year 10 or equivalent	793/1045	3.60	3.06–4.23	1.91	1.59–2.28	688/1154	3.73	3.08–4.50	1.80	1.45–2.22
Year 11 or equivalent	375/882	1.95	1.58–2.40	1.34	1.08–1.67	271/972	1.90	1.51–2.40	1.24	0.97–1.59
Year 12 or equivalent	376/1905	1.00		1.00		311/1969	1.00		1.00	
Parity (total number of previous births for the mother)										
0	977/1751	1.00		1.00		872/1857	1.00		1.00	
1	728/1357	0.98	0.87–1.12	1.19	1.01–1.41	628/1457	0.92	0.81–1.05	1.13	0.95–1.34
>1	1195/1593	1.38	1.23–1.55	1.39	1.17–1.67	1107/1680	1.41	1.26–1.59	1.55	1.29–1.85
Plurality count (total number of births from this pregnancy)										
1	2854/4601	1.00		1.00		2562/4893	1.00		1.00	
2	44/100	0.70	0.48–1.02	0.65	0.40–1.05	45/101	0.88	0.60–1.29	0.90	0.54–1.50
Mother's alcohol consumption during pregnancy										
No	2535/4163	1.00		1.00		2286/4411	1.00		1.00	
Yes	365/538	1.03	0.88–1.22	0.94	0.78–1.13	321/583	1.00	0.84–1.19	0.91	0.72–1.13
Mother's smoking status during pregnancy										
No	1553/3139	1.00		1.00		1395/3303	1.00		1.00	
Yes	1347/1562	1.67	1.49–1.88	1.15	0.99–1.33	1212/1691	1.71	1.53–1.91	1.19	1.04–1.37

†Adjusted for all other variables shown in the table. ‡Reference group.

Table 3 Unadjusted and adjusted odds ratios of reading result below the national minimum standard for NAPLAN Year 3 test, by child's Indigenous status

	Indigenous child (*n* = 4603)					Non-Indigenous child (*n* = 2998)				
	No. below/no. at & above	Unadjusted OR	95% CI	Adjusted OR†	95% CI	No. below/no. at & above	Unadjusted OR	95% CI	Adjusted OR†	95% CI
Age at assessment										
<8	344/232	1.28	1.05–1.56	1.29	1.05–1.59	39/295	0.91	0.63–1.31	0.93	0.64–1.36
8	1980/1659	1.00‡		1.00		305/2132	1.00		1.00	
>8	202/186	0.86	0.68–1.09	0.72	0.56–0.93	30/197	2.08	1.36–3.19	2.10	1.33–3.31
Estimated gestational age, in completed weeks										
<34	101/62	1.54	1.08–2.21	1.44	0.90–2.32	11/60	1.30	0.68–2.50	1.02	0.43–2.41
34–36	295/151	1.56	1.25–1.95	1.27	0.95–1.68	24/123	1.39	0.89–2.19	1.30	0.77–2.18
≥37	2130/1864	1.00		1.00		339/2441	1.00		1.00	
Apgar 5 (numerical score of baby's condition, 5 min after birth)										
≥7	2436/2023	1.00		1.00		365/2579	1.00		1.00	
<7	90/54	1.40	0.95–2.06	1.20	0.78–1.85	9/45	1.45	0.70–2.99	1.44	0.67–3.11
Birthweight (gms)										
≥2500	2155/1867	1.00		1.00		344/2459	1.00		1.00	
<2500	371/210	1.45	1.19–1.77	1.24	0.92–1.67	30/165	1.29	0.86–1.93	1.08	0.62–1.91
Sex										
Girl	1137/1073	1.00		1.00		155/1339	1.00		1.00	
Boy	1389/1004	1.28	1.13–1.45	1.35	1.18–1.55	219/1285	1.46	1.17–1.82	1.48	1.17–1.85
Age of mother at the time of the birth										
<18	489/229	2.00	1.62–2.48	1.91	1.45–2.53	6/38	0.97	0.40–2.36	0.77	0.31–1.94
18–19	361/284	1.23	0.99–1.53	1.22	0.94–1.58	16/75	1.32	0.74–2.34	1.23	0.67–2.25
20–24	731/642	1.06	0.89–1.25	1.13	0.93–1.37	93/456	1.25	0.93–1.68	1.22	0.89–1.66
25–29	524/502	1.00		1.00		120/763	1.00		1.00	
30–34	302/297	0.94	0.77–1.16	1.03	0.82–1.30	90/776	0.71	0.53–0.95	0.68	0.50–0.92
>35	119/123	0.83	0.62–1.12	0.84	0.60–1.16	49/516	0.58	0.41–0.83	0.52	0.36–0.76
Remoteness										
Outer regional area	298/671	1.00		1.00		290/1887	1.00		1.00	
Remote area	339/499	1.60	1.30–1.96	1.46	1.18–1.80	62/549	0.76	0.57–1.02	0.69	0.51–0.94
Very remote area	1889/907	4.73	4.00–5.61	3.51	2.91–4.24	22/188	0.80	0.50–1.27	0.81	0.50–1.31
Primary care giver school education level										
Year 9 or less	1385/637	4.14	3.31–5.16	2.56	2.01–3.25	39/164	2.40	1.58–3.65	1.92	1.23–3.01
Year 10 or equivalent	664/546	2.16	1.74–2.68	1.78	1.41–2.24	129/499	2.45	1.86–3.24	2.00	1.48–2.71
Year 11 or equivalent	310/389	1.36	1.03–1.80	1.36	1.02–1.82	65/493	1.31	0.92–1.87	1.15	0.79–1.66
Year 12 or equivalent	226/446	1.00		1.00		150/1459	1.00		1.00	
Parity (total number of previous births for the mother)										
0	840/675	1.00		1.00		137/1076	1.00		1.00	
1	612/525	0.96	0.81–1.14	1.21	0.98–1.50	116/832	1.11	0.85–1.45	1.18	0.89–1.57
>1	1074/877	1.03	0.88–1.19	1.36	1.09–1.69	121/716	1.34	1.02–1.74	1.50	1.10–2.03
Plurality count (total number of births from this pregnancy)										
1	2485/2039	1.00		1.00		369/2562	1.00		1.00	
2	41/38	0.81	0.50–1.32	0.66	0.38–1.16	5/62	0.55	0.22–1.38	0.50	0.19–1.33
Mother's alcohol consumption during pregnancy										
No	2203/1802	1.00		1.00		332/2361	1.00		1.00	
Yes	323/275	0.89	0.73–1.09	0.96	0.78–1.19	42/263	1.07	0.74–1.56	0.84	0.56–1.24
Mother's smoking status during pregnancy										
No	1320/1106	1.00		1.00		233/2033	1.00		1.00	
Yes	1206/971	0.98	0.85–1.14	1.06	0.90–1.24	141/591	1.95	1.53–2.48	1.64	1.25–2.15

†Adjusted for all other variables shown in the table. ‡Reference group.

Table 4 Unadjusted and adjusted odds ratios of numeracy results below the national minimum standard for NAPLAN Year 3 test, by child's Indigenous status

	Indigenous child (*n* = 4603)					Non-Indigenous child (*n* = 2998)				
	No. below/no. at & above	Unadjusted OR	95% CI	Adjusted OR†	95% CI	No. below/no. at & above	Unadjusted OR	95% CI	Adjusted OR†	95% CI
Age at assessment										
<8	351/225	1.46	1.20–1.78	1.51	1.21–1.90	32/302	1.20	0.81–1.80	1.25	0.83–1.88
8	1813/1826	1.00‡		1.00		200/2327	1.00		1.00	
>8	188/200	0.89	0.69–1.13	0.73	0.55–0.95	23/114	2.17	1.32–3.58	2.23	1.32–3.77
Estimated gestational age, in completed weeks										
<34	96/67	1.54	1.08–2.20	1.22	0.76–1.96	6/65	0.88	0.35–2.21	0.51	0.17–1.54
34–36	272/174	1.56	1.26–1.94	1.14	0.87–1.50	14/133	1.16	0.66–2.05	0.97	0.51–1.85
≥37	1984/2010	1.00		1.00		235/2545	1.00		1.00	
Apgar 5 (numerical score of baby's condition, 5 min after birth)										
≥7	2264/2195	1.00		1.00		251/2693	1.00		1.00	
<7	88/56	1.56	1.08–2.26	1.35	0.88–2.08	4/50	0.93	0.33–2.59	0.99	0.34–2.87
Birthweight (gram)										
≥2500	2009/2015	1.00		1.00		234/2569	1.00		1.00	
<2500	343/236	1.59	1.31–1.93	1.48	1.11–1.98	21/174	1.30	0.80–2.10	1.48	0.78–2.80
Sex										
Girl	1048/1162	1.00		1.00		104/1390	1.00		1.00	
Boy	1304/1089	1.31	1.15–1.48	1.40	1.21–1.62	151/1353	1.48	1.14–1.94	1.49	1.13–1.96
Age of mother at the time of the birth										
<18	453/265	1.95	1.59–2.41	1.92	1.44–2.55	5/39	1.05	0.37–3.03	1.00	0.34–2.99
18–19	353/292	1.37	1.10–1.70	1.46	1.12–1.91	13/78	1.68	0.89–3.16	1.70	0.87–3.32
20–24	689/684	1.04	0.87–1.24	1.18	0.96–1.45	66/483	1.36	0.95–1.95	1.36	0.93–1.97
25–29	490/536	1.00		1.00		80/803	1.00		1.00	
30–34	270/329	0.92	0.74–1.15	1.01	0.79–1.30	54/812	0.66	0.46–0.95	0.62	0.43–0.91
>35	97/145	0.72	0.53–0.99	0.70	0.49–0.99	37/528	0.70	0.46–1.06	0.63	0.41–0.97
Remoteness										
Outer regional area	229/740	1.00		1.00		203/1972	1.00		1.00	
Remote area	299/539	1.83	1.47–2.27	1.65	1.32–2.07	36/575	0.65	0.45–0.94	0.60	0.41–0.88
Very remote area	1824/972	6.35	5.26–7.68	4.62	3.78–5.63	16/196	0.71	0.40–1.26	0.74	0.41–1.32
Primary care giver school education level										
Year 9 or less	1317/705	4.76	3.65–6.20	2.77	2.07–3.71	29/185	2.37	1.47–3.84	1.93	1.17–3.19
Year 10 or equivalent	614/609	2.22	1.70–2.90	1.77	1.34–2.33	74/545	2.06	1.47–2.90	1.74	1.22–2.48
Year 11 or equivalent	225/452	1.22	0.89–1.67	1.19	0.86–1.65	46/520	1.44	0.97–2.15	1.28	0.84–1.94
Year 12 or equivalent	211/470	1.00		1.00		100/1499	1.00		1.00	
Parity (total number of previous births for the mother)										
0	783/733	1.00		1.00		89/1124	1.00		1.00	
1	543/596	0.86	0.73–1.02	1.08	0.87–1.33	85/861	1.25	0.91–1.71	1.37	0.98–1.92
>1	1026/922	1.05	0.91–1.21	1.50	1.21–1.86	81/758	1.38	0.99–1.91	1.64	1.14–2.37
Plurality count (total number of births from this pregnancy)										
1	2312/2212	1.00		1.00		250/2681	1.00		1.00	
2	40/39	1.04	0.62–1.72	0.87	0.48–1.60	5/62	0.87	0.35–2.19	0.88	0.33–2.36
Mother's alcohol consumption during her pregnancy										
No	2057/1950	1.00		1.00		229/2461	1.00		1.00	
Yes	295/301	0.87	0.71–1.07	0.91	0.71–1.17	26/282	0.99	0.63–1.56	0.85	0.52–1.38
Mother's smoking status during her pregnancy										
No	1221/1198	1.00		1.00		174/2105	1.00		1.00	
Yes	1131/1053	1.06	0.92–1.20	1.18	1.01–1.37	81/638	1.64	1.23–2.19	1.38	1.01–1.89

†Adjusted for all other variables shown in the table. ‡Reference group.

remaining a significant association, for both reading (OR: 2.89, 95% CI: 2.46–3.40) and numeracy (OR: 3.19, 95% CI: 2.65–3.84).

Table 3 presents the unadjusted and adjusted ORs and 95% CIs for NAPLAN reading results for Indigenous and non-Indigenous children separately. Among Indigenous children, after adjustment for all other variables and compared with the respective reference group, the factors significantly associated with a NAPLAN reading results below the NMS were: age at assessment (<8 years, OR: 1.29); being a boy (OR: 1.35); maternal age (<18 years, OR: 1.91); living in a remote (OR: 1.46) or very remote area (OR: 3.51); school education level of primary care giver of Year 9 or less (OR: 2.56), Year 10 (OR: 1.78) and Year 11 (OR: 1.36) and parity >1 (OR: 1.36). Indigenous children aged >8 years (OR: 0.72) performed better than the reference group aged 8 years. Among non-Indigenous children the significant associations for the corresponding analysis that were similar to Indigenous children were: being a boy (OR: 1.48); school education level of the primary care giver of Year 9 or less (OR: 1.92) and Year 10 (OR: 2.00); and parity >1 (OR: 1.50). An additional association with lower reading results, among non-Indigenous children, was mother smoking during pregnancy (OR: 1.64). A variation to the poorer performance among Indigenous children with young mothers was that non-Indigenous children with older mothers performed better (30–34 years (OR: 0.68) and 35 years and over (OR: 0.52)) than the reference group with maternal age of 25–29 years. In contrast to the corresponding results for Indigenous children, non-Indigenous children living in remote areas performed better (OR 0.69), and children aged >8 years performed more poorly (OR 2.10) than the respective reference groups.

Table 4 presents results for NAPLAN numeracy assessment. Among Indigenous children, additional associations, in the adjusted results, to those identified for reading were: birthweight <2500 grams (OR: 1.48); maternal age groups 18–19 years (OR: 1.46) and >35 years (0.70) and maternal smoking during pregnancy (OR: 1.18). Among non-Indigenous children the risks associated with numeracy outcomes were similar to those for reading.

Discussion

The study explored the perinatal health and socio-demographic factors associated with school education performance and is one of the first Australian papers to draw together the influences of these factors for both Indigenous and non-Indigenous children.

Our results showed that children born with low birthweight tended to have poorer school education outcomes than children of normal birthweight, a result that is consistent with previous research investigating the relationship between prematurity and educational attainment at age 8 years,[22] and the increased risk for developmental, cognitive and health problems.[23] Similarly, our study confirms that maternal smoking during pregnancy is associated with poor educational outcomes.[24] Smoking is commonly regarded as the most important preventable risk factor to be targeted for improving birth outcomes, particularly among Indigenous mothers.[25] The observed gender differences are again consistent with other studies, with girls performing better scholastically than boys at primary school age.[3,9] Similarly the first- and earlier-born children were advantaged in terms of educational achievement.[26] This may be due to relatively fewer resources available to subsequent children rather than reflecting a positive advantage for the first and earlier-born children.[26] The relevant resources may include a parent's time and skills in providing informal learning opportunities prior to commencement at school.

Consistent with a study in Western Australia,[4] our results confirm that Indigenous children living in geographically remote areas have greater levels of educational disadvantage than their counterparts in less remote areas. A range of factors may be influential including: the continuity and quality of teachers, limited subject choice and limited recreational and educational facilities.[27] Primary care giver school education level was another independent predictor of student educational achievement,[1,5,27–29] with a gradient in both groups of children. Parents with higher educational attainment may have greater interest and expectation in their child's education. Positive school experiences and advantageous education levels may provide a transmission mechanism for advantage across generations.[30,31] Our findings suggest that the gradient may be stronger for Indigenous children, which is consistent with a flow-on effect of poor educational experiences in previous generations.[4]

In addition, our study showed that Indigenous children born to teenage mothers were at increased risk of adverse education outcomes. This specific association was not evident for non-Indigenous children; however in both populations, there was a gradient of improving education outcomes with increasing maternal age, as previously reported.[1,22,32] Younger mothers may be less educated, have less social support and greater financial stress than older mothers.[32,33] A 20-year longitudinal study has shown that young adults, born to teenage mothers, have increased risk for early school leaving, unemployment, early parenthood and violent offending.[34]

The better outcome for older Indigenous children is in the opposite direction to non-Indigenous children but is consistent with previous studies in Western Australia and Canada.[22,29] Possible explanations include greater cognitive maturity and the 'dose-response' of longer exposure to school education. There is a long-standing educational debate about whether children who are not developmentally ready for school learning at age 5 benefit from a delay in school entry.[35] In many developing countries the educational practice has been for children to commence school at age 6 or 7 on the basis that children growing up in conditions of disadvantage need more time to develop their cognitive and language readiness for school learning. However, this option needs to be balanced by the alternative explanation that, for children with low school attendance, the improved result for older children may be a 'dose-response' from having received sufficient schooling to develop learning skills. Better outcomes will be assisted by improved attendance, increased availability of early childhood services and educationally based child care.[4,29]

Major strengths of this study are the substantial sample of Indigenous children and the availability of NAPLAN results. NAPLAN assessment involves almost all children and has the advantage of national comparability.[36] Other strengths of our study include the population-based cohort design and the availability of both perinatal and socio-demographic factors. The

available information included maternal smoking and alcohol consumption during pregnancy that may have independent influences on children's health and educational outcomes.[16,20] Data linkage has many benefits. The administrative data are population based, thereby minimising possible selection bias and can provide detailed information on past events, such as births, avoiding the risk of recall bias associated with parent responses. Data linkage also provides substantial savings in both time and money compared with prospective longitudinal studies.

A limitation of our study was that data linkage was only possible for children who were born and later attended government schools in the NT. The high level of interstate migration of the non-Indigenous birth cohort was evident in the under-representation of non-Indigenous children in the study cohort. In addition information was not available for approximately 30% of NT school-aged children who attend non-government schools.[15] Procedures are in place, within education services, to facilitate availability of non-government school data for future studies. Other reasons for loss to follow-up were that some children would have been absent from school on the day of the NAPLAN assessment, a few would have died and finally information for some eligible children may not have been linked, particularly those with changes in name. Although our study dataset included only 43% of the estimated birth cohort, the study cohort and corresponding birth cohort were a good match for most parameters, particularly among Aboriginal children. As a population-based study, the results can be generalised to Indigenous and non-Indigenous NT children.

Conclusion

Our study contributes to the literature by reporting risks factors associated with education outcomes for a population with substantial disadvantage. Importantly many of the risks factors for Indigenous children are shared with the general population and are modifiable through improvements in health care and community support. Our findings have important implications for the further development of targeted strategies to improve school education outcomes through collaborative health and social interventions. Furthermore, this study demonstrates that cross-agency data linkage, using existing administrative datasets, can be a useful tool to identify priority areas for early intervention and prevention.

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