menzies
school of health research

the centre for child development & education

Early Pathways to School Learning
Lessons from the NT data linkage study

Silburn S, Guthridge S, McKenzie J, Su J-Y, He V, Haste S (Eds.)

The Centre for Child Development and Education

Early Pathways to School Learning

Lessons from the NT Data Linkage Study

Australian Government
National Health and Medical Research Council

Proudly sponsored by NORTHERN TERRITORY GOVERNMENT

AMSANT

CITATION

The following citation should be used when reproducing or quoting any part of this publication:

Silburn S, Guthridge S, McKenzie J, Su J-Y, He V, Haste S (Eds.) *Early Pathways to School Learning: Lessons from the NT Data Linkage Study.* Darwin: Menzies School of Health Research, 2018.

National Library of Australia Cataloguing-in-Publication

Improving Early Child Development and Educational Outcomes in the NT.

Bibliography

ISBN 978-1-922104-33-5 – paperback

ISBN 978-1-922104-34-2 – ebook

This publication was produced by the Menzies School of Health Research through its Centre for Child Development and Education with funding from a National Health and Medical Research Council (NHMRC) Partnership Grant (#1091491) in which the Northern Territory departments of Health, Education and Territory Families, the Aboriginal Medical Services Alliance of the Northern Territory (AMSANT) and the Menzies School of Health Research were organisational partners.

Cover photographs

Menzies School of Health class room in Gunbalanya Oenpelli.
Eribeta and Taniesha, Milikapiti Preschool.
Nikita Davey and Renae, Bagot Community.

NHMRC PARTNERSHIP PROJECT

The production of this monograph was made possible by a National Health and Medical Research Council (NHMRC) Partnership Grant (#1091491) *"Improving the developmental outcomes of Northern Territory children: a data linkage study to inform policy and practice in health, family services and education".*

Chief Investigators: Sven Silburn, John Lynch, Steven Guthridge, Richard Midford, Julie Brimblecombe, Maggie Walter, Stefanie Schurer, Gawaian Bodkin-Andrews, and Peter Shaw.

Associate Investigators: Carrington Shepherd, Fiona Stanley, Kevin Schnepel, Liz Moore, and Sandra Eades.

PARTNERSHIP STEERING COMMITTEE

The NHMRC partnership project was carried out under the direction of a Steering Committee comprising representatives of each of the study's organisational partners, a representative of the Community Advisory Group and Chief Investigators Maggie Walter and Gawaian Bodkin-Andrews. Members of the Steering Committee during the production of this publication included: Susan Bowden (Chair), Anna King (former Chair), Dagmar Schmidt, Leonie Warburton, Elizabeth Moore, Steven Guthridge, Kalinda Griffiths, Maggie Walter, Gawaian Bodkin-Andrews and Sven Silburn.

COMMUNITY ADVISORY GROUP

The project's Community Advisory Group provided guidance and practical advice to ensure the cultural integrity and community relevance of the research and the reporting of its findings. Members of this group included James Smith (Chair), Leisa McCarthy, Terry Byrnes, Kalinda Griffiths, Joe Brown and Joanne Edwards.

ACKNOWLEDGEMENTS

In the spirit of respect, the authors acknowledge the people and elders of the Aboriginal and Torres Strait Islander Nations who are the Traditional Owners of the land and seas of Australia.

We particularly acknowledge the NT families and children whose de-identified administrative data were combined to enable types of analysis not previously possible.

We also thank Nicky O'Brien, Alexandra and Chris Radbone of the SA NT DataLink data integration authority for their technical and administrative assistance in the linkage of the data required for the study.

The dedicated project management of Sharon Haste and John McKenzie is gratefully acknowledged, as is the commitment of the project's analysis and writing team at the Menzies School of Health Research – John McKenzie, Jiunn-Yih Su, Vincent He, Sharon Haste and Sven Silburn.

Foreword

The Northern Territory's future social wellbeing and economic sustainability is critically dependent on children getting the best possible start in life. While it has long been known that far too many of our children are not realising their developmental potential and not progressing as they should at school, the extent to which their early life circumstances influence their pathways of development is less well understood.

The NT Data Linkage Study was established to provide a unique new source of information. By combining information usually held separately within different service organisations, it is helping to establish a more integrated and holistic understanding of the combined effect of the many factors which shape the health, development and learning of NT children. It is also enabling new policy insights through the use of methods of analysis not previously possible.

The research findings reported in the various chapters of this publication highlight the importance of the links between health and education. They help to clarify some of the ways in which children's health and development—especially in the first few years of life—create the foundation for successful school learning and positive educational outcomes.

The findings demonstrate that current disparities in the development and learning outcomes of Aboriginal and non-Aboriginal children are almost entirely attributable to the adverse effects of disadvantage. The main factors predicting these outcomes are children's early life health, and their sociodemographic, family and community circumstances—regardless of their Aboriginal or non-Aboriginal status. Policy investments and service reforms seeking to 'close the gap', must be accompanied by meaningful progress in addressing Aboriginal children's disproportionate exposure to disadvantage—especially in key areas such as housing.

The study findings have several practical implications. The new evidence in particular demonstrates the extent of the benefits of preschool attendance. This is especially true for Aboriginal children. Initiatives enabling their access to, and participation in preschool, are likely to result in substantially improved rates of school attendance and longer-term academic outcomes.

Olga Havnen

CEO Danila Dilba Health Service, and
Chair, Advisory Board, Centre for Child Development and Education

Marion Scrymgour

Former NT Education Minister, and
Patron, Centre for Child Development and Education

Table of Contents

ABOUT THIS PUBLICATION

This publication was produced by the Centre for Child Development and Education at the Menzies School of Health Research through an organisational partnership with the Northern Territory departments of Health, Education, Territory Families and the Aboriginal Medical Services Alliance of the Northern Territory (AMSANT) jointly funded by the Northern Territory Government and the National Health and Medical Research Council (NHMRC).

ATTRIBUTABLE COMMENTS

The views expressed in the numbered chapters of the publication relating to the implications of the project findings for future directions of policy and services are those of the authors.

RELATED PUBLICATIONS

This publication is the foundation document for a planned series of 'research-to-practice' scientific publications based on the analysis of the de-identified NT administrative data. While this initial publication has its main focus on children's educational outcomes, the following publication is an investigation of the early life determinants and developmental pathways of NT born children who have involvement with the child protection and/or juvenile justice systems.

OWNERSHIP OF THE STUDY DATA

The project Steering Committee has overseen all phases of the analysis and reporting of project findings. The data supply agreements with each of the agencies contributing data for linkage specify that their agency maintains intellectual property (IP) rights over the data which they contributed. Where de-identified data is linked from more than one agency, these agreements also specify that the IP rights are then jointly held by those contributing agencies. The Menzies School of Health Research data linkage team has custodial responsibility for the ongoing management of the de-identified datasets linked for the study. They ensure the secure storage of the data and its controlled use for research projects approved by the appropriate NT Health Research Ethics Committees and the Partnership Steering Committee. The Partnership Steering Committee are also responsible for the pre-publication approval of manuscripts reporting study outcomes.

UNDERSTANDING OF THE DATA

The tables and text included in this monograph are derived from the de-identified linked unit-record data extracted from the administrative datasets held by the NT departments of Health, Education and Territory Families regarding the service contact of all children born in the NT over the 20 years between 1994 and 2014.

ACCURACY OF ESTIMATES

All data presented in this monograph have been subject to rigorous statistical analysis. Reported estimates have been calculated at the 95% level of confidence. Where relevant, confidence intervals are reported in the text and are displayed on graphs by means of vertical confidence bars. These indicate that there is a 95% chance that the true value of the data item lies between the upper and lower limits indicated by the confidence bar for that item. Figures in tables have been rounded to three significant digits which means that minor discrepancies can occur between the sums of component items and totals.

COMMUNITY FEEDBACK

The Community Advisory Committee and Steering Committee have assisted the Project Team in developing a communication strategy which will maximise the project findings being available to communities and key stakeholder organisations in formats which facilitate their accessibility and practical use.

CONTACT FOR ENQUIRIES

For further information about the study, its methodology and the topics covered in this monograph please email enquiries to communications@menzies.edu.au

OBTAINING COPIES OF THIS PUBLICATION

This publication is available in hard copy and electronically as a PDF file on Menzies' Centre for Child Development and Education website www.ccde.menzies.edu.au

ACRONYMS

AAPC	Average annual percentage change
ABS	Australian Bureau of Statistics
ACARA	Australian Curriculum, Assessment and Reporting Authority
AEDC	Australian Early Development Census
AIHW	Australian Institute of Health and Welfare
AMSANT	Aboriginal Medical Services Alliance Northern Territory
ARIA	Accessibility/Remoteness Index of Australia
BIC	Bayesian information criterion
CAG	Community Advisory Group
CI	Confidence Interval
ESL	English as a Second Language
EY	Early Years (i.e. Transition to Year 3)
EYA	Early Years Attendance
FaFT	Families as First Teachers
GISCA	National Key Centre for Social Applications of Geographical Information Systems
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification
ICSEA	Index of Community Socio-Educational Advantage
LBW	Low Birthweight
NAAJA	North Australia Aboriginal Justice Agency
NAPLAN	National Assessment Program – Literacy and Numeracy
NHMRC	National Health and Medical Research Council
NT	Northern Territory
NTG	Northern Territory Government
OECD	Organisation for Economic Cooperation and Development
OR	Odds Ratio
SAHMRI	South Australian Health and Medical Research Institute
SEAM	School Enrolment and Attendance Measure
SEM	Structural Equation Modelling
SES	Socioeconomic Status
TFR	Total Fertility Rate

EXECUTIVE SUMMARY

Chapter 1 The NT Data Linkage Study

This chapter provides a general introduction to the study. It briefly reviews the growing national and international literature on children's early life health and other childhood factors associated with their development and school education outcomes. It also describes the benefits of new approaches to the ethical linkage and analysis of de-identified data from separate official datasets.

- The study was made possible by the NT Government's involvement since 2009 as a foundation member of the SA NT DataLink consortium. Based in the South Australian Health and Medical Research Institute (SAHMRI) and administered by the University of South Australia, SA NT DataLink is a nationally accredited agency authorised to provide data linkage services for ethics approved research using NT and South Australian data.
- The NT Data Linkage Study aims to build the research infrastructure for better use to be made of the NT's administrative data holdings, and to create a comprehensive evidence-base for informing policy and evaluating service and program outcomes.
- As almost a third of the NT population is Aboriginal, special care has been taken to ensure the study and its findings are inclusive of Aboriginal perspectives.

Chapter 2 Methodology

This chapter describes the study population, the methods of data linkage and de-identified analysis, and the various NT administrative datasets from which the study data were extracted for analysis. It also outlines how the overall study methodology was developed to be properly inclusive of Indigenous statistical standpoints.

- The study population comprised all children born in the NT between 1994 and 2013 who had an administrative record in one or more of the datasets from which data were provided for record linkage by SA NT DataLink.
- These datasets include NT Perinatal Trends (1994–2013); NT Immunisation (1994–2014); NT Hospital Inpatient Activity (1994–2014), NT Department of Education – Student Activity (2005–2014); National Assessment Program for Literacy and Numeracy (NAPLAN) (2008–2014), Australian Early Development Census (AEDC) (2009/10 and 2012).
- A total of 632,036 individual records were identified as being potentially eligible for inclusion in the study cohort. Clerical review was also undertaken of individuals with duplicate records, those with dates of birth outside the study range, and records with logical data inconsistencies.
- The final number of individuals in each of the linked datasets meeting study inclusion criteria was: AEDC (n = 7,073), Perinatal trends (n = 74,459), Student activity (n = 64,966), NAPLAN (n = 33,707), Immunisation (n = 88,182), Inpatient activity (n = 245,107).
- In assembling and preparing the datasets for analysis, the Menzies research team gave particular attention to investigating how best to define Aboriginal status for each of the various analyses required in the study. Because of variation in how this could be recorded at different times or in different ways between datasets, this is a potential source of bias and under-reporting.
- Given the cultural, terminological and methodological issues associated with defining Aboriginal status, it was determined that for the purposes of the study we should:

    1. Use a single dichotomous variable to define Aboriginal status in reference to data concerning Aboriginal and Torres Strait Islanders, as there is a relatively small number of NT residents who are Torres Strait Islanders and most of these also identify as Aboriginal.

2. Investigate the consistency and completeness of Aboriginal status recording in each of the datasets and rank them in order of concordance with the NT Department of Health datasets which had the most complete and consistent recording.
3. Develop an 'algorithm' (i.e. rule) to define a derived Aboriginal status variable which provides the best coverage for use as a consistent Aboriginal status variable for the various longitudinal analyses.

- The large study population and comprehensive scope of data available enabled these investigations being informed by an eco-epidemiological, life-span, human development conceptual framework.
- The analysis and reporting of findings has aimed to maximise the inclusion of Indigenous statistical standpoints to avoid cultural bias and poor policy outcomes resulting from simplistic use of Indigenous administrative data.

Chapter 3 Early life health and development

This chapter describes key indicators of the early life health and development of NT born children and how these indicators have changed over the period 1994–2013. This provides an epidemiological picture about the study population and a baseline against which progress can be benchmarked. It also identifies some important emerging service needs. The pattern of these trends highlights the extent to which disparities in the health of Aboriginal and non-Aboriginal children become evident very early in life. They also contextualise the investigations reported in later chapters.

Live births and fertility rates

- The changing nature of NT live birth and fertility rates has important implications for forward projections of population growth and the planning of services and policy.
- While there was a small increase in the overall rates of all live births between 2004 and 2013, Aboriginal births had a significant decreasing trend with an average of 1.7% fewer births each year. This decreasing trend was most notable among Aboriginal mothers aged 20–34 years, who account for around two thirds of Aboriginal births.
- Teenage birth rates for both Aboriginal and non-Aboriginal mothers showed significant decreasing trends. While this is encouraging, it is important that future research establishes whether this is associated with increasing contraception use and/or other factors such as the current high rates of sexually transmitted infections and repeated infections in this age group.
- While the total fertility rate (TFR) for non-Aboriginal women showed an increasing trend of 1.2% per year, it is of concern that the TFR for Aboriginal women has followed a decreasing trend, such that by 2013 it was the lowest on record, and close to the population replacement rate of the average 2.1.

Alcohol and smoking in pregnancy

- The proportion of Aboriginal and non-Aboriginal women reporting alcohol consumption during pregnancy has shown an encouraging decline over the study period. However, alcohol consumption rates remain relatively high among Aboriginal women posing increased risk for Fetal Alcohol Spectrum Disorders (FASD).
- The proportion of Aboriginal and non-Aboriginal women reporting that they smoked during pregnancy has also decreased over recent decades. This declined most notably among women in outer regional areas (e.g. Darwin) from 26% to 14.7% between 1996 and 2013.
- Of particular concern is that pregnant women in remote and very remote areas (predominantly Aboriginal) had a significant upward trend on already high smoking rates, such that by 2013 around 50% of Aboriginal mothers reported they smoked before and after 20 weeks gestation.

Antenatal care

- Significant increasing trends for the proportion of women accessing antenatal health care in their first trimester of pregnancy were evident for both Aboriginal and non-Aboriginal women across outer regional, remote and very remote areas.
- Despite these increasing trends, it remains of concern that up to 40% of Aboriginal mothers did not present for antenatal care in the first trimester, and that up to 30% of these women attended less than the recommended seven antenatal visits during pregnancy.

Preterm birth, low birthweight, and perinatal mortality

- The difference between Aboriginal and non-Aboriginal preterm birth rates increased over the study period due to the rate of Aboriginal preterm births increasing from 14.1% to 15.2% between 1996 and 2013, and the non-Aboriginal rate decreasing from 7.1% to 6.7%.
- The overall trends in low birthweight (LBW) among Aboriginal and non-Aboriginal babies showed no significant change over the study period. However, for births to mothers in very remote areas, the rates of LBW showed a significant increasing trend with rates averaging 5.8% higher than Aboriginal babies in outer regional areas.
- Perinatal mortality rates were significantly higher for Aboriginal babies with an annual average of 12.5 more deaths per 100,000 births than their non-Aboriginal counterparts. Similar proportions of this difference were due to stillbirth and neonatal deaths (6.2 and 6.3 deaths per 100,000 births respectively). These rates stand in contrast to much lower national perinatal mortality rates.

Hospitalisations

- Over the study period, the all-episode hospitalisation rates of children aged 0–4 years were 2.4 to 3.0 times higher for Aboriginal children than for non-Aboriginal children.
- The Aboriginal rate fell from 568 per 1,000 in 2001 to an all-time low of 432 per 1,000 in 2006, but then increased steadily to 518 per 1,000 by 2013.
- The unique person hospitalisation rates for Aboriginal children aged 0–4 years decreased from 354 to 143 per 1,000 between 2001 and 2013 while the non-Aboriginal rates decreased from 151 to 95 per 1,000. The higher Aboriginal rates were primarily due to their higher average number of repeat admissions.
- Rates of hospital admission of all children aged 0–4 years for more serious illnesses requiring intensive care decreased significantly. This decrease was mostly due to rates for Aboriginal children falling from 6 per 1,000 in 2001 to 2.5 per 1,000 in 2013.
- Rates of hospitalisation for injuries among all children aged 0–4 years increased significantly between 2001 and 2013. Over this period the Aboriginal rates increased from 19.1 to 36.5 per 1,000 while the non-Aboriginal rates increased from 14.2 to 17.5 per 1,000.
- Rates of hospital admission for acute lower respiratory infections (ALRI) among Aboriginal children aged 0–4 years decreased from 136 per 1,000 in 2001 to 100 per 1,000 by 2013, while the rates for non-Aboriginal children remained relatively constant around 18.5 per 1,000 over the same period.

Early childhood development

- The Australian Early Development Census (AEDC) assessment of NT Aboriginal children commencing school in 2012 showed encouraging improvements on the equivalent 2009 AEDC developmental assessments. These improvements were most notable for Aboriginal children in very remote areas and were also the largest recorded for all states and territories.
- While non-Aboriginal children showed insignificant change between their 2009 and 2012 AEDC assessments, substantial improvements were recorded in the proportions of Aboriginal children assessed as 'developmentally on track' on the following AEDC domains: Social competence (43.6% to 50.3%); Emotional maturity (43.1% to 51.5%), and; Communication skills and general knowledge (37.8% to 50.1%).

- Despite these improvements, Aboriginal children's much higher levels of 'developmental vulnerability' across all five AEDC developmental domains means that without special learning and language support they are at high risk of not making a successful transition into school learning—particularly so for those who do not have English as their home language.
- In comparison with their NT non-Aboriginal counterparts, the proportions of Aboriginal children assessed as 'developmentally vulnerable' in the 2012 AEDC assessments were: Physical health and wellbeing (26.3% vs 8.3%); Social competence (24.5% vs 9.0%); Emotional maturity (23.1% vs 7.8%); Language and cognitive skills (43.2% vs 7.7%), and; Communication skills and general knowledge (26.5% vs 7.2%).

Chapter 4 Early life factors associated with childhood development

Findings are reported from univariate and multivariate regression modelling of the associations between early life factors and children's subsequent developmental outcomes, and how these differ for Aboriginal and non-Aboriginal children, and between different geographical areas of the NT. The analysis was first made with the whole study cohort and then separately when stratified by Aboriginal status. Separate additional analyses were also made to identify factors predictive of children having positive developmental outcomes and how these differed from those predictive of adverse outcomes. Finally, an analysis was made of the aggregate, community-level AEDC outcomes to identify communities having better than expected AEDC developmental outcomes.

- The regression modelling with the whole study cohort included Aboriginal status as a covariate. After taking into account the other covariates in the model, this showed that Aboriginal status had no significant effect as a predictor of AEDC developmental vulnerability. In other words, the main influences predicting children's developmental outcomes were their experiences of early life health and sociodemographic factors—regardless of their Aboriginal or non-Aboriginal status.
- In the non-Aboriginal regression modelling, the factors showing significant independent associations with children being 'developmentally on track' were: female gender (OR = 2.16), age 5.5–6.0 years vs age 5.0 and younger (OR = 1.52), being in the least disadvantaged SES quintile (OR = 1.81), mother did not smoke during pregnancy (OR = 1.4), mother had seven or more antenatal health visits (OR = 1.77), not born premature (OR = 1.73), attended preschool (OR = 1.88), parent/caregiver completed school (OR = 1.79), and having English as a first language (OR = 2.0).
- In the Aboriginal regression modelling, the factors with significant independent associations with children's 'developmentally on track' status were: female gender (OR = 2.67), age 5.5–6.0 years vs age 5.0 and younger (OR = 1.66), being in the middle or lowest quintile of SES disadvantage (OR = 1.56 and OR = 1.92 respectively), not born premature (OR = 2.30), parent/caregiver being employed (OR = 2.23), having English as a first language (OR = 2.64), and the child's home having less than 1.7 persons per bedroom (OR = 2.61).
- In the non-Aboriginal regression modelling, the factors with significant independent associations with developmental vulnerability were: male gender (OR = 3.16), children younger and older than ages 5.5 to 6.0 years (OR = 1.56 and OR = 2.0 respectively), being in the two most disadvantaged SES quintiles (OR = 1.82 and OR = 1.99 respectively), born to a teenage mother (OR = 2.08), mother had gestational diabetes (OR = 1.82), mother smoked during pregnancy (OR = 1.74), mother had fewer than seven antenatal care visits (OR = 2.13), child was mother's fourth or later born child (OR = 2.08), did not attend preschool (OR = 1.78), parent/caregiver did not complete school (OR = 1.98), parent/caregiver being unemployed (OR = 3.21), having ESL (OR = 2.19).

- In the Aboriginal regression modelling, the factors with significant independent associations with developmental vulnerability were: male gender (OR = 1.61), children younger and older than ages 5.5 to 6.0 years (OR = 1.49 and OR = 1.95 respectively), being in the two most disadvantaged SES quintiles (OR = 2.46 and OR = 2.07 respectively), living in remote and very remote areas (OR = 1.48 and OR = 1.80 respectively), being born preterm (OR = 1.88), having had two or more hospitalisation by age 5 years (OR = 1.40), parent/caregiver being unemployed (OR = 2.04), and not having English as a first language (OR = 2.46).
- Some 26 NT Statistical Local Areas (SLAs) with extreme levels of relative socioeconomic disadvantage (i.e. IRSED1 < 650) are located in very remote areas. The average proportion of children in these communities assessed as developmentally vulnerable on one or more AEDC domains was almost double (75% vs 40%) that of the eight NT outer regional SLAs with IRSED values between 850 and the national average of 1000.
- Importantly, children in 12 of the 26 very disadvantaged SLAs had average AEDC outcomes which were 5% to 40% better than would be predicted from their communities' levels of socioeconomic disadvantage.

Chapter 5 School attendance

This chapter describes the patterns of attendance of Aboriginal and non-Aboriginal students in urban, remote and very remote communities, and documents how these have changed over time for each of these student subpopulations. It also investigates how attendance is associated with individual child, family and school/community factors and how this varies by levels of remoteness. It includes a special focus on factors associated with Year 1 school attendance, given that recent Western Australian research (Hancock et al. 2013) showed that enduring patterns of attendance are established very early in a child's school career. The overall aim of these analyses is to advance understanding of the relative importance of such factors and to identify factors potentially modifiable through targeted policy initiatives.

- ***Aboriginal student attendance:*** Multivariate regression conducted separately for Aboriginal students found no less than 11 predictor variables having a significant independent association with their Year 1 attendance. This highlights the extent to which multiple disadvantage influences their school attendance. As there are around 200 days in a typical school year, the predicted separate effects of each of these factors on Aboriginal students' total days of school attended in a school year were:
    1. Living in a community with overcrowded housing - 35 fewer days attended
    2. Attending 30 or more days of preschool - 18 more days attended
    3. Having a parent/carer who is employed - 11 more days attended
    4. Having ESL - 11 fewer days attended
    5. Having a parent/carer with Year 10 or more years of education - 10 more days attended
    6. Having attended 2 or more schools in a school year - 9 fewer days attended
    7. Living in a very remote location - 6 fewer days attended
    8. Being hospitalised for an infectious disease by age 5.5 years - almost 4 fewer days attended
    9. Having LBW - almost 4 fewer days attended.

- ***Non-Aboriginal school attendance:*** The multivariate regression conducted separately for non-Aboriginal students showed 7 factors with a significant independent association with their Year

[1] Socio Economic Indices for Areas (SEIFA): Index of Relative Socio Economic Disadvantage

1 attendance. The predicted separate effect of each these factors on non-Aboriginal students' total days of school attended in a school year were:

1. Living in a community with overcrowded housing - 10 more days attended[2]
2. Mobility between schools - almost 6 fewer days attended
3. Twin status - almost 5 more days attended
4. Teenage motherhood - almost 4 fewer days attended
5. Employed carer status - almost 4 more days attended
6. Maternal smoking during pregnancy - 3 fewer days attended
7. Mothers who attended less than the standard 7 antenatal health care visits - 2 fewer days attended.

- ***Relative influence of individual and community factors:*** A variance decomposition analysis investigated the relative influence of a range of factors on the Year 1 school attendance of Aboriginal children. This compared the percentage of variance attributable to child and family factors with the overall 'fixed effect' of their school/community characteristics.

   1. In very remote areas, school/community characteristics accounted for 67% of the explained variation, preschool attendance accounted for around 24%, while family and other individual child factors together explained around 10%.
   2. In remote areas, school/community characteristics accounted for around 20% of the explained variation in Year 1 attendance, family and parent's characteristics accounted for around 26%, preschool exposure accounted for 23%, while child characteristics including ESL and mobility between schools accounted for 31%.
   3. In outer regional areas, school/community characteristics accounted for just 12% of the variation in school attendance, in comparison with attending preschool 31%, parent and family characteristics 21%, student mobility 16%, and other child-specific characteristics including ESL 20%.

- ***Weekly school attendance rates:*** Across all school years, for both Aboriginal and non-Aboriginal students, attendance rates were substantially lower in the first and last weeks of each quarterly school term.
- ***School attendance by region:*** In contrast to non-Aboriginal students, Aboriginal students' attendance varied markedly by geographic region e.g. being around 80% or higher in outer regional areas, and just 65% or less in very remote areas.
- ***Attendance by school year:*** The attendance of Aboriginal students dropped off markedly in the later years of compulsory schooling. This declined from around 60% in the first quarter of Years 7–9, to less than 50% in the first quarter of Year 10, and then further to around 40% in the final two quarters of each school year.
- ***Child health and attendance:*** Year 1 school attendance was significantly associated with infectious disease hospitalisation (prior to age 5.5 years). For example, around 60% of students with Year 1 attendance less than 60%, had had an infectious disease hospitalisation, while those in other school attendance bands had lower hospitalisation rates (55% in 60–79% band; 49% in 80–89% band; 40% in 90–100% band).
- ***Developmental readiness for school learning:*** Aboriginal students assessed as 'developmentally vulnerable' had significantly lower Year 1 attendance than those considered 'developmentally on track' across all five AEDC domains. This was most evident for the 'Language and cognitive skills' domain (median attendance rate of 65.3% vs 82.7%) and 'Communication skills and general knowledge' domain (66.3% vs 80.1%).

[2] The paradoxical nature of this finding may be due to the small number of non-Aboriginal students in very remote communities whose parents are service workers such as teachers and nurses.

Chapter 6 Preschool participation, school attendance and academic achievement

This chapter reports findings from a series of analyses investigating how children's level of participation in preschool is linked with their subsequent school attendance and academic achievement. An examination was made of the distributions of attendance in preschool and early primary school (i.e. Transition to Year 3), and how they differed for Aboriginal and non-Aboriginal children, and by their ARIA+ remoteness category. Next, multivariate regression modelling, with adjustment for confounding and effect modification, was used to investigate how any level of attendance at preschool was associated with early years school attendance, and by remoteness. For very remote areas only, a comparison was made of how the association between any level of preschool attendance and early years school attendance differed for children attending each of the three main modes of preschool delivery. Finally, fixed effects regression modelling was used to estimate what improvements in early years school attendance could theoretically be expected from different percentage point improvements in preschool attendance.

- Aboriginal children who attended any form of preschool subsequently attended 7.3% more days in early years school education than children with no preschool attendance. After adjusting for all possible confounders, this effect is reduced to 4.5% or 12 additional days per school year.
- In very remote areas, where Aboriginal early years attendance is around 60%, the 4.6% increase associated with preschool attendance is equivalent to 15 additional days of school per year; and in outer regional areas where the average Aboriginal early years attendance is 82%, this would be associated with 11 more days of school attended per year.
- Attendance of Aboriginal children at any of the three types of preschool provided in very remote areas had a significant positive association with early years school attendance. On average, the children who attended a general preschool attended 22 more school days per year; those who attended an early years class attended 13 more school days per year; and those who attended a mobile preschool attended 11 more days of school per year.
- Modelling of the percentage improvements in early years school attendance that could theoretically be expected from different levels of preschool attendance (i.e. ranging from 0% to 100%) found that in comparison with the other modes of preschool delivery, the general preschool model offered the greatest potential impact in increasing children's expected days of school attendance.
- In practical terms, this modelling indicates that a minimum preschool attendance level of 45% is needed for this to be associated with Aboriginal children achieving the population average school attendance of 62%. The corresponding minimum preschool attendance in the other forms of preschool needed for a 62% average school attendance, is 55% for early years classes, and 65% for mobile preschools.

Chapter 7 Modelling the key drivers of school education outcomes

Structural equation modelling (SEM) was used to 'unpack' the relative influence and interplay of main factors identified in earlier chapters as making important contributions to children's Year 3 literacy and numeracy outcomes. The SEM analysis was designed to test two hypotheses: 1) That preschool attendance is positively associated with attendance in the early years of primary school, which after adjusting for differences in AEDC outcomes, has a positive influence on NAPLAN outcomes, and; 2) That preschool attendance positively influences early childhood development (AEDC), which in turn is associated with early school achievement (NAPLAN).

- The strongest direct association was observed for the path from children's preschool attendance to their subsequent school attendance (i.e. Transition to Year 3). This was significant for both Aboriginal and non-Aboriginal students across all remoteness strata, and showed a greater effect for Aboriginal children. The relative strength of these paths in their contribution to Aboriginal students' school attendance in outer regional, remote and very remote areas was equivalent to effect sizes of 0.607, 0.517 and 0.606 respectively.
- The analysis showed the extent to which preschool attendance also benefits children's developmental readiness for school learning (i.e. AEDC outcomes). This association was much stronger for Aboriginal students accounting for effect size contributions to AEDC outcomes of 0.255, 0.267 and 0.090 in outer regional, remote and very remote areas respectively. In contrast, the effect size strength of this path for non-Aboriginal children was 0.195 and 0.190 in outer regional and remote areas, but not significant for these children in very remote areas.
- The strength of the indirect (composite) path effects from preschool attendance via AEDC to NAPLAN was less than expected for all six strata. Its effect size contribution to NAPLAN outcomes was just 0.095 for Aboriginal children in outer regional areas, 0.129 in remote areas, and 0.017 in very remote areas. The comparable effect sizes for non-Aboriginal children in these geographic areas were 0.092, 0.082, and 0.060 respectively.
- The effective strength of the indirect (composite) path from preschool attendance via early years school attendance (i.e. Transition to Year 3) to NAPLAN was mostly stronger for Aboriginal children. The effect size contributions made by this composite path to the NAPLAN outcomes of Aboriginal children were 0.230, 0.129, and 0.311 for outer regional, remote and very remote areas respectively. The comparable indirect effect sizes for non-Aboriginal children were 0.070, 0.142, and 0.110 respectively.
- Together, these findings have clear implications for policy in showing the extent to which increasing children's preschool attendance provides a window of opportunity for long-term gains in their school attendance and NAPLAN achievement.

Chapter 8 Summary and conclusions

This final chapter discusses implications of the overall study findings. Each of the earlier chapters were designed to progressively build a more comprehensive and nuanced understanding of the cumulative effects of the multiple, interacting factors which shape children's early health, development and school learning. The conclusions arising from the study have a number of clear messages for policy makers, government and community service providers. Substantial immediate and longer-term benefits could be realised from policy and service investment which increase children's access to, and participation in, quality preschool early learning. However, future efforts to improve the school attendance and learning outcomes of NT children will depend on the progress made by government and community action in addressing the modifiable early life 'up-stream' determinants of these outcomes, especially Aboriginal children's disproportionate exposure to high levels of disadvantage.

Key findings

- The study findings first and foremost demonstrate the extent to which sociocultural and economic circumstances influence all children's early health, development and learning, and why it is essential that current efforts to improve school attendance and achievement also focus on addressing the known early determinants of these outcomes.
- Findings highlight the extent to which children's development and school learning are underpinned by their health status—particularly in early life and throughout childhood.

- Addressing community-level factors, such as housing overcrowding, is likely to result in substantial improvements in school attendance, especially in very remote communities.
- Improving levels of attendance at preschool offers one of the best immediately available strategies for improving the NT's concerning rates of Aboriginal school attendance and achievement.
- It is also evident that the initial benefits of preschool can easily 'fade out' unless they are reinforced by regular attendance and effective engagement with school learning in the early years of primary school.
- The study findings are consistent with other research in identifying critical transition points in children's school careers which are opportunities for leveraging better outcomes: a) From preschool to Year 1—especially for Aboriginal students through targeted additional learning and language support; and b) From Year 6 to Year 7—through middle school programs maintaining student engagement and retention in high school.
- The overall findings strongly support the direction and potential benefits of the NT Government's recent investment of $35.6 million over four years to implement a whole-of-government plan in collaboration with community organisations to improve early childhood services and the lives of Territorian children (Northern Territory Government 2018). They particularly validate the emphasis on developing a more integrated, place-based approach to the planning and delivery of universal and targeted services to young children and their families.
- Finally, the study findings provide a baseline against which the NT Early Childhood Plan's immediate and longer-term performance outcomes could be monitored using similar data linkage methods.

Implications for future research

The study findings suggest the potential value of future research in the following areas:

1. Investigating reasons for the recent decreasing trend in Aboriginal and non-Aboriginal teenage pregnancy e.g. whether this is associated with increased uptake of contraception in this age group and/or other health and social factors.
2. Investigating the implications of the declining Aboriginal total fertility rate which by 2013 was approaching the population replacement rate of 2.1 live births to women in their reproductive years.
3. Conducting qualitative studies to inform the development and evaluation of preventive public health strategies to reduce the continuing high proportion of Aboriginal women in remote and very remote areas who report smoking during pregnancy.
4. Investigating whether there are homogenous subgroups of students who share similar patterns of attendance over the course of their school career using newly available analytical methods, e.g. trajectory analysis (Nagin et al. 2010) and latent class analysis (Thompson et al. 2017; Hancock et al. 2018). This would assist in the early identification and targeted support for students at increased risk of adverse school outcomes.
5. Undertaking mixed-methods research to investigate family, community and school factors which explain why some communities have better early childhood development (AEDC) outcomes than would be predicted on the basis of their socioeconomic status.
6. Qualitative research into the child, school and curriculum factors which optimise children's engagement with school learning in the early years of primary school. This should also include a focus on the specific learning and school adjustment needs of boys.

1. The NT Data Linkage Study

Sven Silburn, John Lynch, Steven Guthridge, Richard Midford, Julie Brimblecombe, Margaret Walter, Stefanie Schurer, Gawaian Bodkin-Andrews and Peter Shaw

Chapter overview

This chapter describes the origins of the NT Data Linkage Study to investigate the early child development educational and wellbeing outcomes of all children born in the Northern Territory over the 20-year period since 1994. It briefly reviews the rapidly growing national and international literature on the use of new methods of data linkage and de-identification of unit-record data to enable whole-population studies in areas of policy and scientific research. The use of data linkage research for life course analysis is particularly helpful in documenting how children's early-life health and social circumstances can impact their longer-term health, learning, and behavioural outcomes. The unique diversity of the Northern Territory's geographic, cultural, linguistic and socioeconomic circumstances presents significant challenges for population-based research and the types of evidence needed to inform effective policy and services. The Northern Territory's demographic profile differs markedly from other jurisdictions, particularly in that around 30% of the population identify as Aboriginal and/or Torres Strait Islanders. Special care has been taken to ensure that the study design, implementation and reporting of findings are properly inclusive and respectful of Aboriginal perspectives and that the study addresses issues of particular relevance for the NT Aboriginal community. The chapter concludes with a description of the overall study objectives, its project governance arrangements, and its community and scientific advisory processes.

1.1 Background

This data linkage study of Northern Territory children's development in health, education and wellbeing has its origins in 2007 when the Northern Territory (NT) and South Australian (SA) governments collaborated in developing a shared technical capacity for making better use of their administrative data holdings. Both the NT and SA governments are foundation members of the SA NT DataLink consortium which has supported the ongoing operation of the SA NT DataLink data integration authority since its establishment in 2009. This has led to new data-methodologies becoming available for ethically and confidentially combining data usually held and analysed in separate departmental datasets. It has also enabled new types of research and evaluation based on the integration of de-identified unit-record data sourced from different administrative datasets.

The technical feasibility of these new data linkage methods to support epidemiological research based on NT administrative data was first trialled in the NT Early Child Development Data Linkage Demonstration Study (Silburn et al. 2010). Once the demonstration study established the effectiveness and value of these data linkage methods for policy relevant research, the NT Government departments of Health, Education, and Children and Families jointly invested in establishing the Child Development and Education Research Partnership (CDERP) with the Menzies School of Health Research (2014–2016). The partnership's shared aim was to build the NT's collective technical capacity to support data linkage initiatives and to develop a program of research addressing key NT policy concerns. Additional funding was then secured the following year through a National Health and Medical Research Council (NHMRC) Partnership Grant (2015–2017). This enabled the research partnership to be expanded to also include the Aboriginal Medical Services

Association of the Northern Territory (AMSANT) and the inclusion of some of Australia's leading Aboriginal and Torres Strait Islander researchers as investigators on the study. It also expanded the scope of the research program by extending the range of NT administrative datasets contributing data for linkage and the years of data capture.

1.2 Data linkage research

Use of administrative data for research
Administrative data are increasingly being used in health, educational and social economic research both in Australia and internationally (Gavrielov-Yusim et al. 2003; Jutte et al. 2011). Population-level data originally collected for administrative purposes (e.g. the provision of health services), has been used in a range of studies evaluating policy outcomes, assessing the effectiveness of interventions, determining the cost-effectiveness of programs, investigating socioeconomic inequalities between population groups, comparing geographical variations and identifying secular trends (Waltz et al. 2005; Goldacre et al. 2005; Productivity Commission, 2013; Garratt et al. 2010).

Given that administrative data are collected on a routine basis, they represent an inexpensive resource for research. They are particularly useful in that they usually cover the whole population thus avoiding the shortcomings of samples and sample selection. Their long-term data recording often spans many years allowing for long study observation times and longitudinal or time-series analyses (Mazzali et al. 2015). Because these data have already been collected and are generally readily available, shorter research timeframes are also possible (Curtis et al. 2013).

At the same time, administrative data not collected for specified research purposes can also have limitations (Grosse et al. 2010; Rice et al. 2015). These may include a lack of demographic information, selection bias, under-reporting, incomplete data recording and data inconsistencies. It is therefore important that research using administrative data should identify such limitations and adopt appropriate statistical techniques in addressing these (Ali 2013).

In contrast to conventional experimental studies with a limited number of selected patients, whole of population observational studies using administrative data are generally more representative and better suited to inform policy (Productivity Commission 2013). Australia has not fully tapped this potential - but is well placed to do so with high-quality administrative data, advanced computing infrastructure and legislation that enables the safe use of administrative data for secondary purposes. The Australian Government's 2015 Review of Public Sector Data Management noted that "information held by the Government is to be managed for public purposes, and is a national resource" (Commonwealth of Australia, 2015).

Linkage of administrative data for research
The idea and techniques for linking administrative data for public health research dates back to the middle of the 20th century (Dunn 1946; Newcombe et al. 1959). However, it is only with more recent advances in computing technology, data storage, and statistical methods that pioneering efforts in the de-identified linkage of administrative data for research purposes have been made possible (Kelmen 2000; Lovett 2008; Holman et al. 2008). Over the past decade, the Australian Government and all Australian states and territories have invested in establishing data linkage research capacity to make more effective use of their

administrative data. Australia's first national data linkage network, the Population Health Research Network (PHRN), was established in 2009 with the aim of "building a nationwide data linkage infrastructure capable of securely and safely linking and integrating data collections…" (Boyd et al. 2012).

Data linkage research and child outcomes

Longitudinal data linkage studies are of particular value in improving scientific, community and policy understanding of what matters most in strengthening children's development, education and longer-term opportunities in life (Santos et al. 2012; Goldfeld et al. 2014; Falster et al. 2015; Carr et al. 2016).

There are now several Australian data linkage studies that have investigated factors relating to child and youth outcomes, including school attendance and academic achievement (Hancock et al. 2013), antecedents of child protection involvement (O'Donnell et al. 2010), antecedents of juvenile justice involvement (Ferante et al. 2013), birth outcomes and childhood academic achievement (Moore et al. 2014), perinatal and sociodemographic antecedents of early childhood development and school education outcomes (Guthridge et al. 2015 & 2016), developmental pathways to positive early child health and development (Falster et al. 2015; Carr et al. 2016), neighbourhood effects on early child development (Goldfeld et al. 2014), antecedents of teenage pregnancy (Gaudie et al. 2010), antecedents of teenage self-harm hospital admissions (Mitrou et al. 2010), and the intergenerational effects of forced removal on Western Australian Aboriginal children (Silburn et al. 2006).

De-identified data linkage research has particular advantages in complex research settings such as the NT where the cost of collecting population-based data is much higher than elsewhere in Australia. This is in part due to the high proportion of the population who are Aboriginal and/or Torres Strait Islanders with many living in very small communities scattered across vast areas. Data linkage offers an effective solution to the 'siloed' nature of the administrative data sources. Combining administrative data usually retained separately by health, education and other agencies enables a more holistic investigation of the complex interplay between individual, environmental and social forces shaping people's lives.

For government policy to be better informed by evidence, a more systematic understanding is needed of how various factors impact at the population level and especially for subpopulations with special needs. This requires studies able to identify which factors matter most in strengthening children's trajectories of development, and how they cumulatively and interactively influence outcomes over the life course. Despite its many research advantages, the complexity, duplication and lack of cohesion in the multiple approval processes required for data linkage research are costly and often involve lengthy delays, especially for national studies (Garvey et al. 2014). This has led to calls for the streamlining of data linkage applications and ethics approval processes across jurisdictions (Mitchell 2015).

In summary, this NT Data Linkage Study offers an innovative new means for generating the comprehensive evidence-base needed to inform priority setting and the development of policy and services appropriate to the needs of NT children, their families and communities. It offers an inexpensive means of prospectively following the life outcomes of the general child and youth population and/or identified subpopulation cohorts. This will be of special value in evaluating the impact of policy and specific programs.

1.3 The NT research context

The NT's unique population characteristics and the diversity of its socioeconomic, cultural and geographic circumstance present significant challenges for the planning, resourcing and implementation of policy and services for children and their families. Its demographic profile differs substantially from other Australian states and territories in having a much larger percentage of the population who are Aboriginal and/or Torres Strait Islanders. In the 2011 Census, 27% of the NT population was counted as Aboriginal and/or Torres Strait Islander compared to 4% or less in all other jurisdictions (ABS 2012). Of the NT-born children in this data linkage study, 39% had school enrolment records in which they were identified as Aboriginal and/or Torres Strait Islanders.

Of particular relevance to children's outcomes, the NT has high levels of inequality between Aboriginal and non-Aboriginal children on a range of socioeconomic indicators. The impacts of disadvantage are evident early in children's lives. This is evident in health status indicators such as rates of prematurity and low birthweight, measures of child growth and nutrition, otitis media (middle ear infections) and hearing loss, chronic respiratory and other infections, and rates of hospitalisation. Importantly however, while such adverse health issues early in a child's life can significantly affect their longer-term health and development, it is also true that most of these conditions are preventable.

The investigations described in this publication have therefore focused on the early-life health and sociodemographic factors associated with three outcomes which are each important indicators of population health: a) NT children's developmental status assessed at the time they commence primary school education; b) their patterns of school attendance; c) and unpacking how these factors contribute to children's subsequent success in school learning as measured by the National Assessment Program – Literacy and Numeracy (NAPLAN).

1.4 Aboriginal perspectives and involvement

Given that almost a third of the NT population is Aboriginal, special care has been taken to ensure that the study methods are carried out in a culturally inclusive and respectful manner and that they address issues of particular relevance and importance to this population.

The project team has been guided by the core values and ethics described in the *NHMRC Guidelines for Ethical Conduct in Aboriginal and Torres Strait Islander Health Research* (NHMRC 2003). Firstly, the conception and development of the research plan for the study's funding through a NHMRC Partnership Grant was developed in consultation with Aboriginal and Torres Strait Islander researchers and the Menzies School of Health Research Child Health Indigenous Advisory Group.

The organisational partners in the NHMRC funded study include the Aboriginal Medical Service Alliance of the Northern Territory (AMSANT) along with the NT departments of Health, Education, and Children and Families and the Menzies School of Health Research. Each of these partner organisations is represented on the project Steering Committee. This body is responsible for the scientific conduct of the study and provides strategic advice and support for the use of their organisation's data in the ethics approved research program. The Steering Committee also reviews the study outputs and has final sign-off for the public release of findings.

Terminology used in referring to Aboriginal or Torres Strait Islander people

'Aboriginal and Torres Strait Islander' is the preferred terminology for referring to the Indigenous peoples of Australia. This acknowledges their distinct cultural identities whether they live in urban, regional or remote areas of the nation. According to the official Commonwealth definition *"An Aboriginal or Torres Strait Islander is a person of Aboriginal or Torres Strait Islander descent, who identifies as being of Aboriginal or Torres Strait Islander origin and who is accepted as such by the community with which the person associates"* (IATSIS 2012). This definition has informed the standard Indigenous status question used in the Census, ABS surveys, and other official administrative records. It asks whether a person identifies as either 'Aboriginal', 'Torres Strait Islander' or 'Both Aboriginal and Torres Strait Islander'. In the Northern Territory, 'Aboriginal' is the preferred official term for inclusively referring to both Aboriginal and Torres Strait Islander peoples. This respectfully acknowledges the relatively small percentage of the NT population who identify as Torres Strait Islanders and the greater proportion of these people who also identify as Aboriginal.

The study is also supported by a community advisory group which has representation from a broad range of Indigenous stakeholders with interests in children's outcomes. These include organisations such as the Northern Territory Aboriginal Justice Association (NAAJA), academic bodies such as the Australian Centre for Indigenous Knowledge and Education (ACIKE), as well as Aboriginal health researchers and educators.

The Community Advisory Group plays a key role in assisting the project team in promoting community understanding of the public good benefits of data linkage and how the ethical requirements for de-identified analysis guarantee the confidentiality and security of data and protect the privacy of individuals. This group also assists the Steering Committee in reviewing the project's research outputs and ensuring that the reporting of findings is done in culturally accessible ways which are appropriate to the information needs of Indigenous communities and the general NT population.

The study methodology has also been informed by the *National Best Practice Guidelines for Data Linkage Activities Relating to Aboriginal and Torres Strait Islander people* (AIHW 2012). This requires all relevant aspects of the data linkage activity, including data linkage quality assessment, analysis of the linked data, and methods for deriving Indigenous status, to be fully documented and publicly reported.

In following these best practice guidelines, careful attention has been taken in firstly establishing the completeness and comparability of Indigenous status information within each of the data being linked. An important recommendation of the guidelines is the need for documentation of the methods used for deriving a consistent Indigenous status variable for use in analysis. The approach taken by the study team in doing this is described in detail in Chapter 2.

Figure 1.1 Project governance arrangements

1.5 Study design and implementation

The planned program of data linkage research was developed in collaboration with the project's partner organisations. Their involvement in this collaborative enterprise reflects their interest in building data infrastructure and analytic capacity in the NT to enable their administrative data being integrated to provide more holistic, and contextually relevant evidence for the coordinated development of policy and community-based services.

While the study has its main focus on elucidating the factors which are associated with children having positive developmental outcomes, the linkage of data from usually separate data sources provides unique opportunities for scientific investigation of the longer-term consequences of commonly occurring maternal and child health issues of policy concern in the NT e.g. low birthweight and adverse pregnancy outcomes, alcohol and tobacco use in pregnancy, gestational diabetes, suboptimal child nutrition and failure to thrive, iron deficiency anaemia, otitis media and hearing disorders (Silburn et al. 2011).

Given the marked differences between urban and remote NT communities, and the variations in living circumstance between remote communities, the child-specific linked data have also been combined with community-level data relevant during two developmental epochs of children's lives: conception to age five; and the years of compulsory school attendance (ages 6–16).

The comprehensive nature of the linked longitudinal datasets supports research approaches not previously possible in the NT. These are focusing on 'unpacking' the nature and extent of individual child and sociodemographic factors most salient in shaping children's developmental health and wellbeing and their success in school learning. In addition to clarifying these relationships, the study is documenting both the prevalence and the independent effects of these factors on four child outcomes of high policy concern in the NT:

1. Early childhood development and readiness for school learning
2. School attendance, and literacy and numeracy
3. Involvement with the NT child protection system
4. Involvement with the NT juvenile justice system.

The study findings concerning the first two of these outcomes are described in this monograph, while those for the second two will be reported in later publications to be published later in 2018. These publications include investigation of the relative strength and joint contribution of some of the following early life factors:

a) Child clinical factors (e.g. interuterine alcohol and nicotine exposure, gestational age, birth weight, birth complications, perinatal health status, infant growth and nutritional status);

b) Parental and family factors (e.g. maternal age and education, family composition and mobility);

c) Community level factors (e.g. socioeconomic advantage/disadvantage, geographic remoteness, environmental health and housing, community social functioning, educational level of adults, and cultural factors such as traditional language use and the percentage of adults who speak English).

Importantly, the study's linkage of whole population data means that it includes comparable information for children with positive developmental outcomes as well as for those with more adverse outcomes. Also, the study's large study population and lengthy periods of data capture support most of the analyses being able to be stratified by children's Aboriginal status. This provides an opportunity for systematically investigating how children's differing socioeconomic circumstances and other risk and protective factors jointly influence their life course pathways in health, education and psychosocial wellbeing.

1.6 References

Ali AK. 2013. Methodological Challenges in Observational Research: A Pharmacoepidemiological Perspective. British Journal of Pharmaceutical Research;3(2):161-75.

Bell MF, Bayliss DM, Glauert R, Harrison A, Ohan JL. 2016. Chronic illness and developmental vulnerability at school entry. *Pediatrics* 2016 May 13;137(5). Epub 2016 Apr 13.

Boyd JH, Ferrante AM, O'Keefe CM, Bass AJ, Randall SM, Semmens JB. 2012. Data linkage infrastructure for cross-jurisdictional health-related research in Australia. *BMC health services research*;12(1):480.

Carr VJ, Harris F, Raudino A, Luo L, Kariuki M, Liu E. 2016. New South Wales child development study (NSW-CDS): An Australian multiagency, multigenerational, longitudinal record linkage study. *BMJ Open*. 2016; 6(2).

Commonwealth of Australia, 2015. Department of the Prime Minister and Cabinet, Public Sector Data Management (available on line at: https://www.dpmc.gov.au/sites/default/files/publications/public_sector_data_mgt_project.pdf).

Curtis E, Drennan J. 2013. Quantitative Health Research: Issues And Methods: McGraw-Hill Education (UK).

Dunn HL. Record Linkage. 1946. American Journal of Public Health. Vol 36, 1412-1416.

Falster K, Jorm L, Eades S, Lynch J, Banks E, Brownell M, Craven R, Einarsdottir K, Randall D. 2015. What factors contribute to positive early childhood and development in Australian Aboriginal children? Protocol for a population-based cohort study (The Seeding Success Study). *BMJ Open*, 5:e007898 doi:10.1136/bmjopen-2015-007898.

Ferante AM. 2013. Assessing gender and ethnic differences in developmental trajectories of offending. *Australian and New Zealand Journal of Criminology*. 46, 3, pp.379–402.

Garratt E, Barnes, H. and Dibben, C. 2010. Health administrative data: Exploring the potential for academic research,. St Andrews: Administrative Data Liaison Service.

Gaudie J, Mitrou F, Lawrence D, Stanley FJ, Silburn SR, Zubrick SR. 2010. Antecedents of teenage pregnancy from a 14-year follow-up study using data linkage. *BMC Public Health*. Vol. 10, p. 63.

Gavrielov-Yusim N, Friger M. 2013. Use of administrative medical databases in population-based research. *Journal of Epidemiology and Community Health. 68(3)* 283-287. doi:10.1136/jech-2013-202744.

Goldacre M, Glover J. 2013. The value of linked data for policy development, strategic planning, clinical practice and public health–an international perspective. In: Symposium on health data linkage, 2003.

Goldfeld S, Woolcock G, Katz I, Tanton R, Brinkman S, O'Connor E, Mathews T, Giles-Corti B. 2014. Neighbourhood effects influencing early childhood development: Conceptual model and trial. *Social Indicators Research*;120(1):197-212.

Grosse SD, Boulet SL, Amendah DD, Oyeku SO. 2010. Administrative data sets and health services research on hemoglobinopathies: a review of the literature. *American journal of preventive medicine*; 38(4):S557-S67.

Guthridge S, Li L, Silburn S, Li S, McKenzie J, and Lynch J. 2015. Impact of perinatal health and sociodemographic factors on school education outcomes: A population study of Indigenous and non-Indigenous children in the Northern Territory. *Journal of Paediatrics and Child Health*: 51 (8) 778–786.

Guthridge S, Li L, Silburn S, Li S, McKenzie J, and Lynch J. 2016. Early influences on developmental outcomes among children, at age 5, in Australia's Northern Territory. *Early Childhood Research Quarterly*. 35, 124-134.

Hancock KJ, Shepherd CCJ, Lawrence D & Zubrick SR. 2013. Student attendance and educational outcomes: Every day counts. Report for the Department of Education, Employment and Workplace Relations, Canberra. (Available online at: http://telethonkids.org.au/media/472779/final_report_2013.pdf).

Holman CDAJ, Bass JA, Rosman DL, Smith MB, Semmens JB, Glasson EJ, et al. 2008. A decade of data linkage in Western Australia: strategic design, applications and benefits of the WA data linkage system. Australian Health Review;32(4):766-77.

Kelman CW. Monitoring health care using national administrative data collections [PhD thesis]; 2000. Available from: https://digitalcollections.anu.edu.au/bitstream/1885/47457/6/02whole.pdf.

Jutte DP, Roos LL and Brownell MD. 2011. Administrative Record Linkage as a Tool for Public Health Research. *Annual Review of Public Health 2011*. 32:91–108.

Lovett R, Fisher J, Al-Yaman F, Dance P, Vally H. 2008. A review of Australian health privacy regulation regarding the use and disclosure of identified data to conduct data linkage. Australian and New Zealand journal of public health; 32(3):282-5.
Mazzali C, Duca P. 2015. Use of administrative data in healthcare research. *Internal and emergency medicine*: 10: 517. doi:10.1007/s11739-015-1213-9.
Mitrou F, Gaudie J, Lawrence D, Silburn SR, Stanley FJ, Zubrick SR. 2010. Antecedents of hospital admission for deliberate self-harm from a 14-year follow-up study using data linkage. *BMC Psychiatry.* Vol. 10, p. 82Moore EA, Harris F, Laurens KR, Green MJ, Brinkman SA, Lenroot RK and Carr V (2014) Birth outcomes and academic achievement in childhood: A population record linkage study. *Journal of Early Childhood Research*, doi: 10.1177/1476718X13515425.
Newcombe HB, Kennedy JM, Axford SJ and James AP. 1959. Automatic Linkage of Vital Records. *Science*, New Series, Vol. 130, No. 3381 (Oct. 16, 1959), pp. 954-959. American Association for the Advancement of Science.
NHMRC. 2003. Values and Ethics: Guidelines for Ethical Conduct in Aboriginal and Torres Strait Islander Health Research. Canberra: NHMRC.
O'Donnell M, Nassar N, Jacoby P, Leonard H, Mathews R, Patterson Y, Stanley F. 2010. Characteristics of non-Aboriginal and Aboriginal children and families with substantiated child maltreatment: A population based study. *International Journal of Epidemiology*, 39(3), 921-928.
Productivity Commission. 2013. Annual Report 2012-13, Annual Report Series, Productivity Commission, Canberra. Available at http://www.pc.gov.au/about/governance/annual-reports/2012-13/annual-report-2012-13.pdf.
Rice HE, Englum BR, Gulack BC, Adibe OO, Tracy ET, Kreissman SG, et al. 2015. Use of patient registries and administrative datasets for the study of pediatric cancer. *Pediatric blood & cancer*;62(9):1495-500.
Santos R, Brownell M, Ekuma O, Mayer T, Soodeen R. 2012. The Early Development Instrument (EDI) in Manitoba: Linking Socioeconomic Adversity and Biological Vulnerability at Birth to Children's Outcomes at Age 5. Winnipeg, MB: Manitoba Centre for Health Policy, (PDF available online at http://earlylearning.ubc.ca/media/publications/santos_2012_mchp_edi_report_web.pdf).
SA NT DataLink. 2016. *Supporting health, social and economic research, education and policy in South Australia and the Northern Territory. SA NT DataLink home page.* (Available online at: https://www.santdatalink.org.au/home).
Silburn SR, Zubrick SR, Lawrence DM, Mitrou FG, De Maio JA, Blair E, Cox A, Dalby RB, Griffin JA, Pearson G, Hayward C. 2006. The intergenerational effects of forced separation on the social and emotional wellbeing of Aboriginal children and young people. *Family Matters*. No. 75, pp. 10-17.
Waltz C, Strickland O, Lenz E. 2005. Measurement in nursing and health research. New York: Springer Publishing Company.

2. Methodology

Sven Silburn, Steven Guthridge, John McKenzie, Margaret Walter, Gawaian Bodkin-Andrews, Vincent He and Jiunn-Yih Su

Chapter overview

This chapter describes the study population and the NT administrative datasets from which data were accessed for record linkage and de-identified analysis. The steps involved in the data linkage process are then described along with technical aspects of the data linkage work carried out for the project by the SA NT DataLink data linkage authority. This includes an analysis of the completeness, consistency and quality of the data linkage and the quality assurance checks carried out to maximise linkage precision. Next, the processes involved in preparing the linked data for analysis are described. These include the project's data management, data security, and reporting arrangements and measures to ensure the privacy and confidentiality of individuals and communities in the study. The chapter then outlines the ethics and other approval processes governing researchers' access to the linked data for the NHMRC partnership project's program of research. The derivations of key demographic and other key variables are defined to ensure their consistency of use in the multiple analyses required for this and planned future publications. Special attention is given to documenting the implications of how Aboriginal status is best defined for analysis of data linked from separate data sources as these can differ in their quality and completeness of recording. The chapter concludes with discussion of post-colonial Indigenous standpoints on the limitations and potential risks of statistical analysis of 'official' administrative data concerning Indigenous people and an outline of how this has informed the study's statistical approach.

2.1 The study population

The study population included all children born in the NT between 1 January 1994 and 31 December 2013. This also included a subset of around 600 children who may have become parents in their own right during the time window of data capture. The data from the relevant datasets for this subset of young people and their children are therefore available for investigation of intergenerational effects.

2.2 Datasets included

The administrative datasets from which data were supplied for the initial data linkage in 2015 included NT Perinatal Trends, the NT Hospital Inpatient Activity, Australian Early Development Census (Commonwealth of Australia 2015), NT Child Protection, NT Student Activity, and National Assessment Program - Literacy and Numeracy (ACARA 2015). Details of these datasets are summarised below in Table 2.1.

Table 2.1 Details of datasets included

Data Custodian	Dataset	Date Range	Capture Date
NT Chief Health Officer	Perinatal Trends	01/01/1994 – 31/12/2013	Date of birth
NT Dept. of Health	Immunisation	01/01/1994 – 30/06/2014	Immunisation date
NT Health System Performance	Inpatient Activity	01/07/2000 – 30/06/2014	Admission date
NT Dept. of Children & Families	Child Protection	01/07/1998 – 30/06/2014	Notification date
Australian Govt. Dept. of Education	AEDC	2009 and 2012	Assessment date
NT Dept. of Education	Student Activity	01/05/2005 – 31/12/2014	Census date
NT Dept. of Education	NAPLAN	01/01/2008 – 31/12/2014	Test date

The NT Perinatal Trends dataset includes records for all births in the NT. It includes demographic variables, and information on maternal health, the pregnancy, labour, birth and perinatal outcomes.

The Immunisation dataset contains children's records of all the scheduled immunisations which NT children are recommended to have received according to their age. The relative completeness of NT immunisation coverage (94%) means that the information in this dataset can identify children whose immunisation records cease due to their out migration from the NT (National Health Performance Authority 2016). This has enabled the creation of a derived censoring variable needed for the study's longitudinal analyses to take account of this potential source of bias.

The NT Hospital In-patient Activity dataset includes records of all public hospital separations (discharges, transfers and deaths) in the NT. It includes patient demographics, diagnoses, and procedures coded according to the Australian Modification of the International Statistical Classification of Diseases and Related Problems (ICD-10-AM).

The NT Child Protection dataset includes records of all child protection contacts with the NT Department of Children and Families (renamed Territory Families in 2016). This includes notifications, investigations, substantiations and out-of-home care, including the number and type of placements.

The Australian Early Development Census (AEDC) is a population measure of children's development which is assessed early during children's first year of full-time schooling (usually at around age five years). This measure has been adapted and validated for use with Indigenous and non-Indigenous Australian children (Silburn et al. 2009). It includes teacher ratings of five areas of functioning relevant to children's developmental readiness for school learning: physical health and wellbeing, social competence, emotional maturity, language and cognitive skills (school-based), and communication skills and general knowledge. The recommended practice for AEDC assessments of Aboriginal children in NT schools is that teachers should do this jointly with an Aboriginal staff member as a cultural consultant.

The Student Activity dataset includes records of all children enrolled in NT Department of Education schools. This includes demographic information on students and their primary carer, details of student enrolments, re-enrolments, and records of each possible day and half-day of school attendance since first enrolment.

NAPLAN dataset. The National Assessment Program – Literacy and Numeracy (NAPLAN) is a series of standardised tests focused on basic skills that is administered annually to Australian students in Year 3, 5, 7 and 9. These assess students' reading, writing, language (spelling, grammar and punctuation) and numeracy. The tests are designed to be carried out on the same days all across Australia in any given year and parents are able to decide whether their children take the test or not. The NAPLAN program is overseen by the Council of Australian Governments' Education Council and was designed to determine if Australian students are achieving outcomes. The current study included NAPLAN records for 33,218 individuals.

2.3 The data linkage process

The first step in the data linkage process was the establishment of formal agreements with the data custodians of each of the relevant administrative datasets with regard to their supply of data for linkage. Next, applications for ethics approval were prepared and submitted to the Human Research Ethics Committees which supervise health related research in the 'Top End' and Central Australian areas of the NT.

Having secured the data custodian agreements and ethics approvals, it was then possible to submit a data linkage application to SA NT DataLink to carry out the linkage work to enable a de-identified linked dataset being assembled for analysis. SA NT DataLink is a nationally accredited data integration authority administered by the University of South Australia and operationally based within the South Australian Medical Research Institute (SAMRI) in Adelaide (SA NT DataLink 2016).

SA NT DataLink utilised sophisticated probabilistic linkage methods, as well as clerical checking, to match records from separate administrative datasets to the same child in our study (Christen 2012). This enabled each identified individual child within the scope of the study to be assigned an anonymous Linkage Key (a 10 digit random number). SA NT DataLink then returned to each of the data custodians the lists of children in the study with their associated Linkage Keys attached.

The next stage of the linkage process involved data custodians using their specific list of study children to extract the data items required for the study from their administrative dataset. The names and other identifying details for these children were then deleted to create a de-identified data file containing only the relevant content data for each study child and their Linkage Keys. The de-identified data files from each of the data custodians were then supplied to the research team at Menzies.

The final stage of the linkage process involved the Menzies research team merging each of the de-identified data files using the Linkage Keys for all children in the study supplied independently from SA NT DataLink. This created the de-identified analysis datasets used in carrying out the project's program of research.

The overall data linkage process is designed around a 'separation principle'. This principle ensures that at every step of linkage no single person or agency ever sees name-identified service information which they are not entitled to see. Each of the agencies providing administrative data for linkage have access to their service data only. Similarly, the staff at SA NT Datalink only ever see the person identifying details needed for record matching (i.e. name, sex, date of birth etc.) and the assignment of anonymous Linkage Keys. This means they never have access to any service information on any person included in the study. Finally, the project researchers only ever see children's service data when it has been completely de-identified.

2.4 Linkage processing details

Number of individual records. A total of 632,036 individual records were identified by SA NT DataLink for children potentially eligible for inclusion in the 1994–2013 NT birth cohorts. These were from the following datasets: Perinatal (n = 74,425), Immunisation (n = 89,479), Inpatient Activity (n = 47,465), Child Protection (n = 24,162), AEDC (n = 7,120), Student Activity (n = 328,818) and NAPLAN (n = 60,567).

There were 509 records found to have a date of birth outside the 1994–2013 birth cohorts. Manual checking of these records showed that while they may have had incomplete or incorrectly recorded dates of birth, they had other identifying information indicating they met the birth cohort criteria. This confirmed they were valid for inclusion in the study.

Connectivity between datasets. The degree of connectedness between the datasets was investigated by identifying 'clusters' of records which contain a record in two or more of the study data datasets.

Table 2.2 Records of children appearing in one or more dataset

	AEDC	Perinatal Trends	Student Activity	NAPLAN	Immunisation	Inpatient Activity	Child Protection
'Clusters'[1]	6,861	68,589	58,776	33,293	77,253	45,290	22,896
Unmatched records	212	5,870	6,180	414	11,929	2,192	1,238
Probable individuals	7,073	74,459	64,956	33,707	89,182	47,482	24,107

1. *Because a 'cluster' may contain records from more than one other dataset there is some 'double counting'*

Table 2.3 Connectivity between datasets [1, 2]

	AEDC	Perinatal Trends	Student Activity	NAPLAN	Immunisation	Inpatient Activity	Child Protection
AEDC	0 n/a	5,002 6.7%	5,825 9.0%	2,412 7.2%%	6,303 7.1%	3,891 8.2%	2,034 8.4%
Perinatal	5,002 70.7%	0 n/a	33,439 51.5%	20,063 59.5%	62,106 69.6%	36,940 77.8%	17,955 74.5%
Student Activity	5,825 82.4%	33,439 44.9%	0 n/a	33,285 98.7%	39,685 44.5%	26,758 56.4%	15,923 66.1$
NAPLAN	2,412 34.1%	20,063 26.9%	33,285 51.2%	0 n/a	23,163 26.0%	10,116 21.3%	16,454 68.3%
Immunisation	6,303 89.1%	62,106 83.4%	39,685 61.1%	23,163 68.7%	0 n/a	39,105 82.4%	19,167 79.5$
Inpatient Activity	3,891 55.0%	36,940 49.6%	26,758 41.2%	10,116 30.0%	39,105 43.85	0 n/a	15,608 64.7%
Child Protection	2,034 28.8%	17,955 24.1%	15,923 24.5%	16,454 48.8%	19,167 21.5%	15,608 32.9%	0 n/a

1. *The cluster count corresponds to the number of groups that have records that only link to other records within that dataset.*
2. *The connectedness percentage was calculated as (number of shared clusters from both datasets/(minimum total number of probable individuals or clusters from both datasets).*

This process is termed 'blocking'. It is designed to increase the computational efficiency of matching by reducing the need for every record having to be matched with every other record. Using a key person identifier ('Last Name and First Name Initial') as a blocking variable, the raw data were subdivided into mutually exclusive subsets with the assumption that matches do not occur across different blocks. However, because typographical errors or changes of name do happen, some person matches may still occur across blocks. To address this, other blocking variables (e.g. 'Street Address' and 'Date of Birth') were used to maximise the likelihood that a linkage missed in the first pass of the data would be detected in subsequent passes.

Quality assurance checking. A number of checks were made of the completeness of the linkage variables for the AEDC, Student Activity and Perinatal datasets. For example, in the NAPLAN dataset, Student ID was checked if it had a corresponding Student Master ID in the Student Activity dataset. This located 538 records without a corresponding Student ID in the Student Activity file. These records were referred to data custodians for advice for their reconciliation. Where such linking errors were identified, clerical checking was undertaken to make the following types of correction: a) assigning the record to an existing group; b) assigning the record to a new group; c) and/or removing 'false' links to a group leaving the record with no links to other records i.e. leaving it as an unmatched record.

Table 2.4 Data linkage matchings statistics: Student Activity, NAPLAN and AEDC datasets

Datasets	Submitted for Probabilistic Matching	Matches made	Matches not accepted (Match score <13)	Matches accepted (Match score >26)	Groups Clerically Reviewed
Student Activity + NAPLAN	120,401	168,674	19,077	77,559	10,085
AEDC	7,120	10,697	1,772	5,506	3,238

The final stage of quality assurance checking was to make a clerical review of records not meeting defined standards of matching precision during the probabilistic matching process. This is particularly important in matching information for NT Aboriginal children for whom there may be multiple changes of names and addresses. Table 2.4 above shows the number of groups which required clerical checking to produce the final NAPLAN and AEDC datasets.

2.5 Data preparation

On receipt of the de-identified data files from their respective data custodians, the Menzies research team undertook additional logic checks to identify any residual duplicate or invalid records. Next, the consistency of variable names and value labels of data items common to more than one of the datasets was checked. For example, in one dataset the variable Sex could have value labels of 1 = Male, and 2 = Female; but in the other the value labels might have been 1 = Male and 0 = Female. Where such differences were observed these were re-labelled to ensure their consistency when the datasets were merged to create the analysis datasets.

Then, using the full list of Linkage Keys provided to the project's data administrator (only), the separate datasets supplied by each data custodian were statistically merged. The new availability of additional information in the combined datasets then made it possible for a further set of logic checks to be carried out. This identified any remaining inconsistencies and informed what types of correction might be required to resolve these.

The final stage of data preparation involved standardising and documenting key variables likely to be commonly used in the multiple analyses to be conducted for the preparation of this and future publications. These included some of the main outcome variables to be examined for reporting in this monograph e.g. categorical and continuous measures of school enrolment, school attendance, and NAPLAN academic outcomes. They also included key demographic variables to ensure consistency of their use in analysis e.g. age groups, levels of remoteness and indicators of socioeconomic status.

Particular care was taken to ensure that the study variables identifying children's Aboriginal and Torres Strait Islander status were defined in a culturally sensitive and methodologically rigorous manner. While the recording of Aboriginal and Torres Strait Islander status in NT administrative data is believed to be more complete and accurate than in other Australian jurisdiction, there are significant complexities and cultural sensitivities which need to be acknowledged in any population based research which includes data on Aboriginal and Torres Strait Islander people.

The methodology for establishing the Aboriginal and Torres Strait Islander status variables for the purposes of this study was informed by the *National Best Practice*

Guidelines for Data Linkage Activities Relating to Aboriginal and Torres Strait Islander people (AIHW 2012). The study team were also guided in the development of the methodology by Chief Investigators Maggie Walter and Gawaian Bodkin-Andrews.

The AIHW guidelines require the methods used for defining Indigeneity to be fully documented and made publicly available. The approach taken in establishing the most appropriate way to utilise the linked datasets to define Aboriginal and Torres Strait Islander status is described below in section 2.6.

2.6 Data confidentiality

The identity and privacy of the study children, families and communities are protected by ensuring that all aspects of the study methodology conform with a) the *Australian Code for the Responsible Conduct of Research* (NHMRC 2007); b) *Values and Ethics: Guidelines for Ethical Conduct in Aboriginal and Torres Strait Islander Health Research* (NHMRC 2003); c) and the '*National best practice guidelines for data linkage activities relating to Aboriginal and Torres Strait Islander people*'(AIHW and ABS 2012).

The privacy of all study participants is protected by the research only using de-identified unit-record data. Their confidentiality is also maximised by ensuring that ethics committee approved safeguards are in place regarding the secure storage, controlled access and use of the de-identified dataset. The implementation of these safeguards is also monitored by the project's Steering Committee.

In terms of the reporting of the study findings, only aggregated statistical data is ever reported. Cells in statistical tables having a person count of less than 10 people have these values suppressed thus minimising the possibility of identification or re-identification of any individual or specific community.

All named researchers have been required to sign a Data Security Declaration to confirm their obligation to abide by the study's written code of practice in using the data. All hard copy of statistical output analyses is required to be physically stored in secure, locked storage cabinets in the research offices of those researchers with named ethics approval for analysing the linked data.

The Lead Investigator for the study is required to take all reasonable steps as outlined in the *Northern Territory Information Act (NT Government 2003)* to protect the study information from misuse and loss, and from unauthorised access, modification or disclosure.

Communities will not be identified in any publicly released report or study publication. However, where a community specifically requests a report regarding its own community-level findings, this can only be considered if a) the request is made by a local community body with authorisation to give consent on behalf of the community; b) and if the community request is submitted via the NHMRC project's *Data Access and New Projects Protocol.* Copies of this protocol are available on request to the project manager of the NHMRC data linkage study at the Menzies School of Health Research.

2.7 Defining Aboriginal status

As discussed earlier in Chapter 1, there are significant methodological and cultural issues which must be taken into account in any data linkage research using linked administrative data which includes recording people's Indigenous status. This is particularly important in the Northern Territory context for several reasons.

Apart from the NT having a much larger proportion of the total population who are Aboriginal, the age structure of the NT Aboriginal population is much younger than the NT non-Aboriginal population. The NT's cultural and linguistic diversity can be a factor leading to variations in the recording of names and other personal identifying information (e.g. date of birth) occurring more frequently in NT administrative data than other jurisdictions. This can arise for a range of reasons including that some Aboriginal groups have cultural requirements that names should not be used and/or be replaced for a period by a non-specific cultural name.

The recording of Aboriginal status in NT administrative data is believed to be more complete than other jurisdictions. Across Australia, there has been a steady upward trend in the proportion of people identifying as Aboriginal and Torres Strait Islander in each successive census since 1971. Across Australia, there were 649,200 Aboriginal and Torres Strait Islander people counted in the 2016 Census. This was an increase of 18% from the 2011 Census (ABS 2018). Over the same period, the NT had an 11.8% increase in its Aboriginal and Torres Strait Islander population (ABS 2017). Reasons for these changes are unclear but could reflect wider social norms and pressures, changing incentive or disincentive to identify, and variations in collection methodology (Biddle 2014; ABS 2018).

Whatever the reasons for changes in rates of Aboriginal identification, it remains the case that people have a right to self-identification and there are many reasons why people may or may not choose to identify given their personal circumstances and/or the context in which information about their Aboriginality is requested.

The NT Department of Health has invested considerable resources over recent years in the establishment of a 'NT Client Master Index'. This is a secure and protected database which holds a select range of linkage variables (e.g. name, date of birth, sex, address) across multiple NT datasets.

The NT Client Master Index has enabled SA NT DataLink to progressively refine the precision of the person identifying information for the NT population. This is incrementally improved with each occasion that data custodians provide identifiers for new linkage or data updates. This process has been of particular value in maximising the reliability of the Aboriginal status identifiers.

The current study includes data from multiple datasets in which the administrative recording of Aboriginal status is made independently by different agencies, sometimes over different times and occasions of service contact. While individuals are simply 'flagged' as Aboriginal (or not) in the various study datasets, it needs to be kept in mind that this grouping includes diversity, and that it is the 'self-identification' part of the official Commonwealth definition (below) that is recorded.

"An Aboriginal or Torres Strait Islander is a person of Aboriginal or Torres Strait Islander descent who identifies as an Aboriginal or Torres Strait Islander and is accepted as such by the community in which he [or she] lives" (ABS 2013).

This should ideally be recorded in response to the standard official question asked of the person (or their parent/carer). However, it is clear this is not uniformly followed (AIHW 2010), as data quality issues are common and self-identification can change over time and according to circumstances (NSW Aboriginal Affairs 2015).

Additionally, the recording of Aboriginal and Torres Strait Islander status is frequently outside the control of Aboriginal and Torres Strait Islander people. In administrative data especially this is often recorded by a non-Indigenous third person, such as a nurse or intake officer. Guthrie and Walter (2013) have established that such recorders commonly report embarrassment in asking the identity question, and frequently resort to guessing Aboriginal and Torres Strait Islander status based on physical appearance.

Aboriginal and/or Torres Strait Islander
Australians can be Aboriginal, Torres Strait Islander or both. In the NT datasets linked for this study there are relatively few Torres Straight Islanders. In Table 2.5 it can be seen that of the 119,059 *s*tudents enrolled in NT government schools there were 181 (0.3%) identified as Torres Strait Islanders only and another 1,461 (2.25%) who were also identified as Aboriginal.

Following consultation with the study's Community Advisory Group, it was agreed that for the analytic purposes of this study a single dichotomous variable should be used to differentiate non-Indigenous children from Aboriginal and Torres Strait Islander children; and, to ensure consistency with the preferred official terminology in the NT, these two groups are referred to as 'Aboriginal' and 'non-Aboriginal'.

Effects of 'incorrect' identification
The potential and real effects of bias created by systematic under-reporting of Aboriginality in administrative datasets are well known (Lawrence et al. 2012; Taylor et al. 2012; Fremantle et al. 2015). The systematic review of this issue by Thompson et al. (2012) highlights how misclassification can have a profound effect on the analysis of outcomes. They comment "under-identification of Indigenous status must be addressed in health analyses concerning Indigenous health differentials – they cannot be ignored or wished away" (Thompson et al. 2012).

Table 2.5 Indigenous status recorded in the Student Information dataset

Aboriginal status	Count	%
Non-Aboriginal	38,376	59.1
Aboriginal	23,527	36.2
Torres Strait Islander	181	0.3
Aboriginal & Torres Strait Islander	1,461	2.25
Not Stated	1,390	2.1
Total	*119,059*	*100*

Recently Gialamas et al. (2016) used linked administrative data and algorithmic methods to improve the identification of Aboriginal children in South Australian education data. They found that the gaps in educational outcomes can narrow dramatically as the indigeneity identification algorithm becomes more inclusive. An example of this was: "… the proportion of Aboriginal children who performed above the national minimum standard in Year 3 reading increased by 12 percentage points when the algorithm incremented from once to ever …". Such changes can impact both the numerator and denominator when calculating rates. This further underlines the importance for analysis of longitudinal data being based on consistent definitions of Aboriginal status.

Consistency of Aboriginal status variables
Whilst recognising people's rights to self-identification, the methodology of all of the linkage studies cited above involved assigning a single Aboriginal status variable to each individual across all linked data. This is considered to be ethically appropriate for longitudinal studies using de-identified population based data. It also significantly improves the precision and validity of the research outputs.

These studies employed different approaches to how Aboriginal status was derived. The most commonly used method was to identify individuals who had 'ever' identified as Aboriginal over different recording periods. Other approaches 'flagged' individuals who identified 'always', 'on two or more times' or 'the majority of occasions'. This raises the question of whether the same approach is optimal in every situation.

Choi and Barnes (2015) developed an index to measure the degree of consistency between two linked datasets and used it to evaluate the quality of Aboriginal and Torres Strait Islander identification between datasets and across jurisdictions. NT data was found to be more reliable than any other jurisdiction across census, deaths and hospital records. Overall, records were more reliable for people living in outer regional and (very) remote areas.

Few of the above studies attempted to evaluate the quality of each dataset in order to give greater weight to the datasets with the best data. Christensen et al (2014) specifically ruled this out in their Western Australian study "we focussed on an approach that was internally consistent, avoiding discussions of more or less trusted datasets or 'gold standards', which we felt were inconsistent with the principle of self-identification".

On the other hand, the AIHW best practice guidelines recommend consideration be made of the scope, coverage and quality of the available Aboriginal and Torres Strait Islander status data when selecting a consistent Aboriginal and Torres Strait Islander status variable. They also recommend using sensitivity analysis to compare the effect of various selection methods on the study outcomes of main interest.

The algorithmic approach we developed for establishing the optimum Aboriginal identifier for use in analyses involving data linked from two or more of the study datasets has followed the recommendation of the AIHW guidelines. This first involved a systematic evaluation of the completeness and quality of each dataset. Next an investigation was made of the consistency with which individual children were identified as Aboriginal or non-Aboriginal between different combinations of the study datasets. This was used in establishing a 'quality ranking' of each dataset. Finally, the consequence of using the different ways of defining Aboriginal status was investigated by comparing what effect they would have if used in calculating one of the study's key outcomes of interest: school attendance rates. (Further details of the methodology and analyses conducted in developing this algorithm are reported in Appendix 2.1).

In summary, our consideration of the cultural and methodological issues associated with defining Aboriginal status for data linkage studies involving NT administrative data supports the following conclusions:

1. For the purposes of this study, it is appropriate for a single dichotomous Aboriginal status variable to be used, given the small number of Torres Strait Islanders in the NT and the fact that most of these individuals also identify as Aboriginal.
2. This publication will respectfully use the term 'Aboriginal' in reference to data concerning the Aboriginal and Torres Strait Islander peoples in the NT population context.
3. In recognising people's rights to self-identification as Aboriginal or non-Aboriginal, it is understood that inconsistencies can arise in its recording between different datasets and over time. This may vary according to the context in

which this information is sought and people's personal circumstances at the time.

4. To reduce potential bias and inaccuracies that can arise from the under-reporting of Aboriginal status, a variety of possible derivations of combined Aboriginal status variables were investigated.
5. The NT Department of Health datasets were found to have the most complete and consistent recording of Aboriginal status. Ranking the other datasets in order of their concordance with the health data enabled the development of an algorithm in which each individual's derived Aboriginal status was determined by the highest ranked data available for them.
6. The above algorithm was considered to provide the best coverage and also represents an appropriate middle ground between the most inclusive and exclusive methodologies for deriving 'consistent' Aboriginal status variables needed for the study's longitudinal analyses.

2.8 Socioeconomic status

A limited amount of person-level sociodemographic information is recorded in the NT Department of Education's school enrolment data (e.g. the child's primary carer's age, employment status and education). The AEDC and Child Protection datasets also include some family demographic information. Additionally, two area-based measures of socioeconomic status were linked to each of the study children's linked data: The Socio-Economic Indicators for Areas (SEIFA), and the Index of Community Socio-Educational Advantage (ICSEA).

Socio-Economic Indicators for Areas (SEIFA)

For the purposes of this study, we assigned the SEIFA index for the area of each child's usual place of residence. SEIFA is a set of five indices developed by the Australian Bureau of Statistics (ABS) to compare the relative socioeconomic characteristics of areas at the time of each national census (ABS 2011). Because of the wide variation in socioeconomic advantage and disadvantage in the NT, we restricted our use of these indices to the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD). This index has a mean Australian value of 1,000 and a Standard Deviation of 100. As the index is designed to compare individual areas at the time of the census, there are complexities which need to be considered in longitudinal analysis involving the use of SEIFA indices created from data collected in different census years. For example, some of the census variables and related weights for the index are likely to have changed; the boundaries of the relevant area(s) may also have changed.

Our preliminary analyses identified some inconsistencies in the SEIFA values of NT communities in very remote areas. At the extreme end of the national distribution of disadvantage, the regression models used in creating these indices become unstable and are likely to under-estimate the actual level of disadvantage. A separate component of the present study reported in Chapter 4 describes how the additional community-level information available through data linkage can be used in conjunction with other publicly available community-level data to improve SEIFA's predictive association with key human development outcomes such as education.

Index of Community Socio-Educational Advantage (ICSEA)

The Index of Community Socio-Educational Advantage (ICSEA) is a scale of socio-educational advantage that is computed for each school across Australia. Developed by the Australian Curriculum, Assessment and Reporting Authority (ACARA), it is designed to enable ‘fair’ comparisons of NAPLAN test achievement by students in different schools. A value on the index corresponds to the average level of educational advantage of the school’s student population relative to those of other schools. It has a mean national score of 1,000 and standard deviation of 100. There are also concerns about the reliability and validity of ICSEA scores for very remote NT schools at the extreme end of the national distribution of disadvantage, where the underlying regression model used to derive the ICSEA scores appears to become non-linear. A component of this study is therefore investigating how the linked individual-level data and other publicly available community-level data can be used to derive weightings to improve ICSEA’s predictive associations with NAPLAN outcomes. This is described in Chapter 4.

2.9 Community-level variables

The data linked for each individual child have also been linked to a range of other community-level data, sourced from publicly available data such as ABS community profiles (ABS 2013) and aggregated data tables from other NT administrative data sources (e.g. housing and environmental health). These data items were selected on the basis of their relevance to the social, economic and environmental circumstances of families in raising their children. They include aggregate measures of environmental health (e.g. housing quality and overcrowding) and human capital (percentage of people aged 15+ with Year 10 or more education, percentage of people aged 15+ who speak English, percentage of people aged 15+ who are employed).

Further information on these community-level variables is reported in Chapter 4 along with a description of how these have been used to establish more reliable and valid indices of relative advantage/disadvantage for the NT remote community context. This was considered important for this study given the observed limitations of nationally-based indices such as SEIFA and ICSEA, particularly in relation to more NT Aboriginal communities.

2.10 Geographic variables

In the interests of protecting personal and community confidentiality, this publication only reports findings aggregated according to the ARIA classification of children’s usual area of residence. ARIA is the Accessibility/ Remoteness Index of Australia developed for the Australian Bureau of Statistics by the National Key Centre for Social Applications of Geographical Information Systems (GISCA).

The purpose of the ARIA index is to provide a statistical classification that informs policy development by classifying Australia into large regions that share common characteristics of remoteness. The concept of geographic remoteness is important in informing policy and the allocation of government resources. This needs to take account of the fact that the provision of services is strongly influenced by the typically long distances that people are required to travel outside cities and other urban areas.

At its highest level of geographic grouping, the current ARIA classification (referred to as ARIA+) has five categories: major cities of Australia, inner regional Australia, outer regional Australia, remote Australia and very remote Australia. Only the last three of these categories apply in the NT. For this reason these are the only three categories reported where analyses are stratified by remoteness (ABS 2011).

2.11 Statistical analysis

All statistical analyses have been performed using the statistical software STATA 14. The preliminary analysis conducted in preparing the extracted linked data items into analysis datasets involved extensive data checking which will continue as new and updated datasets are progressively linked in. The large study population and the comprehensive scope of the individual and community-level data linked for the study have facilitated use of new methods of longitudinal analysis. This has enabled the research being approached from an eco-epidemiological, life-span, human development standpoint.

The initial chapters of this publication report findings from univariate and bivariate analyses and trends over time. Later chapters use a range of multivariate modelling methods, with adjustment for confounding, to build a more nuanced description of key factors associated with NT children's trajectories of development than has previously been possible.

2.12 Indigenous statistical standpoints

While data linkage is a valued tool for policy development, its practice poses specific risks for Aboriginal and Torres Strait Islander peoples and communities. Population level/ administrative data cannot be understood as neutral. Data items are largely derived and used from Western epistemological standpoints and reflect the priorities and interests of data creators and collectors. These do not necessarily coincide with the priorities and interests of those who are the subject of the data. This problem is magnified when linking many datasets, if each one reflects the aspirations of their custodians, rather than those of Aboriginal and Torres Strait Islander peoples and communities.

This aspect of administrative data has been significantly critiqued by First Nations scholars. Indigenous scholars bolster this critique by pointing to the long-term systemic failure of governments in their use of administrative data in enabling positive development outcomes for First Nations communities (Andersen 2016; Kukatai & Taylor 2016; Walter 2016).

Within the Australian context, Aboriginal and Torres Strait Islander scholars particularly critique the simplistic use of Indigenous administrative/population-level data to inform policy decisions. They argue such usage fails to account for the lived experiences of Aboriginal and Torres Strait Islander communities and peoples (Behrendt 2004; Moreton-Robinson 2015; Nakata 2007).

These critiques underpin the emergence of Indigenous statistical methodological approaches; methodologies which centre Indigenous standpoints in the creation, analyses and interpretation of data relating to First Nations communities (Kukatai & Walter 2015; Lovett 2016).

Walter and Andersen (2013) suggest that an Indigenous statistical methodological framework incorporates three key premises; that the research move beyond dominant Western discourses to prioritise Indigenous cultural frameworks; that research processes are critically evaluated to identify and challenge direct and indirect cultural biases and stereotyping discourses; and that the translation of results reflects, not erases, the diverse contexts and lived experiences of Aboriginal and Torres Strait Islander peoples.

The study design, analysis and reporting of findings have aimed to address these concerns and avoid cultural bias and reduce the risk of adverse policy outcomes resulting from simplistic use of Indigenous administrative data.

2.13 References

ABS. 2011. Australian Statistical Geography Standard (ASGS): Volume 5 - Remoteness Structure, July 2011. Catalogue no. 1270.0.55.005.

ABS. 2011. *Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2011* (cat. no. 2033.0.55.001).

ABS. 2012a. *Census of Population and Housing – Counts of Aboriginal and Torres Strait Islander Australians, 2011*, Cat. No. 2075.0, ABS, Canberra.

ABS. 2013. *Perspectives on Aboriginal and Torres Strait Islander Identification in Selected Data Collection Contexts ABS Information Paper* Catalogue No. 4726.0 Commonwealth of Australia.

ABS. 2017. *Census of Population and Housing: Aboriginal and Torres Strait Islander Population 2016* (Cat. N. 2071.0).

ABS. 2018. Understanding the Increase in Aboriginal and Torres Strait Islander Counts, 2011-2016 (Cat. No. 2077.0).

Behrendt L. 2004. Election 2004: Indigenous rights and institutions. *Australian Review of Public Affairs.* (Available online at: http://www.australianreview.net/digest/2004/08/behrendt.html).

ACARA (Australian Curriculum, Assessment and Reporting Authority). 2015. *National Assessment Program – Literacy and Numeracy: 2014 Technical Report*. (Available online at: https://www.nap.edu.au/_resources/2014_NAPLAN_technical_report.pdf).

ACARA. 2014. *Guide to understanding the Index of Community Socio-educational Advantage (ICSEA) 2013 values*. Available online at: http://www.acara.edu.au/_resources/Guide_to_understanding_2013_ICSEA_values.pdf).

AIHW and ABS. 2012. *National best practice guidelines for data linkage activities relating to Aboriginal and Torres Strait Islander people:* (Available online at: http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=10737422213).

Anderson C. 2016. The colonialism of Canada's Métis health population dynamics: Caught between bad data and no data at all. Journal of Population Research, 33 (1) 67–82.

Biddle N. 2014. *Data about and for Aboriginal and Torres Strait Islander Australians.* Closing the Gap Clearinghouse Issues Paper no, 10 July 2014.

Behrendt L. 2004. Election 2004: Indigenous rights and institutions. *Australian Review of Public Affairs.* (Available online at: http://www.australianreview.net/digest/2004/08/behrendt.html).

Choi and Barnes. 2015. *Consistency of Indigenous identification in Australian official statistics.* Social Policy Research Centre, Canberra Workshop 13-14 May 2015.

Christen P. 2012. *Data Matching - Concepts and Techniques for Records Linkage, Entity Resolution, and Duplicate Detection.* Berlin Heidelberg: Springer-Verlag.

Christensen D, Davis G, Draper G, Mitrou F, McKeown S, Lawrence D, McAullay D, Pearson G, Rikkers W, Zubrick S R. 2014. Evidence for the use of an algorithm in resolving inconsistent and missing Indigenous status in administrative **data** collections. Australian Journal of Social Issues. 49 (4) 423-443.

Commonwealth of Australia. (2015) *Australian Early Development Census: Early Development Instrument and response criteria*. (Available online at: http://www.aedc.gov.au/resources/detail/aedc-early-development-instrument-and-response-criteria).

Fremantle J, Ring I, Teshia G, Solomon A, Gachupin F, Smylie J, Cutler TL & Waldon JA. 2015 Indigenous Mortality (Revealed): The Invisible Illuminated. *American Journal of Public Health*, 105 (4) 644-652.

Guthrie J and Walter M. 2013. 'The Positioning of Indigenous Australians as Health Care Recipients' pp. 239-249 in C. Banwell (ed) When Culture Impacts Health Elsevier Inc.

Gialamas A, Pilkington R, Berry J, Scalzi D, Gibson G, Brown A and Lynch J. 2016. Identification of Aboriginal children using linked administrative data: Consequences for measuring inequalities *Journal of Paediatrics and Child Health*) (Accepted for publication 29 November 2015)

Kennedy B, Howell S, Breckell C. 2009. *Indigenous identification in administrative data collections and the implications for reporting Indigenous health status*. Technical Report #3, Health Statistics Centre, Queensland Health. (Available online at: https://www.health.qld.gov.au/__data/assets/pdf_file/0018/364203/techreport_3.pdf).

Kennedy B, Howell S, Breckell C. 2009. *Indigenous identification in administrative data collections and the implications for reporting Indigenous health status*. Technical Report #3, Health Statistics Centre, Queensland Health. (Available online at: https://www.health.qld.gov.au/__data/assets/pdf_file/0018/364203/techreport_3.pdf).

Kukutai T & Walter M. 2015. Recognition and indigenizing official statistics: Reflections from Aotearoa New Zealand and Australia. *Statistical Journal of the IAOS, 31*(2), 317–326.Lovett, 2016).
Kukutai T & Walter M. 2015. Recognition and indigenizing official statistics: Reflections from Aotearoa New Zealand and Australia. *Statistical Journal of the IAOS, 31*(2), 317–326.Lovett, 2016).
Kukutai T and Taylor J (Eds). 2016. Indigenous Data Sovereignty: Towards an Agenda. *CAEPR Research Monograph, 2016/34*. ANU Press. Canberra.

Lawrence D, Christensen D, Mitrou F, Draper G, Davis G, McKeown S, et al. 2012. Adjusting for under-identification of Aboriginal and/or Torres Strait Islander births in time series produced from birth records: Using record linkage of survey data and administrative data sources. *BMC Medical Research Methodology.* 12(9). doi:10.1186/471-2288-12-90.

Nakata M. 2007. *The* Cultural Interface. *The Australian Journal of Indigenous Education:* (Re) Contesting Indigenous Knowledges & Indigenous Studies; Vol 36 (S1).

Moreton-Robinson A. 2015. The White Possessive. Minneapolis: Minnesota Press.

National Centre for Classification in Health. 2015. *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification*. Australian Consortium for Classification Development (Available online at: https://www.accd.net.au/Education.aspx).

NHMRC, ARC and Australian Universities. 2013. *Australian Code of Responsible Conduct of Research: Revision of the joint NHMRC/AVCC Statement and guidelines on research practice*. (Available online at: https://www.nhmrc.gov.au/_files_nhmrc/file/research/research-integrity/r39_australian_code_responsible_conduct_research_150811.pdf).

NHMRC. 2003. *Values and Ethics: Guidelines for Ethical Conduct in Aboriginal and Torres Strait Islander Health Research*. Canberra: NHMRC. (Available online at: https://www.nhmrc.gov.au/guidelines-publications/e52).

National Health Performance Authority. 2016. Healthy Communities: Immunisation rates for children in 2014–15. Sydney: National Health Performance Authority; Available from: http://www.myhealthycommunities.gov.au/our-reports.

Northern Territory Government. 2003. *Information Act*. (Available online at: http://notes.nt.gov.au/dcm/legislat/legislat.nsf/2afcb7bfe1e1348e6925705a001697fb/f8841e16139b1b3069257fb50081793e/$FILE/ATT139N2.pdf/Repi013.pdf).

NSW Aboriginal Affairs. 2015. *Aboriginal identification: the way forward. An Aboriginal peoples' perspective.* Sydney, Australia.

SA NT DataLink. 2016. *Supporting health, social and economic research, education and policy in South Australia and the Northern Territory. SA NT DataLink home page.* (Available online at: https://www.santdatalink.org.au/home).

Silburn S, Brinkman S, Fergusson-Hill S, Styles I, Walker R and Shepherd C**.** 2009 *The Australian Early Development Index (AEDI) Indigenous Adaptation Study*. AEDI National Program Support Centre, Centre for Community Child Health and Telethon Institute for Child Health Research (available online at https://www.aedc.gov.au/researchers/aedc-research/publications/publication/aedi-indigenous-adaptation-study-report).

Taylor LK, Bentley J, Hun J, Madden R, McKeown S, Brandt P and Baker D. 2012. Enhanced reporting of deaths among Aboriginal and Torres Strait Islander peoples using linked administrative health datasets. *BMC Medical Research Methodolo*gy, 12(1), 91-99. doi:10.1186/1471-2288-12-91 PMID:22747900.

Thompson S, Woods JA and Katzenellenbogen JM. 2012. The quality of Indigenous identification in administrative health data in Australia: insights from studies using data linkage. *BMC Medical Informatics and Decision Making, 12*(133).

Walter M. 2016. 'Data Politics and Indigenous representation in Australian statistics' pp 79-98 in T. Kukutai and J. Taylor (eds) Indigenous Data Sovereignty: Towards an Agenda. CAEPR Research Monograph, 2016/34. ANU Press. Canberra.

Walter, M., Lovett, R. Priest, N and Thurber, K. 2016. 'Good Methodology in analysis of data on Indigenous health and wellbeing' Paper presented at The Lowitja Institute International Indigenous Health and Wellbeing Conference, Identity | Knowledge | Strength, 8, 9 & 10 November 2016, Melbourne.

2.14 Appendices

This technical appendix provides background information and further detail regarding the methodological issues involved in establishing an 'algorithmic' approach for selecting the 'optimum' Aboriginal identifier to use in analyses involving data linked from two or more of the NT administrative datasets.

2.14.1 Identifying Aboriginal status

The first step in the process of identifying the study children's Aboriginal status was based on the understanding that the NT Department of Health's Perinatal dataset had high quality person identifiers achieved through the continuous improvement and updating of the NT Client Master Index (CMI).

However, the Perinatal dataset presented two special challenges. Firstly, the Aboriginal status of the baby was only recorded from 2000 onward. From then until 2007 there was a high rate of 'missing' Aboriginal status (20%), but from 2008 to 2013 its recording was almost complete with just 0.5% 'missing'.

In dealing with this type of inconsistency some authors have suggested using the mother's 'status' as a proxy for the child's (Kennedy et al. 2009). While the mother's Aboriginal status is well recorded in the NT Health data, it is not the only determinant of the child's Aboriginal status.

In considering how to resolve this we examined the effect of three options for creating a derived variable for the child's Aboriginal status:

a) using the mother's recorded Aboriginal status as a proxy for the child's; b) using an 'or' rule i.e. deeming the child to be 'Aboriginal' if either the mother or baby's status was recorded as Aboriginal; c) and using just the baby's recorded Aboriginal status. The findings from this investigation are summarised in Table 2.A.1 (below) where it can be seen that if an 'or' rule was applied this would result in the percentage of children 'identified' as Aboriginal increasing from 29.0% to 39.6%.

The completeness and consistency of the record of Aboriginal status was then examined in the other Health and non-Health datasets used in this study. This is summarised in Tables 2.A.2 and 2.A.3 below.

2.14.2 Consistency of Aboriginal status recording

This was examined by firstly establishing counts for a) each individual's dataset sources of non-missing Aboriginal status; b) and the number of these datasets which were consistent in identifying the individual as Aboriginal. Table 2.A.4 (below) tabulates these 'Source counts' and their associated 'Aboriginal status counts'.

Table 2.A.1 Perinatal data: Mothers' and babies' recorded Aboriginal status

	Mother or baby Aboriginal		Mother Aboriginal		Baby Aboriginal	
	Count	%	Count	%	Count	%
Non-Aboriginal	44,953	60.4	47,016	63.1	25,706	35.0
Aboriginal	29,490	39.6	27,425	36.8	21,622	29.0
Missing	23	0.03	25	0.03	27,138	36.0
Total	**74,466**	**100**	**74,466**	**100**	**74,466**	**100**

Table 2.A.2 Health datasets: Aboriginal status recorded

	Hospitalisation		Immunisation		Perinatal Mother	
	Count	%	Count	%	Count	%
Non-Aboriginal	23,096	48.74	40,370	74.01	47,016	63.14
Aboriginal	24,229	51.13	14,179	25.99	27,425	36.83
Missing	64	0.14	0	0	25	0.03
Total	**47,389**	**100**	**54,549**	**100**	**74,466**	**100**

Table 2.A.3 Non-health datasets: Aboriginal status recorded [1,2]

	AEDC		Student Info		Child Protection		NAPLAN	
	Count	%	Count	%	Count	%	Count	%
Non-Aboriginal	3,981	56.3	38,376	59.1	7,786	32.2	18,309	55.1
Aboriginal	3,092	43.7	25,169	38.8	15,939	66.0	14,909	44.9
Missing	0	0	1,390	2.1	0	0		
Total	**7,073**	**100**	**64,935**	**100**	**23,725**	**100**	**33,218**	**100**

1. The hospitalisation data contained 246 individuals with inconsistent Aboriginal status and 64 with no Aboriginal status recorded.
2. The immunisation data has a total of 10,731 records (concerning 1,476 children) with missing Aboriginal status. There were 9 children with conflicting Aboriginal status.
3. There were 24,154 child protection records on a total of 23,725 individuals. Duplicate linkage keys were noted for 123 individuals and 12 of these had an inconsistent record of Aboriginal status so the oldest duplicates were removed.
4. NAPLAN data are recorded annually for students in Years 3, 5, 7 and 9. There were records for 33,218 individuals; 154 had inconsistent recordings of Aboriginal status so the most recent Aboriginal status value was accepted.

Table 2.A.4 'Source' and 'Aboriginal' counts

Source Count (no. of datasets)	Aboriginal count	%	Cumulative %
0	784	0.65	0.65
1	35,767	29.67	30.32
2	31,798	26.38	56.7
3	22,377	18.56	75.27
4	15,697	13.02	88.29
5	10,493	8.7	96.99
6	3,321	2.76	99.75
7	304	0.25	100

For perfectly consistent data, the 'Aboriginal Count' would be either 0 or equal to the 'Source Count' depending on the individual's actual Aboriginal status. In Table 2.A.5 (below) the column on the far right shows the percentage of children with inconsistent Aboriginal status associated with the number of datasets sourced. For example, if four datasets were sourced to meet the 'ever Aboriginal' rule this this would result in a level of inconsistency of 1.34% + 1.54% + 2.70% = 5.58%.

2.14.3 Ranking the quality of the Aboriginal status variables

We generated a new Aboriginal status variable, 'Main Aboriginal Status' based on a quality ranking of the study datasets. Each individual was assigned the status recorded in the dataset having the highest highest-ranked quality. Those whose status was still missing were assigned the value from the dataset with the 2nd ranked quality and so on.

For the reasons described earlier, the Department of Health datasets were considered the most reliable for assessing Aboriginal status. Health Department staff ranked the hospitalisation data as the most reliable followed by immunisation and then perinatal (mother) based on the order in which they were linked to the Client Master Index (CMI) and the degree of validation checking they were known to have had. The ranking of the non-health datasets was determined by their degree of correlation with the health data.

Table 2.A.5 Consistency and inconsistency of Aboriginal status by number of datasets sourced [1]

Source Count (No. of datasets)	Aboriginal Status (%)								% Inconsistcy by source count
	0	1	2	3	4	5	6	7	
0	100	0	0	0	0	0	0	0	-
1	80.45	19.55	0	0	0	0	0	0	-
2	74.29	**2.14**	23.56	0	0	0	0	0	**2.14**
3	62.57	**1.44**	**2.34**	33.65	0	0	0	0	**3.79**
4	46.71	**1.34**	**1.54**	**2.70**	47.70	0	0	0	**5.58**
5	34.9	**0.83**	**1.5**	**0.71**	**2.61**	59.45	0	0	**5.65**
6	27.01	**0.72**	**1.42**	**0.93**	**0.87**	**3.7**	65.34	0	**7.65**
7	25	**0.99**	**0.33**	**0.33**	**0.99**	**1.32**	**1.97**	69.08	**5.93**
Total	**65.66**	**6.9**	**7.02**	**6.69**	**6.47**	**5.28**	**1.81**	**0.17**	-

1. *Cell values highlighted in red indicate percentage inconsistent*

Table 2.A.6 Correlation of Aboriginal status between data sources

Dataset	Perinatal Baby	Perinatal Mother	Ever	Immun'n	Hosp'n	AEDC	NAPLAN	Student Info	Child Protect'n
Perinatal Baby	1								
Perinatal Mother	0.9063	1							
Ever	0.992	0.9429	1						
Immunisation	0.9657	0.8512	0.9264	1					
Hospitalisation	0.9813	0.8911	0.9463	0.988	1				
AEDC	*0.9253*	*0.8747*	*0.9303*	*0.9443*	*0.9478*	*1*			
NAPLAN	0.9301	0.8418	0.8911	0.9285	0.9439	0.9673	1		
Student Info	0.9317	0.8507	0.8943	0.9306	0.9416	0.9715	0.9885	1	
Child Protection	0.9666	0.8293	0.9135	0.9975	0.9812	0.9379	0.9254	0.9231	1

While tetrachoric correlations are preferred for dichotomous data, the STATA outputs had some stability issues due to the high pairwise correlations of the variables. For this reason Pearson's correlations were used instead and yielded similar results. This showed that that the highest-ranked non-health data source was Child Protection, followed by NAPLAN, Student Information and the AEDC.

2.14.4 Sensitivity analysis

The consequence of the different ways of defining Aboriginal status was then investigated by comparing what effect they would have if used in calculating one of the study's key outcomes of interest: school attendance rates. In Table 2.A.7 below, it can be seen that the calculated rate of attendance is lowest using the 'Always Aboriginal' derivation and highest using the 'Ever Aboriginal' derivation, and the difference would be negative for the 'Always Aboriginal' cohort. This suggests that more inclusively defined measures of Aboriginal status tend to 'narrow the gap' when reporting outcomes of Aboriginal and non-Aboriginal children. Importantly, this table also shows that the quality of all Aboriginal status variables has been improving over time. This is most clearly seen in the narrowing 'spread' of variances for the 'Ever Aboriginal' and 'Always Aboriginal' derivations.

Table 2.A.7 Attendance variances associated with alternate Aboriginal status derivations

Child's age (years)	Aboriginal status derivation	Year of Birth 1994	1997	2000	2003
7	Dept. of Ed Aboriginal			1.1	0.8
	Ever Aboriginal			1.4	1.3
	Mostly Aboriginal			0.7	0.5
	Always Aboriginal			–0.3	–0.6
9	Dept. of Ed Aboriginal		1.4	1	0.8
	Ever Aboriginal		2	1.1	1.2
	Mostly Aboriginal		1.2	0.7	0.5
	Always Aboriginal		–1	–0.3	–0.5
11	Dept. of Ed Aboriginal	1.4	1.2	1	0.6
	Ever Aboriginal	1.6	1.8	1.3	0.9
	Mostly Aboriginal	1.3	1	0.7	0.3
	Always Aboriginal	–1.3	–1	–0.3	–0.5
13	Dept. of Ed Aboriginal	1	2	0.9	
	Ever Aboriginal	1.3	1.7	1.2	
	Mostly Aboriginal	1	0.9	0.6	
	Always Aboriginal	–2	–1.1	–0.3	
15	Dept. of Ed Aboriginal	0.9	2.4		
	Ever Aboriginal	1.4	2.9		
	Mostly Aboriginal	0.8	1.8		
	Always Aboriginal	–1.5	–1.6		

3. Early life health and development

Jiunn-Yih Su, Sven Silburn, Stefanie Schurer, Steven Guthridge, Vincent He, John McKenzie

Chapter overview

This chapter reports time trends for indicators of the early health and developmental status of children born in the Northern Territory (NT) over the period 1994–2013. These indicators were selected on the basis of the literature regarding their known association with longer-term life outcomes including children's readiness for school learning. Understanding the pattern of trends for these early life factors is important for identifying emerging service needs, and to inform the prioritisation and targeting of policy and services to improve outcomes for children.

The analyses are conducted separately for Aboriginal and non-Aboriginal children and by three levels of geographic remoteness; namely, outer regional, remote and very remote areas (Pink 2013). An analysis of the administrative data for each of these population segments enables a more contextualised understanding of their differing service needs. This is also helpful in monitoring progress of policy initiatives such as recent National Partnership Agreements to improve Indigenous child development and education outcomes under the 'Closing the Gap' strategy (Gardiner-Garden 2017).

Stratifying the trend analyses by levels of geographic remoteness is important given the unique geographic distribution of the NT population, with up to 70% of people residing in two larger urban areas (Darwin and Alice Springs) and the remaining 30% living in smaller communities dispersed across the vast area of the Territory. While higher levels of remoteness are associated with lower levels of accessibility to essential facilities, it is also the case that other local socioeconomic factors play a major role in children's health and developmental outcomes.

The trend analyses reported in this chapter have also assisted in generating hypotheses about which indicator variables appear most relevant to include in the multivariate analyses reported in later chapters of this publication.

3.1 Describing time trends

Describing trends in population data is a means of establishing a dynamic and ecological view of a population's health and wellbeing status. This is typically used in population-based research for purposes such as:

1. Identifying whether and how health and developmental outcomes have increased or decreased over time.
2. Comparing the evolution of outcomes in one time period with outcomes in another time period e.g. comparing rates of children's participation in preschool before and after the introduction of policies for universal access to preschool.
3. Comparing one population to another e.g. Aboriginal children living in urban areas and Aboriginal children living in very remote communities.
4. Making future projections e.g. to aid the planning of preventive health interventions and other services by estimating likely resource requirements.

3.2 Perinatal health indicators

Sentinel health data relevant to maternal health during pregnancy and children's birth outcomes is routinely recorded through NT Midwives Collection (Case, Dempsey and Zhang 2015). This is the NT component of ongoing and comprehensive collections of data by birth attendants across Australia. The collections are used for population-level monitoring of pregnancy characteristics and outcomes including perinatal morbidity and mortality. The perinatal health indicators, described in this chapter, were selected on the basis of their established relevance to children's development and education outcomes (Guthridge et al. 2015 2016). Reporting of the time trends in these indicators was grouped in two categories: maternal health and perinatal health.

3.2.1 Analysis methods

A retrospective analysis was conducted of the de-identified health and clinical data of mothers and babies for births that took place in the NT during the 20-year period between 1994 and 2013. Each record represents a single childbirth event where the baby was at least 20 weeks gestation or had a birthweight of at least 400 grams and was either live born or stillborn.

The Aboriginal status variable used in these analyses was derived from the algorithm described in Chapter 2. Records for which Aboriginal status was missing (n=4) or the value in the variable of residential district was either interstate/immigrant (n=1,725) or not stated at all (n=33) were excluded from the analysis.

The level of remoteness variable is derived from data on the Accessibility/Remoteness Index of Australia (ARIA+) retrieved from the Australian Bureau of Statistics (ABS). As described in Chapter 2, this variable defines five remoteness area (RA) categories: major cities, inner regional, outer regional, remote, and very remote. In the NT, only three of these remoteness levels are distinguished: outer regional, remote, and very remote. The estimated resident population data, released by the Health Gains Planning branch of the NT Department of Health in 2015, were used to calculate population rates. These were calculated based on census data from the ABS.

Long-term trends in the rates of selected perinatal health indicators for mothers and babies were analysed using the publicly available Joinpoint Regression Program, version 4.3.1.0 (Division of Cancer Control & Population Sciences 2017). This program identifies the significance of changes in the trend of each measured outcome, calculated for a two-tailed p value < 0.05. It also reports the annual percentage change (APC) in a given time period and the average annual percentage increasing or decreasing change (AAPC) over the entire study period and their confidence intervals (95% CI).

3.3 Maternal health

3.3.1 Live births

Between 1994–2013, a total of 71,990 live births were recorded for 44,784 mothers in the NT. Almost four in ten births (39.1%) were of Aboriginal children, and 31.0% of the mothers identified as Aboriginal. A description of the annual number of live births by Aboriginal status over this period is shown in Figure 3.1 (below) and Table 3.A.1 in the Appendix.

The proportions of non-Aboriginal and Aboriginal live births followed significant trends in opposite directions in the two consecutive time periods: 1994–2003 (period 1), and 2003–2013 (period 2). In period 1, the total number of non-Aboriginal live births trended downward with an APC of –1.6% (95%CI: –2.2~–1.1%, P_{trend} <0.0005) while the total number of Aboriginal live births trended upward with an APC of 2.7% (95%CI: 1.8~3.5%, P_{trend} <0.0005). In period 2, the total number of non-Aboriginal live births followed a significant upward trend with an APC of 1.1% (95%CI: 0.7~1.6%, P_{trend}<0.0005) while the total number of Aboriginal live births decreased significantly with an APC of –1.7% (95%CI: –2.4~–1.0%, P_{trend} =0.0001).

Figure 3.1 Annual number of live births by Aboriginal status, NT, 1994–2013

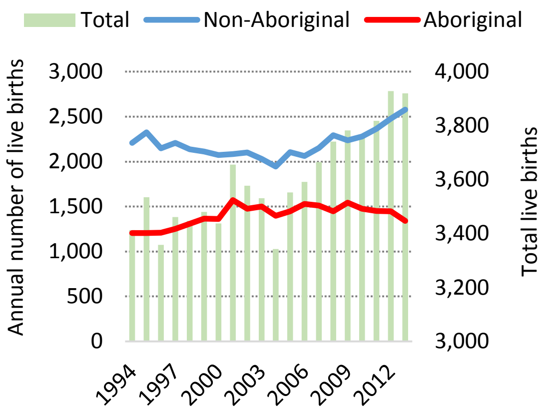
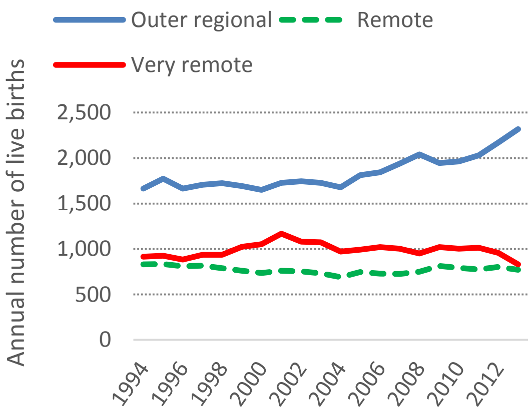


Figure 3.2 Annual number of live births by level of remoteness, NT, 1994–2013



Over these two decades, the total number of NT live births increased by around 50 additional births each year. Of note is the substantial increase in the annual number of live births in the non-Aboriginal population which increased by almost 32% between 2004 and 2013 (1,953 to 2,174).

Figure 3.2 (above) describes the NT live birth trends according to the levels of remoteness of the mother's usual residence. This shows that the annual number of live births in outer regional areas (Darwin and surrounds) remained constant between 1994 and 2004. However, from 2004, a sharp increasing trend was evident (APC = 2.9%: 95% CI = 2.1%–3.7%; P_{trend}=0.025). The high concentration of the non-Aboriginal population in the outer regional areas is consistent with the overall increase in non-Aboriginal births over this period.

For remote NT areas, the live birth rate remained essentially constant over the two decades, ranging between 700–800 per annum. However, for very remote areas the annual number of live births peaked in 2001 and then followed a significant decreasing trend (APC = –1.4%; 95%CI =–2.2%–0.5%; P_{trend}= 0.004). As almost all of these births were for Aboriginal mothers, this is also reflective of the overall declining trend in Aboriginal births over this period.

In summary, the recent live birth trends have important implications for estimating the NT's projected population growth and its longer-term sustainability. Establishing the reasons for the recent decline in Aboriginal live births warrants further detailed investigation.

3.3.2 Fertility rates

Understanding the nature of population growth associated with fertility requires investigation of changes in total fertility rates (TFR) and age-specific fertility rates (OECD 2017). The TFR represents the number of children a woman would bear during her lifetime if she experienced current age-specific fertility rates at each age of her reproductive life (OECD 2017). For a population to remain at its current level, the required TFR is 2.1. In other words, every woman would need to give birth to an average of 2.1 children during their reproductive years (Nargund 2009).

We calculated the age-specific fertility rates for five separate age groups (15 to 49 years) and the TFR by Aboriginal status for the most recent 13 years of the study. The TFR for non-Aboriginal women followed an increasing trend (AAPC =

0.64%; 95%CI = 0.24%–1.04%; P_{trend}=0.004). In contrast, the TFR for Aboriginal women followed a decreasing trend (AAPC = –1.15% per year (95%CI: –1.73% to –0.56%, P_{trend}=0.001). Also of particular note, was that the TFR for Aboriginal women in 2013 was just 2.15. This is close to the replacement rate of 2.1 and was the lowest TFR on record.

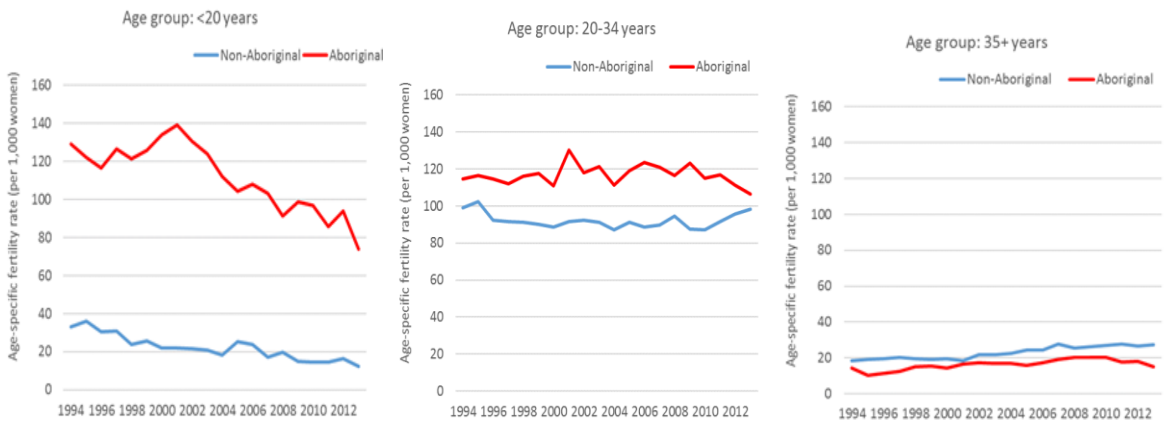
To further unpack the trends in total fertility rates and investigate the distribution of the recent changes across the age groups of the mothers, the age-specific fertility rates for the three aggregate age groups were examined. These included teenage mothers (less than 20 years), adult mothers (20–34 years), and older adult mothers (35 years and older). The fertility rates for teenage mothers were calculated using the NT female population for the 15–19 year age group. The rates for the older mothers were based on the NT female population for the 35–49 year age group.

As can be seen in Figure 3.3 (below), the fertility rates for women aged <20 years, and therefore teen pregnancy rates, for both Aboriginal and non-Aboriginal mothers decreased substantially over the full study period. A marked decreasing trend was observed for Aboriginal teenage mothers from 2001 to 2013 (AAPC=–4.0%; 95%CI = –5.0% to –3%; P_{trend}<0.0005). The age-specific TFR for these mothers almost halved over the same period, from 139.0 to 74.0 per 1,000 women. The TFRs of non-Aboriginal teenage mothers decreased by 62.7% over the 20-year period, from 33.0 to 12.3 per 1,000 women. (AAPC= –4.5%; 95%CI = –5.5 to –3.6%, P_{trend}<0.0005).

The TFRs for the 20–34 year age group remained relatively constant for both Aboriginal and non-Aboriginal women over the whole study period. However, for the most recent five years, Aboriginal TFRs decreased while non-Aboriginal TFRs increased.

Births to mothers aged 35 years and over represented 18.2% and 6.5% for non-Aboriginal and Aboriginal women, respectively. This age group was the only one in which the Aboriginal fertility rate was not higher than the non-Aboriginal rate.

Figure 3.3 Age-specific fertility rate (per 1,000 women) by Aboriginal status, NT, 1994–2013 [1]



[1] The small numbers of births born to mothers aged less than 15 years and mothers aged 50 years and over were included in the numerators in these rate calculations (into the 15-19 and 45-49 year age groups respectively), but the denominators only include population data for women aged between 15 and 49 years.

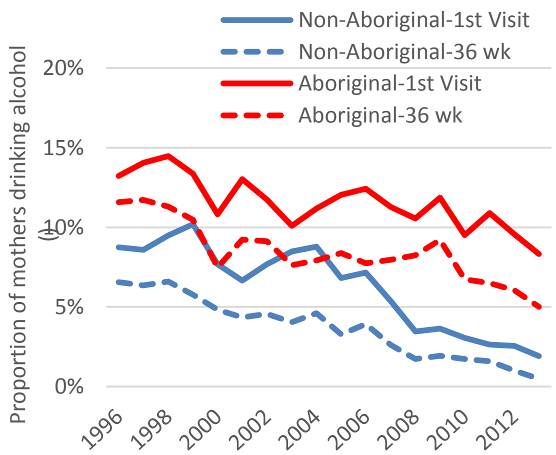
In summary, the decreasing fertility rates for both non-Aboriginal and Aboriginal teenage women represent an encouraging reduction for this high risk population. However, fertility rates for Aboriginal women aged 20–34 years have also decreased in recent years, and the overall decline in the number of Aboriginal live births warrants further investigation.

3.3.3 Alcohol consumption in pregnancy

There is overwhelming evidence from systematic reviews and meta-analyses, that alcohol consumption during pregnancy increases the risk of low birthweight (LBW) and preterm birth (Patra et al. 2011; Jaddoe et al. 2007; Mariscal et al. 2006).

The study population available for analysis of the NT trends in the reporting of alcohol consumption during pregnancy was restricted to just 69.8% of all recorded births. This was due to the large number of records with missing data on the two variables recording maternal alcohol use at the first antenatal visit and at 36 weeks gestation. The recording of these separate data items commenced in 1996.

Figure 3.4 Proportion of mothers who reported alcohol consumption at first antenatal visit and 36 weeks gestation by Aboriginal status, NT, 1996–2013



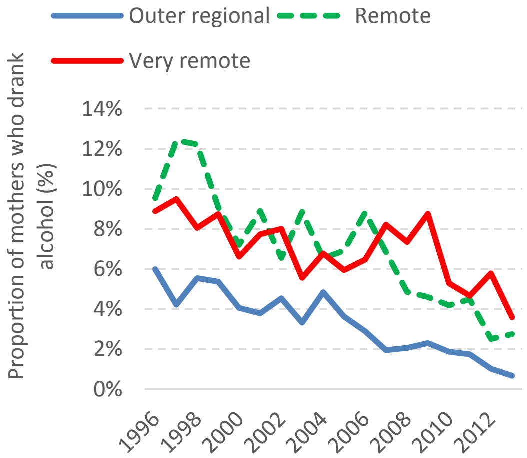
The proportion of missing data was greater for Aboriginal mothers (34.2%) than non-Aboriginal mothers (27.6%), especially in the earlier years of data collection and in 'very remote' areas. The analysis findings which follow should thus be interpreted with caution.

At their first antenatal visit, 8.0% (95% CI: 7.8–8.2%) of all NT women reported drinking alcohol during pregnancy. The proportion of all mothers who reported drinking alcohol at 36 weeks gestation was significantly lower at 5.2% (95% CI: 5.0–5.4%).

Around 11.5% (95% CI: 11.0%–11.9%) of Aboriginal mothers reported at their first antenatal visit that they drank alcohol and 8.3% (95% CI: 7.9%–8.7%) at 36 weeks gestation. This compared with 6.0% (95% CI: 5.7–6.2%) of non-Aboriginal mothers reporting at their first antenatal visit that they drank alcohol and 3.4% (95% CI: 3.2-3.6%) at 36 weeks gestation.

Figure 3.4 shows a significant decreasing trend in maternal alcohol consumption in pregnancy for both Aboriginal and non-Aboriginal populations between 1996 and 2013, at both the first antenatal visit and at 36 weeks gestation (full results are presented in

Figure 3.5 Proportion of mothers who drank alcohol during pregnancy by level of remoteness, NT, 1996–2013



Appendix Table 3.A.2). Importantly, the proportion of Aboriginal mothers reported to have been drinking alcohol at 36 weeks gestation decreased by 56.9% during this period (from 11.6% to 5.0%). Over the same period, the reported alcohol consumption among non-Aboriginal mothers decreased by 92.4% (from 6.6% to 0.5%).

Comparable reductions in the trends of maternal alcohol use in pregnancy were evident when analysed by level of remoteness. In Figure 3.5 it can be seen that the proportion of mothers reported to have consumed alcohol at week 36 decreased consistently across all levels of remoteness. The pace of this decrease was highest in the outer regional areas and lowest in the very remote areas (AAPC=-8.1% and -2.8% respectively). By 2013, the proportion of mothers from outer regional areas who drank alcohol during pregnancy had dropped to a low level of 0.7%, compared with 2.7% and 3.6% for remote and very remote categories, respectively.

In summary, there have been encouraging decreasing trends in the proportion of both Aboriginal and non-Aboriginal mothers, across all levels of remoteness, who reported consuming alcohol during pregnancy. However, the extent of the continuing differences between populations indicates the need for continuing public health effort to reduce alcohol consumption among pregnant women - especially in very remote areas.

3.3.4 Smoking in pregnancy

There is substantial literature confirming that smoking during pregnancy increases risks of perinatal mortality, low birth weight and other adverse pregnancy outcomes (Hodyl et al. 2014; MacArthur and Knox 1988; Butler, Goldstein, and Ross 1972). There is also evidence that cessation of smoking at earlier stages of pregnancy reduces the risk of LBW and perinatal mortality. Trend data on the proportion of pregnant women who smoke and the proportion who ceased smoking during pregnancy assists monitoring progress of public health efforts to reduce smoking related harm (Rogers 2009; AIHW 2009; Chan and Sullivan 2008).

In the NT Midwives Collection, data on smoking status during pregnancy was recorded as two separate variables at the first antenatal visit and again at 36 weeks gestation.[2] Due to changes in 2010 for the data definitions of early- and late-stage smoking, the following trend analysis was firstly confined to the relevant variables for the period of 1996–2009. We also separately report summary statistics on the data on the new variables for the three-year period from 2011–2013.

Analysis of the 1996–2009 maternal smoking trends also excluded 29% of birth records with missing data on either of these two smoking variables. A higher proportion of Aboriginal birth records had missing maternal smoking data (27.9%) than for non-Aboriginal births (19.5%). In contrast, for the period 2011–2013 the analysis required the exclusion of just 10.6% of Aboriginal birth records, due to missing data for either of the smoking variables. Also, technical problems with the 1998 data meant that the maternal smoking rates for that year could not be shown in Figure 3.6 (below).

[2] The method for collecting data on smoking during pregnancy was revised from July 2010 and the two previously used variables were replaced with two new ones. Smoking at first visit was replaced with smoking before 20 weeks gestation and smoking at 36 weeks was replaced with smoking after 20 weeks gestation. The discontinuity in the trends in both pairs of variables made combining the two pairs of variables of early and late stage smoking inappropriate.

Figure 3.6 Proportion of mothers who reported smoking at first antenatal visit and 36 weeks gestation by Aboriginal status, NT, 1996–2013

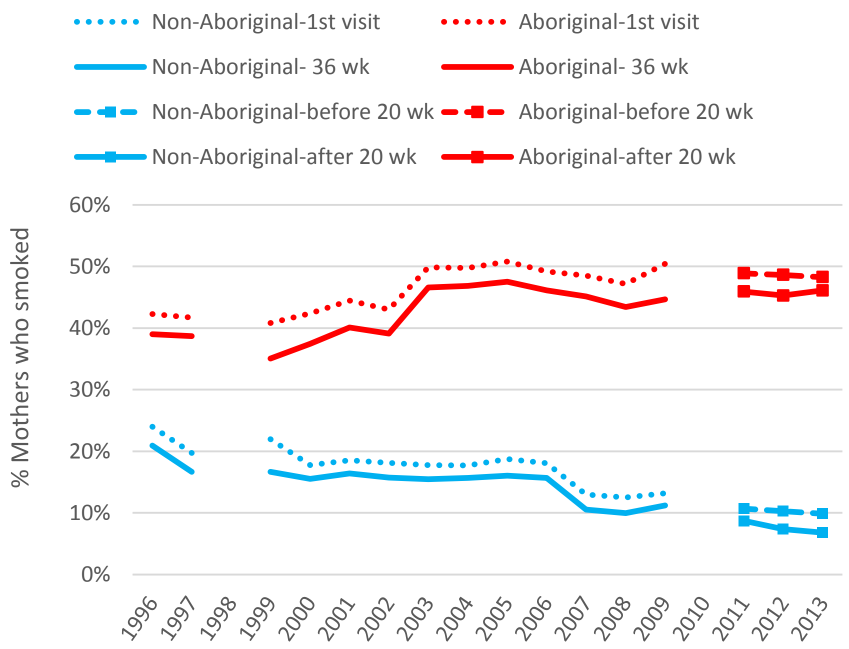
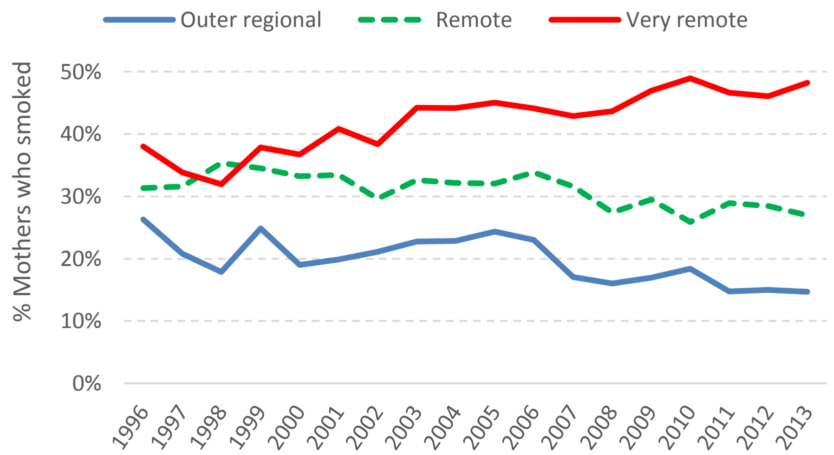


Figure 3.7 Proportion of mothers who smoked during pregnancy by level of remoteness, NT, 1996–2013



This also meant that the trend analysis needed to be limited to births from 1999 to 2009. During this period, the proportions of mothers who smoked at the two different stages of pregnancy generally followed the same pattern. The trend analysis was therefore confined to using the variable for smoking at 36 weeks gestation.

The proportion of non-Aboriginal records with missing data in any of the variables recording smoking status were excluded from the analysis.

The mothers who reported they smoked at 36 weeks gestation remained around 16% between 1999 and 2006 and then dropped to about 10.5% during 2007–2009. Among Aboriginal mothers, this proportion increased from 35.0% in 1999 to 44.6% in 2009. The overall trend (1999–2009) for Aboriginal mothers was significant (AAPC= 2.3%: 95%CI = 0.7 to 4.0%, P_{trend}=0.0056).

Rates of maternal smoking during pregnancy (i.e. at any stage of the pregnancy) were also analysed by level of remoteness. In Figure 3.7 (above), a comparable divergence in the trends is evident for outer regional areas and very remote areas. The average annual rate difference between outer regional and very remote categories was 22.4%. This followed a consistently increasing trend over this period (AAPC=6.1%; 95%CI = 5.2 to 7.0%, P_{trend}<0.0005).

In summary, while there are some encouraging signs of a decline in non-Aboriginal mothers smoking during pregnancy and a moderation of trends of Aboriginal mothers reporting smoking during pregnancy – the need for further public health interventions to reduce this health risk behaviour remains urgent – especially given that NT smoking rates remain among the highest in Australia.

3.3.5 Antenatal care

Antenatal care is crucial to the health of women and their unborn babies as it provides opportunities for maternal education, preventive screening, and treatment to improve pregnancy outcomes (Carroli, Rooney, and Villar 2001; Carroli et al. 2001). There is general agreement, internationally, on the need for at least seven antenatal visits. This is reflected in the guidelines of the Minymaku Kutju Tjukurpa Women's Business Manual which recommends a minimum of seven to ten antenatal visits for women in remote NT settings. The manual also recommends the first visit be made prior to ten weeks of pregnancy, followed by monthly visits until 28 weeks, fortnightly visits until 36 weeks, and weekly visits until birth (Congress Alukura 2014). In this section, we examine two key indicators of antenatal care (Rumbold et al. 2011), including a) The proportion of mothers who presented for their first antenatal visit in the first trimester (<13 weeks gestation); b) and the proportion of mothers who had seven or more antenatal visits during their pregnancy.

As data on the gestational age at the first antenatal visit was missing for 19–30% of records for the years 1994–1999 and 8% or less for the years 2000–2013, the analysis was limited to antenatal visits in the period from 2000–2013. In Figure 3.8 (below) it can be seen that between 2000 and 2013, the proportion of mothers presenting for their first antenatal visit in the first trimester increased by 36.2% in non-Aboriginal mothers and by 56% in Aboriginal mothers.

Figure 3.8 Proportion of mothers presenting for their first antenatal visit in the first trimester by Aboriginal status, NT, 2000–2013

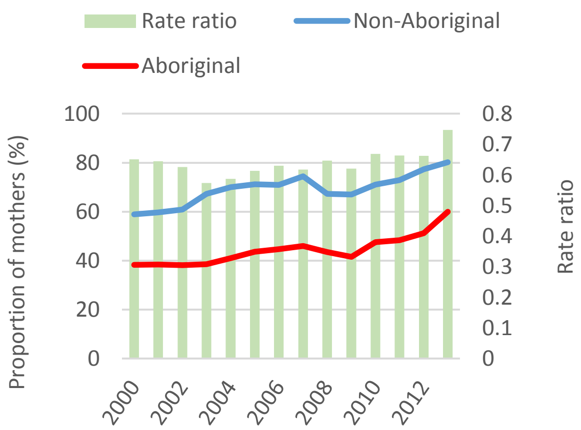
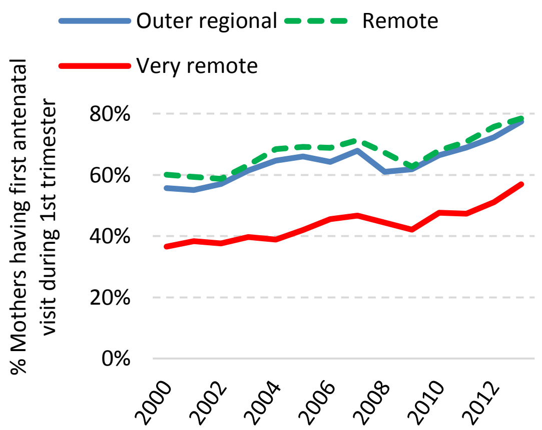


Figure 3.9 Proportion of mothers presenting for their first antenatal visit in the first trimester by level of remoteness, NT, 2000–2013

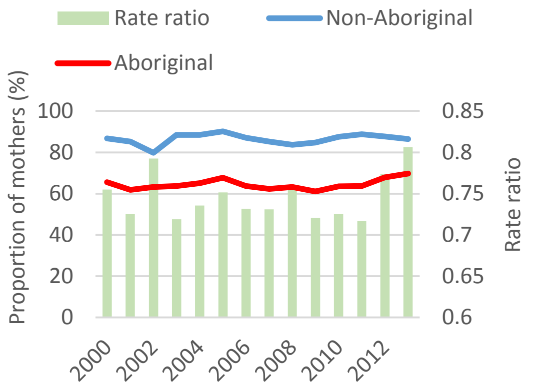


A significant upward trend was observed over the 14 years for both non-Aboriginal (AAPC=2.5%, 95%CI: 1.0 to 4.0%, P_{trend}=0.0009) and Aboriginal mothers (AAPC=3.5%; 95%CI = 1.6 to 5.4%, P_{trend}=0.0003). Trends in the first antenatal care visit in the first trimester of pregnancy by level of remoteness are shown in Figure 3.9 (above). It shows that there were increasing trends for both outer regional and remote areas throughout the 14-year period (P_{trend}=0.005 and 0.028 respectively).

While the proportion of mothers in very remote regions who accessed antenatal care in the first trimester also showed an increasing trend (P_{trend}<0.0005), they remained around 20 percentage points lower than those in outer regional areas throughout this period. It remains of concern that by 2013, more than 40% of pregnant women in very remote areas had not accessed an antenatal visit in the first trimester.

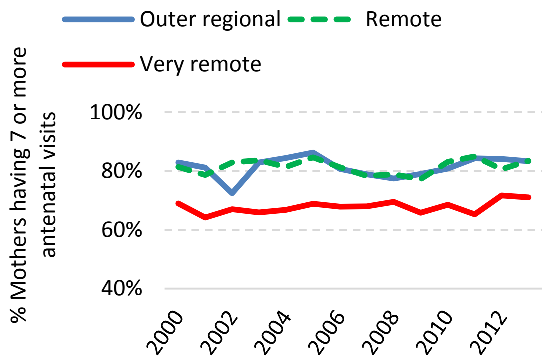
Trend analysis of mothers attending seven or more antenatal visits was limited to the period 2000–2013 due to the level of missing data on this item prior to 2000. In Figures 3.10 and 3.11 (below) it can be seen that there was little change in the proportions of mothers attending seven or more antenatal visits for both Aboriginal and non-Aboriginal mothers.

Figure 3.10 Proportion of mothers having seven or more antenatal visits during their pregnancy by Aboriginal status, NT, 2000–2013



Also women receiving this level of antenatal health care remained at essentially similar levels across all three levels of remoteness.

Figure 3.11 Proportion of mothers having seven or more antenatal visits during their pregnancy by level of remoteness, NT, 2000–2013



3.4 Perinatal health

3.4.1 Preterm births

The prevention of preterm birth is generally considered a public health priority (Frey and Klebanoff 2016). Preterm birth is defined as the delivery of a baby before the 37th week of gestation is completed (Tucker and McGuire 2004). Complications of preterm birth are the second most common cause of death in children under five years old, and are responsible for an estimated 35% of the 3.1 million annual neonatal deaths globally (Liu et al. 2012; Berkowitz and Papiernik 1993). In addition to causing mortality, preterm birth can also have lifelong effects on neurodevelopment and increased risk of visual disorders; cerebral palsy, learning disorders as well as chronic disease in adulthood (Mwaniki et al. 2012).

For the analyses in this section only live singleton births or the first live born of multiple births were included, to enable the calculation of the proportion of live birth events being preterm. As data on gestational age at birth was missing in only <0.1% of non-Aboriginal births and 0.4% of Aboriginal births and these records were spread across eight years (i.e. not concentrated in one or a few years), they were excluded from the analyses.

The rate of preterm births in non-Aboriginal mothers had a mild but significant decreasing trend over the study period 1996–2013 (AAPC=-0.94%: 95%C= -1.59 to -0.28%, P_{trend}=0.0081), while those for Aboriginal mothers remained relatively unchanged. This meant that the difference between these two rates followed a significant increasing trend for both the Aboriginal-to-non-Aboriginal rate ratio (AAPC=1.30: 95%CI = 0.40% to 2.21%, P_{trend}=0.0075) and the rate difference (AAPC=1.66: 95%CI = 0.21% to 3.13%, P_{trend}=0.0276).

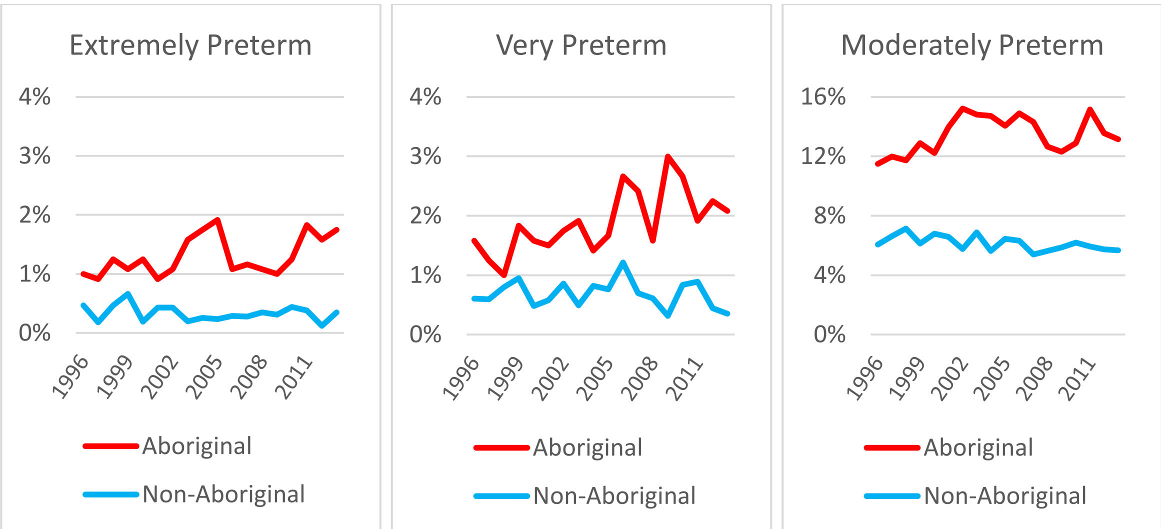
When the analysis was stratified by level of remoteness, this yielded similar results. Preterm birth rates for outer regional and remote areas were at similar levels, while the rates for very remote areas were consistently higher than those for outer regional areas by about 5–7 percentage points.

The gap between these two categories has significantly widened with time (P_{trend}=0.0007). This would appear to be attributable to the increasing trend in very remote areas (P_{trend}=0.020) and the decreasing trend in outer regional areas (P_{trend}=0.019).

In Figure 3.12 (below) it can be seen that a similar pattern of trends was evident when the analysis examined considered the proportion of births that were extremely preterm (<28 weeks), very preterm (29–31 weeks), and moderately preterm (32–37 weeks) gestation.

In summary, the continuing trend in preterm birth among Aboriginal women and in very remote areas remains a significant concern, given the long-term risk this can have for children's subsequent development and health outcomes. Further public health investment is clearly needed in culturally accessible maternal health programs and routine antenatal care, especially for the NT population groups in greatest need.

Figure 3.12 Preterm birth rate by subcategory and Aboriginal status, NT, 2000–2013



3.4.2 Birthweight

Low birthweight (LBW) is an important contributing factor for perinatal and infant mortality (Panaretto et al. 2006; Rush et al. 1976); and the development of chronic diseases in later life (Curhan, Chertow, et al. 1996; Curhan, Willett, et al. 1996; Tamakoshi et al. 2006).

Studies have associated LBW with increased risk for developmental and school learning difficulties (Fletcher 2011; Martorell et al. 2010; Pinto-Martin et al. 2004). Rates of LBW are widely used as an indicator of mothers' reproductive health and birth outcomes, as well as the effectiveness of public health interventions to improve them (Bird et al. 2016; Dolan-Mullen, Ramirez and Groff 1994; Kramer 1987).

In Australia, the ongoing monitoring of LBW has been made possible by all states and territories routinely collecting birthweight data, which is also collated for national reporting.

In this section we describe NT trends in the average birthweight and rates of LBW (as a proportion of all live births) by the child's Aboriginal status and by level of remoteness over the period 1994–2013. LBW is defined as a birthweight of less than 2,500 grams.

Over this 20-year period, the average birthweight for newborns of Aboriginal mothers was 242.4 grams lower than babies of their non-Aboriginal counterparts, and this difference was significant for both sexes. Figure 3.13 (below) shows the rate of LBW for Aboriginal and non-Aboriginal babies over the study period. (The data table associated with this figure is presented in Appendix Table 3.A.2). These data show no significant trends in the improvement of LBW rates for either Aboriginal or non-Aboriginal babies over this time. However, as can be seen below in Figures 3.13 and 3.14, there have been increasing trends in both the rate differences and rate ratios. Further detail of these changes is presented in Appendix Table 3.A.3. Also, when analysed by level of remoteness, only outer regional areas showed any reducing trend. This reduced from 9.4% in 1994 to 5.2% in 2013.

Figure 3.13 Annual rates of low birthweight of live born babies by Aboriginal status, NT, 1994–2013

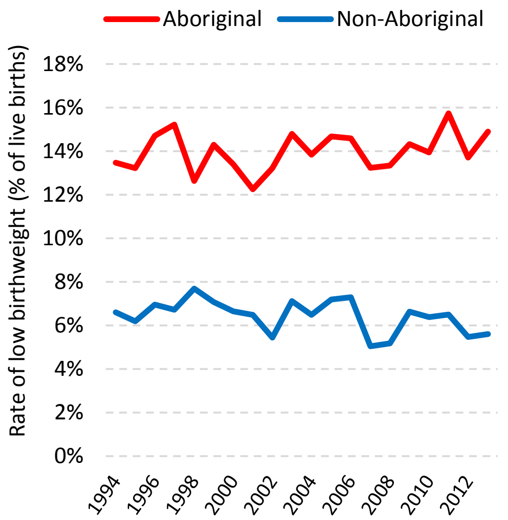
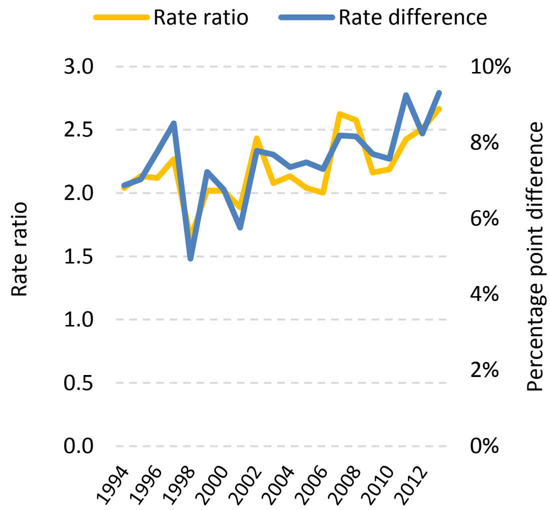


Figure 3.14 Annual rate differences and rate ratios of low birthweight by Aboriginal status, NT, 1994–2013



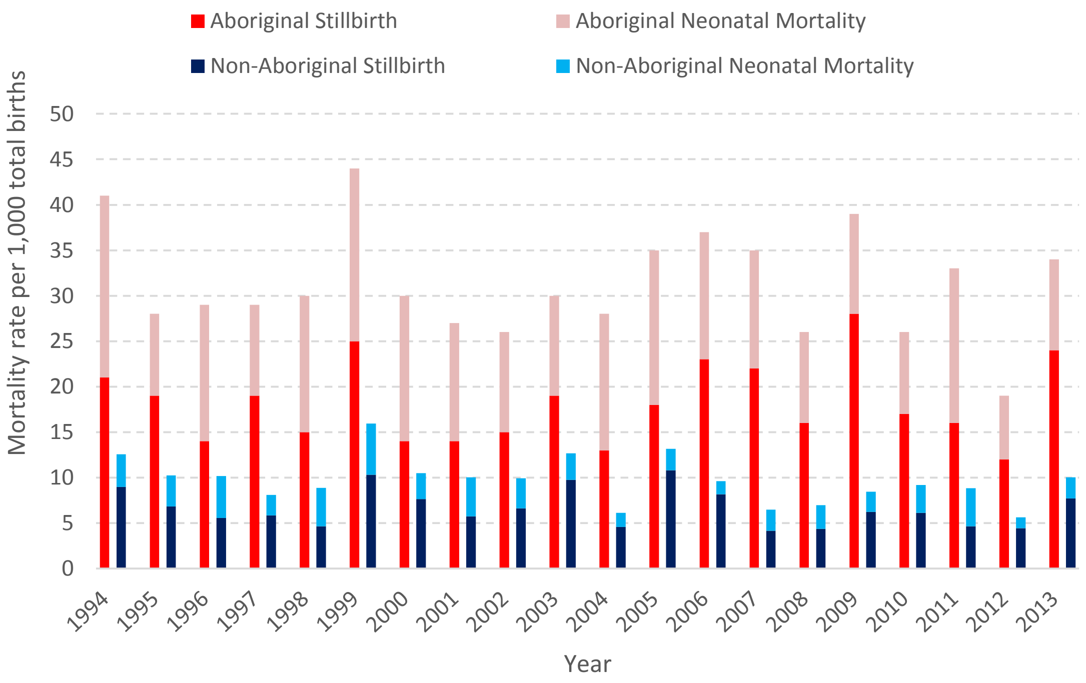
3.4.3 Perinatal mortality

The perinatal mortality rates are universally used as a key indicator of the general health status and the quality of care delivered to pregnant women and newborn babies. Perinatal deaths include stillbirths and neonatal deaths (death of live born babies within 28 days of birth). These deaths are commonly associated with poor maternal health and inadequate health care during pregnancy, labour and birth and the early postnatal period (World Health Organization 2006). Other contributing factors include income-poverty, poor maternal nutritional intake, early onset of childbearing, high numbers of closely spaced pregnancies, poor hygiene or difficulties caring for the newborn.

Figure 3.15 (below) and Table 3.A.1 in the Appendix presents perinatal mortality rates, including stillbirth and neonatal rates, and related trends by Aboriginal status. The rates for stillbirths, neonatal mortality, and perinatal mortality were calculated as numbers of deaths per 1,000 total births.

In both Aboriginal and non-Aboriginal populations, the perinatal mortality rates (represented by the heights of each individual combined bars in Figure 3.13) did not show any significant trend over the 20-year study period (P_{trend}=0.0585 and 0.0637, respectively). No significant trend was identified in the gap between the two rates either in terms of rate difference (P_{trend}=0.279) or rate ratio (P_{trend}=0.578). On average, the Aboriginal perinatal mortality rate was significantly higher than the non-Aboriginal rate by 12.5 per 1,000 births (95% CI: 11.9-13.1, p<0.0005). The difference occurred in both components of this rate: the stillbirth rate was also significantly higher in the Aboriginal population by 6.2 per 1,000 births (95%CI: 5.6-6.8, p<0.0005); and the neonatal mortality rates had an average difference of 6.3 per 1,000 births (95%CI: 5.7-6.9, p<0.0005).

Figure 3.15 Rates of stillbirth, neonatal mortality and perinatal mortality by Aboriginal status, NT, 1993–2014



3.5 Hospitalisation

Rates of hospitalisation of children are a useful indication of illness or injury not manageable at community-based primary health services. Hospitalisation statistics, such as the overall hospitalisation rate, the rate for conditions requiring intensive care and the average length of stay are commonly used as population-level indicators of the intensive health service needs of a population. These in turn may reflect the quality, effectiveness and availability of preventive public health programs and services (e.g. immunisation, nutrition and injury prevention) as well as primary care and regional differences in the social determinants of health.

In this section we report trends in three key hospitalisation statistics for the study children in their first five years of life: hospitalisations involving any lengths of stay in the Intensive Care Unit (ICU); hospitalisations due to injuries,[3] and hospitalisations due to acute lower respiratory tract infections (ALRI).[4]

3.5.1 Methods

The hospitalisation dataset for this project was retrieved from the 'NT Inpatient Activity' data collection, which records hospitalisation data from the five public hospitals in the NT.[5] These included a total of 73,206 hospitalisations recorded for 31,994 patients aged under five years between 2001 and 2013. Male patients (55.1%, 95%CI: 54.5~55.6%) accounted for a significantly higher proportion than female patients (44.9%, 95%CI: 44.4~45.5%).

To calculate rates by calendar year, the time range of the data analysed was from 1 January 2000 to 31 December 2013.

These de-identified hospitalisation data include information on the admissions diagnoses, coded using the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM). Hospitalisations unrelated to such conditions were excluded.[6] The population data used for the calculation of hospitalisation rates was the 2011 Census estimated resident population data for the 0–4 year age group in the NT (ABS 2012).

Two types of annual hospitalisation rates were calculated: the *all-episode* rate, which uses all hospitalisation episodes as the numerator, and; the *unique-person* rate, which uses the number of unique persons identified in the dataset. Only hospitalisations where the patient's age at the time of admission was under five years were included.

3.5.2 Overall hospitalisation rates and frequencies

As illustrated in Figure 3.16 (below), the hospitalisation rates of Aboriginal children aged under five years were 2.4–3.0 times higher than their non-Aboriginal counterparts and increased markedly between 2008 and 2013. However, the differences in unique-person hospitalisation rates were consistently smaller with the Aboriginal to non-Aboriginal ratio ranging between 1.4 and 1.8 in the years after 2002.

---

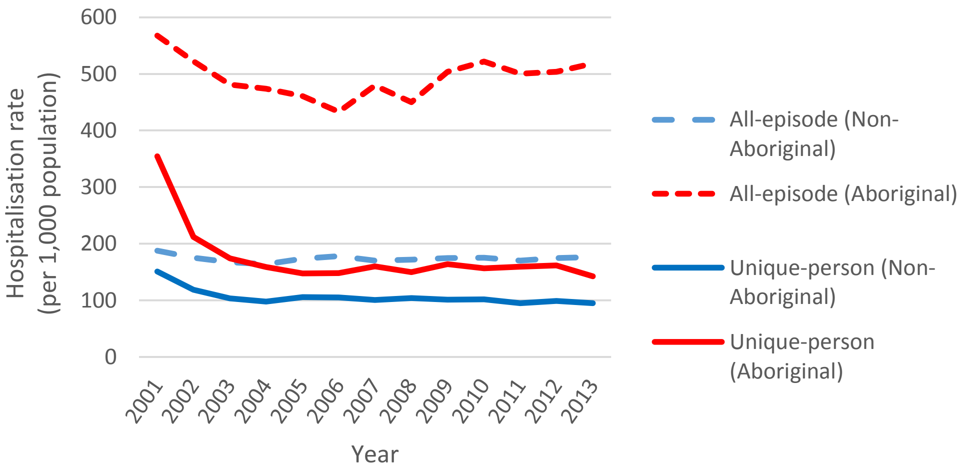
[3] Hospitalisations where the principal diagnosis was in the ICD-10-AM range S00–T75 or T79 from *Chapter XIX Injury, poisoning and certain other consequences of external causes.*

[4] ICD-10-AM range J10–J22 from *Chapter X: Diseases of the respiratory system.*

[5] Data from the Darwin Private Hospital, the only private hospital in the NT, was not included.

[6] The ICD-10-AM categories not representing illness or injuries were: Z38: Live born infants according to place of birth and type of delivery (i.e. normal birth hospital care), and; Z76: Persons encountering health services in other circumstances (e.g. child accompanying mother's hospitalisation)

Figure 3.16 All-episode and unique-person hospitalisation rates for the 0–4 year age group by Aboriginal status, NT, 2001–2013



Importantly, the hospitalisation rates show a significant decreasing trend during the 13-year period for both Aboriginal and non-Aboriginal children aged under five years (chi-square for trend, p<0.0005).

To investigate the reasons for the differences in all-episode and unique-person hospital separation rates, we calculated the number of hospitalisations per person for the individuals included in the numerators (i.e. including all hospitalisations for children when they were under five years of age). As can be seen in Figure 3.16 (and detailed in Appendix Table 3.A.4), 13.7% of non-Aboriginal children were hospitalised more than two times while in Aboriginal children the proportion was 2.8 times higher at 38.1%. In other words, Aboriginal children were almost three times as likely to be hospitalised three or more times during the first five years of their life than their non-Aboriginal counterparts (p<0.0005). The average number of hospitalisations was also significantly higher in Aboriginal children (2.81 vs 1.64, p<0.0005). The greater proportion of repeated admissions for Aboriginal children partly explains the differences in trends between populations.

Figure 3.17 Distribution of the number of admissions for children ever admitted before age 5 years, by Aboriginal status, NT, 2001–2013

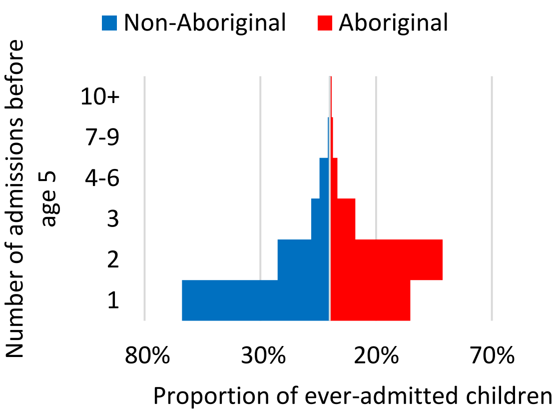
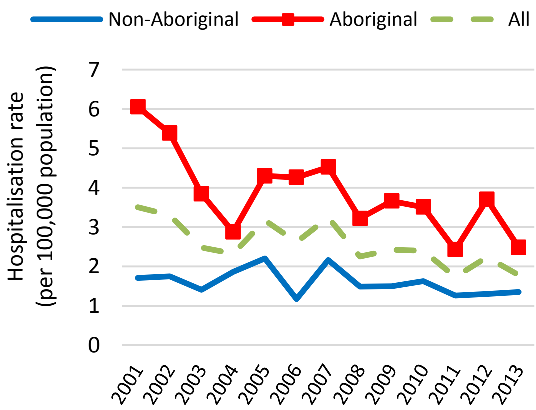


Figure 3.18 Rates of intensive care unit hospitalisation of children before age 5 years by Aboriginal status, NT, 2001–2013



3.5.3 Hospitalisation requiring care in the intensive care unit

The number and rate of hospitalisations involving a stay in the ICU among children aged under five years are presented in Figure 3.18 (above) and Table 3.A.5 in the Appendix. These hospitalisation rates showed a significant decreasing trend for Aboriginal children ($p<0.0005$). Over the same period a non-significant decrease was evident for non-Aboriginal children. The rate difference decreased from 4.4 to 1.1 per 1,000 children between 2001 and 2013, while the rate ratio decreased by 48.1% (from 3.5 in 2001 to 1.8 in 2013).

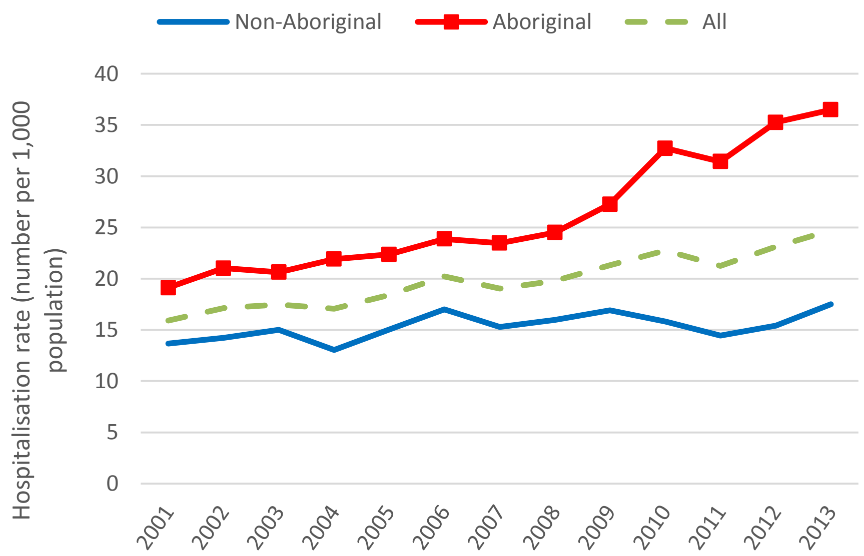
3.5.4 Hospitalisation rates and frequency of admissions due to injury

In Australia, Aboriginal children have been reported as more likely than non-Aboriginal children to be hospitalised for unintentional injury (Moller et al. 2015) and for all types of injuries (AIHW 2016). The number and rate of hospitalisations due to injuries among children aged under five years in the NT are summarised in Figure 3.23 and Table 3.A.6 in the Appendix. Both Aboriginal and non-Aboriginal rates showed an increasing trend over the 13-year period. The Aboriginal rate increased by 90.9% while the non-Aboriginal rate increased by 28.1%. During the same period, the rate difference increased 3.5-fold (from 5.4 to 19.0 per 1,000), while the rate ratio increased by nearly 50% (from 1.4 to 2.1).

3.5.5 Hospitalisations due to acute lower respiratory tract infections (ALRI)

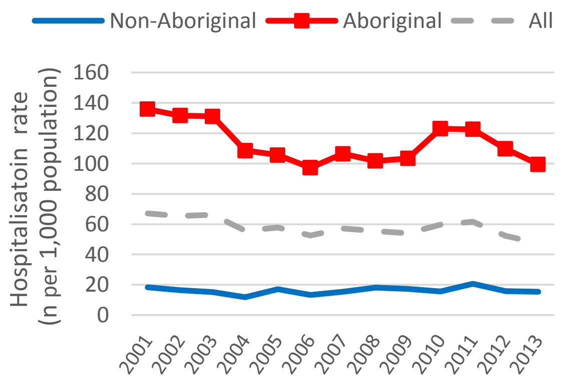
Previous studies show that ALRIs are a major cause of paediatric morbidity in Aboriginal children (Carville et al. 2007; Burgner and Richmond 2005; Janu et al. 2014; O'Grady et al. 2010); and the rates of severe pneumonia in hospitalised NT Aboriginal children are among the highest reported in the world (O'Grady, Torzillo, and Chang 2010). Our analysis shows that Aboriginal hospitalisation rates due to ALRI are substantially higher than the corresponding non-Aboriginal rates, although the difference is narrowing due to decreasing Aboriginal rates.

Figure 3.19 Rates of hospitalisation (per 1,000 population) due to injury for children aged 0–4 years by Aboriginal status, NT, 2001–2013



The numbers and rates of hospitalisations due to ALRIs among children aged under five years in the NT are summarised in Figure 3.20 (below) and Table 3.A.7 in the Appendix. While the non-Aboriginal rate fluctuated between 11 and 20 per 1,000 population, and showed no trend over the 13-year period, the Aboriginal rates showed an overall downward trend with a 26.7% decrease between 2001 and 2013. During the same period, the rate difference decreased by 28.4% (from 117.4 to 84.0 per 1,000), while the rate ratio decreased by 12.8% (from 7.4 to 6.4).

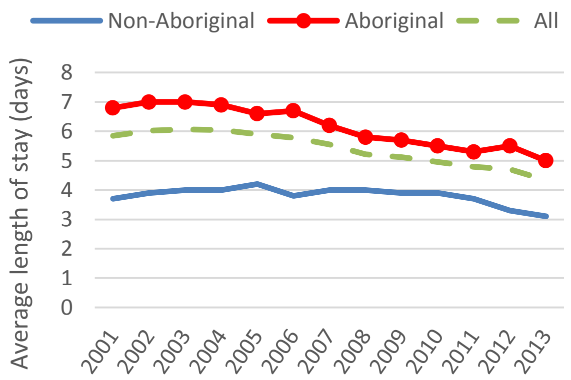
Figure 3.20 Rates of hospitalisation due to acute lower respiratory tract infections for children 0–4 years by Aboriginal status, NT, 2001–2013



3.5.6 Length of hospital stay

Data on the annual average length of stay (LOS) per hospitalisation episode is summarised in Figure 3.21 (below) and Table 3.A.8 in the Appendix. The average LOS trend decreased by 16.2% in non-Aboriginal children and by 26.5% in Aboriginal children. The gap between the two rates is also narrowing: the rate difference decreased by 38.7%, while the rate ratio declined by 12.2%.

Figure 3.21 Annual average length of stay per hospitalisation episode for children 0–4 years by Aboriginal status, NT, 2001–2013



3.6 Early childhood development

There is a growing body of evidence showing how children's development from birth to around age five is crucial in laying the foundations for longer-term health, learning and socio-emotional wellbeing (Center on the Developing Child at Harvard University 2010; Moore 2006). The rate of brain growth during this period is more rapid than at any other stage in life, and it is also a time of increased sensitivity to environmental circumstances. This makes it a time of potential vulnerability to adverse influences, but also a time of greater opportunity for positive development (D'Angiulli et al. 2009; Hillemeier et al. 2011; Odd et al. 2008; Quigley et al. 2012; Smithers et al. 2013; Stuart, Otterblad Olausson, and Kallen 2011).

Furthermore, early childhood developmental outcomes are recognised as important markers of the welfare of children, and can predict future health and human capital. It is within this context the Council of Australian Governments (COAG) recognised the need for all communities to have information about early childhood development and initiated the development of the Australian Early Development Census (AEDC) (Australian Government 2013, 2015).

The AEDC is designed to assess the developmental status of children early in their first year of full-time schooling, at around age five years. The AEDC involves a teacher rated assessment of children's competencies in five areas of development relevant to their transition into school learning. These include: a) physical health and wellbeing, b) social competence, c) emotional maturity, d) language and cognitive skills, and e) communication skills and general knowledge. Aggregate AEDC results can be used by communities, governments and policy makers to identify national, regional and community service needs, and to inform what resources and supports may be needed for children having the best possible start in school learning.

The AEDC questionnaire is completed by teachers using a secure web-based data entry system. The recommended administration procedure for Aboriginal and Torres Strait Islander students is that this should, wherever possible, be made jointly by the child's teacher in consultation with an Indigenous staff member as a cultural consultant.

The AEDC checklists item scores are combined to determine a child's domain score on each of the AEDC's five domain scales. Domain scores can range from zero to ten. For each AEDC domain, these scores are used to define the numbers and proportions of children considered:

- **a) developmentally on track** – children having a domain score which is in the top 75% of the national AEDC population;
- **b) developmentally at risk** – children having a domain score between 10 and 25 per cent of the national AEDC population, and;
- **c) developmentally vulnerable** – children who score below 10 per cent of the national AEDC population.

Children categorised as 'developmentally vulnerable' are considered highly likely to experience some difficulty in making the transition into the school system and typically require ongoing additional learning support to achieve good long-term outcomes. These children do not only require additional support in the classroom, their families may also require external support in caring for and nurturing their children to achieve good developmental and learning outcomes.

3.5.1 AEDC outcomes (2009 and 2012)

In this section we describe the childhood development outcomes of NT born children as recorded in the 2009 and 2012 AEDC data collections. The 2015 AEDC data collection was not available at the time of data linkage.

A total of 3,570 of the study cohort were assessed in 157 schools in the2009 AEDC data collection; and, in 3,457 students in 154 schools in the 2012 collection. Similar proportions of males and females were observed in both AEDC collections. A slightly higher proportion of Aboriginal students were included in the 2009 collection (45.5% vs 40.2%). The proportion of students in the most disadvantaged quintile of SEIFA[7] decreased from 42.7% to 29.8% between 2009 and 2012.

Other changes between these AEDC assessment years mostly concerned language-related items such as children having English as a second language (ESL) (43.1% vs 36.7%); speaking a language other than English at home changing from 42.4% to 37.7%; children identified by the school as having a language background other than English (LBOTE) (45.7% vs 40.1%).

Full details of the demographic characteristics of the children assessed on the AEDC in 2009 and 2012 are presented in Table 3.A.10 in the Appendix.

---

[77] SEIFA Index of Relative Socio-Economic Disadvantage. More information on this index is available at: http://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa

Table 3.1 AEDC outcomes by domain and developmental category, NT, 2009 and 2012

Domain	Year	Total	Developmentally on track		Developmentally at risk		Developmentally vulnerable	
			n	%	n	%	n	%
Physical health and wellbeing	2012	3,137	2,253	71.8	413	13.2	471	15.0
	2009	3,210	2,062	64.2	497	15.5	651	20.3
Social competence	2012	3,133	2,089	66.7	579	18.5	465	14.8
	2009	3,203	1,984	61.9	598	18.7	621	19.4
Emotional maturity	2012	3,108	2,098	67.5	590	19	420	13.5
	2009	3,174	1,998	63	653	20.6	523	16.5
Language and cognitive skills (school-based)	2012	3,118	1,937	62.1	535	17.2	646	20.7
	2009	3,179	1,780	56	575	18.1	824	25.9
Communication skills and general knowledge	2012	3,137	2,147	68.4	537	17.1	453	14.4
	2009	3,212	1,976	61.5	575	17.9	661	20.6

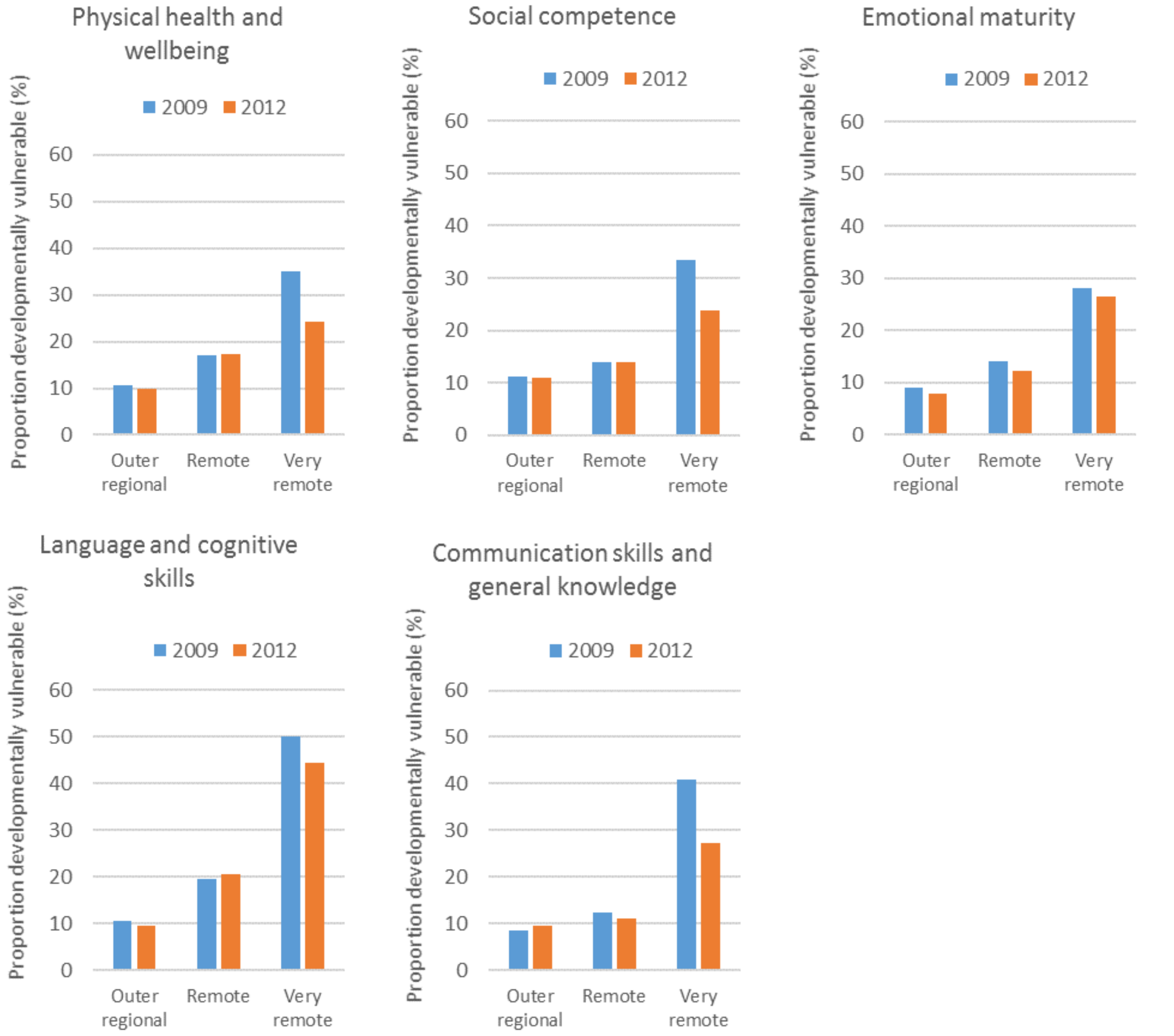
Table 3.1 (above) details the numbers and percentages of NT children assessed as being developmentally 'on track', 'at risk', and 'vulnerable' for each of the five AEDC domains in 2009 and 2012. This reveals substantial differences in proportions of Aboriginal and non-Aboriginal children considered to be 'developmentally vulnerable' in both years. However, it is important to note that sizeable improvements in Aboriginal children's AEDC developmental outcomes occurred between 2009 and 2012. These jurisdictional-level improvements were the highest among all states and territories between these years (Australian Government 2013).

Figure 3.22 (below) illustrates the findings from the analysis stratified by level of remoteness for these two years. This showed similar differences between outer regional areas and very remote areas for all five AEDC domains for both years. Of particular note are the substantial improvements in AEDC developmental outcomes between 2009 and 2012 among children in very remote areas.

As the majority of Aboriginal children in the NT live in very remote areas, these findings come as no surprise. In both stratified analyses, the greatest improvement in Aboriginal children was found in the 'communication skills and general knowledge' domain, which comprises data items concerning pre-literacy competencies and basic knowledge relevant to school learning.

In summary, there were encouraging improvements in the AEDC developmental profiles of Aboriginal students and students living in very remote areas between 2009 and 2012. Despite these significant improvements, the overall levels of developmental vulnerability of Aboriginal students in the NT remain higher

Figure 3.22 AEDC outcomes: proportion of children being developmentally vulnerable by AEDC domain and Aboriginal status, NT, 2009 and 2012



than those of non-Aboriginal students in the NT as well as Aboriginal students in other Australian jurisdictions. These continuing high rates of developmental vulnerability have important implications for the way in which schools, and child and family services need to be tailored to meet the learning, language and family support needs of students and facilitate their successful transition into school learning.

3.7 Discussion

This chapter's examination of time trends in NT children's early life health and developmental outcomes highlights the extent and changing nature of disparities in the early life circumstances of Aboriginal and non-Aboriginal children. While these early life factors are known to be important in laying the foundation for children's readiness for school learning and subsequent educational achievement, this is explored in more detail in later chapters of this publication.

Understanding the population-level changes in the early determinants of educational and other life course outcomes can assist in identifying emerging service needs and leverage points where prevention and early intervention have the greatest potential to improve children's trajectories of development.

Some of the observed trends in these early life factors have implications for the NT's population growth and sustainability, and will need to be taken into account for policy planning and services to improve children's longer-term health, capability and wellbeing. Documenting these trends can provide a baseline against which progress can be benchmarked.

Live births and fertility rates: Birth rates are a key component of forward projections of population growth. For the NT, a healthy population growth is essential both politically and economically (Marks 2017). A small increasing trend in all NT births was evident between 2004 and 2013, with around 50 additional births each year. However, over this period there was also a small, but significant, decreasing trend in Aboriginal births (average annual decrease of 1.7%). This, together with the recent trend in the TFR and age-specific fertility rates has implications for the sustainability of NT population, specifically, of Aboriginal population. While the TFR for non-Aboriginal women followed an increasing trend of 1.2% per year, it is of concern that the TFR for Aboriginal women followed a decreasing trend such that by 2013 it was the lowest on record and close to the population replacement rate of 2.1.

The changes in the rates of births to mothers aged 20–34 years are of particular relevance to service planning as these births account for around two-thirds of Aboriginal births and three-quarters of non-Aboriginal births. At the same time, the decrease in teenage fertility rates for both non-Aboriginal and Aboriginal populations is encouraging as this reflects a reduction in teenage pregnancy. This may be attributable to increasing use of contraception in this age group and/or other factors.

Understanding the main drivers of these changes warrants further investigation as they have far reaching implications for health and social policy. There are a number of possible health and non-health factors which may have played a causal role in the observed trends. For example, primary care services have long had policies and practices aimed at reducing teenage pregnancy which may account for decreasing trends in teenage pregnancy. However, it is also the case that the NT's high rates of sexually transmitted infections (STIs) and repeated episodes of STI could also account for some of the reduction in fertility rates. Evidence confirming the former would be encouraging while evidence of the latter could have significant implications for population sustainability.

Alcohol use in pregnancy: Also encouraging is a downward trend in the proportion of Aboriginal and non-Aboriginal mothers reporting alcohol consumption during pregnancy. However, alcohol consumption rates remain relatively high among Aboriginal mothers during pregnancy. Given the growing scientific, clinical and community understanding of Fetal Alcohol Spectrum Disorders (FASD), and recent evidence that this can also be associated with heavy pre-conception alcohol consumption by both fathers and mothers (Day et al. 2016), there is a need for greater public health effort directed to alcohol control measures which reduce alcohol consumption more generally, as well as preventive health education regarding the risks associated with alcohol use in pregnancy. These could include primary health services developing health promotion initiatives tailored to their local community circumstances, and routine screening of pregnant women and women of reproductive age regarding their patterns of alcohol use. Where indicated, this can be an opportunity for preventive health education, brief counselling, or referral to an alcohol treatment service.

Smoking in pregnancy: The proportion of mothers reporting they smoked during pregnancy has decreased on average over recent decades. For women in outer regional areas (e.g. Darwin area), smoking rates during pregnancy have declined from 26.0% in 1996 to 14.7% in 2013. However, for women in remote and very remote areas (predominantly Aboriginal) there was a significant upward trend on already high smoking rates. Of particular concern is that by 2013 around 50% of Aboriginal mothers giving birth reported they smoked before and after 20 weeks gestation. This confirms the relevance of recent national initiatives to address Indigenous smoking behaviour through community education or other preventive strategies (Australian Government Department of Health 2017). Although there was a decline in smoking during pregnancy for non-Aboriginal mothers, 10% were reported to be smoking in 2013, which is high in comparison with the national rates. Continued effort in public health interventions to reduce smoking during pregnancy among both Aboriginal and non-Aboriginal women is clearly required.

Antenatal care: Health service investments to increase the proportion of women having their first antenatal visit in the first trimester appear to have resulted in significant increases in all subpopulations and levels of remoteness in the NT. However, it remains of concern that by 2013, there were up to 40% of Aboriginal mothers who did not present for antenatal care in the first trimester, and up to 30% of these women attended less than seven antenatal visits during their pregnancy. Fewer antenatal visits mean fewer opportunities and lower likelihood for interventions that could be delivered to reduce health risks for both the mother and the fetus (such as smoking and alcohol consumption mentioned above).

This points to the need for concerted public health effort to improve women's access to antenatal care, to improve community understanding of its benefits, and to ensure resources are available to support women receiving the recommended levels of antenatal care- especially in remote and very remote areas.

Preterm birth: The rate difference in the preterm births of Aboriginal and non-Aboriginal children ranged between 5% and 7% over the study period. This gap widened due to the rate of Aboriginal preterm births increasing from 14.1% to 15.2% between 1996 and 2013 while the non-Aboriginal rate decreased from 7.1% to 6.7% over the same period. Worsening trends in the rates of preterm birth for Aboriginal women in remote and very remote areas are concerning, given the increased risk which preterm birth can have for children's subsequent health and development. This again highlights the importance of policy and service investments in maternal health and antenatal care in addressing known risks for preterm birth.

Low birthweight: No significant trend was evident in the rate of LBW among either Aboriginal or non-Aboriginal babies over the study period. Results of stratified analyses by level of remoteness showed no significant trends in the rates of LBW for remote areas. However, for births to mothers residing in very remote areas, the rates of LBW showed a significant increasing trend with rates averaging 5.8% higher than those for mothers living in outer regional areas. This further emphasises the importance of targeted and equitable public health interventions to improve maternal health and antenatal care in Aboriginal women and women living in very remote areas of the NT.

Perinatal mortality: Aboriginal perinatal mortality rates were significantly higher than the non-Aboriginal rates (12.5 more deaths per 1,000 births). Similar proportions of this difference were due to stillbirth and neonatal deaths (mortality rates in these categories were 6.2 and 6.3 per 1,000 births higher respectively). These stand in contrast to much lower national rates. These findings are not surprising given the increasing trends in smoking rates described above. They also further highlight the ongoing need to improve the health and nutrition of pregnant women and reduce their exposure to other known health risks in pregnancy.

Hospitalisations: A key analytic innovation in this chapter was the investigation into reasons for the differences between all-episode hospitalisation rates and the more specific (unique-person) hospitalisation rates. This revealed encouraging trends in the unique-person hospitalisation rates in both Aboriginal and non-Aboriginal children aged less than five years. The analysis showed the main factor contributing to the comparatively higher hospitalisation rates in Aboriginal children, was the significantly higher proportion of Aboriginal children experiencing repeated hospitalisations. Practice measures to reduce the number of repeated hospitalisations of young Aboriginal children (aged 0–4 years), may also facilitate better developmental outcomes by the time children commence school. This is explored further in Chapter 4.

While the rates for more serious illnesses requiring intensive care decreased significantly, the rates of hospitalisation due to injuries among children aged less than five years increased significantly between 2001 and 2013, substantially more so for Aboriginal children. Over the same period, a significant reduction was evident in the rates of hospitalisation for acute lower respiratory infections (ALRI), again, more so for Aboriginal children. These reductions could indicate the cumulative impact of preventive public health programs (e.g. universal vaccination with pneumococcal vaccines, and programs to improve children's nutrition) as well as the improved primary health care service delivery to this population. The higher rates of hospitalisation due to injury in Aboriginal children is consistent with other Australian studies, and highlights the need for public health interventions tailored to the NT population and remote community contexts.

It is encouraging that the average Length of Hospital Stay (LOS) has decreased for both Aboriginal and non-Aboriginal children. Given the limited amount of literature on the impact of the length of hospital stay on childhood development, this factor has been included as a covariate in the investigations of possible determinants of developmental outcomes in early childhood reported in Chapter 4.

Australian Early Development Census (AEDC): The gains in the AEDC developmental outcomes of NT Aboriginal students between 2009 and 2012 are of particular note. These improvements were most pronounced among students in very remote NT areas. However, despite the overall improvements, the levels of developmental vulnerability of NT Aboriginal students remain much higher than those of their non-Aboriginal counterparts, as well as those of Aboriginal students in other states and territories. Evidence reported in later chapters of this publication is consistent with other Australian and international studies showing the extent to which children's early development and readiness for school learning influences their academic progress.

In conclusion, the early life trends reviewed in this chapter identify areas of progress and some significant emerging new trends. They highlight how significant disparities emerge very early in children's lives and the appropriateness of the focus of NT's new 10-year early childhood strategy, "*Starting Early for a Better Future"* on building across-government and community capacity for supporting healthy child development (Northern Territory Government 2017). The trend data reported here could provide a baseline for monitoring progress and highlighting areas and population groups with the greatest capacity to benefit.

As is evident from the way these trends have changed over time, most are clearly amenable to change. This highlights their suitability as areas for further targeted interventions by early child health services.

3.8 References

AIHW. 2009. *Aboriginal and Torres Strait Islander health performance framework 2008 report: detailed analyses (AIHW Cat. No. IHW 22.)* (Australian Institute of Health and Welfare (AIHW): Canberra).

AIHW: Pointer S, 2016. *Hospitalised injuries in Aboriginal and Torres Strait Islander children and young people: 2011–13* (AIHW: Canberra).

Australian Government. 2013. *A snapshot of early childhood development in Australia 2012-AEDI National Report* (Australian Government: Canberra).

Commonwealth of Australia. 2015. *Australian Early Development Census – National Report 2015* (Australian Government: Canberra).

Australian Government Department of Health. 2017. 'Tackling Indigenous Smoking (TIS)', Australian Government Department of Health,, Accessed 11 December 2017. http://www.health.gov.au/internet/main/publishing.nsf/content/indigenous-tis-lp.

Berkowitz, G. S., and E. Papiernik. 1993. 'Epidemiology of preterm birth', *Epidemiol Rev*, 15: 414-43.

Bird, A. L., C. C. Grant, D. K. Bandara, J. Mohal, P. E. Atatoa-Carr, M. R. Wise, H. Inskip, M. Miyahara, and S. M. Morton. 2016. 'Maternal health in pregnancy and associations with adverse birth outcomes: Evidence from Growing Up in New Zealand', *Aust N Z J Obstet Gynaecol*.

Blencowe, H., S. Cousens, M. Z. Oestergaard, D. Chou, A. B. Moller, R. Narwal, A. Adler, C. Vera Garcia, S. Rohde, L. Say, and J. E. Lawn. 2012. 'National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications', *Lancet*, 379: 2162-72.

Burgner, D., and P. Richmond. 2005. 'The burden of pneumonia in children: an Australian perspective', *Paediatr Respir Rev*, 6: 94-100.

Butler, N. R., H. Goldstein, and E. M. Ross. 1972. 'Cigarette smoking in pregnancy: its influence on birth weight and perinatal mortality', *BMJ*, 2: 127-30.

Carroli, G., C. Rooney, and J. Villar. 2001. 'How effective is antenatal care in preventing maternal mortality and serious morbidity? An overview of the evidence', *Paediatr Perinat Epidemiol*, 15 Suppl 1: 1-42.

Carroli, G., J. Villar, G. Piaggio, D. Khan-Neelofur, M. Gulmezoglu, M. Mugford, P. Lumbiganon, U. Farnot, P. Bersgjo, and W. H. O. Antenatal Care Trial Research Group. 2001. 'WHO systematic review of randomised controlled trials of routine antenatal care', *Lancet*, 357: 1565-70.

Carville, K. S., D. Lehmann, G. Hall, H. Moore, P. Richmond, N. de Klerk, and D. Burgner. 2007. 'Infection is the major component of the disease burden in aboriginal and non-aboriginal Australian children: a population-based study', *Pediatr Infect Dis J*, 26: 210-16.

Case, A, K Dempsey, and X Zhang. 2015. *Northern Territory Midwives' Collection. Mothers and Babies 2012* (Northern Territory Department of Health: Darwin).

Center on the Developing Child at Harvard University. 2010. 'The foundations of lifelong health are built in early childhood', Centre on the Developing Child, Harvard University, Accessed 11 November 2017. http://developingchild.harvard.edu/wp-content/uploads/2010/05/Foundations-of-Lifelong-Health.pdf.

Chan, D. L., and E. A. Sullivan. 2008. 'Teenage smoking in pregnancy and birthweight: a population study, 2001-2004', *Med J Aust*, 188: 392-96.

Congress Alukura. 2014. *Minymaku Kutju Tjukurpa Women's Business Manual, 5th Ed.* (Centre for Remote Health: Alice Springs).

Curhan, G. C., G. M. Chertow, W. C. Willett, D. Spiegelman, G. A. Colditz, J. E. Manson, F. E. Speizer, and M. J. Stampfer. 1996. 'Birth weight and adult hypertension and obesity in women', *Circulation*, 94: 1310-15.

Curhan, G. C., W. C. Willett, E. B. Rimm, D. Spiegelman, A. L. Ascherio, and M. J. Stampfer. 1996. 'Birth weight and adult hypertension, diabetes mellitus, and obesity in US men', *Circulation*, 94: 3246-50.

Day J , Savani S, Krempley BD, Nguyen M, JB Kitlinska, 2016. Influence of paternal preconception exposures on their offspring: through epigenetics to phenotype. *Am J Stem Cells* 2016;5(1):11-18.

D'Angiulli, A., W. Warburton, S. Dahinten, and C. Hertzman. 2009. 'Population-level associations between preschool vulnerability and grade-four basic skills', *PLoS One*, 4: e7692.

Division of Cancer Control & Population Sciences. 2017. 'Joinpoint trend analysis software', National cancer institute, USA, Accessed 2 February 2017. https://surveillance.cancer.gov/joinpoint/.

Dolan-Mullen, P., G. Ramirez, and J. Y. Groff. 1994. 'A meta-analysis of randomized trials of prenatal smoking cessation interventions', *Am J Obstet Gynecol*, 171: 1328-34.

Fletcher, JM. 2011. 'The medium term schooling and health effects of low birth weight: Evidence from siblings', *Econ Educ Rev*, 30: 517-27.

Frey, H. A., and M. A. Klebanoff. 2016. 'The epidemiology, etiology, and costs of preterm birth', *Semin Fetal Neonatal Med*, 21: 68-73.

Gardiner-Garden, J. 2017. 'Closing the Gap', Australian Government, Accessed 10 July 2017. http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/BriefingBook44p/ClosingGap.

Guthridge, S., L. Li, S. Silburn, S. Q. Li, J. McKenzie, and J. Lynch. 2015. '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', *J Paediatr Child Health*, 51: 778-86.

Guthridge S, Li L, Silburn S, Li SQ, McKenzie J and Lynch J. 2016. 'Early influences on developmental outcomes among children, at age 5, in Australia's Northern Territory', *Early Child Res Q*, 35: 124-34.

Hillemeier, M. M., P. L. Morgan, G. Farkas, and S. A. Maczuga. 2011. 'Perinatal and socioeconomic risk factors for variable and persistent cognitive delay at 24 and 48 months of age in a national sample', *Matern Child Health J*, 15: 1001-10.

Hodyl, N. A., L. E. Grzeskowiak, M. J. Stark, W. Scheil, and V. L. Clifton. 2014. 'The impact of Aboriginal status, cigarette smoking and smoking cessation on perinatal outcomes in South Australia', *Med J Aust*, 201: 274-78.

Jaddoe, V. W., R. Bakker, A. Hofman, J. P. Mackenbach, H. A. Moll, E. A. Steegers, and J. C. Witteman. 2007. 'Moderate alcohol consumption during pregnancy and the risk of low birth weight and preterm birth. The generation R study', *Ann Epidemiol*, 17: 834-40.

Janu, E. K., B. I. Annabattula, S. Kumariah, M. Zajaczkowska, J. S. Whitehall, M. J. Edwards, S. Lujic, and I. B. Masters. 2014. 'Paediatric hospitalisations for lower respiratory tract infections in Mount Isa', *Med J Aust*, 200: 591-94.

Janus, M, SA Brinkman, and EK Duku. 2011. 'Validity and psychometric properties of the early development instrument in Canada, Australia, United States, and Jamaica', *Soc Indic Res*, 103: 283-97.

Kramer, M. S. 1987. 'Determinants of low birth weight: methodological assessment and meta-analysis', *Bull World Health Organ*, 65: 663-737.

Liu, L., H. L. Johnson, S. Cousens, J. Perin, S. Scott, J. E. Lawn, I. Rudan, H. Campbell, R. Cibulskis, M. Li, C. Mathers, R. E. Black, W. H. O. Child Health Epidemiology Reference Group of, and Unicef. 2012. 'Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000', *Lancet*, 379: 2151-61.

MacArthur, C., and E. G. Knox. 1988. 'Smoking in pregnancy: effects of stopping at different stages', *Br J Obstet Gynaecol*, 95: 551-55.

Mariscal, M., S. Palma, J. Llorca, R. Perez-Iglesias, R. Pardo-Crespo, and M. Delgado-Rodriguez. 2006. 'Pattern of alcohol consumption during pregnancy and risk for low birth weight', *Ann Epidemiol*, 16: 432-38.

Marks, L. 2017. 'Slow population growth will cost Northern Territory one of two federal seats: Demographer', *ABC News*.

Martorell, R., B. L. Horta, L. S. Adair, A. D. Stein, L. Richter, C. H. Fall, S. K. Bhargava, S. K. Biswas, L. Perez, F. C. Barros, C. G. Victora, and Group Consortium on Health Orientated Research in Transitional Societies. 2010. 'Weight gain in the first two years of life is an important predictor of schooling outcomes in pooled analyses from five birth cohorts from low- and middle-income countries', *J Nutr*, 140: 348-54.

Moller, H., K. Falster, R. Ivers, and L. Jorm. 2015. 'Inequalities in unintentional injuries between indigenous and non-indigenous children: a systematic review', *Inj Prev*, 21: e144-52.

Moore, Tim. 2006. *Early childhood and long term development: The importance of the early years* (Australian Research Alliance for Children & Youth: Perth).

Mwaniki, M. K., M. Atieno, J. E. Lawn, and C. R. Newton. 2012. 'Long-term neurodevelopmental outcomes after intrauterine and neonatal insults: a systematic review', *Lancet*, 379: 445-52.

Nargund, G. 2009. 'Declining birth rate in Developed Countries: A radical policy re-think is required', *Facts Views Vis Obgyn*, 1: 191-93.

Northern Territory Government. 2017. 'Starting Early For a Better Future', Northern Territory Government, Accessed 11 December 2017. https://nt.gov.au/news/2017/october-2017/starting-early-for-a-better-future.

O'Grady, K. A., K. J. Lee, J. B. Carlin, P. J. Torzillo, A. B. Chang, E. K. Mulholland, S. B. Lambert, and R. M. Andrews. 2010. 'Increased risk of hospitalization for acute lower respiratory tract infection among Australian indigenous infants 5-23 months of age following pneumococcal vaccination: a cohort study', *Clin Infect Dis*, 50: 970-78.

O'Grady, K. A., P. J. Torzillo, and A. B. Chang. 2010. 'Hospitalisation of Indigenous children in the Northern Territory for lower respiratory illness in the first year of life', *Med J Aust*, 192: 586-90.

Odd, D. E., F. Rasmussen, D. Gunnell, G. Lewis, and A. Whitelaw. 2008. 'A cohort study of low Apgar scores and cognitive outcomes', *Arch Dis Child Fetal Neonatal Ed*, 93: F115-20.

OECD. 2017. 'Fertility rates (indicator). doi: 10.1787/8272fb01-en.', Accessed 17 February 2017.

Panaretto, K., H. Lee, M. Mitchell, S. Larkins, V. Manessis, P. Buettner, and D. Watson. 2006. 'Risk factors for preterm, low birth weight and small for gestational age birth in urban Aboriginal and Torres Strait Islander women in Townsville', *Aust N Z J Public Health*, 30: 163-70.

Patra, J., R. Bakker, H. Irving, V. W. Jaddoe, S. Malini, and J. Rehm. 2011. 'Dose-response relationship between alcohol consumption before and during pregnancy and the risks of low birthweight, preterm birth and small for gestational age (SGA)-a systematic review and meta-analyses', *BJOG*, 118: 1411-21.

Pink, B. 2013. *Australian statistical geography standard (ASGS): Volume 5-Remoteness structure* (Australian Bureau of Statistics: Canberra).

Pinto-Martin, J., A. Whitaker, J. Feldman, A. Cnaan, H. Zhao, J. R. Bloch, D. McCulloch, and N. Paneth. 2004. 'Special education services and school performance in a regional cohort of low-birthweight infants at age nine', *Paediatr Perinat Epidemiol*, 18: 120-29.

Quigley, M. A., G. Poulsen, E. Boyle, D. Wolke, D. Field, Z. Alfirevic, and J. J. Kurinczuk. 2012. 'Early term and late preterm birth are associated with poorer school performance at age 5 years: a cohort study', *Arch Dis Child Fetal Neonatal Ed*, 97: F167-73.

Rogers, J. M. 2009. 'Tobacco and pregnancy', *Reprod Toxicol*, 28: 152-60.

Rumbold, A. R., R. S. Bailie, D. Si, M. C. Dowden, C. M. Kennedy, R. J. Cox, L. O'Donoghue, H. E. Liddle, R. K. Kwedza, S. C. Thompson, H. P. Burke, A. D. Brown, T. Weeramanthri, and C. M. Connors. 2011. 'Delivery of maternal health care in Indigenous primary care services: baseline data for an ongoing quality improvement initiative', *BMC Pregnancy Childbirth*, 11: 16.

Rush, R. W., M. J. Keirse, P. Howat, J. D. Baum, A. B. Anderson, and A. C. Turnbull. 1976. 'Contribution of preterm delivery to perinatal mortality', *BMJ*, 2: 965-68.

Smithers, L. G., J. W. Lynch, S. Yang, M. Dahhou, and M. S. Kramer. 2013. 'Impact of neonatal growth on IQ and behavior at early school age', *Pediatrics*, 132: e53-60.

Stuart, A., P. Otterblad Olausson, and K. Kallen. 2011. 'Apgar scores at 5 minutes after birth in relation to school performance at 16 years of age', *Obstet Gynecol*, 118: 201-8.

Tamakoshi, K., H. Yatsuya, K. Wada, K. Matsushita, R. Otsuka, P. O. Yang, K. Sugiura, Y. Hotta, H. Mitsuhashi, T. Kondo, and H. Toyoshima. 2006. 'Birth weight and adult hypertension: cross-sectional study in a Japanese workplace population', *Circ J*, 70: 262-67.

Tucker, J., and W. McGuire. 2004. 'Epidemiology of preterm birth', *BMJ*, 329: 675-78.

World Health Organization. 2006. *Neonatal and perinatal mortality: country, regional and global estimates* (World Health Organization: Geneva).

Yap, M., and N. Biddle. 2012. *Indigenous population project 2011 Census papers, Paper 2 Indigenous ferlility and family formation* (Centre for Aboriginal Economic Policy Research, Australian National Univesity: Canberra).

3.9 Appendices

Table 3.A.1 Perinatal mortality, NT, 1994–2013

Year	Total Births			Live Births			Stillbirths						Neonatal Mortality						Perinatal Mortality					
	Number			Number			Number			Rate (per 1000 births)			Number			Rate (per 1000 births)			Number			Rate (per 1000 births)		
	Non-Aboriginal	Aboriginal	Total	Non-Aboriginal	Aboriginal	Total	Non-Aboriginal	Aboriginal	Total	Non-Aboriginal	Aboriginal	Total	Non-Aboriginal	Aboriginal	Total	Non-Aboriginal	Aboriginal	Total	Non-Aboriginal	Aboriginal	Total	Non-Aboriginal	Aboriginal	Total
1994	2,228	1,225	3,453	2,208	1,204	3,412	20	21	21	9.0	17.1	6.1	8	20	48	3.6	16.3	13.9	28	41	69	12.6	33.5	20.0
1995	2,343	1,226	3,569	2,327	1,207	3,534	16	19	19	6.8	15.5	5.3	8	9	33	3.4	7.3	9.2	24	28	52	10.2	22.8	14.6
1996	2,160	1,224	3,384	2,148	1,210	3,358	12	14	14	5.6	11.4	4.1	10	15	37	4.6	12.3	10.9	22	29	51	10.2	23.7	15.1
1997	2,222	1,271	3,493	2,209	1,252	3,461	13	19	19	5.9	14.9	5.4	5	10	28	2.3	7.9	8.0	18	29	47	8.1	22.8	13.5
1998	2,147	1,325	3,472	2,137	1,310	3,447	10	15	15	4.7	11.3	4.3	9	15	34	4.2	11.3	9.8	19	30	49	8.8	22.6	14.1
1999	2,135	1,392	3,527	2,113	1,367	3,480	22	25	25	10.3	18.0	7.1	12	19	53	5.6	13.6	15.0	34	44	78	15.9	31.6	22.1
2000	2,095	1,381	3,476	2,079	1,367	3,446	16	14	14	7.6	10.1	4.0	6	16	38	2.9	11.6	10.9	22	30	52	10.5	21.7	15.0
2001	2,097	1,586	3,683	2,085	1,572	3,657	12	14	14	5.7	8.8	3.8	9	13	34	4.3	8.2	9.2	21	27	48	10.0	17.0	13.0
2002	2,118	1,491	3,609	2,104	1,476	3,580	14	15	15	6.6	10.1	4.2	7	11	32	3.3	7.4	8.9	21	26	47	9.9	17.4	13.0
2003	2,052	1,521	3,573	2,032	1,502	3,534	20	19	19	9.7	12.5	5.3	6	11	37	2.9	7.2	10.4	26	30	56	12.7	19.7	15.7
2004	1,962	1,410	3,372	1,953	1,397	3,350	9	13	13	4.6	9.2	3.9	3	15	27	1.5	10.6	8.0	12	28	40	6.1	19.9	11.9
2005	2,129	1,467	3,596	2,106	1,449	3,555	23	18	18	10.8	12.3	5.0	5	17	45	2.3	11.6	12.5	28	35	63	13.2	23.9	17.5
2006	2,083	1,551	3,634	2,066	1,528	3,594	17	23	23	8.2	14.8	6.3	3	14	34	1.4	9.0	9.4	20	37	57	9.6	23.9	15.7
2007	2,163	1,536	3,699	2,154	1,514	3,668	9	22	22	4.2	14.3	5.9	5	13	27	2.3	8.5	7.3	14	35	49	6.5	22.8	13.2
2008	2,302	1,464	3,766	2,292	1,448	3,740	10	16	16	4.3	10.9	4.2	6	10	26	2.6	6.8	6.9	16	26	42	7.0	17.8	11.2
2009	2,248	1,572	3,820	2,234	1,544	3,778	14	28	28	6.2	17.8	7.3	5	11	30	2.2	7.0	7.9	19	39	58	8.5	24.8	15.2
2010	2,291	1,492	3,783	2,277	1,475	3,752	14	17	17	6.1	11.4	4.5	7	9	30	3.1	6.0	7.9	21	26	47	9.2	17.4	12.4
2011	2,374	1,468	3,842	2,363	1,452	3,815	11	16	16	4.6	10.9	4.2	10	17	38	4.2	11.6	9.9	21	33	54	8.8	22.5	14.1
2012	2,490	1,460	3,950	2,479	1,448	3,927	11	12	12	4.4	8.2	3.0	3	7	21	1.2	4.8	5.3	14	19	33	5.6	13.0	8.4
2013	2,594	1,365	3,959	2,574	1,341	3,915	20	24	24	7.7	17.6	6.1	6	10	36	2.3	7.3	9.1	26	34	60	10.0	24.9	15.2
Mean	2,212	1,421	3,633	2,197	1,403	3,600	14.65	18.2	18.2	6.6	12.8	5.0	6.65	13.1	34.4	3.2	9.2	9.5	21.3	31.3	52.6	9.6	22.0	14.5

Table 3.A.2 Mean birthweight (grams) and 95% confidence interval by sex and Aboriginal status, NT, 1994–2013

Category	Non-Aboriginal		Aboriginal		p value
Male	3,433.0	(3,425.4–3,440.5)	3,179.7	(3,168.7–3,190.7)	<0.0005
Female	3,301.3	(3,293.8–3,308.7)	3,070.0	(3,059.4–3,080.7)	<0.0005
Total	3,368.9	(3,363.6–3,374.3)	3,126.5	(3,118.8–3,134.2)	<0.0005

Table 3.A.3 Trend analysis of the rate of low birthweight and differences between Aboriginal and non-Aboriginal babies, NT, 1994–2013

Item	Aboriginal rate	Non-Aboriginal rate	Rate difference	Rate ratio
AAPC*	0.32	–0.87	1.25	1.22
95%CI^	–0.2~0.8	–1.8~0.0	0.3~2.2	0.4~2.0
p value	0.1978	0.0545	0.0094	0.0039

* Average annual percentage change (unit=%)

^ Confidence interval

Table 3.A.4 Number of hospitalisations per person for the 0–4 year age group by Aboriginal status, NT, 2001–2013

Number of hospitalisations	Non-Aboriginal		Aboriginal		Total		
	Persons	%	Persons	%	Persons	%	P value
1	9,122	59.2	6,535	34.8	15,657	45.8	
2	3,217	25.6	4,415	25.5	7,632	25.6	
3	1,147	9.0	2,512	14.7	3,659	12.1	
4-6	643	5.0	2,942	17.3	3,585	11.8	
7-9	115	0.8	819	4.8	934	3.0	
10+	48	0.4	479	2.9	527	1.8	
Total	14,292		17,702		31,994		
Mean*	1.64 (1.62–1.67)		2.81 (2.77–2.85)		2.29 (2.26–2.31)		<0.0005

* Mean number of hospitalisations per person (95% CI)

Table 3.A.5 Numbers and rates (per 1,000 population) of hospitalisations involving a stay in the intensive care unit for the 0–4 year age group by Aboriginal status, NT, 2001–2013

Year	Non-Aboriginal		Aboriginal		All	
	Cases	Rate	Cases	Rate	Cases	Rate
2001	18	1.7	45	6.1	63	3.5
2002	18	1.8	41	5.4	59	3.3
2003	14	1.4	30	3.8	44	2.5
2004	18	1.9	23	2.9	41	2.3
2005	21	2.2	35	4.3	56	3.2
2006	11	1.2	35	4.3	46	2.6
2007	21	2.2	37	4.5	58	3.2
2008	15	1.5	26	3.2	41	2.3
2009	16	1.5	29	3.7	45	2.4
2010	18	1.6	27	3.5	45	2.4
2011	14	1.3	18	2.4	32	1.7
2012	15	1.3	27	3.7	42	2.2
2013	16	1.4	18	2.5	34	1.8

Table 3.A.6 Numbers and rates (per 1,000 population) of hospitalisations due to injuries for children aged 0–4 years by Aboriginal status, NT, 2001–2013

Year	Non-Aboriginal		Aboriginal		All	
	Cases	Rate	Cases	Rate	Cases	Rate
2001	144	13.7	142	19.1	286	15.9
2002	146	14.2	160	21.0	306	17.1
2003	149	15.0	161	20.6	310	17.5
2004	126	13.0	175	21.9	301	17.1
2005	143	15.0	182	22.4	325	18.4
2006	159	17.0	196	23.9	355	20.2
2007	148	15.3	192	23.5	340	19.0
2008	161	16.0	198	24.5	359	19.8
2009	180	16.9	216	27.3	396	21.3
2010	175	15.8	252	32.7	427	22.7
2011	160	14.4	233	31.4	393	21.3
2012	177	15.4	257	35.2	434	23.1
2013	207	17.5	264	36.5	471	24.7

Table 3.A.7 Numbers and rates (per 1,000 population) of hospitalisations due to acute lower respiratory tract infections for children aged 0–4 years by Aboriginal status, NT, 2001–2013

Year	Non-Aboriginal		Aboriginal		All	
	Cases	Rate	Cases	Rate	Cases	Rate
2001	194	18.4	1,009	135.8	1,203	67.0
2002	168	16.4	1,002	131.7	1,170	65.5
2003	152	15.3	1,023	131.1	1,175	66.3
2004	115	11.9	867	108.6	982	55.7
2005	162	17.0	859	105.6	1,021	57.9
2006	125	13.4	799	97.3	924	52.6
2007	150	15.5	871	106.5	1,021	57.2
2008	184	18.3	822	101.7	1,006	55.4
2009	185	17.4	819	103.4	1,004	54.1
2010	174	15.7	947	123.0	1,121	59.7
2011	230	20.8	909	122.6	1,139	61.6
2012	182	15.8	800	109.7	982	52.3
2013	183	15.5	720	99.5	903	47.4

Table 3.A.9 Annual average length of stay per hospitalisation episode for children aged 0–4 years by Aboriginal status, NT, 2001–2013

Year	Non-Aboriginal	Aboriginal	All	Difference	Ratio
2001	3.7	6.8	5.8	3.1	1.8
2002	3.9	7.0	6.0	3.1	1.8
2003	4.0	7.0	6.1	3.0	1.8
2004	4.0	6.9	6.0	2.9	1.7
2005	4.2	6.6	5.9	2.4	1.6
2006	3.8	6.7	5.8	2.9	1.8
2007	4.0	6.2	5.5	2.2	1.6
2008	4.0	5.8	5.2	1.8	1.5
2009	3.9	5.7	5.1	1.8	1.5
2010	3.9	5.5	5.0	1.6	1.4
2011	3.7	5.3	4.8	1.6	1.4
2012	3.3	5.5	4.7	2.2	1.7
2013	3.1	5.0	4.3	1.9	1.6
Total	3.8	6.2	5.4	2.4	1.6
95%CI	3.7–3.9	6.0–6.3	5.3–5.5		

Table 3.A.10 Demographic characteristics of NT born students assessed in the 2009 and 2012 AEDC collections

Category	2009		2012	
Number of children	3570		3457	
Schools contributing to the results	157		154	
Census completed by an Indigenous teacher	320		287	
Mean Age	5 years 5 months		5 years 5 months	
	Number	% of all	Number	% of all
Sex				
Male	1790	50.1%	1788	51.7%
Female	1780	49.9%	1669	48.3%
Aboriginal status				
Aboriginal	1623	45.5%	1388	40.2%
Non-Aboriginal	1947	54.5%	2069	59.8%
Relative socio-economic disadvantage of community where chidren live				
Quintile 1 (most disadvantaged)	1526	42.7%	1029	29.8%
Quintile 2	253	7.1%	273	7.9%
Quintile 3	613	17.2%	491	14.2%
Quintile 4	749	21.0%	1068	30.9%
Quintile 5 (least disadvantaged)	429	12.0%	596	17.2%
Remoteness				
Outer Regional	1633	45.7%	1845	53.4%
Remote	538	15.1%	554	16.0%
Very Remote	1343	37.6%	1003	29.0%
Other characteristics*				
Census completed by an Indigenous teacher^	320	9.0%	287	8.3%
Born outside of Austrlia	158	4.4%	256	7.4%
Has English as a second language	1537	43.1%	1270	36.7%
Speaks a language other than English at home	1513	42.4%	1304	37.7%
LBOTE	1631	45.7%	1386	40.1%
With special needs	156	4.4%	184	5.3%

* These are separate categories, i.e. not mutually exclusive.
^ Data missing in 1,928 (54.0%) records in 2009; none missing in 2012

Table 3.A.11 AEDC outcomes: Physical health and wellbeing domain, NT, 2009 and 2012

Category	Subcategory	Number of children		Developmentally on track (%)		Developmentally at risk (%)		Developmentally vulnerable (%)	
		2009	2012	2009	2012	2009	2012	2009	2012
Overall	Northern Territory	3210	3137	64.2	71.8	15.5	13.2	20.3	15.0
Sex	Male	1578	1578	59.5	67.1	17.6	14.9	22.9	18.1
	Female	1632	1559	68.8	76.7	13.5	11.4	17.7	11.9
Aboriginal status	Aboriginal	1365	1177	44.1	57.0	20.2	16.7	35.8	26.3
	Non-Aboriginal	1845	1960	79.1	80.7	12.0	11.0	8.8	8.3
Relative socio-economic disadvantage	Quintile 1 (most disadvantaged)	1292	851	46.2	55.5	20.1	18.5	33.8	26.1
	Quintile 2	235	248	66.8	62.5	12.3	10.9	20.9	26.6
	Quintile 3	568	456	79.1	78.1	10.7	11.8	10.2	10.1
	Quintile 4	704	1014	74.2	78.6	13.6	11.5	12.2	9.9
	Quintile 5 (least disadvantaged)	411	568	82.0	83.3	12.7	10.2	5.4	6.5
Remoteness	Outer Regional	1534	1739	76.7	79.3	12.7	10.8	10.7	10.0
	Remote	561	583	70.6	69.1	12.3	13.6	17.1	17.3
	Very Remote	1115	815	44.0	57.8	21.0	18.0	35.1	24.2
Language background*	Speaks a language other than English at home	1273	1108	47.5	59.0	18.2	16.3	34.3	24.7
	English as second language	1292	1068	45.3	57.7	19.2	16.4	35.5	25.9
	LBOTE	1381	1176	47.6	59.4	18.6	16.2	33.8	24.4

* These are separate categories, thus not mutually exclusive.

Table 3.A.12 AEDC outcomes: Social competence domain, NT, 2009 and 2012

Category	Subcategory	Number of children		Developmentally on track (%)		Developmentally at risk (%)		Developmentally vulnerable (%)	
		2009	2012	2009	2012	2009	2012	2009	2012
Overall	Northern Territory	3203	3133	61.9	66.7	18.7	18.5	19.4	14.8
Sex	Male	1576	1577	54.3	59.7	20.8	21.1	24.9	19.2
	Female	1627	1556	69.3	73.8	16.7	15.8	14.0	10.4
Aboriginal status	Aboriginal	1358	1174	43.6	50.3	22.6	25.1	33.8	24.5
	Non-Aboriginal	1845	1959	75.5	76.5	15.8	14.5	8.8	9.0
Relative socio-economic disadvantage	Quintile 1 (most disadvantaged)	1286	849	45.3	48.4	23.4	27.2	31.3	24.4
	Quintile 2	235	247	67.2	57.5	14.0	18.2	18.7	24.3
	Quintile 3	567	456	73.7	74.8	16.1	13.8	10.2	11.4
	Quintile 4	704	1013	70.6	73.8	16.3	16.2	13.1	10.0
	Quintile 5 (least disadvantaged)	411	568	80.1	78.7	14.1	13.4	5.8	7.9
Remoteness	Outer Regional	1533	1738	73.5	73.7	15.3	15.4	11.2	11.0
	Remote	561	582	67.2	69.2	18.9	16.8	13.9	13.9
	Very Remote	1109	813	43.3	49.9	23.3	26.3	33.5	23.7
Language background*	Speaks a language other than English at home	1267	1107	44.0	53.8	22.8	22.9	33.2	23.3
	English as second language	1285	1067	43.4	52.2	23.1	23.6	33.5	24.2
	LBOTE	1374	1175	45.1	54.3	22.6	22.5	32.4	23.2

* These are separate categories, thus not mutually exclusive.

Table 3.A.13 AEDC outcomes: Emotional maturity domain, NT, 2009 and 2012

Category	Subcategory	Number of children		Developmentally on track (%)		Developmentally at risk (%)		Developmentally vulnerable (%)	
		2009	2012	2009	2012	2009	2012	2009	2012
Overall	Northern Territory	3174	3108	63.0	67.5	20.6	19.0	16.5	13.5
Sex	Male	839	906	53.8	58.1	23.1	23.4	23.1	18.5
	Female	1159	1192	71.8	77.0	18.2	14.6	10.0	8.5
Aboriginal status	Aboriginal	1333	1160	43.1	51.5	29.6	25.4	27.2	23.1
	Non-Aboriginal	1841	1948	77.3	77.1	14.0	15.1	8.7	7.8
Relative socio-economic disadvantage	Quintile 1 (most disadvantaged)	1259	829	45.0	50.2	28.7	24.4	26.4	25.5
	Quintile 2	234	245	69.2	60.8	16.2	22.5	14.5	16.7
	Quintile 3	567	455	74.8	71.2	16.1	18.5	9.2	10.3
	Quintile 4	703	1011	72.0	76.4	16.4	14.8	11.7	8.8
	Quintile 5 (least disadvantaged)	411	568	82.7	76.9	11.7	17.4	5.6	5.6
Remoteness	Outer Regional	1532	1735	76.3	74.6	14.6	17.4	9.1	8.0
	Remote	560	580	66.3	70.7	19.6	17.1	14.1	12.2
	Very Remote	1082	793	42.3	49.7	29.5	23.8	28.2	26.5
Language background*	Speaks a language other than English at home	1243	1093	45.3	53.5	28.6	24.6	26.1	21.9
	English as second language	1260	1052	44.0	51.7	29.4	25.3	26.7	23.0
	LBOTE	1349	1160	46.0	54.1	28.2	24.5	25.8	21.4

* These are separate categories, thus not mutually exclusive.

Table 3.A.14 AEDC outcomes: Language and cognitive skills domain, NT, 2009 and 2012

Category	Subcategory	Number of children		Developmentally on track (%)		Developmentally at risk (%)		Developmentally vulnerable (%)	
		2009	2012	2009	2012	2009	2012	2009	2012
Overall	Northern Territory	3179	3118	56.0	62.1	18.1	17.2	25.9	20.7
Sex	Male	1566	1570	49.6	57.6	19.4	19.0	31.0	23.4
	Female	1613	1548	62.2	66.7	16.8	15.3	21.0	18.0
Aboriginal status	Aboriginal	1357	1172	25.4	32.7	24.4	25.0	50.2	42.3
	Non-Aboriginal	1822	1946	78.8	79.9	13.4	12.4	7.9	7.7
Relative socio-economic disadvantage	Quintile 1 (most disadvantaged)	1285	848	32.1	31.3	23.0	24.5	44.9	44.2
	Quintile 2	234	248	53.9	62.5	18.0	14.1	28.2	23.4
	Quintile 3	559	452	72.3	72.1	12.5	15.5	15.2	12.4
	Quintile 4	691	1006	71.1	73.6	17.8	14.7	11.1	11.7
	Quintile 5 (least disadvantaged)	410	564	84.4	80.0	11.0	13.1	4.6	6.9
Remoteness	Outer Regional	1522	1729	74.6	76.4	14.9	13.9	10.5	9.7
	Remote	549	577	63.2	61.7	17.1	17.7	19.7	20.6
	Very Remote	1108	812	26.9	32.0	22.9	23.7	50.2	44.3
Language background*	Speaks a language other than English at home	1264	1103	27.5	37.6	22.9	21.2	49.7	41.2
	English as second language	1284	1062	24.5	34.5	23.3	22.4	52.2	43.1
	LBOTE	1372	1170	27.6	38.2	22.7	21.5	49.6	40.3

* These are separate categories, thus not mutually exclusive.

Table 3.A.15 AEDC outcomes: Communication skills and general knowledge domain, NT, 2009 and 2012

Category	Subcategory	Number of children		Developmentally on track (%)		Developmentally at risk (%)		Developmentally vulnerable (%)	
		2009	2012	2009	2012	2009	2012	2009	2012
Overall	Northern Territory	3212	3137	61.5	68.4	17.9	17.1	20.6	14.4
Sex	Male	1578	1579	57.0	64.0	18.6	18.9	24.5	17.2
	Female	1634	1558	65.9	73.0	17.3	15.3	16.8	11.7
Aboriginal status	Aboriginal	1367	1177	37.8	50.1	23.1	23.4	39.1	26.5
	Non-Aboriginal	1845	1960	79.1	79.4	14.0	13.4	6.9	7.2
Relative socio-economic disadvantage	Quintile 1 (most disadvantaged)	1295	852	41.0	49.8	21.4	22.0	37.6	28.3
	Quintile 2	235	248	66.0	63.7	19.2	18.2	14.9	18.2
	Quintile 3	568	456	73.4	75.4	16.0	14.9	10.6	9.7
	Quintile 4	704	1013	74.4	77.3	17.6	14.5	8.0	8.2
	Quintile 5 (least disadvantaged)	410	568	85.1	77.1	9.3	15.9	5.6	7.0
Remoteness	Outer Regional	1533	1737	77.2	75.9	14.2	14.5	8.7	9.6
	Remote	561	584	67.9	68.7	19.6	20.2	12.5	11.1
	Very Remote	1118	816	36.9	52.3	22.2	20.5	41.0	27.2
Language background*	Speaks a language other than English at home	1273	1107	34.8	48.2	25.4	23.0	39.8	28.8
	English as second language	1294	1.67	32.6	45.1	25.4	24.7	42.0	30.2
	LBOTE	1382	1175	35.2	48.4	25.0	23.3	39.8	28.3

* These are separate categories, thus not mutually exclusive.

4. Early life factors associated with childhood development

Jiunn-Yih Su, Sven Silburn, Steven Guthridge and Vincent He

Chapter overview

This chapter builds on the research literature regarding early life factors shaping children's developmental outcomes and extends the analysis of Northern Territory (NT) children's outcomes on the Australian Early Development Census (AEDC) reported in Chapter 3. Using linked individual-level data extracted from NT Government administrative datasets, we examine how children's developmental status at the time of their entry to full-time schooling is associated with their early life health, demographic and socioeconomic circumstances.

To take account of NT children's widely differing living circumstances and geographic distribution, these analyses have been stratified by Aboriginal status and geographic location (where the data permits). Our methodological approach has a focus on understanding the factors associated with children being developmentally 'on track', as well as identifying factors associated with developmental 'vulnerability' and 'risk'.

Given the clear observed association between socioeconomic status (SES) and children's AEDC outcomes, we were also interested in investigating exceptions to such associations. This involved identifying communities where child development results were better than would be expected based on their socioeconomic status. Identifying such communities is important for what can be learned from their experience in enabling children to achieve better developmental outcomes.

The findings provide NT relevant evidence which can be used to strengthen existing policies and programs aimed at improving early childhood development. They can also be used in the design and implementation of new universal and targeted interventions which maximise positive developmental determinants and further enhance their effect given the NT's population and community circumstances.

4.1 Introduction

Early childhood is a crucial stage of life during which the foundations of all future health, learning and behaviour are established. It is a period of increased sensitivity to biological and social environmental circumstances. This is evident in the substantial research literature showing the extent to which adverse experiences early in life influence the course of development and long-term outcomes in health, capability and wellbeing (Centre on the developing child 2010; Moore 2006; Hertzman and Williams 2009). At the same time, there is a rapidly growing body of research describing how early childhood is also a time of increased opportunity for life-long benefits from positive child rearing and early learning experiences (D'Angiulli et al. 2009; Hillemeier et al. 2011; Quigley et al. 2012; Smithers et al. 2013; Odd et al. 2008; Stuart, Olausson, and Källen 2011).

This chapter builds on this literature and reports findings from analyses of linked individual-level data extracted from NT Government administrative datasets. We examine how children's developmental status at the time of their entry to full-time schooling is associated with their earlier health, demographic and socioeconomic circumstances. As detailed earlier in Chapter 3, Australia conducts a cross-sectional national census of children's early childhood development every three years through the AEDC program. The AEDC involves teachers systematically assessing children across five areas of early development known to be associated with readiness for school learning.

The AEDC provides communities with information about how children in their community have developed up to the time they begin full-time school—at around age five years. AEDC data on children's developmental outcomes are also used to inform policy making and service planning to improve the developmental outcomes of Australian children (Goldfeld et al. 2009). The AEDC was first implemented in 2009 as the Australian Early Development Index (AEDI, renamed as AEDC in July 2014) and repeated in 2012 and 2015 as one of the Council of Australian Government's social progress indicators (Guthridge et al. 2016; Australian Government Department of Education and Training 2015). The AEDC data analysed and reported in this chapter are confined to those collected in NT schools in 2009 and 2012 as the 2015 data were not yet available for this linkage study.

While it is important for communities and policy makers to have an understanding of the factors associated with children being developmentally on track (i.e. having AEDC scores in the top 75% of the national AEDC population), it is equally important to know about children whose AEDC scores are in the developmentally at-risk range (i.e. scores between the 10th and 25th percentile of the national AEDC population), and those who score in the developmentally vulnerable range (i.e. scores below the 10th percentile of the national AEDC population). Children who score in the developmentally at-risk range are likely to experience considerable difficulty progressing in their school learning without some additional learning support. Children scoring in the developmentally vulnerable range are also typically assessed as needing special learning and/or language support. The AEDC's capacity to identify children with additional support needs is important for ensuring that such support can be provided as early as possible. It is also important for school development planning and resource allocation to ensure that schools are 'ready' to meet the identified needs of their school entry student cohorts (Brinkman et al. 2012; Lynch et al. 2010; Chittleborough et al. 2016).

The chapter reports findings from a series of analyses investigating how early childhood health and sociodemographic factors are associated with AEDC developmental outcomes. In addition to examining outcomes in terms of developmental vulnerability in one or more AEDC domains, this analysis also investigates factors that facilitate positive developmental outcomes (Falster et al. 2015). The chapter also includes an analysis to identify communities in which children's AEDC developmental outcomes are better than would be predicted by their socioeconomic circumstances.

4.2 Analysis methods

A life-course, eco-epidemiological analytic framework is used in examining the way in which individual socioeconomic and demographic characteristics, health conditions and hospital incidents are associated with AEDC early childhood development as the outcome of interest. In line with the study's overall methodological approach (described in Chapters 1 and 2), we have sought to achieve a more comprehensive understanding of how these associations may differ for Aboriginal and non-Aboriginal children and between different geographical areas of the NT.

For these reasons, univariate and multivariate data analysis was conducted for the selected cohort as a whole, and then stratified by Aboriginal status separately. This stratification is important as it allows different predictors of the outcome to be identified for each of the two subpopulations. The three Australian Bureau of Statistics (ABS) area categorisations of remoteness (out of five categories) which apply in the NT (i.e. outer regional, remote and very remote) have been included as a factorial covariate in the analyses to differentiate the effects of remoteness on the examined outcomes. However, no more localised levels of remoteness were stratified in the analyses due to the concern that such stratification could lead to very small numbers of children in some categories, and the inclusion of multiple categorical variables in the regression models.

The interpretation of results and discussion of their policy and practice implications has been contextualised to the NT context, and consideration given to other possible determinants or moderating factors, not included in the analyses. The limitations and implications of the study findings are discussed to provide readers with other information relevant to the interpretation of the findings. This has been enabled by the involvement of NT Aboriginal organisations and Aboriginal researchers in the overall research process, from the initial study design to the interpretation and reporting of findings.

4.2.1 Data sources and study cohort selection

The administrative datasets were probabilistically linked by the SA NT Data Linkage Unit to create a unique linkage key for each child across all datasets; de-identified individual datasets with relevant variables were then retrieved with the linkage key by responsible agencies and provided for analyses in this chapter (details about this process are described in more detail in Chapter 2). They included the AEDC 2009 and 2012 datasets, the NT Perinatal dataset, the NT Hospitalisation dataset, and the NT Government schools School Enrolment Information dataset. Also included in the analysis were community-level data on socioeconomic disadvantages and level of accessibility/remoteness (described in section 4.2.3) from the ABS.

The analysis cohort comprised NT children enrolled in their first year of full-time schooling in NT schools who were assessed as part of the AEDC national program in 2009 and 2012. Most of these students were aged 5 years at the time of their assessment but the age distribution ranged from 4 to 6 years. Given that four separate administrative datasets were linked for the analysis, children not represented in all four datasets were excluded from the analysis cohort. The cohort selection process started with the full AEDC dataset for the NT (n = 7,027 children). Children known to the school as having special needs requiring special assistance based on medical diagnoses were excluded from the analysis (n = 340) as they were not eligible for assessment on the AEDC domain score checklists (Australian Government Department of Education and Training 2016; Guthridge et al. 2016).

4.2.2 Outcome measures

The two main outcomes of interest examined were a) the dichotomous AEDC variable 'developmentally on track in all five domains' ('ontrack5'), and b) 'developmental vulnerability in one or more domains' ('dv1'). The first variable records whether a child received on track results on all five AEDC domains; a positive value in this variable indicates that the child was developmentally on track as assessed with the AEDC. The second variable records whether a child received 'vulnerable' results on one or more of the five AEDC domains; a positive value in this variable indicates that the child was assessed as being developmentally vulnerable in at least one domain with the AEDC. At the population level, these variables have been widely used as a population-level measure of child development for comparisons across communities, population groups and geographic regions (Australian Government Department of Education and Training 2015; Brinkman et al. 2012; Chittleborough et al. 2016; Falster et al. 2015; Guthridge et al. 2016; Lynch et al. 2010).

4.2.3 Covariates

Perinatal and maternal health covariates

We selected two groups of covariates from the Perinatal dataset based on the literature regarding their potential developmental influence. The first group comprised nine perinatal variables describing prenatal maternal health issues. These included drinking alcohol and smoking, fewer than seven antenatal health care visits, existing or pregnancy-induced hypertension and diabetes, sexually transmitted infection, teenage pregnancy (< 20 years), parity and plurality (twin birth). The second group concerned the perinatal health of the child and included those for antepartum haemorrhage, emergency caesarean section (CS), fetal distress, APGAR score at 5 minutes < 7, whether resuscitated at birth, low birthweight (< 2,500 grams), preterm birth (gestational age < 37 weeks), preterm categories (very preterm (< 34 weeks), preterm (34–36 weeks) and term (> 37 weeks)), admission to special care nursery, and long hospital stay at birth (longer than the 90^{th} percentile—9 days for all children, 7 and 10 days for non-Aboriginal and Aboriginal children, respectively).

Hospitalisation covariates

For childhood hospitalisations, we only included hospitalisations of children that occurred up to the time when the AEDC was administered. Hospitalisations with the ICD-10 principal diagnosis codes not representing health conditions requiring hospitalisation were excluded (e.g. the code Z38 represent live born infants admitted following normal birth, and Z76 indicates the child was admitted as accompanying boarders). The impact of hospitalisation due to infection on child development was investigated by creating a variable for 'hospitalisation due to infection' by identifying those records bearing the ICD-10 codes listed in Table 4.1 as the principal diagnosis. For both covariates for all hospitalisations and hospitalisations due to infection, we counted the number of hospitalisations and the total length of hospital stay (excluding leave days).

Table 4.1 Selected ICD-10 codes for identifying hospitalisations due to infection

ICD-10 codes	Infectious diseases
A00-B99	Certain infectious and parasitic diseases
G00	Bacterial meningitis, not elsewhere classified
G01	Meningitis in bacterial diseases classified elsewhere
G02	Meningitis in other infectious and parasitic diseases classified elsewhere
G03	Meningitis due to other and unspecified causes
G04	Encephalitis, myelitis and encephalomyelitis
H10	Conjunctivitis
H65, 66	Otitis media
J00-11	Upper respiratory tract infections
J12-22, J40	Lower respiratory tract infections
L00	Staphylococcal scalded skin syndrome
L01	Impetigo
L02	Cutaneous abscess, furuncle and carbuncle
L03	Cellulitis and acute lymphangitis

Socioeconomic and other covariates

Data on the ABS Index of Relative Socio-Economic Disadvantage (IRSD) were available for each child's community of residence. The IRSD is one of the Socio-Economic Indexes for Areas (SEIFA) (2011 version) and is a measure of relative disadvantage that summarises a range of census information about the economic and social conditions of people and households within an area. We reduced the number of its categories by transforming the original decile data into quintiles to facilitate data analysis and interpretation, considering the comparatively small size of the NT population.

Geographic remoteness was categorised using ABS data on the Accessibility/Remoteness Index of Australia (ARIA+) Index for the NT. All suburbs and communities in the NT fall within just three of the five ARIA+ categories: outer regional, remote and very remote. This index provides indications on the level of accessibility and remoteness of the residential location of the children included in the study. Community-level data from Census 2011 on housing and bedroom occupancy were also included as covariates for the level of crowdedness in living conditions. These covariates were linked to the study dataset using the statistical local area (SLA) variable.

As there is evidence that early childhood education factors such as engagement with preschool programs (Goldfeld et al. 2016), and socioeconomic factors such as parental education attainment (Dickson, Gregg and Robinson 2013) and employment status are associated with child developmental outcomes (Bradley and Corwyn 2002), we had included relevant variables about these factors from the School Enrolment Information dataset as covariates in the analysis. Specifically, the covariates used were: 'whether attended preschool', 'employment status of the primary caregiver', and 'whether the primary caregiver had finished school or not'. These covariates were retrieved and linked to other datasets through the linkage keys for individual children. A detailed description of these variables and how they were derived is provided in Chapter 5.

4.2.4 Statistical analysis

The statistical analyses and logistic regression model building were performed in three steps. First, descriptive statistics of covariates in relation to the outcome measure were calculated and the level of missing data determined. Next, univariate logistic regression was conducted to investigate the unadjusted association between each covariate and the outcome measure; after that, the multivariate model building was started by including all covariates with unadjusted $p < 0.25$ (from the Wald chi-square test of the univariate logistic regression) into a full model for multivariate logistic regression (Bendel and Afifi 1977; Mickey and Greenland 1989; Bursac et al. 2008). Covariates with adjusted $p \geq 0.05$ were then removed from the model one at a time to progressively optimise it to achieve the most parsimonious model. The following covariates were retained throughout the model building process, either because they were deemed as significant covariates, or, to control for confounding: gender, Aboriginal status, age at AEDC, and the IRSD and ARIA+ indexes. Finally, possible interactions between related covariates were also tested. Statistical significance for all analyses was set at $p < 0.05$. All statistical analyses were conducted using Stata for Windows, Version 14 (StataCorp 2015). Missing data at the variable level affected the number of children available for the regression model building. The level of missing data and how they were managed in the statistical analyses were reported under each outcome measure.

4.3 Early life factors associated with developmental vulnerability

4.3.1. Analysis methodology

The analysis cohort initially consisted of all NT children assessed in the two cycles of AEDC that were examined (2009 and 2012, n = 7,027). In order to select the analysis cohort of children who were eligible for AEDC and also represented in all four datasets, the following cohort selection process was performed:

1. Children with special needs were excluded as they were not eligible for AEDC assessment (n = 340).
2. Children with missing data for the variable 'dv1' were excluded (n = 395).
3. Children from the AEDC dataset who could not be matched to any records in the Perinatal dataset were excluded (n = 1,868), leaving a total of 4,424 children remaining in the merged dataset.
4. After merging this combined dataset with the School Enrolment Information dataset, we found 794 children from the

AEDC dataset who could not be matched, leaving 3,630 children available for analysis.

5. The further merging process with the Hospitalisation dataset revealed that all children remaining in the combined dataset were represented in the Hospitalisation dataset (n = 3,630).
6. The data collection for some covariates from the Perinatal, Hospital and School Enrolment Information datasets was not complete. Hence, we reported the levels of variable-level missing data for each covariate together with univariate analysis results.

In conducting logistic regression, the category of the selected covariates least likely to be associated with developmental vulnerability was used as the reference category. The analysis was first performed with data for all children (with Aboriginal status retained as a covariate in the model); then the analysis stratified by Aboriginal status was performed with the results reported separately for non-Aboriginal and Aboriginal children.

4.3.2. Results

All children

After excluding children who were not unit-record linked in all four of the included administrative datasets, a total of 3,603 children were available for analysis. During the univariate logistic regression analysis, only three out of the total of 33 covariates produced unadjusted p value > 0.25 (antepartum haemorrhage, emergent CS and fetal distress). We included the remaining 27 covariates in the model building process using multivariate logistic regression. A total of 13 covariates remained in the final parsimonious model, including the five deliberately retained ones (see Table 4.2 below and also Table 4.A.1 in the Appendix).

Notably, none of the perinatal factors showed significant associations with the outcome measure in the final model. After controlling for all other covariates in the final model, Aboriginal status was not significantly associated with the outcome measure, i.e. developmental vulnerability (adjusted p = 0.057). As in other studies, male gender was strongly associated with developmental vulnerability: the odds for being developmentally vulnerable at age 5 were more than two times higher in boys than in girls. The age of child at the time of AEDC also showed significant associations: compared with the age group of 5.5–6 years, children in all other age groups were more likely to yield vulnerable results, especially the age group of > 6 years (adjusted odds ratio: 2.28).

Among maternal factors, ‘teenage mother’, ‘maternal diabetes’, ‘smoking during pregnancy’ and ‘antenatal visit < 7 times’ were significant predictors for developmental vulnerability. With regard to hospitalisation before the age of 5 years, it was the number, but not the length, of hospitalisations that was significantly associated with developmental vulnerability.

The covariate ‘did not attend preschool’ did not show significant association with the outcome measure, but the primary caregiver’s unemployed status and status of not finishing school were both strong predictors for the outcome. For the IRSD (or SEIFA index of disadvantage), only the two most disadvantaged quintiles produced significant associations. Neither of the two more remote levels of remoteness showed a significant association with the outcome, compared with the outer regional level. Finally, English as a second language (ESL) was a strong predictor in the final model: the odds of being developmentally vulnerable at age 5 in those who spoke ESL were 2.29 times higher than those who spoke English as the first language.

Non-Aboriginal children

The number of non-Aboriginal children available for analysis was 1,672. In the univariate analysis, eight covariates produced unadjusted $p > 0.25$. With the exception of remoteness, these were omitted from the multivariate analysis. The final parsimonious model built through the multivariate logistic regression analysis contained 13 covariates, including the five deliberately retained in the model (see Table 4.2 below and also Table 4.A.2 in the Appendix).

For non-Aboriginal children, the odds of being developmentally vulnerable in boys were more than three times higher than girls. In terms of the child's age at AEDC, those aged less than 5 years and those aged 5–5.5 years were significantly more likely to be assessed as developmentally vulnerable than those aged 5.5–6 years.

All the maternal covariates significantly associated with developmental vulnerability for all children were also significant predictors of this outcome for non-Aboriginal children. In addition, one category of parity showed a significant association with the outcome: the odds of developmental vulnerability in children whose mother had four or more previous pregnancies that resulted in a birth of at least 20 weeks gestation were more than two times higher, compared with children whose mother had only 0–1 such previous pregnancies.

As with the results for all children, all perinatal covariates dropped out of the final model. Likewise, none of the hospitalisation covariates were present in the final model. All the covariates under the category of 'socioeconomic and other factors' that were retained in the final model for all children performed the same in the final model for non-Aboriginal children. In addition, the covariate 'did not attend preschool' also produced significant association with the outcome, compared with children who did attend preschool. Children who did not attend preschool had a 1.78 times increased likelihood of being developmentally vulnerable.

Aboriginal children

A total of 1,958 Aboriginal children were available for analysis after the exclusion process described earlier in section 4.2. In the univariate analysis, five covariates produced unadjusted $p > 0.25$, and were thus excluded from multivariate analysis (see Table 4.2 below and also Table 4.A.3 in the Appendix). In the final model, only eight covariates were retained, including the five that were deliberately kept. 'Male gender' and 'age of child at AEDC' (all three categories) were significant predictors of the outcome for both Aboriginal and non-Aboriginal children. None of the maternal covariates showed significant association. Among perinatal covariates, 'preterm birth' (< 37 weeks gestational age) was significantly associated with developmental vulnerability, and this was true only in Aboriginal children (adjusted odds ratio (OR) = 1.88). Among hospitalisation factors, only those hospitalised due to infection for two or more times were associated with the outcome.

Table 4.2 Significant and controlled predictors for developmental vulnerability in one or more domains of AEDC 2009 and 2012, NT

Significant / controlled factors	All children (n=3,630)		Non-Aboriginal Children		Aboriginal Children (n=1,958)	
	OR_{adj} (95%CI)	P_{adj}	OR_{adj} (95%CI)	P_{adj}	OR_{adj} (95%CI)	P_{adj}
Controlled factors						
Aboriginal status#						
Non-Aboriginal	Reference					
Aboriginal	1.217 (0.99-1.61)	0.057				
Sex of child						
Female	Reference		Reference		Reference	
Male	2.07 (1.72-2.49)	<0.0005	3.16 (2.39-4.17)	<0.0005	1.61 (1.26-2.05)	<0.0005
Age of child at AEDC						
5y7m-6y	Reference		Reference		Reference	
5y and under	1.42 (1.08-1.86)	0.011	1.56 (1.06-2.29)	0.023	1.49 (1.02-2.17)	0.037
5y1m-5y6m	1.43 (1.16-1.78)	0.001	1.47 (1.07-2.03)	0.018	1.39 (1.05-1.85)	0.02
6y1m-7y6m	2.28 (1.36-3.84)	0.002	2.00 (0.70-5.74)	0.196	1.95 (1.13-3.37)	0.017
SEIFA-D^						
Quintile 1 (least disadvantaged)	Reference		Reference		Reference	
Quintile 2	1.35 (0.97-1.88)	0.076	1.28 (0.87-1.88)	0.204	1.68 (0.78-3.64)	0.188
Quintile 3	1.07 (0.74-1.53)	0.728	1.10 (0.71-1.70)	0.660	1.28 (0.59-2.78)	0.536
Quintile 4	1.79 (1.20-2.67)	0.004	1.82 (1.11-2.99)	0.018	2.46 (1.10-5.48)	0.028
Quintile 5 (most disadvantaged)	1.83 (1.26-2.65)	0.001	1.99 (1.23-3.22)	0.005	2.07 (0.97-4.43)	0.062
Remoteness						
Outer regional	Reference		Reference		Reference	
Remote	1.01 (0.77-1.33)	0.925	0.71 (0.47-1.06)	0.096	1.48 (1.00-2.18)	0.047
Very Remote	1.25 (0.89-1.77)	0.196	0.97 (0.53-1.80)	0.934	1.80 (1.14-2.85)	0.012
Other significant factors						
Mother <20 years old						
No	Reference		Reference			
Yes	1.51 (1.13-2.00)	0.005	2.08 (1.15-3.76)	0.016		
Diabetes						
No	Reference		Reference			
Yes	1.72 (1.22-2.41)	0.002	1.82 (1.11-2.96)	0.017		
Smoking						
No	Reference		Reference			
Yes	1.23 (1.01-1.51)	0.041	1.74 (1.26-2.39)	0.001		
Antenatal visits <7 times						
No	Reference		Reference			
Yes	1.51 (1.21-1.89)	<0.0005	2.13 (1.48-3.06)	<0.0005		
Parity						
0-1			Reference			
2-3			1.12 (0.82-1.53)	0.479		
>=4			2.08 (1.06-4.05)	0.032		
Preterm birth (gestatitional age<37 weeks)						
No					Reference	
Yes					1.88 (1.27-2.79)	0.002
Number of hospitalisations						
None	Reference					
1	1.30 (1.05-1.62)	0.039				
2 and over	1.30 (1.05-1.62)	0.018				
Number of hospitalisations due to infection						
None					Reference	
1					1.10 (0.81-1.50)	0.524
2 and over					1.40 (1.03-1.91)	0.034
Did not attend preschool						
No			Reference			
Yes			1.78 (1.03-3.06)	0.038		
Parents/Caregiver didn't finish school						
No	Reference		Reference			
Yes	1.54 (1.25-1.90)	<0.0005	1.98 (1.48-2.65)	<0.0005		
Parents/Caregiver being unemployed						
No	Reference		Reference		Reference	
Yes	2.16 (1.67-2.79)	<0.0005	3.21 (1.80-5.72)	<0.0005	2.04 (1.56-2.65)	<0.0005
English as a second language						
No	Reference		Reference		Reference	
Yes	2.29 (1.81-2.90)	<0.0005	2.19 (1.48-3.25)	<0.0005	2.46 (1.80-3.36)	<0.0005

Derived Aboriginal status of this NHMRC project
^ Index of Relative Socio-Economic Disadvantage (IRSD) from ABS

In the group of socioeconomic and other covariates, primary caregiver's status of being unemployed showed a strong association with the outcome. The 4th quintile (the second most disadvantaged quintile) under the IRSD and the remote and very remote categories of remoteness were significant predictors of the outcome in Aboriginal children. Finally, ESL proved to be a strong predictor for developmental vulnerability in both non-Aboriginal and Aboriginal children with adjusted OR both greater than 2.

4.4 Early life factors associated with positive development

4.4.1. Analysis methodology

The AEDC dataset included a derived variable indicative of 'positive' early childhood development. Children with a positive value by the AEDC 'ontrack5' variable are those assessed as being developmentally ready for formal schooling across all five AEDC domains (Falster et al. 2015). The selection of the study cohort for this analysis drew on the cohort of all NT children assessed in the two cycles of AEDC that were examined (2009 and 2012, n = 7,027). It involved the following steps to select children who were a) eligible for AEDC assessments, and b) also represented in all four included datasets:

1. Children with special needs were excluded as they were not eligible for AEDC assessment (n = 340).
2. Children with missing data for the variable 'ontrack5' were excluded (n = 331).
3. Children from the AEDC dataset who could not be matched to any records in the Perinatal dataset were excluded (n = 1,891), leaving a total of 4,464 children remaining in the merged dataset.
4. The merging of this combined dataset with School Enrolment dataset revealed 819 children from the AEDC dataset who could not be matched. These were excluded from the study cohort, which had 3,645 children available for analysis.
5. Further merging with the Hospitalisation dataset found all children in this study cohort were represented. Therefore, the resultant study cohort contained a total of 3,645 children.
6. Variable level missing data were reported under the Results section below.

For the logistic regression analysis in this section, the covariate category least likely to be associated with on track developmental outcomes was selected as the reference category. The same process of logistic regression described in the previous section was used to determine significant predictors of on track outcomes in all children, non-Aboriginal children and then Aboriginal children.

4.4.2. Results

All children (i.e. Aboriginal and non-Aboriginal)

Of the 33 covariates included in the univariate logistic regression analysis, 3 produced unadjusted p value > 0.25 and were excluded from the multivariate analysis (see Table 4.3 below and also Table 4.A.4 in the Appendix). After conducting the multivariate logistic regression, the final model contained 13 covariates, including the 5 deliberately retained ones. Female gender was a strong predictor with girls being more than twice as likely (adjusted OR = 2.26) than boys to have a positive developmental outcome. Non-Aboriginal children were also more likely to have a positive outcome than Aboriginal children (adjusted OR = 1.71), as were children aged 5.5–6 years at the time of AEDC assessment than those aged 5 years or younger (adjusted OR: 1.45).

Three maternal covariates were significantly associated with on track outcomes: 'not having

Table 4.3 Significant and controlled predictors for on track developmental outcomes in all five domains of AEDC 2009 and 2012, NT

Significant / controlled factors	All children (n=3,630)		Non-Aboriginal (n=1,676)		Aboriginal (n=1,969)	
	OR_{adj} (95%CI)	P_{adj}	OR_{adj} (95%CI)	P_{adj}	OR_{adj} (95%CI)	P_{adj}
Controlled factors						
Aboriginal status#						
Aboriginal	Reference					
Non-Aboriginal	1.71 (1.35-2.16)	<0.0005				
Sex of child						
Male	Reference		Reference		Reference	
Female	2.26 (1.89-2.71)	<0.0005	2.16 (1.74-2.67)	<0.0005	2.67 (1.91-3.73)	<0.0005
Age of child at AEDC						
5y and under	Reference		Reference		Reference	
5y1m-5y6m	1.03 (0.81-1.31)	0.804	1.07 90.82-1.40)	0.628	1.07 (0.67-1.71)	0.771
5y7m-6y	1.45 (1.12-1.88)	0.005	1.52 (1.13-2.06)	0.006	1.66 (1.01-2.71)	0.044
6y1m-7y6m	0.52 (0.24-1.08)	0.081	0.64 (0.23-1.82)	0.403	0.49 (0.16-1.50)	0.21
SEIFA-D^						
Quintile 5 (most disadvantaged)	Reference		Reference		Reference	
Quintile 4	1.36 (0.92-2.00)	0.12	1.18 (0.74-1.89)	0.488	1.17 (0.62-2.20)	0.629
Quintile 3	1.70 (1.25-2.32)	0.001	1.56 (1.07-2.28)	0.021	1.86 (1.10-3.13)	0.02
Quintile 2	1.25 (0.92-1.71)	0.156	1.26 (0.87-1.83)	0.223	1.20 (0.68-2.12)	0.527
Quintile 1 (least disadvantaged)	1.93 (1.38-2.70)	<0.0005	1.81 (1.22-2.68)	0.003	1.92 (0.92-4.00)	0.082
Remoteness						
Very Remote	Reference		Reference		Reference	
Remote	1.60 (1.11-2.32)	0.012	1.25 (0.74-2.11)	0.406	0.80 (0.35-1.83)	0.604
Outer regional	1.62 (1.12-2.34)	0.011	1.12 (0.68-1.85)	0.652	1.21 (0.53-2.73)	0.653
Other significant factors						
No diabetes						
No	Reference		Reference			
Yes	1.88 (1.30-2.71)	0.001	1.92 (1.23-2.99)	0.004		
Did not smoke						
No	Reference		Reference			
Yes	1.27 (1.03-1.58)	0.026	1.40 (1.06-1.85)	0.017		
Antenatal visits >=7 times						
No	Reference		Reference			
Yes	1.40 (1.09-1.80)	0.009	1.77 (1.27-2.45)	0.001		
Normal birthweight (>=2500g)						
No					Reference	
Yes					2.30 (1.25-4.23)	0.007
Term birth (gestatitional age>=37 weeks)						
No			Reference			
Yes			1.73 (1.13-2.65)	0.012		
Preterm birth category (gestational age, weeks)						
<34	Reference	-				
34-36	1.44 (0.63-3.30)	0.387				
37 and over	2.28 (1.09-4.75)	0.028				
Had attended preschool						
No	Reference		Reference			
Yes	1.59 (1.09-2.32)	0.016	1.88 (1.17-3.00)	0.009		
Parents/Caregiver had finished school						
No	Reference		Reference			
Yes	1.52 (1.24-1.86)	<0.0005	1.79 (1.40-2.29)	<0.0005		
Parents/Caregiver being employed						
No	Reference				Reference	
Yes	1.89 (1.36-2.63)	<0.0005			2.23 (1.50-3.30)	<0.0005
English as first language						
No	Reference		Reference		Reference	
Yes	2.50 (1.93-3.24)	<0.0005	2.00 (1.41-2.85)	<0.0005	2.64 (1.72-4.03)	<0.0005
Average number of persons per bedroom≤1.7						
No					Reference	
Yes					2.61 (1.13-6.01)	0.024

Derived Aboriginal status of this NHMRC project
^ Index of Relative Socio-Economic Disadvantage (IRSD) from ABS

diabetes', 'did not smoke during pregnancy' and 'antenatal visit >=7 times'. Also, the only perinatal health covariate found to be associated with positive development was 'full-term birth' (i.e. 37 weeks and over). Among the socioeconomic and other covariates, 'having attended preschool' was associated with on track outcomes, as were the primary caregivers having finished school and that they were employed, all producing adjusted odds ratios > 1.50. Among the quintiles of the IRSD, quintile 3 and quintile 1 (the least disadvantaged) showed significant associations with positive development. In terms of levels of geographic remoteness, both the remote and outer regional categories were significantly associated with positive development. Finally, having English as a first language was the strongest of all predictors able to be investigated (adjusted OR = 2.50).

Non-Aboriginal children

Eight covariates with non-significant associations ($p > 0.25$) in the unadjusted analysis were excluded from the multivariate analysis and 11 covariates were retained in the final model. With the exception of the primary carer's employment and Aboriginal status, these were the same covariates as the ones retained in the final model for all (i.e. Aboriginal and non-Aboriginal) children (see Table 4.3 below and also Table 4.A.5 in the Appendix).

Aboriginal children

There were fewer covariates predicting positive development in the Aboriginal only analysis, with just eight retained in the final model (see Table 4.3 below and also Table 4.A.6 in the Appendix). As was the case for non-Aboriginal children, female gender and the age group of 5.5–6 years were significantly associated with positive outcomes. 'Full-term birth' also proved to be a significant predictor. Among socioeconomic and other factors, the primary caregiver being employed was significantly associated with positive development. Among the IRSD quintiles, only Quintile 3 showed a significant association with on track outcomes. While none of the levels of geographic remoteness were significant predictors of a positive development outcome, having 'English as a first language' was. Finally, the strongest predictor of children having a positive development outcome was living in a community where housing over-crowding was not a problem (as represented by the average number of persons per bedroom ≤ 1.7). These children were more than two and a half times more likely (adjusted OR = 2.61) to have on track scores across all five AEDC domains.

4.5 'Overcoming the odds' communities with better than expected AEDC outcomes

As reported in earlier sections of this chapter, there is a clear association between socioeconomic status (SES) and children's developmental outcomes at age 5. Children living in communities in the most disadvantaged quintiles of IRSD were significantly associated with developmental vulnerability while the least disadvantaged quintiles were associated with on track developmental outcomes. This association has also been demonstrated in other Australian studies (Brinkman et al. 2012; Edwards 2005; Najman et al. 2004; Malacova et al. 2009) and overseas (Santos et al. 2012; Bradley and Corwyn 2002; Janus and Duku 2007; Malacova et al. 2009).

In recent years, researchers have begun investigating exceptions to such associations, especially the communities where child development results are found to be better than would be expected based on their socioeconomic status. As a part of the Kids in Communities Study (KICS), Goldfield et al. (2015) analysed national AEDC data to identify such 'off-diagonal' communities. The identification of these communities has enabled investigation of the community-level or neighbourhood-level factors (in contrast to the usually investigated individual-level factors) that affect child development and especially those that are potentially amenable to change. Gregory and co-authors (2015) have also recently been commissioned by the South Australian Government to conduct a similar study to identify 'off-diagonal' communities, using both AEDC and National Assessment Program – Literacy and Numeracy (NAPLAN) data.

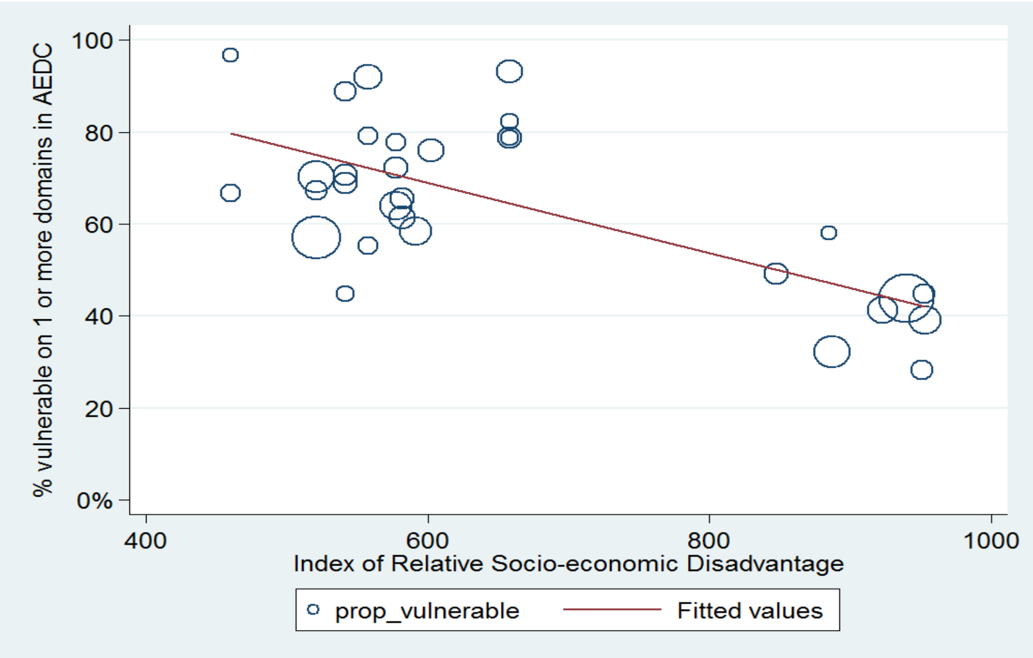
In this part of the study, we applied three different models on a selection of community-level variables regarding SES and remoteness to identify 'off-diagonal communities' and discussed their implications for programs and policies concerning early childhood development.

4.5.1. Analytic methods

In order to identify communities where the results of child development were better than should be expected according to the average SES of individual communities, we merged the AEDC dataset with the data on the IRSD of SEIFA (used as the proxy for SES) and ARIA+ (i.e. the level of accessibility/remoteness) obtained from the ABS. For the IRSD, higher scores represent lower socioeconomic disadvantage, and hence higher SES.

The initial sample size after the merging was 6,292. As performed in section 4.3, we excluded children with special needs first (n = 340), and then children with missing data in the variable 'dv1', a dichotomous variable from the AEDC dataset with dv1 = 1 representing the result of 'being vulnerable on one or more domains of AEDC' (n = 395). The proportion of children who were assessed to be developmentally vulnerable on one or more AEDC domains (named the proportion of vulnerability henceforth) was calculated for each community. The community names were based on the variable 'lcslaname' of the AEDC dataset. They were matched to the geographical unit of SA2 or SLA in the ABS data (the details of the matching method are described in Chapter 6). In total, there were 79 NT communities identified in the AEDC dataset.

Figure 4.1 Percentage of children developmentally vulnerable by SES and community, AEDC 2009 and 2012, NT



We explored three models of identifying 'off-diagonal' communities. The first model followed the method used in the study by Gregory et al. (2015). A simple linear regression was performed to determine the association between the two variables, and a regression line fitted to the scatter plot to indicate this association. The corresponding value on this regression line for each community represents the expected proportion of vulnerability based on predicted association in the linear regression. The difference between the actual and the expected proportions was calculated (as the residual of the regression model). Those communities where AEDC vulnerability was 3% or more lower than expected were considered to be 'better than expected' off-diagonal communities.

Model 2 included several relevant community-level covariates in the regression model. The ARIA+ index, 'average household size' and 'average persons per bedroom' were included in the regression model to control for their effects and enhance the variance captured by the model. Finally, to improve the estimation of the association between the proportion of AEDC vulnerability and SES, Model 3 employed a multi-level regression in which the ARIA+ index was used as a 'level' variable with all other variables from Model 2 included as covariates.

In all three models, we excluded communities with IRSD scores > 960 (approximately the top two quintiles) as the advantaged nature of these communities made them irrelevant to the investigation of communities in adversity performing better than expected. Also, communities with less than 30 children assessed in the AEDC 2009 and 2012 were also excluded on the basis of their small numbers.

4.5.2. Results

The distribution of proportion of vulnerability against IRSD scores was displayed in Figure 4.1 (above). Each circle in this chart represents an individual SLA in the NT and their circle size is in proportion to the number of children whose AEDC scores were used in the analysis. Circles above the red fitted regression line represent SLAs where the proportion of vulnerability was higher than would be expected whereas those below the regression line indicates lower than expected observed proportion of vulnerability. While we have suppressed the names of these SLA areas for confidentiality reasons, it is of note that the upper left hand group of SLA areas are all remote Aboriginal communities, while the group on the lower right hand side are urban communities and suburbs; the residents of which are predominantly non-Aboriginal. It is also obvious that the proportion of circles that deviate considerably far away from the regression line is higher in the upper left hand group.

Table 4.4 Number of SLAs with less than expected proportions of AEDC developmental vulnerability

Category	Model 1	Model 2	Model 3
Number of SLA areas identified	15	12	7
Very remote	11	10	5
Remote	0	0	0
Outer regional	4	2	2

The number of such off-diagonal SLAs by remoteness levels is summarised in Table 4.4 (above). This shows that as the model becomes more comprehensive from Model 1 to Model 3, the total number of SLAs identified decreased from 15 to 12 and then to 7. In the most comprehensive model (Model 3), only 7 areas remained, including 5 very remote ones and 2 outer regional ones. These 2 outer regional areas appeared in all 3 models and are both areas with high proportions of the urban-dwelling NT Aboriginal population.

4.6 Discussion

A key finding from the multivariable regression analysis for all NT born children, was that when Aboriginal status was included as a covariate, it had no significant effect as a predictor of AEDC developmental vulnerability once the effect of the other covariates in the model was taken into account. In other words, the main influences predicting children's developmental outcome were their experiences of early life health and sociodemographic factors, regardless of their Aboriginal or non-Aboriginal status.

This is comparable to a similar finding from an earlier study by Guthridge et al. (2016) based on the NT's 2009 AEDC assessment data. They found the likelihood of Aboriginal children scoring as developmentally vulnerable reduced from almost seven times more likely (OR = 6.9) to less than twice as likely (OR = 1.7) once adjustment was made for the effect of other covariates. They also found that more than half of the difference in the AEDC outcomes of Aboriginal and non-Aboriginal children was explained by potentially modifiable early health and sociodemographic factors. A possible reason for the current study showing an even stronger relative influence of health and sociodemographic factors, is that it employed a larger sample size (n = 3,630 vs n = 1,922) and used data from both the 2009 and 2012 AEDC cycles.

At the same time, it is also evident that Aboriginal children are much more likely to have greater exposure to the early life health and socioeconomic factors assessed by the covariates in the model. The subsequent regression analyses conducted separately for Aboriginal and non-Aboriginal children were therefore undertaken to 'tease out' how their differing exposure to these early life circumstances was related to their AEDC outcomes. This also enabled an investigation of the relative importance of these factors for Aboriginal and non-Aboriginal children in shaping their developmental outcomes at the age of five years.

In the non-Aboriginal regression modelling for developmental vulnerability, none of the perinatal heath and hospitalisation covariates were significant and were therefore dropped from the final model. However, in the final model, the same maternal and socioeconomic covariates had significant effects as was the case in the model for all children. Of particular note, was the finding that non-Aboriginal children who 'did not attend preschool' were 1.78 times more likely to be developmentally vulnerable on their entry to full-time school. This has important implications for policy in highlighting the developmental and school readiness benefits of children's access to and their level of participation in preschool.

With regard to the regression analysis conducted separately for Aboriginal children regarding developmental vulnerability, both male gender and the child's age at the time of their AEDC assessment had similar significant predictive associations as the model for non-Aboriginal children. None of the maternal covariates showed significant association for Aboriginal children, but importantly, a number of perinatal covariates did, which was not the case for non-Aboriginal children. Most particularly, 'preterm birth' (< 37 weeks gestational age) and having two or more hospitalisations due to infection were significantly associated with developmental vulnerability. The other covariates showing significant associations for Aboriginal children only, were primary caregiver's being unemployed, having socioeconomic status (IRSD) in the 4th quintile (the second most disadvantaged), and living in remote and very remote areas. Importantly, having 'ESL' was a strong predictor for developmental vulnerability for both non-Aboriginal and Aboriginal children—effectively doubling the likelihood of developmental vulnerability on entry to school.

The finding regarding the number of hospitalisations due to infection (≥ 2) being significantly associated with developmental vulnerability has important implications for public and primary health service delivery. Reducing Aboriginal children's susceptibility to infections and their high rates of associated hospitalisation requires concerted program effort across several service sectors including primary health care, nutrition programs, environmental health and housing programs. While the health benefits of such programs are well understood, their longer-term benefits for children's development and opportunities for educational success also require greater policy recognition.

The differences between Aboriginal and non-Aboriginal children in the factors most salient in their association with vulnerable early childhood outcomes have important implications for the targeting of policy and programs to enable more equitable developmental outcomes. They also highlight the extent to which Aboriginal children's greater exposure to multiple adversities in early life is associated with their developmental readiness for school learning. This is important given the evidence in the literature concerning the extent to which AEDC outcomes are associated with children making a more successful transition into formal schooling and their longer-term educational outcomes (Goldfeld et al, 2016). This suggests the need for greater policy emphasis on addressing underlying issues of socioeconomic disadvantage and early child health—especially in more remote communities.

The Aboriginal specific finding concerning children having ESL being almost twice as likely to score on the developmentally vulnerable range on the AEDC also has important implications for policy and service design. It highlights the need for these children to have access to special language and learning support before, during and after their transition to full-time school to facilitate them achieving their full educational potential.

The findings from the analysis investigating factors associated with children being developmentally on track across all five AEDC domains have relevance for universally delivered services to improve the outcomes of all children. The 'protective' factors found to be most significant for all children were essentially the same as those typically reported in other Australian longitudinal studies e.g. female gender, non-Aboriginal status, having attended preschool, mother not smoking during pregnancy, and mother having more than seven antenatal health checks.

However, when the data were analysed separately for the Aboriginal and non-Aboriginal subpopulations, a number of other factors stood out as being of particular benefit for the positive development of Aboriginal children. They included 'full-term birth' (adjusted OR = 2.1), the primary caregiver being employed (adjusted OR = 3.1), higher socioeconomic status (adjusted OR = 1.9), having English as a first language (adjusted OR = 1.9) and having no housing over-crowding (adjusted OR = 2.61).

These findings on the positive development of Aboriginal children highlight the need for more targeted investment in preventive services, e.g. enabling better access to and use of antenatal health care, programs to ensure pregnant women have adequate nutrition, and interventions to prevent smoking and alcohol use in pregnancy. As also discussed in the section on the investigation for vulnerable outcomes above, these findings highlight the need for early language support being available from an early age for Aboriginal children (e.g. in preschool), and especially those who do not having English as their first language. They also provide further evidence for the critical importance of adequate housing for children's healthy development.

The analysis reported in the final section of the chapter concerning communities/areas where children were 'overcoming the odds' in achieving better developmental outcomes has important implications—both for policy and future research. It is the first such attempt to describe the numbers of children and the level of remoteness of 'off-diagonal' communities in the NT. These communities should be the focus of future in-depth, qualitative studies to identify the key factors enabling better (or worse) developmental outcomes (e.g. local factors such as service availability and coordination, community engagement and participation, and community leadership). Better understanding of these facilitating (or impeding) factors would assist the formulation of better policy and programs as well as local initiatives to improve child development in other communities.

The extent to which the AEDC outcomes vary between communities and areas of the NT highlights the need for a more differentiated approach to service delivery. The AEDC's community-level findings offer a potentially useful metric which could be used to inform a 'needs-based' approach to service planning and application of the principle of 'proportionate universalism' i.e. services being universal, not targeted, but with a scale and intensity that is proportionate to the level of disadvantage (Meghit et al, 2010). This is also consistent with the recent policy emphasis on the need for 'place-based' interventions and improving local service coordination.

The research team will discuss the implications of the findings reported in this chapter with relevant NT and Australian government departments and NT community organisations, with a view to advancing understanding of key factors shaping early child development, and the opportunities they suggest for policy, service planning and community action to improve outcomes.

4.7 References

Australian Government Department of Education and Training. 2015. *Australian Early Development Census – National Report 2015* (Australian Government Department of Education and Training: Canberra, ACT).

Commonwealth of Australia. 2016. *AEDC Data Dictionary* (Commonwealth of Austalia: Canberra, ACT).

Bendel, R. B., and A. A. Afifi. 1977. 'Comparison of stopping rules in forward regression', *Journal of the American Statistical Association*, 72.

Bradley, R. H., and R. F. Corwyn. 2002. 'Socioeconomic status and child development', *Annu Rev Psychol*, 53: 371-99.

Brinkman, S, Angela Gialamas, Azizur Rahman, Murthy N Mittinty, Tess A Gregory, Sven Silburn, Sharon Goldfeld, Stephen R Zubrick, Vaughan Carr, and Magdalena Janus. 2012. 'Jurisdictional, socioeconomic and gender inequalities in child health and development: analysis of a national census of 5-year-olds in Australia', *BMJ open*, 2: doi:10.1136/bmjopen-2012-001075.

Bursac, Zoran, C. Heath Gauss, David Keith Williams, and David W. Hosmer. 2008. 'Purposeful selection of variables in logistic regression', *Source Code for Biology and Medicine*, 3: 17.

Centre on the developing child. 2010. *The foundations of lifelong health are built in early childhood. Retrieved from* www.developingchild.harvard.edu (Centre on the Developing Child, Harvard University).

Chittleborough, Catherine R, Amelia K Searle, Lisa G Smithers, Sally Brinkman, and John W Lynch. 2016. 'How well can poor child development be predicted from early life characteristics?: A whole-of-population data linkage study', *Early Childhood Research Quarterly*, 35: 19-30.

D'Angiulli, Amedeo, William Warburton, Susan Dahinten, and Clyde Hertzman. 2009. 'Population-level associations between preschool vulnerability and grade-four basic skills', *PloS one*, 4: e7692.

Dickson, Matt, Paul Gregg, and Harriet Robinson. 2013. "Early, late or never? When does parental education impact child outcomes?" In.: Discussion Paper Series, Forschungsinstitut zur Zukunft der Arbeit.

Edwards, B. 2005. 'Does it take a village? An investigation of neighbourhood effects on Australian children's development', *Family Matters*, 72: 36-43.

Falster, Kathleen, Louisa Jorm, Sandra Eades, John Lynch, Emily Banks, Marni Brownell, Rhonda Craven, Kristjana Einarsdóttir, Deborah Randall, and Sharon Goldfeld. 2015. 'What factors contribute to positive early childhood health and development in Australian Aboriginal children? Protocol for a population-based cohort study using linked administrative data (The Seeding Success Study)', *BMJ open*, 5: e007898.

Goldfeld, Sharon, Elodie O'Connor, Meredith O'Connor, Mary Sayers, Tim Moore, Amanda Kvalsvig, and Sally Brinkman. 2016. 'The role of preschool in promoting children's healthy development: Evidence from an Australian population cohort', *Early Childhood Research Quarterly*, 35: 40-48.

Goldfeld, Sharon, Mary Sayers, Sally Brinkman, Sven Silburn, and Frank Oberklaid. 2009. 'The process and policy challenges of adapting and implementing the Early Development Instrument in Australia', *Early Education and Development*, 20: 978-91.

Goldfeld, Sharon, Geoffrey Woolcock, Ilan Katz, Robert Tanton, Sally Brinkman, Elodie O'Connor, Talya Mathews, and Billie Giles-Corti. 2015. 'Neighbourhood effects influencing early childhood development: Conceptual model and trial measurement methodologies from the kids in communities study', *Social Indicators Research*, 120: 197-212.

Gregory, T., B. Keech, A. Sincovich, and S. Brinkman. 2015. *Thriving in Adversity: Identification of off-diagonal South Australian communicates using AEDC and NAPLAN data. Government Report* (South Australia Department for Education and Child Development: Adelaide).

Guthridge, Steven, Lin Li, Sven Silburn, Shu Qin Li, John McKenzie, and John Lynch. 2016. 'Early influences on developmental outcomes among children, at age 5, in Australia's Northern Territory', *Early Childhood Research Quarterly*, 35: 124-34.

Hertzman, C., and R. Williams. 2009. 'Making early childhood count', *CMAJ*, 180: 68-71.

Hillemeier, Marianne M, Paul L Morgan, George Farkas, and Steven A Maczuga. 2011. 'Perinatal and socioeconomic risk factors for variable and persistent cognitive delay at 24 and 48 months of age in a national sample', *Maternal and child health journal*, 15: 1001-10.

Janus, Magdalena, and Eric Duku. 2007. 'The school entry gap: Socioeconomic, family, and health factors associated with children's school readiness to learn', *Early Education and Development*, 18: 375-403.

Lynch, John W, Catherine Law, Sally Brinkman, Catherine Chittleborough, and Michael Sawyer. 2010. 'Inequalities in child healthy development: some challenges for effective implementation', *Social Science & Medicine*, 71: 1244-48.

Malacova, Eva, Jianghong Li, Eve Blair, Eugen Mattes, Nicholas de Klerk, and Fiona Stanley. 2009. 'Neighbourhood socioeconomic status and maternal factors at birth as moderators of the association between birth characteristics and school attainment: a population study of children attending government schools in Western Australia', *Journal of epidemiology and community health*, 63: 842-49.

Mickey, J., and S. Greenland. 1989. 'A study of the impact of confounder-selection criteria on effect estimation', *American Journal of Epidemiology*, 129.

Moore, T. 2006. *Early childhood and long term development: the important of the early years* (Australian Research Alliance for Children & Youth: West Perth, WA).

Najman, J. M., R. Aird, W. Bor, M. O'Callaghan, G. M. Williams, and G. J. Shuttlewood. 2004. 'The generational transmission of socioeconomic inequalities in child cognitive development and emotional health', *Soc Sci Med*, 58: 1147-58.

Odd, David E, Finn Rasmussen, D Gunnell, Glyn Lewis, and Andy Whitelaw. 2008. 'A cohort study of low Apgar scores and cognitive outcomes', *Archives of Disease in Childhood-Fetal and Neonatal Edition*, 93: F115-F20.

Quigley, Maria A, Gry Poulsen, Elaine Boyle, Dieter Wolke, David Field, Zarko Alfirevic, and Jennifer J Kurinczuk. 2012. 'Early term and late preterm birth are associated with poorer school performance at age 5 years: a cohort study', *Archives of Disease in Childhood-Fetal and Neonatal Edition*, 97: F167-F73.

Santos R, Brownell M, Ekuma O, Mayer T, and Soodeen R. 2012. *The early development instrument (EDI) in Manitoba: linking socioeconomic adversity and biological vulnerability at birth to chidren's outcomes at age 5* (Manitoba Centre for Health Policy: Winnipeg, MB).

Smithers, Lisa G, John W Lynch, Seungmi Yang, Mourad Dahhou, and Michael S Kramer. 2013. 'Impact of neonatal growth on IQ and behavior at early school age', *Pediatrics*, 132: e53-e60.

StataCorp. 2015. *Stata Statistical Software: Release 14* (StataCorp LP: College Station, TX).

Stuart, Andrea, Petra Otterblad Olausson, and Karin Källen. 2011. 'Apgar scores at 5 minutes after birth in relation to school performance at 16 years of age', *Obstetrics & Gynecology*, 118: 201-08.

Carey G, Crammond B and De Leeuw E. 2015 Towards health equity: a framework for the application of proportionate universalism. *International Journal for Equity in Health*. 14:81.

4.8 Appendices

Table 4.A.1 Results of univariate and multivariate logistic regressions on early childhood factors that may be associated with developmental vulnerability in one or more domains in AEDC 2009 and 2012, All children (i.e. both Aboriginal and non-Aboriginal), NT

Selected factors	All children (n = 3,630)					
	Vulnerable/Not vulnerable	% Missing (of 3,630)	Crude OR (95% CI)	P-unadj	Adjusted OR (95% CI) (n = 2,711)	P-adj
Demographic factors						
Sex of child		0.0				
Female	695/1,096		Reference			
Male	958/881		1.71 (1.50–1.96)	< 0.0005	2.07 (1.72–2.49)	< 0.0005
Aboriginal status#		0.0				
Non-Aboriginal	391/1,281		Reference			
Aboriginal	1,262/696		5.94 (5.13–6.88)	< 0.0005	1.217 (0.99–1.61)	0.057
Age of child at AEDC		0.0				
5y7m–6y	444/626		Reference		Reference	
5y and under	293/391		1.06 (0.87–1.28)	0.579	1.42 (1.08–1.86)	0.011
5y1m–5y6m	783/918		1.20 (1.03–1.40)	0.019	1.43 (1.16–1.78)	0.001
6y1m–7y6m	133/42		4.46 (3.09–6.44)	< 0.0005	2.28 (1.36–3.84)	0.002
Maternal & pregnancy factors						
Mother < 20 years old		0.0				
No	1,261/1,797		Reference		Reference	
Yes	392/180		3.10 (2.56–3.76)	< 0.0005	1.51 (1.13–2.00)	0.005
Diabetes		0.0				
No	1,497/1,848		Reference		Reference	
Yes	156/129		1.49 (1.17–1.90)	0.001	1.72 (1.22–2.41)	0.002
Hypertension		0.0				
No	1,593/1,934		Reference			
Yes	60/43		1.69 (1.14–2.52)	0.009	-	-
STI during pregnancy		0.0				
No	1,501/1,915		Reference			
Yes	152/62		3.13 (2.31–4.23)	< 0.0005	-	-
Smoking		8.4				
No	805/1,339		Reference		Reference	
Yes	646/535		2.01 (1.74–2.32)	< 0.0005	1.23 (1.01–1.51)	0.041
Alcohol consumption		17.7				
No	1,130/1,504		Reference			
Yes	175/180		1.29 (1.04–1.62)	0.023	-	-
Antenatal visits < 7 times		1.3				
No	1,084/1,619		Reference		Reference	
Yes	532/347		2.29 (1.96–2.68)	< 0.0005	1.51 (1.21–1.89)	< 0.0005
Plurality, twin		0.0				
No	1,620/1,925		Reference			
Yes	33/52		0.75 (0.49–1.17)	0.210	-	-
Parity		0.0				
0–1	956/1,340		Reference			
2–3	502/517		1.36 (1.17–1.58)	< 0.0005	-	-
≥ 4	195/120		2.28 (1.79–2.90)	< 0.0005	-	-
Perinatal factors						
Antepartum haemorrhage		0.0				
No	1,624/1,950		Reference			
Yes	29/27		1.29 (0.76–2.19)	0.345	-	-
Emergency CS		0.0				
No	1,370/1,654		Reference			
Yes	283/323		1.06 (0.89–1.26)	0.529	-	-
Fetal distress		0.0				
No	1,467/1,770		Reference			
Yes	186/207		1.08 (0.88–1.34)	0.450	-	-
APGAR score at 5 min < 9		0.0				
No	1,619/1,955		Reference			
Yes	32/22		1.76 (1.02–3.03)	0.043	-	-
Resuscitation at delivery		0.0				
No	721/915		Reference			
Yes	932/1,062		1.11 (0.98–1.27)	0.108	-	-

Low birthweight (< 2,500 g)		0.0				
No	1,446/1,825		Reference			
Yes	207/152		1.72 (1.38–2.14)	< 0.0005	-	-
Preterm birth (gestational age < 37 weeks)		0.0				
No	1,418/1,824		Reference		-	-
Yes	235/153		1.98 (1.59–2.45)	< 0.0005	-	-
Preterm birth category (gestational weeks)		0.0				
37 and over	1,418/1,824		Reference			
34–36	170/115		1.90 (1.49–2.43)	< 0.0005	-	-
< 34	65/38		2.20 (1.47–3.30)	< 0.0005	-	-
Admitted to special care nursery		1.07				
No	1,282/1,639		Reference			
Yes	363/307		1.51 (1.28–1.79)	< 0.0005	-	-
Long hospital stay at birth (≥ 9 days)		0.0				
No	1,429/1,811		Reference			
Yes	224/166		1.71 (1.38–2.11)	< 0.0005	-	-
Hospitalisation factors						
Number of hospitalisations		0.0				
None	352/899		Reference		Reference	
1	298/391		1.95 (1.60–2.36)	< 0.0005	1.30 (1.05–1.62)	0.039
2 and over	1,003/687		3.73 (3.19–4.36)	< 0.0005	1.30 (1.05–1.62)	0.018
Total length of hospital stay		0.0				
None	352/899		Reference			
1–9 days	640/771		2.12 (1.80–2.49)	< 0.0005	-	-
10–29 days	446/230		4.95 (4.05–6.06)	< 0.0005	-	-
30 days and over	215/77		7.13 (5.35–9.51)	< 0.0005	-	-
Number of hospitalisations due to infection		0.0				
None	768/1,424		Reference			
1	394/323		2.26 (1.91–2.68)	< 0.0005	-	-
2 and over	491/230		3.96 (3.31–4.74)	< 0.0005	-	-
Total hospitalisation days due to infection		0.0				
None	1,268/1,730		Reference			
1–9 days	204/189		2.12 (1.80–2.49)	< 0.0005	-	-
10–29 days	137/51		4.95 (4.05–6.06)	< 0.0005	-	-
30 days and over	44/7		7.13 (5.35–9.51)	< 0.0005	-	-
Socioeconomic & other factors						
Did not attend preschool		0.0				
No	1,461/1,849		Reference			
Yes	192/128		1.90 (1.50–2.40)	< 0.0005	-	-
Parents/Caregiver didn't finish school		14.0				
No	374/1,137		Reference		Reference	
Yes	947/664		4.34 (3.72–5.05)	< 0.0005	1.54 (1.25–1.90)	< 0.0005
Parents/Caregiver being unemployed		18.3				
No	773/1,598		Reference		Reference	
Yes	430/163		5.45 (4.47–6.66)	< 0.0005	2.16 (1.67–2.79)	< 0.0005
SEIFA-Disadvantage^		0.0				
Quintile 1 (least)	81/332		Reference		Reference	
Quintile 2	184/498		1.51 (1.13–2.04)	0.006	1.35 (0.97–1.88)	0.076
Quintile 3	163/398		1.68 (1.24–2.27)	0.001	1.07 (0.74–1.53)	0.728
Quintile 4	109/159		2.81 (1.99–3.96)	< 0.0005	1.79 (1.20–2.67)	0.004
Quintile 5 (most)	1,116/590		7.75 (5.96–10.08)	< 0.0005	1.83 (1.26–2.65)	0.001
Remoteness		0.0				
Outer regional	470/1,237		Reference		Reference	
Remote	249/348		1.88 (1.55–2.29)	< 0.0005	1.01 (0.77–1.33)	0.925
Very remote	934/392		6.27 (5.35–7.35)	< 0.0005	1.25 (0.89–1.77)	0.196
English as a second language		0.0				
No	522/1,500		Reference		Reference	
Yes	1,131/477		6.81 (5.89–7.89)	< 0.0005	2.29 (1.81–2.90)	< 0.0005
Average household size > 5		0.0				
No	1,366/1,835		Reference			
Yes	287/142		2.72 (2.19–3.36)	< 0.005	-	-
Average number of persons per bedroom > 1.7		0.0				
No	771/1,642		Reference			
Yes	882/335		5.61 (4.82–6.53)	< 0.0005	-	-

Derived Aboriginal status of this NHMRC project

^ Index of Relative Socio-Economic Disadvantage (IRSD) from ABS

Table 4.A.2 Results of univariate and multivariate logistic regressions on early childhood factors that may be associated with developmental vulnerability in one or more domains in AEDC 2009 and 2012, Non-Aboriginal children, NT

Potential predictors	Non-Aboriginal children (n = 1,672)					
	Vulnerable/Not vulnerable	% Missing (of 1,672)	Crude OR (95% CI)	P-unadj	Adjusted OR (95% CI) (n = 1,527)	P-adj
Demographic factors						
Sex of child		0.0				
Female	135/708		Reference		Reference	
Male	256/573		2.34 (1.85–2.97)	< 0.0005	3.16 (2.39–4.17)	< 0.0005
Age of child at AEDC		0.0				
5y7m–6y	90/391		Reference		Reference	
5y and under	93/274		1.47 (1.06–2.05)	0.02	1.56 (1.06–2.29)	0.023
5y1m–5y6m	200/604		1.44 (1.09–1.90)	0.011	1.47 (1.07–2.03)	0.018
6y1m–7y6m	8/12		2.90 (1.15–7.29)	0.024	2.00 (0.70–5.74)	0.196
Maternal & pregnancy factors						
Mother < 20 years old		0.0				
No	363/1,241		Reference		Reference	
Yes	28/40		2.39 (1.46–3.93)	0.001	2.08 (1.15–3.76)	0.016
Diabetes		0.0				
No	356/1,211		Reference		Reference	
Yes	35/70		1.70 (1.11–2.60)	0.014	1.82 (1.11–2.96)	0.017
Hypertension		0.0				
No	383/1,258		Reference			
Yes	8/23		1.14 (0.51–2.57)	0.748	-	-
STI during pregnancy		0.0				
No	383/1,269		Reference			
Yes	8/12		2.21 (0.90–5.44)	0.085	-	-
Smoking		3.4				
No	259/1,028		Reference		Reference	
Yes	116/212		2.17 (1.67–2.83)	< 0.0005	1.74 (1.26–2.39)	0.001
Alcohol consumption		13.9				
No	292/1,010		Reference			
Yes	39/98		1.38 (0.93–2.04)	0.111	-	-
Antenatal visits < 7 times		0.3				
No	315/1,145		Reference		Reference	
Yes	73/134		1.98 (1.45–2.70)	< 0.0005	2.13 (1.48–3.06)	< 0.0005
Plurality, twin		0.0				
No	375/1,245		Reference			
Yes	16/36		1.48 (0.81–2.69)	0.204	-	-
Parity		0.0				
0–1	265/957		Reference		Reference	
2–3	101/291		1.25 (0.96–1.63)	0.094	1.12 (0.82–1.53)	0.479
≥ 4	25/33		2.74 (1.60–4.68)	< 0.0005	2.08 (1.06–4.05)	0.032
Perinatal factors						
Antepartum haemorrhage		0.0				
No	387/1,266		Reference			
Yes	[< 5]/15		0.87 (0.29–2.64)	0.809	-	-
Emergency CS		0.0				
No	335/1,085		Reference			
Yes	56/196		0.93 (0.67–1.28)	0.636	-	-
Fetal distress		0.0				
No	345/1,165		Reference			
Yes	46/116		1.34 (0.93–1.92)	0.114	-	-
APGAR score at 5 min < 9		0.0				
No	389/1,271		Reference			
Yes	[< 5]/10		0.65 (0.14–3.00)	0.584	-	-
Resuscitation at delivery		0.0				
No	173/598		Reference			
Yes	218/683		1.10 (0.88–1.39)	0.398	-	-
Low birthweight (< 2,500 g)		0.0				
No	362/1,207		Reference			
Yes	29/74		1.31 (0.84–2.04)	0.239	-	-
Preterm birth (gestational age < 37 weeks)		0.0				
No			Reference			
Yes			1.56 (1.09–2.22)	0.014	-	-

Preterm birth category (gestational weeks)		0.0				
37 and over	353/1,201		Reference			
34–36	28/60		1.59 (1.00–2.53)	0.051	-	-
< 34	10/20		1.70 (0.79–3.67)	0.175	-	-
Admitted to special care nursery		1.9				
No	315/1,075		Reference			
Yes	71/179		1.35 (1.00–1.83)	0.05	-	-
Long hospital stay at birth (≥ 7 days)		0.0				
No	343/1,138		Reference			
Yes	48/143		1.11 (0.79–1.58)	0.545	-	-
Hospitalisation factors						
Number of hospitalisations		0.0				
None	171/722		Reference			
1	89/259		1.45 (1.08–1.94)	0.013	-	-
2 and over	131/300		1.84 (1.42–2.40)	< 0.0005	-	-
Total length of hospital stay						
None	171/722		Reference			
1–9 days	176/470		1.58 (1.24–2.01)	< 0.0005	-	-
10–29 days	36/72		2.11 (1.37–3.26)	0.001	-	-
30 days and over	8/17		1.99 (0.84–4.68)	0.116	-	-
Number of hospitalisations due to infection		0.0				
None	306/1,051		Reference			
1	65/160		1.40 (1.02–1.91)	0.038	-	-
2 and over	20/70		0.98 (0.59–1.64)	0.943	-	-
Total hospitalisation days due to infection		0.0				
None	355/1,162		Reference			
1–9 days	32/111		0.94 (0.63–1.42)	0.782	-	-
10–29 days	[< 5]/8		1.64 (0.49–5.47)	0.423	-	-
30 days and over	0		Omitted	-		
Socioeconomic & other factors						
Did not attend preschool		0.0				
No	364/1,217		Reference		Reference	
Yes	27/64		1.41 (0.87–2.25)	0.147	1.78 (1.03–3.06)	0.038
Parents/Caregiver didn't finish school		3.9				
No	222/958		Reference		Reference	
Yes	149/278		2.31 (1.81–2.96)	< 0.0005	1.98 (1.48–2.65)	< 0.0005
Parents/Caregiver being unemployed		4.8				
No	326/1,197		Reference		Reference	
Yes	37/32		4.25 (2.60–6.92)	< 0.0005	3.21 (1.80–5.72)	< 0.0005
SEIFA-Disadvantage^		0.0				
Quintile 1 (least)	66/294		Reference		Reference	
Quintile 2	118/401		1.31 (0.94–1.84)	0.115	1.28 (0.87–1.88)	0.204
Quintile 3	73/283		1.15 (0.79–1.66)	0.463	1.10 (0.71–1.70)	0.660
Quintile 4	52/106		2.19 (1.43–3.35)	< 0.0005	1.82 (1.11–2.99)	0.018
Quintile 5 (most)	82/197		1.85 (1.28–2.69)	0.001	1.99 (1.23–3.22)	0.005
Remoteness		0.0				
Outer regional	298/978		Reference		Reference	
Remote	64/222		0.95 (0.70–1.29)	0.724	0.71 (0.47–1.06)	0.096
Very remote	29/81		1.17 (0.75–1.83)	0.476	0.97 (0.53–1.80)	0.934
English as a second language		0.0				
No	322/1,173		Reference		Reference	
Yes	69/108		2.33 (1.68–3.23)	< 0.0005	2.19 (1.48–3.25)	< 0.0005
Average household size > 5		0.0				
No	375/1,254		Reference			
Yes	16/27		1.98 (1.06–3.72)	0.033	-	-
Average number of persons per bedroom > 1.7		0.0				
No	367/1,229		Reference			
Yes	24/52		1.55 (0.94–2.54)	0.086	-	-

^ Index of Relative Socio-Economic Disadvantage (IRSD) from ABS

Table 4.A.3 Results of univariate and multivariate logistic regressions on early childhood factors that may be associated with positive development in one or more domains in AEDC 2009 and 2012, Aboriginal children, NT

Potential predictors	Aboriginal children (n = 1,958)					
	Vulnerable / Not vulnerable	% Missing (of 1,958)	Crude OR (95% CI)	P-unadj	Adjusted OR (95% CI) (n = 1,372)	P-adj
Demographic factors						
Sex of child		0.0				
Female	560/388		Reference		Reference	
Male	702/308		1.58 (1.31–1.90)	< 0.0005	1.61 (1.26–2.05)	< 0.0005
Age of child at AEDC		0.0				
5y7m–6y	354/235		Reference		Reference	
5y and under	200/117		1.13 (0.86–1.50)	0.379	1.49 (1.02–2.17)	0.037
5y1m–5y6m	583/314		1.23 (0.99–1.53)	0.056	1.39 (1.05–1.85)	0.02
6y1m–7y6m	125/30		2.77 (1.80–4.26)	< 0.0005	1.95 (1.13–3.37)	0.017
Maternal & pregnancy factors						
Mother < 20 years old		0.0				
No	898/556		Reference			
Yes	364/140		1.61 (1.29–2.01)	< 0.0005	-	-
Diabetes		0.0				
No	1,141/637		Reference			
Yes	121/59		1.15 (0.83–1.59)	0.416	-	-
Hypertension		0.0				
No	1,210/676		Reference			
Yes	52/20		1.45 (0.86–2.45)	0.163	-	-
STI during pregnancy		0.0				
No	1,118/646		Reference			
Yes	144/50		1.66 (1.19–2.33)	0.003	-	-
Smoking		12.7				
No	546/311		Reference			
Yes	530/323		0.93 (0.77–1.14)	0.500	-	-
Alcohol consumption		20.8				
No	838/494		Reference			
Yes	136/82		0.98 (0.73–1.31)	0.881	-	-
Antenatal visits < 7 times		2.2				
No	769/474		Reference			
Yes	459/213		1.33 (1.09–1.62)	0.005	-	-
Plurality, twin		0.0				
No	1,245/680		Reference			
Yes	17/16		0.58 (0.29–1.16)	0.122	-	-
Parity		0.0				
0–1	691/383		Reference			
2–3	401/226		0.98 (0.80–1.21)	0.874	-	-
≥ 4	170/87	a	1.08 (0.81–1.44)	0.586	-	-
Perinatal factors						
Antepartum haemorrhage		0.0				
No	1,237/684		Reference			
Yes	25/12		1.15 (0.58–2.31)	0.690	-	-
Emergency CS		0.0				
No	1,035/569		Reference			
Yes	227/127		0.98 (0.77–1.25)	0.886	-	-
Fetal distress		0.0				
No	1,122/605		Reference			
Yes	140/91		0.83 (0.63–1.10)	0.194	-	-
APGAR score at 5 min < 9		0.1				
No	1,230/684		Reference			
Yes	30/12		1.39 (0.71–2.73)	0.339	-	-
Resuscitation at delivery		0.0				
No	548/317		Reference			
Yes	714/379		1.09 (0.90–1.31)	0.365	-	-
Low birthweight (< 2,500 g)		0.0				
No	1,065/623		Reference			
Yes	197/73		1.30 (0.98–1.73)	0.069	-	-
Preterm birth (gestational age < 37 weeks)		0.0				
No	1,065/623		Reference		Reference	
Yes	197/73		1.58 (1.19–2.10)	0.002	1.88 (1.27–2.79)	0.002
Preterm birth category		0.0				

(gestational age, weeks)						
37 and over	1,065/623		Reference			
34–36	142/55		1.51 (1.09–2.09)	0.013	-	-
< 34	55/18		1.79 (1.04–3.07)	0.035	-	-
Admitted to special care nursery		0.4				
No	967/564		Reference			
Yes	292/128		1.33 (1.05–1.68)	0.016		
Long hospital stay at birth (≥ 10 days)		0.0				
No	1,099/629		Reference			
Yes	163/67		1.39 (1.03–1.88)	0.031	-	-
Hospitalisation factors						
Number of hospitalisations		0.0				
None	181/177		Reference			
1	209/132		1.55 (1.15–2.09)	0.004	-	-
2 and over	872/387		2.20 (1.73–2.80)	< 0.0005	-	-
Total length of hospital stay		0.0				
None	18/177		Reference			
1–9 days	464/301		1.51 (1.17–1.94)	0.001	-	-
10–29 days	410/158		2.54 (1.92–3.35)	< 0.0005	-	-
30 days and over	207/60		3.37 (2.37–4.81)	< 0.0005	-	-
Number of hospitalisations due to infection		0.0				
None	462/373		Reference		Reference	
1	329/163		1.63 (1.29–2.06)	< 0.0005	1.10 (0.81–1.50)	0.524
2 and over	471/160		2.38 (1.90–2.98)	< 0.0005	1.40 (1.03–1.91)	0.034
Total length of stay for hospitalisations due to infection		0.0				
None	913/568		Reference			
1–9 days	172/78		1.37 (1.03–1.83)	0.031	-	-
10–29 days	133/43		1.92 (1.34–2.76)	< 0.0005	-	-
30 days and over	44/7		3.91 (1.75–8.74)	0.001	-	-
Socioeconomic & other factors						
Did not attend preschool		0.0				
No	1,097/632		Reference			
Yes	165/64		1.49 (1.10–2.01)	0.011	-	-
Parents/Caregiver didn't finish school		22.6				
No	152/179		Reference			
Yes	798/386		2.43 (1.90–3.12)	< 0.0005	-	-
Parents/Caregiver being unemployed		29.9				
No	447/401		Reference		Reference	
Yes	393/131		2.69 (2.12–3.42)	< 0.0005	2.04 (1.56–2.65)	< 0.0005
SEIFA-Disadvantage^		0.0				
Quintile 1 (least)	15/38		Reference		Reference	
Quintile 2	66/97		1.72 (0.88–3.38)	0.114	1.68 (0.78–3.64)	0.188
Quintile 3	90/115		1.98 (1.03–3.83)	0.042	1.28 (0.59–2.78)	0.536
Quintile 4	57/53		2.72 (1.35–5.51)	0.005	2.46 (1.10–5.48)	0.028
Quintile 5 (most)	1,034/393		6.67 (3.63–12.25)	< 0.0005	2.07 (0.97–4.43)	0.062
Remoteness		0.0				
Outer regional	172/259		Reference		Reference	
Remote	185/126		2.21 (1.64–2.98)	< 0.0005	1.48 (1.00–2.18)	0.047
Very remote	905/311		4.38 (3.48–5.53)	< 0.0005	1.80 (1.14–2.85)	0.012
English as a second language		0.0				
No	200/327		Reference		Reference	
Yes	1,062/369		4.71 (3.81–5.82)	< 0.0005	2.46 (1.80–3.36)	< 0.0005
Average household size > 5		0.0				
No	991/581		Reference			
Yes	271/115		1.38 (1.09–1.76)	0.009	-	-
Average number of persons per bedroom > 1.5		0.0				
No	404/413		Reference			
Yes	858/283		3.10 (2.56–3.76)	< 0.0005	-	-

^ Index of Relative Socio-Economic Disadvantage (IRSD) from ABS

Table 4.A.4 Results of univariate and multivariate logistic regressions on early childhood factors that may be associated with positive development (scoring on track on all five AEDC domains) in 2009 and 2012, non-Aboriginal children, NT

Selected factors	Non-Aboriginal children (n = 1,676)					
	On track 5/ Not on track 5	% Missing (of 1,676)	Crude OR (95% CI)	P-unadj	Adjusted OR (95% CI) (n = 1,554)	P-adj
Demographic factors						
Sex of child		0.0				
Male	361/470		Reference		Reference	
Female	509/336		1.97 (1.62–2.40)	< 0.0005	2.16 (1.74–2.67)	
Age of child at AEDC		0.0				
5y and under	178/189		Reference		Reference	
5y1m–5y6m	406/398		1.08 (0.85–1.39)	0.526	1.07 (0.82–1.40)	
5y7m–6y	280/205		1.45 (1.10–1.90)	0.008	1.52 (1.13–2.06)	
6y1m–7y6m	6/14		0.46 (0.17–1.21)	0.115	0.64 (0.23–1.82)	
Maternal & pregnancy factors						
Mother ≥ 20 years old		0.0				
No	30/38		Reference			
Yes	840/768		1.39 (0.85–2.26)	0.191	-	
No diabetes		0.0				
No	41/64		Reference		Reference	
Yes	829/742		1.74 (1.16–2.61)	0.007	1.92 (1.23–2.99)	
No hypertension		0.0				
No	11/20		Reference			
Yes	859/786		1.99 (0.95–4.17)	0.070	-	
No STI during pregnancy		0.0				
No	11/9		Reference			
Yes	859/797		0.88 (0.36–2.14)	0.781	-	
Did not smoke		3.4				
No	136/194		Reference		Reference	
Yes	705/584		1.72 (1.35–2.20)	< 0.0005	1.40 (1.06–1.85)	
Did not drink alcohol		14.0				
No	72/66		Reference			
Yes	680/624		1.00 (0.70–1.42)	0.995	-	
Antenatal visits ≥ 7 times		0.3				
No	85/124		Reference		Reference	
Yes	784/678		1.69 (1.26–2.26)	0.001	1.77 (1.27–2.45)	
Plurality, twin		0.0				
Yes	22/30		Reference			
No	848/776		1.49 (0.85–2.61)	0.162	-	
Parity		0.0				
≥ 4	22/36		Reference			
2–3	194/200		1.59 (0.90–2.80)	0.110	-	
0–1	654/570		1.88 (1.09–3.23)	0.023	-	
Perinatal factors						
No antepartum haemorrhage		0.0				
No	9/10		Reference			
Yes	861/796		1.20 (0.49–2.97)	0.691	-	
No emergency CS		0.0				
No	126/126		Reference			
Yes	744/680		1.09 (0.84–1.43)	0.511	-	
No fetal distress		0.0				
No	81/82		Reference			
Yes	789/724		1.10 (0.80–1.52)	0.551	-	
APGAR score at 5 min ≥ 9		0.0				
No	6/7		Reference			
Yes	864/799		1.26 (0.42–3.77)	0.677	-	
No resuscitation at delivery		0.0				
No	446/457		Reference			
Yes	424/349		1.24 (1.03–1.51)	0.026	-	
No special care nursery stay		2.0				
No	111/140		Reference			
Yes	740/652		1.43 (1.09–1.88)	0.009	-	
Normal birthweight (≥ 2,500 g)		0.0				
No	41/62		Reference			

Yes	829/744		1.68 (1.12–2.53)	0.012	-
Term birth (gestational age ≥ 37 weeks)		0.0			
No	46/73		Reference		Reference
Yes	824/733		1.78 (1.22–2.61)	0.003	1.73 (1.13–2.65)
Pre-term birth category (gestational age, weeks)		0.0			-
< 34	8/22		Reference		
34–36	38/51		2.05 (0.82–5.10)	0.123	-
37 and over	824/733		3.09 (1.37–6.99)	0.007	-
No long hospital stay at birth (> 7 days)		0.0			
No	83/109		Reference		
Yes	787/697		1.48 (1.10–2.01)	0.011	-
Hospitalisation factors					
Number of hospitalisations		0.0			
2 and over	196/235		Reference		
1	167/183		1.09 (0.82–1.45)	0.533	-
None	507/388		1.57 (1.24–1.97)	< 0.0005	-
Total length of hospital stay		0.0			
30 days and over	8/17		Reference		
10–29 days	42/66		1.35 (0.54–3.41)	0.523	-
1–9 days	313/335		1.99 (0.84–4.67)	0.116	-
None	507/388		2.78 (1.19-6.50)	0.019	-
Number of hospitalisations due to infection		0.0			
2 and over	44/46		Reference		
1	99/126		0.82 (0.50–1.34)	0.431	-
None	727/634		1.20 (0.78–1.84)	0.405	-
Length of stay for hospitalisations due to infection		0.0			
30 days and over	0				
10–29 days	6/[< 5]		Reference		
1–9 days	71/78		0.61 (0.16–2.24)	0.453	-
None	793/724		0.73 (0.21–2.60)	0.627	-
Socioeconomic & other factors					
Had attended preschool		0.0			
No	38/53		Reference		Reference
Yes	832/753		1.54 (1.00–2.36)	0.048	1.88 (1.17–3.00)
Parents/Caregiver had finished school		3.9			
No	178/249		Reference		Reference
Yes	665/518		1.80 (1.44–2.25)	< 0.0005	1.79 (1.40–2.29)
Parents/Caregiver being employed		4.8			
No	25/44		Reference		
Yes	810/716		1.99 (1.21–3.29)	0.007	-
SEIFA-Disadvantage^		0.0			
Quintile 5 (most)	126/154		Reference		Reference
Quintile 4	76/83		1.12 (0.76–1.65)	0.572	1.18 (0.74–1.89)
Quintile 3	197/161		1.50 (1.09–2.05)	0.012	1.56 (1.07–2.28)
Quintile 2	263/256		1.26 (0.94–1.68)	0.126	1.26 (0.87–1.83)
Quintile 1 (least)	208/152		1.67 (1.22–2.29)	0.001	1.81 (1.22–2.68)
Remoteness		0.0			
Very remote	51/60		Reference		Reference
Remote	144/142		1.19 (0.77–1.85)	0.431	1.25 (0.74–2.11)
Outer regional	675/604		1.31 (0.89–1.94)	0.168	1.12 (0.68–1.85)
English as first language		0.0			
No	67/110		Reference		Reference
Yes	803/696		1.89 (1.38–2.61)	< 0.0005	2.00 (1.41–2.85)
Average household size ≤ 5		0.0			
No	15/28		Reference		
Yes	855/778		2.05 (1.09–3.87)	0.026	-
Average number of persons per bedroom ≤ 1.7		0.0			
No	34/43		Reference		
Yes	836/763		1.39 (0.87–2.20)	0.165	-

^Index of Relative Socio-Economic Disadvantage (IRSD) from ABS

Table 4.A.5 Results of univariate and multivariate logistic regressions on early childhood factors that may be associated with positive development (scoring on track on all five AEDC domains) in 2009 and 2012, Aboriginal children, NT

Selected factors	Non-Aboriginal children (n = 1,969)					
	On track 5/ Not on track 5	% Missing (of 1,969)	Crude OR (95% CI)	P-unadj	Adjusted OR (95% CI) (n = 1,380)	P-adj
Demographic factors						
Sex of child		0.0				
Male	90/926		Reference		Reference	
Female	184/769		2.46 (1.88–3.22)	< 0.0005	2.67 (1.91–3.73)	< 0.0005
Age of child at AEDC		0.0				
5y and under	41/276		Reference		Reference	
5y1m–5y6m	121/786		0.95 (0.78–1.14)	0.561	1.07 (0.67–1.71)	0.771
5y7m–6y	105/484		1.19 (0.97–1.45)	0.099	1.66 (1.01–2.71)	0.044
6y1m–7y6m	7/149		0.17 (0.09–0.30)	< 0.0005	0.49 (0.16–1.50)	0.21
Maternal & pregnancy factors						
Mother ≥ 20 years old		0.0				
No	56/451		Reference			
Yes	218/1,244		1.41 (1.03–1.93)	0.031	-	-
No diabetes		0.0				
No	20/160		Reference			
Yes	254/1,535		1.32 (0.82–2.15)	0.255	-	-
No hypertension		0.0				
No	9/63		Reference			
Yes	265/1,632		1.14 (0.56–2.31)	0.724	-	-
No STI during pregnancy		0.0				
No	13/182		Reference			
Yes	261/1,513		2.42 (1.36–4.30)	0.003	-	-
Did not smoke		12.7				
No	119/741		Reference			
Yes	136/722		1.17 (0.90–1.53)	0.241	-	-
Did not drink alcohol		20.90				
No	37/182		Reference			
Yes	200/1,139		0.86 (0.59–1.27)	0.455	-	-
Antenatal visits ≥ 7 times		2.2				
No	82/596		Reference			
Yes	190/1,058		1.31 (0.99–1.72)	0.06	-	-
Plurality, twin		0.0				
Yes	7/26		Reference			
No	267/1,669		0.59 (0.26–1.38)	0.227	-	-
Parity		0.0				
≥ 4	26/234		Reference			
2–3	86/542		2.12 (1.52–2.97)	< 0.0005	-	-
0–1	162/919		3.08 (2.24–4.24)	< 0.0005	-	-
Perinatal factors						
No antepartum haemorrhage		0.0				
No	7/30		Reference			
Yes	267/1,665		0.69 (0.30–1.58)	0.377	-	-
No emergency CS		0.0				
No	48/311		Reference			
Yes	226/1,384		1.06 (0.76–1.48)	0.741	-	-
No fetal distress		0.0				
No	32/201		Reference			
Yes	242/1,494		1.02 (0.68–1.51)	0.932	-	-
APGAR score at 5 min ≥ 9		0.1				
No	[< 5]/40		Reference			
Yes	271/1,653		2.19 (0.67–7.12)	0.194	-	-
No resuscitation at delivery		0.0				
No	156/945		Reference			
Yes	118/750		0.95 (0.74–1.23)	0.715	-	-
No special care nursery stay		0.4				
No	45/375		Reference			
Yes	228/1,314		1.45 (1.03–2.03)	0.033	-	-
Normal birthweight (≥ 2,500 g)		0.0				
No	28/228		Reference		Reference	

Yes	246/1,467		1.37 (0.90–2.07)	0.141	2.30 (1.25-4.23)	0.007
Term birth (gestational age ≥ 37 weeks)		0.0				
No	21/250		Reference			
Yes	253/1,445		2.08 (1.31–3.32)	0.002	-	-
Pre-term birth category (gestational age, weeks)		0.0			-	
< 34	[< 5]/69		Reference			
34–36	17/181		1.80 (0.92–3.51)	0.086	-	-
37 and over	253/1,445		3.75 (2.04–6.88)	< 0.0005	-	-
No long hospital stay at birth (> 10 days)		0.0				
No	26/204		Reference			
Yes	248/1,491		1.31 (0.85–2.01)	0.225	-	-
Hospitalisation factors						
Number of hospitalisations		0.0				
2 and over	134/1,134		Reference			
1	52/290		1.92 (1.57–2.35)	< 0.0005	-	-
None	88/271		3.75 (3.18–4.41)	< 0.0005	-	-
Total length of hospital stay		0.0				
30 days and over	16/252		Reference			
10–29 days	57/516		1.91 (1.19–3.05)	0.007	-	-
1–9 days	113/656		4.82 (3.13–7.43)	< 0.0005	-	-
None	88/271		10.12 (6.57–15.59)	< 0.0005	-	-
Number of hospitalisations due to infection		0.0				
2 and over	49/589		Reference			
1	58/435		1.91 (1.44–2.53)	< 0.0005	-	-
None	167/671		4.68 (3.70–5.91)	< 0.0005	-	-
Length of stay for hospitalisations due to infection		0.0				
30 days and over	[< 5]/42		Reference			
10–29 days	6/174		0.71 (0.22–2.30)	0.566	-	-
1–9 days	26/227		3.34 (1.17–9.55)	0.025	-	-
None	238/1,252		5.48 (1.96–15.32)	0.001	-	-
Socioeconomic & other factors						
Had attended preschool		0.0				
No	23/208		Reference			
Yes	251/1,487		1.53 (0.97–2.40)	0.066	-	-
Parents/Caregiver had finished school		22.6				
No	148/1,044		Reference			
Yes	85/247		2.43 (1.80–3.28)	< 0.0005	-	-
Parents/Caregiver being employed		29.9				
No	41/486		Reference		Reference	
Yes	178/675		3.13 (2.18–4.48)	< 0.0005	2.23 (1.50–3.30)	< 0.0005
SEIFA-Disadvantage^		0.0				
Quintile 5 (most)	116/1,320		Reference		Reference	
Quintile 4	28/82		3.84 (2.90–5.08)	< 0.0005	1.17 (0.62–2.20)	0.629
Quintile 3	61/144		5.15 (4.16–6.38)	< 0.0005	1.86 (1.10–3.13)	0.02
Quintile 2	46/119		5.02 (4.10–6.15)	< 0.0005	1.20 (0.68–2.12)	0.527
Quintile 1 (least)	23/30		7.73 (6.10–9.80)	< 0.0005	1.92 (0.92–4.00)	0.082
Remoteness		0.0				
Very remote	84/1,141		Reference		Reference	
Remote	58/253		4.55 (3.56–5.82)	< 0.0005	0.80 (0.35–1.83)	0.604
Outer regional	132/301		7.93 (6.48–9.71)	< 0.0005	1.21 (0.53–2.73)	0.653
English as first language		0.0				
No	105/1,334		Reference		Reference	
Yes	169/361		5.95 (4.54–7.79)	< 0.0005	2.64 (1.72–4.03)	< 0.0005
Average household size ≤ 5		0.0				
No	31/360		Reference			
Yes	243/1,335		2.11 (1.43–3.13)	< 0.0005	-	-
Average number of persons per bedroom ≤ 1.7		0.0				
No	70/1,080		Reference		Reference	
Yes	204/615		1.53 (0.97–2.40)	0.066	2.61 (1.1–-6.01)	0.024

^ Index of Relative Socio-Economic Disadvantage (IRSD) from ABS

5. School attendance

Vincent He, Jiunn-Yih Su, John McKenzie, and Stefanie Schurer

Chapter overview

This chapter reports the findings from the analysis of linked, de-identified education and child health data concerning student attendance in the Northern Territory (NT) government schools. It describes the patterns of attendance of Aboriginal and non-Aboriginal students in urban, remote and very remote communities, and documents the changing trends for each of these student subpopulations.

Further analysis is conducted to determine the extent to which school attendance rates are associated with individual child, family and school/community factors. The overall aim of the analyses reported in the chapter is to advance understanding of the relative importance of such factors and to identify particular factors that are potentially modifiable through targeted policy initiatives.

Because previous Australian research has shown that "disparities in attendance rates are evident from Year 1" and "are carried into, and become wider, in secondary school" (Hancock et al. 2013), the chapter has included an in-depth analysis of factors associated with the attendance of students in Year 1, which is the first year of compulsory schooling in the NT. The chapter also describes how attendance rates vary within and between school terms and across all school years, which can help in identifying critical points in the course of a student's school career that may represent opportunities for interventions to improve school attendance and retention.

5.1 Introduction

School attendance rates in the Northern Territory (NT) have historically been much lower than other Australian jurisdictions. In 2016, the rate of attendance for students in years 1 -10 enrolled in all NT schools was 82.2%, which is around 10% less than the comparable rate of 92.5% for all Australian jurisdictions (ACARA 2016).

In the first school term of 2017, the attendance of year 1 - 12 students was 90.3% for non-Aboriginal students and 69% for Aboriginal students. During this period, the average attendance of Aboriginal students varied with their community's level of geographic remoteness, and was 57.2% in very remote areas, 72.0% in remote areas and 83.7% in outer regional areas. (NT Department of Education, 2017). Community and professional concern about continuing low rates of attendance over recent years has seen a series of NT and Australian government initiatives seeking to improve school attendance. For instance, the 'Remote School Attendance Strategy' has operated in 77 remote schools in the NT and other jurisdictions since Term 1, 2014; it involves the employment of local attendance officers working with schools and counselling families to ensure children attend school regularly (Australian Government Department of Prime Minister and Cabinet 2014).

The School Enrolment and Attendance Measure (SEAM) is another associated Australian Government initiative implemented in conjunction with the NT Department of Education since 2013, and is now running in 23 remote NT communities (Australian Government Department of Human Services 2017). The program requires that all parent/carers in SEAM communities who are in in receipt of income support payments for school-aged children must ensure that their children are enrolled in school and attending regularly. Where a child is not attending regularly, the carers/parents are required to attend a conference where a school attendance plan is agreed. If then after every attempt has been made to support a child's regular attendance and they are still not attending school, a parent's income support payment can be suspended and only restored when required steps have been taken by the family within 13 weeks to ensure regular school attendance.

The NT Department of Education current attendance strategy 'Every Day Counts' involves a broader whole-of-government approach to overcome barriers to school attendance: Community safety and health, better family support, and quality early childhood services and schools (Northern Territory Department of Education 2016). It also emphasises strengthening partnerships with families, communities, schools and other agencies to supporting children's active engagement in schooling.

However, in remote community settings, where 44.2% of the NT population reside, school attendance and educational outcomes are also affected by a range of other factors such as: high teacher turnover; student mobility; teacher and program quality; families' cultural obligations; seasonal issues; housing overcrowding; and high rates of childhood illness and hearing impairment (Wilson 2014). A recent Queensland review of school attendance found that attendance was strongly affected by the economic and cultural characteristics of the particular communities in which children live (Education and Innovation Committee 2014).

Growing concern about the slow progress in meeting the 'Closing the Gap' target of the Council of Australian Government (COAG) for NAPLAN literacy and numeracy outcomes led to the Productivity Commission investigating factors that may affect the educational achievement of Aboriginal primary school students (Productivity Commission 2014). It analysed de-identified national NAPLAN achievement data and attendance data from the Australian Curriculum, Assessment and Reporting Authority (ACARA). It found that, of the student's characteristics available in the data, their socioeconomic status explained the largest amount of variation in NAPLAN achievement. Importantly, it also showed that the average attendance rate of the student's school and the proportion of Aboriginal students enrolled in the same school were also important in explaining the NAPLAN achievement for Aboriginal students.

5.2 Factors associated with year one school attendance

Our study of NT school attendance began with an investigation into whether and the extent to which individual student characteristics and socio-demographic factors were associated with school attendance for all NT-born Year 1 students attending NT governmental schools between 2005 and 2014 (N=18,440).[8]

5.2.1. Data and analysis methods

For the analysis, de-identified individual school attendance data provided by the Department of Education were linked to similarly de-identified individual perinatal and hospital records provided by the Department of Health. These individual records were also linked with community-level information sourced from publicly available Australian Bureau of Statistics (ABS) data aggregated at the level of the Statistical Local Area (SLA).

The estimation of the associations between selected factors and Year 1 school attendance rates was conducted using linear regression. The outcome variable was the student's attendance rate which was calculated as the proportion of school days attended (i.e. bound between 0 and

[8] Students with expected attendance days<50 were excluded, leaving 18,440 students for the analysis.

1). The variables in the regression model were selected based on previous Australia studies on school attendance (Hancock et al. 2013; Purdie and Buckley 2010; Biddle 2014). These variables (associated with school attendance) fell under the following 6 categories:

a) Child-specific characteristics (i.e. demographic, perinatal and perinatal characteristics, and proxy for child health status);
b) English as a Second Language;
c) Parent/carers characteristics (i.e. socioeconomic conditions)
d) Attended preschool;
e) School mobility
f) School/community characteristics.

Because of the marked differences in the socioeconomic, demographic and cultural characteristics of the NT's Aboriginal and non-Aboriginal populations, these analyses were performed separately for Aboriginal and non-Aboriginal students. Because many children were observed within the same school, the standard errors at the school level were clustered to account for these repeated observations. Associations were considered statistically significant if their likelihood of occurring by chance were estimated to be less than 5% (i.e. $p < 0.05$).

5.2.2. Results

In the final multivariable model, 11 predictor variables showed statistically significant associations with Year 1 school attendance rates for Aboriginal students, and 10 for Non-Aboriginal students. The findings are shown in Figures 5.1 below, and the full modelling results are reported at the end of the chapter in Appendix 5.A.1. The predictive power of the model was generally better for Aboriginal children than for non-Aboriginal children, as were the predicted changes associated with covariates as evidenced by greater variation in Year 1 school attendance covered in the model for Aboriginal students. The results are expressed in terms of the number of school days per year (given there was a total of 200 school days per year). The factors found to have significant association with attendance rate are listed below together with their associated expected change in school attendance (that is, the change in the number of school days attended on average when the factor was present compared with when the factor was not present, with all other covariates held constant, which is displayed in brackets):

- Living in a community with overcrowded housing, i.e. an average of more than two persons per bedroom (35 <u>fewer</u> days spent at school in a school year);
- Having attended more than 30 days of pre-school (18 <u>more</u> school days attended);
- Child's parent/carer was employed (11 <u>more</u> school attended);
- English as a second language (11 <u>fewer</u> school days attended);
- Having a parent/carer with year ten or more years of education (10 <u>more</u> school days);
- Having attended two or more schools in a school year (9 <u>fewer</u> school days);
- Living in a very remote location (6 <u>fewer</u> school days);
- Hospitalised for an infectious disease by age 5.5 years (almost 4 <u>fewer</u> school days);
- Having low-birthweight (almost 4 <u>fewer</u> school days).

The situation was different for non-Aboriginal students. Their most significant factors associated with Year 1 school attendance were:

- Living in a community with overcrowded housing (10 <u>more</u> school days per year)[9]

[9] This finding for non-Aboriginal students in very remote regions may be due to their parents usually being employed (e.g. as nurses, teachers, police) and

- Moving school within a school year was associated with almost 6 fewer school days attended
- Twin status was associated with almost 5 more school days attended
- Teenage motherhood was associated with almost 4 fewer school days
- Employed carer status was associated with almost 4 more school days
- Maternal smoking during pregnancy (3 fewer school days attended)
- Mothers who attended less than the standard seven antenatal health care visits (2 fewer school days attended).

5.3 Geographic location and predictors of attendance

While the analysis above was informative in identifying the factors predictive of Year 1 school attendance, it is equally important to understand whether and to what extent their predictive power differed by the geographic remoteness of the school. This is important, given that schools in remote and very remote areas have different resources and constraints on their capacity to cater for the needs of their student populations than schools in outer regional areas such as Darwin.

5.3.1 Data and analysis methods

A variance decomposition analytic approach was used. Firstly, the total variation explained by the variation in all observable factors (i.e. the model covariates) is calculated. This is followed by a calculation of the *percentage contribution* each of the predictor variables makes to the total explained variation in Year 1 school attendance. Also, to avoid estimating too many separate coefficients, this analysis was conducted by grouping the significant predictor variables by type (Meghit and Rivkin 2010). These variable groups were:

a) *Child-specific characteristics*: age, gender, 'born as first child', 'birth parity', birthweight, 'mother's age when child was born', 'mother's smoking status', 'more than 7 antenatal visits', 'hospitalisations due to infectious diseases before the age of 5.5 years';

b) *English as a second language;*

c) *Parent/carers characteristics*: employed vs. non-employed, completed Year 10 vs. not completed Year 10;

d) *Attended preschool;*

e) *School mobility*: attended more than one school in a school year;

f) *School/community fixed characteristics*[10] i.e. unmeasured school/community factors which are assumed to have remained essentially constant between pre-school and Year 1.

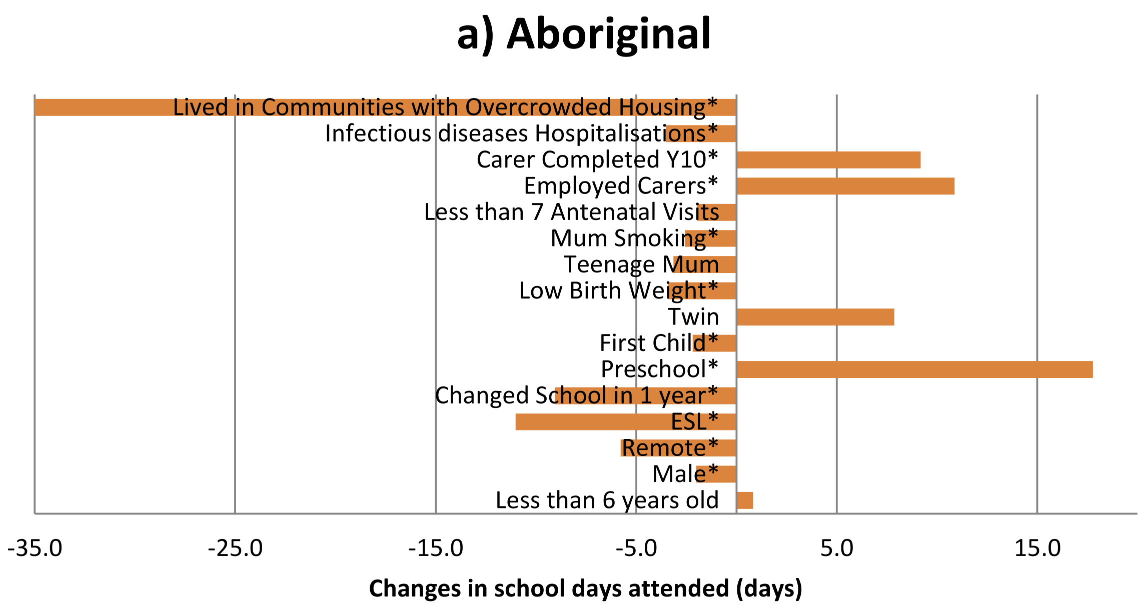
The analysis then calculated the contribution of each variable group to the overall variation in school attendance by the three levels of geographic remoteness defined in the ARIA. The percentage contributions of all 6 groups of variables therefore add up to 100%. This statistical method enables a comparative assessment being made of how each of the variable groups influence the spread in Year 1 school attendance in each of the 3 available levels of geographic remoteness in the NT. [11] The findings of this analysis are shown graphically in Figure 5.2 below, and details of the estimation results are provided in Appendix Table 5.A.2.

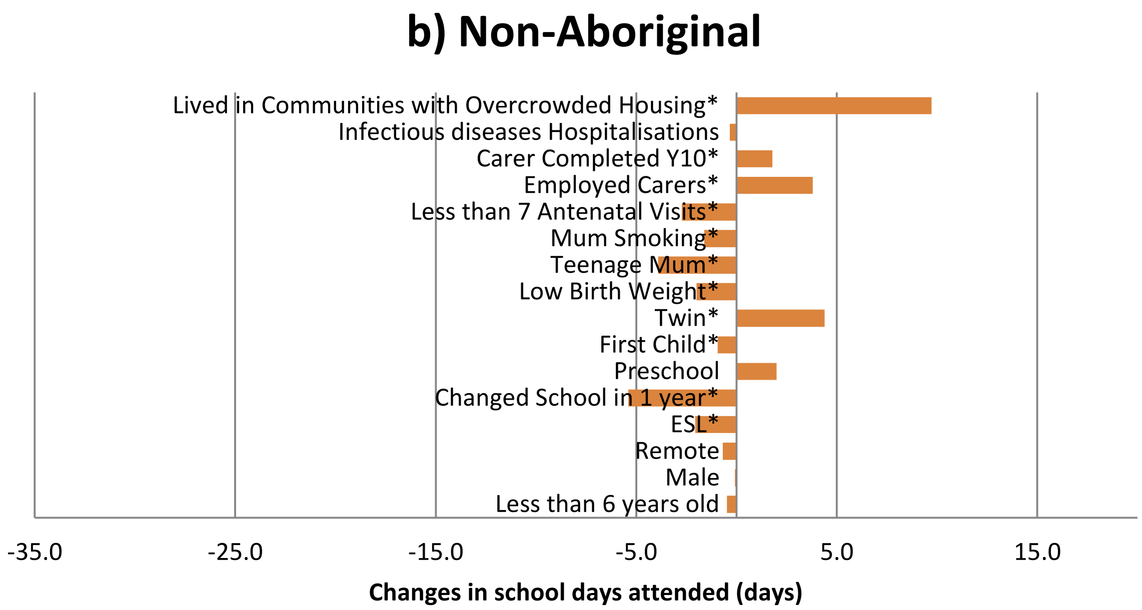
having higher household income than the community average.

[10] The school/community fixed effect refers to the assumption that the net effect of the overall characteristics of each school and its community remain essentially constant.

[11] Accessibility/Remoteness Index of Australia (ARIA+).

Figure 5.1 Changes in school days attended in Year 1 associated with the selected factors as predicted by the adjusted model



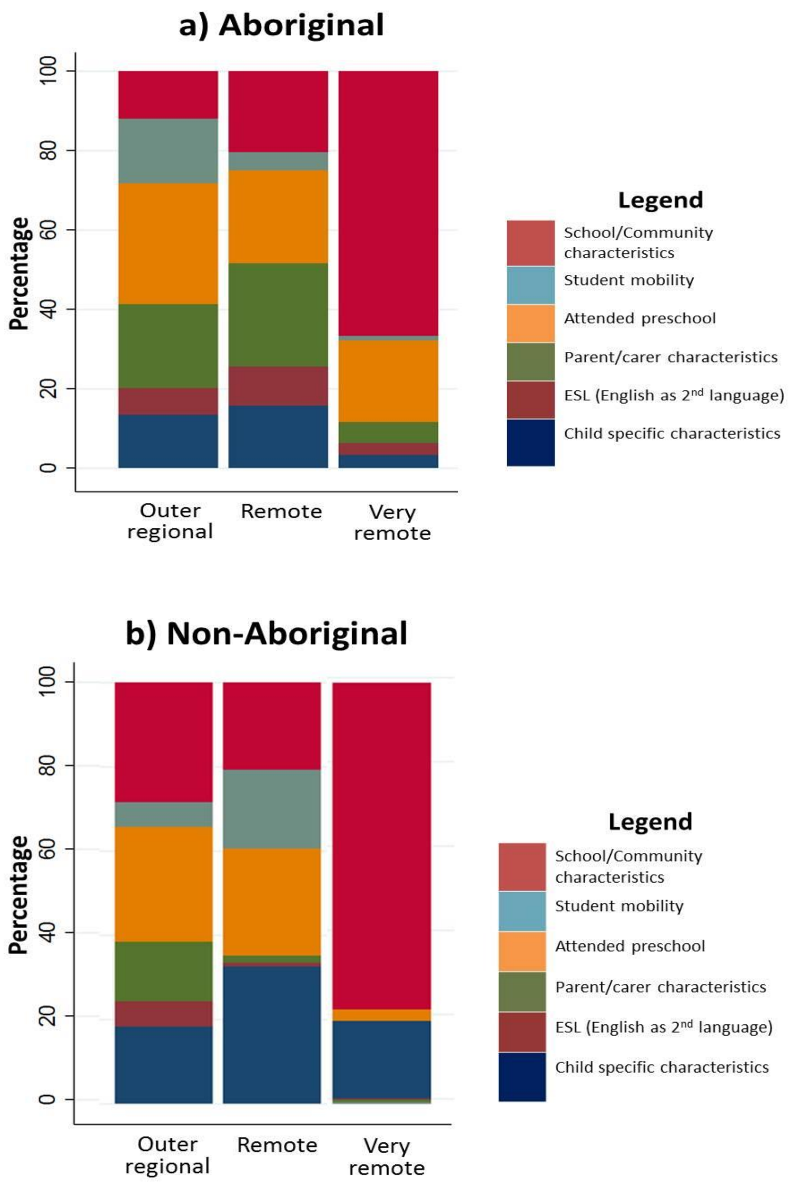


* Indicates statistical significance at the 5% level (p< .05)

Of particular note is that the full model explained almost 42%, 35%, and 32% of the variation in school attendance for Aboriginal students in very remote areas, remote areas, and outer regional areas, respectively. In contrast, the model explained only 18%, 13%, and 8% of the variation in school attendance of non-Aboriginal students in very remote areas, remote areas, and outer regional areas, respectively (see Table 5.A.2 in the Appendix). The fixed characteristics of individual schools and their communities thus emerged as the dominant predictor of Year 1 school attendance in very remote schools for both Aboriginal and non-Aboriginal students, explaining 67% and 80% of the explained variation in attendance, respectively. In contrast, in the outer regional regions, school/community fixed effects explained just 12% of the variance in Year 1 school attendance for Aboriginal and 28% for non-Aboriginal students.

For both Aboriginal and non-Aboriginal students preschool attendance contributes substantially to the explained variation in Year 1 attendance, ranging between 21% and 31%. Notably, preschool attendance accounted for almost one-third of the explained variation for Aboriginal students living in the outer regional regions. The only exception was for non-Aboriginal students in very remote schools, where variation in preschool exposure contributes little to the

Figure 5.2. Percentage contribution of variable groups to the total explained variation in school attendance by geographic remoteness for a) Aboriginal, and b) non-Aboriginal students



variation in school attendance (3%). Variation in students' school mobility was only relevant to variations in Year 1 school attendance for Aboriginal students in outer regional schools (16%), and non-Aboriginal students in remote schools (19%). The education and employment status of parents/carers explained a large proportion of the variation in Year 1 school attendance for Aboriginal students living in the remote regions (26%) and both Aboriginal and non-Aboriginal students living in the outer regional regions (21% and 14% respectively).

In summary, these findings suggest that especially for students in very remote areas, the nature of a student's school and their community circumstances were the predominant influence on students' year 1 attendance.

5.4. Weekly attendance over the school year

While the previous analyses focused on school attendance in Year 1 only, in this section we expand the analysis to consider attendance over the years of compulsory schooling from Year 1 to Year 10. This broader focus enables investigation of factors influencing attendance at different stages of a student's school career. The greater variation in the data also enables examination of the impact of seasonal and weekly variation in school attendance.

5.4.1 Weekly attendance rates by school year

The investigation started with a descriptive analysis of the weekly variation in attendance rate (calculated as the proportion of school days recorded as having attended school) across the full school year. Figure 5.3 depicts the changes in school attendance rates for different stages of schooling years, including early years (Years 1-3 of primary school), primary years (Years 4-6 of primary school), middle years (Years 7-9) and Year 10, separately for Aboriginal and non-Aboriginal students by geographic remoteness. The weekly attendance rates were calculated and displayed in Figure 5.2 for each of the 10 weeks of the four school terms of a year.

For both Aboriginal and non-Aboriginal students, the overall pattern of attendance within each school term was essentially the same, independent of the school's geographic remoteness. This follows a hump-shaped pattern in each of the quarterly school terms i.e. attendance rates are substantially lower in the first and last weeks of each school term. They are also lower for Aboriginal students in very remote locations in the third and fourth quarter of the year.

Attendance rates were much the same for non-Aboriginal students regardless of their school's geographic location. In contrast, the attendance rates of Aboriginal students vary markedly between different levels of geographic remoteness. This heterogeneity in attendance rates by school location was observed for all year levels. While attendance rates at the beginning of the school year are 80% (or higher) for Aboriginal students in outer regional locations, they are just 65% (or less) in very remote areas.

The attendance of Aboriginal students in very remote areas can be seen to drop markedly in the later years of schooling. For instance, their attendance rates are just 60% in the first quarter of Years 7-9, but are less than 50% in Year 10. Furthermore, attendance of Year 10 Aboriginal students falls to 40% in terms 3 and 4. Possible reasons for the extent of this drop in attendance in terms 3 and 4 are not evident from these analyses, but could reflect seasonal patterns of mobility and cultural activities in different parts of the NT.

Figure 5.3. Patterns of weekly school attendance rates, by Year-level

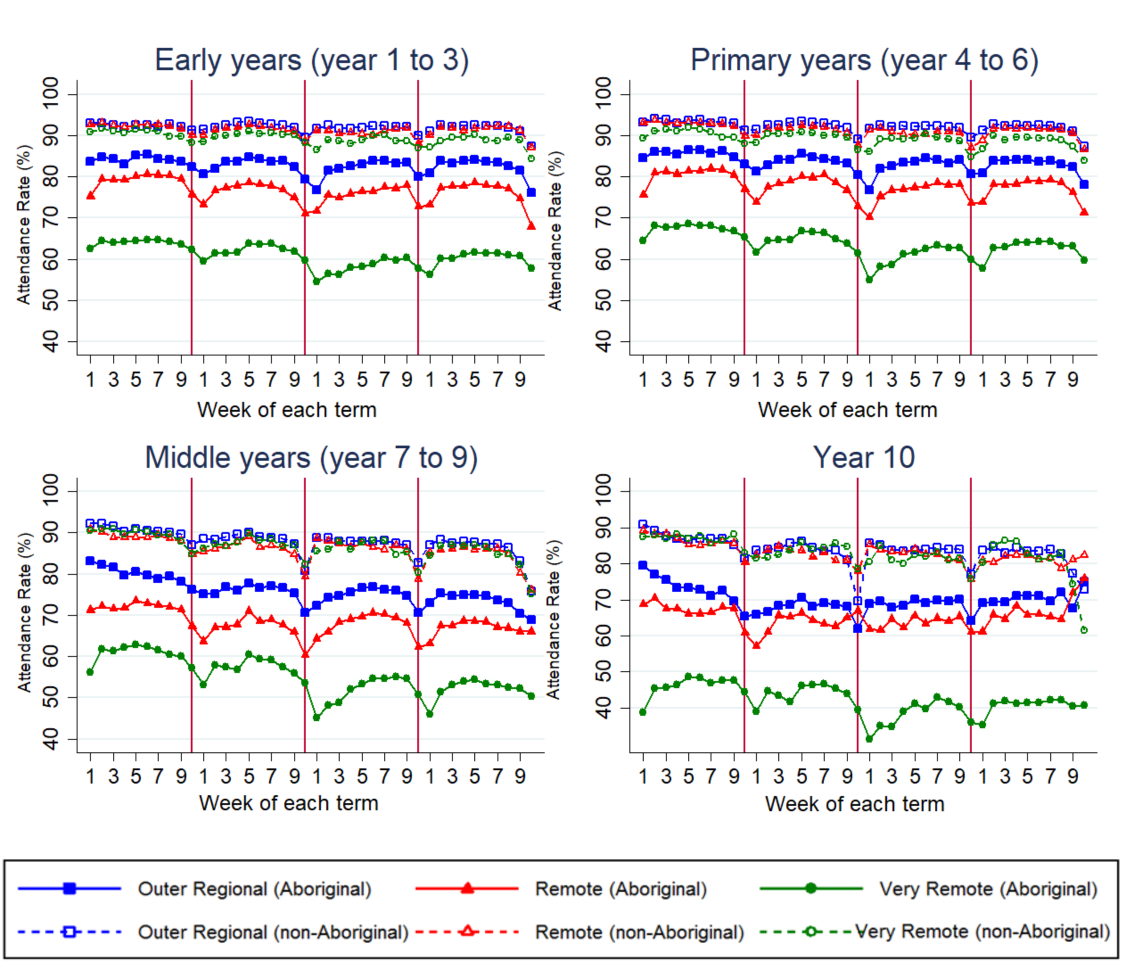
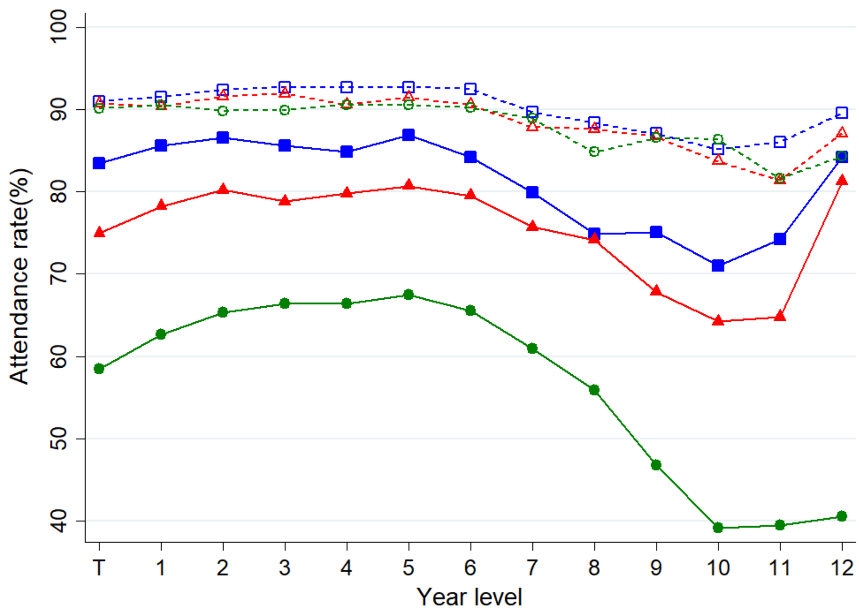


Figure 5.4. School attendance by Year level (Transition to Year 12) and remoteness*



This graph uses the same legend as that of Figure 5.3.

5.4.2 Annual attendance rates by school year

After investigating the variations of weekly attendance rates across the 4 terms of the same school year, the analysis further examined the patterns of yearly school attendance rates from Transition to Year 12 by the level of geographic remoteness of the schools (see Figure 5.4 above). It can be seen that attendance rates tend to drop off from Year 6 onward for both Aboriginal and non-Aboriginal students. Attendance rates for Aboriginal students in very remote areas in Year 11 and 12 remain at 40%. In contrast, attendance rates in Year 12 for Aboriginal students in outer regional and remote schools increase again to reach almost the same levels of school attendance of non-Aboriginal students. This is likely to be an artefact of the drop in enrolments of Aboriginal children after the age of compulsory schooling (about Year 10) and that Aboriginal students who remained in school became were those who likely attended school regularly throughout their careers and continue to do so as they are committed to completing high school.

5.5 Health status and attendance

To further investigate the findings described in sections 5.2 and 5.3 (above) concerning the extent to which child-specific factors were associated with school attendance, we then investigated how the rates of early childhood (i.e. up to age 5.5 years) infectious diseases might be associated with children's subsequent attendance in Year 1. This is important for the NT setting because hospitalisation due to infectious diseases is a commonly used indicator of the general health status of child populations (Santos et al. 2012) and the hospitalisation rates for childhood infectious diseases have been high in the NT (O'Grady, Torzillo, and Chang 2010; Carlin et al. 1998; Clucas et al. 2008; Currie and Carapetis 2000).

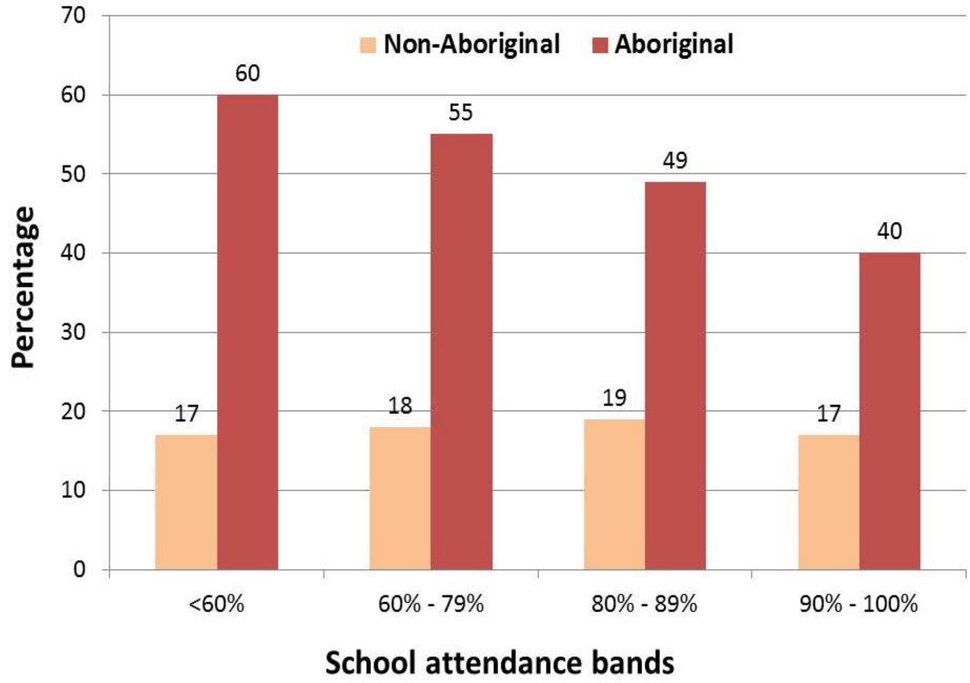
It can be seen in Figure 5.5 (below) that, while the hospitalisation rate (defined in this section as the proportion of students ever being hospitalised due to infection-related diseases before the age of 5.5 years) did not differ among the 4 bands of attendance rates in non-Aboriginal students, it showed a decreasing gradient from the lowest band of attendance rates to the highest one. In other words, our analysis showed that, in Aboriginal students, as the hospitalisation rate due to infectious diseases increases, the likelihood for Aboriginal students to have lower attendance rates increases. Further details of the gradient in school attendance associated with different types of hospitalisations up to age 5.5 years are provided in Appendix Table 5.A.3.

5.6. Early childhood development and attendance

We next investigated the association between children's Year 1 school attendance and their early development outcomes assessed in the 2009 and 2012 Australian Early Development Census (AEDC). Children's AEDC scores are considered a reliable indication of their readiness for formal schooling (Australian Government Department of Education and Training 2015). Children are assessed by teachers using the AEDC on-line checklist early in their first year of compulsory education – usually when aged around 5 years.

For the purpose of this investigation, an analysis cohort was assembled which comprised 3,681 NT-born children who had been assessed in the 2009/10 and 2012 Australian Early Development Census (AEDC) and attended Year 1 in NT government schools. Univariable linear regression was performed to produce unadjusted estimates of each included covariate's association with the outcome measure. It was followed by multivariable regression modelling performed with adjustment for school-fixed effect to

Figure 5.5 Percentage of Year 1 students hospitalised for infection-related diseases before 5.5 years old

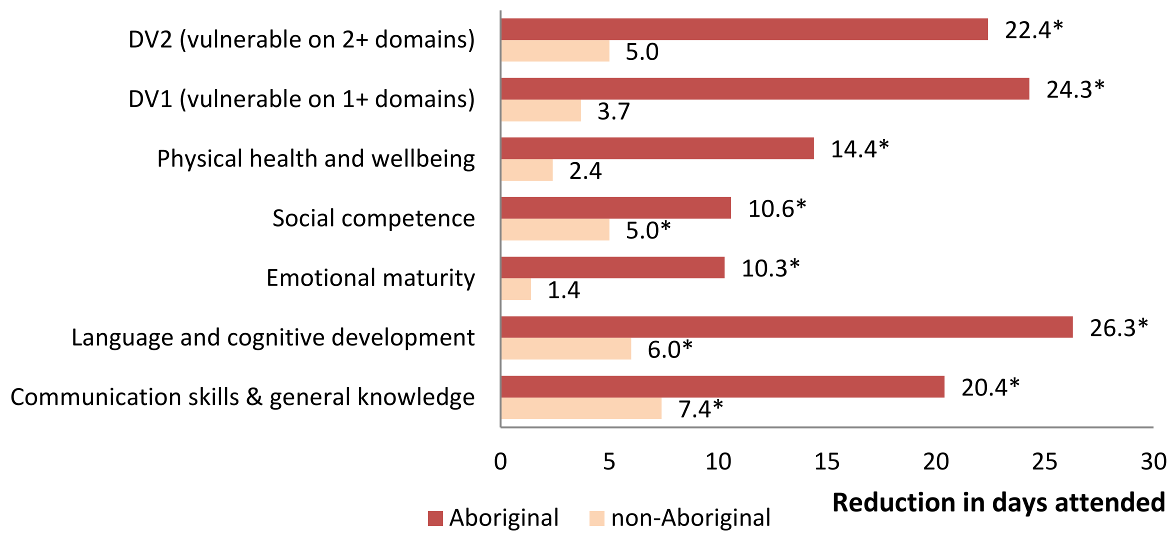


produce the adjusted estimation of association at the level of schools. Potential confounding and influence coming from other factors was controlled for by retaining a number of factors based on past literature in the adjusted model. They included: the child's age in months at the time of AEDC; gender; English as a second language (ESL); student mobility (a derived dichotomous variable on whether the child had attended 2 or more schools in Year 1); % of preschool days attended; history of low birthweight; whether born to a teenage mother; parent/carer's employment status; and parent/carer's educational status.

Given there was a total of 200 school days per year, the results are expressed in terms of the estimated reduction in days of school attendance associated with being '*developmentally on-track'* and *'developmentally vulnerable'* on each of the five AEDC domains, and being '*developmentally vulnerable on one or more domains' (DV1),* and being *'developmentally vulnerable on two or more domains (DV2).'*

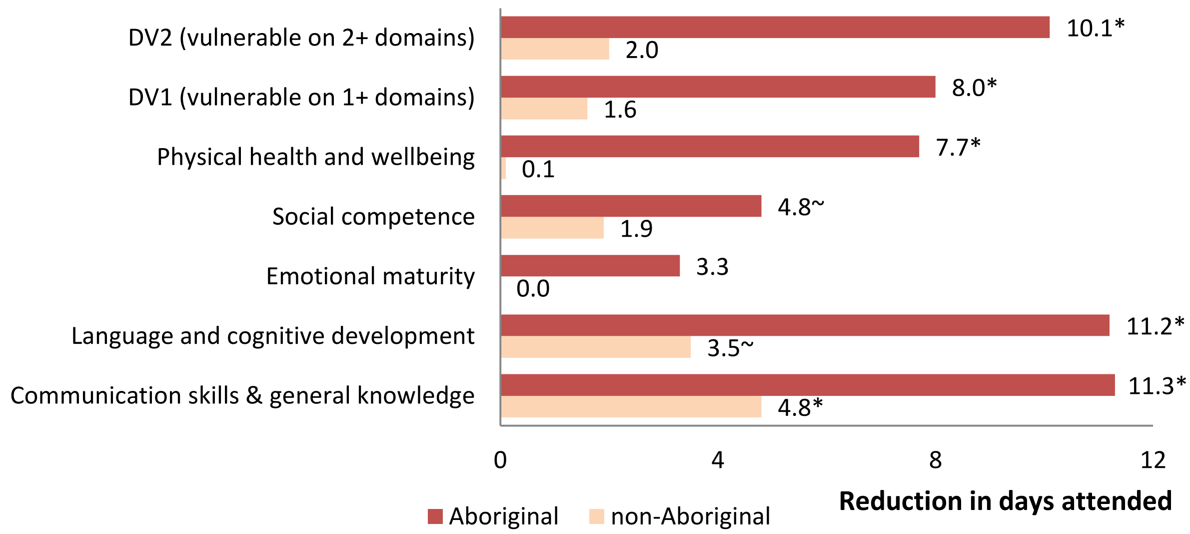
Figure 5.6a below describes the unadjusted findings while Figure 5.6b presents adjusted results from the final model where effects of the other covariates are taken into account. Further details on the median attendance rates for students that are developmentally 'on-track' and 'vulnerable' for each of these AEDC domain and general outcome scores are provided in the chapter appendix (Table 5.A.4).

Figure 5.6a Expected reduction in Year 1 school attendance associated with vulnerable outcomes in specific AEDC domain(s) by Aboriginal status of students (unadjusted findings)



The expected associated change is reported as the reduction (in days) of school days attended in a school year.
* Indicates statistical significance of the association at the 0.1% level (p<0.001)

Figure 5.6b Expected reduction in Year 1 school attendance associated with vulnerable outcomes in specific AEDC domain(s) by Aboriginal status of students (adjusted findings)



The expected associated change is reported as the reduction (in days) of school days attended in a school year.
* Indicates statistical significance of the association at the 0.1% level (p<0.001)
~ Indicates statistical significance of the association at the 1% level (p<0.01)

5.7 Discussion

The findings reported in this chapter add to the Australian literature on the school attendance of Aboriginal students by the analysis of NT student's daily school attendance records linked with other unit-record administrative data. This has enabled the use of advanced statistical techniques to investigate a broader range of factors affecting NT school attendance in ways not previously possible.

However, given their quantitative nature and the inherent limitations, the available linked data did not enable consideration of other key factors identified in the literature such as school not being sufficiently engaging for Aboriginal children and their families (Boulden 2006; Krakouer 2016); and issues such as bullying and racism which can both have profound effects on student attendance, achievement, well-being and self-concept (Biddle and Priest 2014; Bodkin-Andrews 2011; Bodkin-Andrews and Craven 2014; Bodkin-Andrews, Denson, and Bansel 2013; Bodkin-Andrews et al. 2010; Zubrick et al. 2010). These are all important points to bear in mind when considering the implications and significance of these findings.

Our analysis approach was informed by one of the key findings of the 2013 Western Australian school attendance study which linked data on all children attending WA Government schools over a two year period (Hancock et al. 2013). They established that a child's pattern of school attendance is established very early in the course of their school career and tend to persist over time. We therefore began our analysis with an investigation of how the data we had available on child-specific and socio-demographic factors was associated with Year 1 school attendance.

5.7.1 Predictors of Year 1 attendance

For Aboriginal students, the factor having the greatest impact on Year 1 attendance was living in a community with overcrowded housing (i.e. an average of more than two persons per available bedroom in the community). After taking account of the effects of the other factors in the analysis, this factor alone was associated with 35 fewer school days attended in the school year. Where a child's circumstances include all the factors having a significant adverse effect this could result in almost 90 days of school absence in a school year, which is close to 50% of the approximately 200 possible school days a year (Hughes 2015).

These findings point to a number of preventable or modifiable factors which should be addressed to school attendance in the NT and which should be a more central focus of public policy.

Firstly, improving family housing circumstances – especially in remote communities – would appear to offer significant potential for improving Aboriginal children's participation in school as well as many other aspects of their health and development.

Secondly, recent government initiatives to increase Aboriginal children's opportunities for participating in preschool seem well-placed and should be extended. For example, through the first National Partnership Agreement on Early Childhood Education (National Partnership) signed by the Council of Australian Governments in late 2008, all governments in Australia committed to providing all children the access to a quality early childhood education program, delivered by a qualified early childhood teacher for 15 hours per week in the year before they attend full-time school (Australian Government Department of Education and Training 2017). It is encouraging therefore to see the Australian Government committing a further $428 million to provide a one-year extension to these National Partnership arrangements.

Thirdly, more investment is needed to enable schools and teaching staff to support the specific language and learning needs of Aboriginal children who have English as second language – especially in their early years of schooling. This need is further heightened by our findings in Chapter 4 that ESL was a strong predictor for being developmentally vulnerable. While the findings from this analysis are consistent with other studies in confirming the benefits for parents having higher levels of education and being employed, they also show how student mobility between schools, and children's health status are also key factors affecting school attendance.

5.7.2 Factors affecting attendance by region

The next stage of analysis sought to further investigate how the effects of these socioeconomic, family demographic and child specific factors differed according to the geographic remoteness of the school and its community. A particular advantage of the statistical procedure used in this analysis (fixed effects modelling) is that it enables estimation of the independent contribution which each of the non-school and community factors makes to the overall observed variation in attendance. However, the limitation of this procedure is that it combines the percentage variation associated with the school and local community effects. That said, the findings offer useful insights into the relative importance of the non-school/community factors and how these differ by the school's level of remoteness.

This modelling showed that the fixed effects of individual schools and their communities were by far the most dominant predictor of Year 1 school attendance in remote and very remote schools explaining 67% and 80% of the explained variation for Aboriginal and non-Aboriginal students respectively. In contrast, in outer regional and remote schools, these effects explained just 12% of the explained variance. But in these areas, attendance at preschool and parent/carer characteristics were relatively more influential. Also student mobility contributed more to attendance variation in outer regional schools than in remote or very remote school (16.3% vs. 4.7% and 1.1% respectively). In summary variation of these influences on Year 1 attendance by the school's level of remoteness highlights the need for school attendance policies to be tailored according to the evidence of which factors matter most in each area of school remoteness.

The descriptive analysis of how attendance rates varied from week to week within school terms and across the full school year for Aboriginal and non-Aboriginal students in different year-levels (Early years, Primary school, middle school, Year 10), yielded some important policy relevant findings. The marked drop in attendance evident in the first and last few weeks of each school quarter represents a significant lost opportunity for school learning. Given overwhelming evidence in the literature that every day of schooling matters for student's educational outcomes, preventing the high number of these lost days of attendance would seem a worthy policy objective. The adverse effect of these absences on student educational outcomes need to be better understood by parents and carers. Schools should also engage with their communities in developing locally relevant solutions. One such example of a community solution for this type of problem is the 'wet-season' school initiative developed in Gunbalanya (Trevaskis 2012). This involved modifying the school calendar to make schooling available when families are unable to leave the community in the height of the 'wet' season.

5.7.3 Attendance and retention

The findings that attendance rates tend to drop off from Year 6 onward for both Aboriginal and non-Aboriginal students highlights the importance of middle schooling in maintaining the engagement of students. For children and young people in traditional Aboriginal communities this can be the age when there are cultural obligations associated with initiation which can involve time spent out of the community (McTurk et al. 2008). The newly attained adult status of initiated students can also affect student attitudes towards schooling. Recent NT policy initiatives to increase the availability of more adult oriented VET in school programs appear to be having some success in this regard (Spiers and Spiers 2007; Miller 2005) - especially those which can be seen to lead to valued local employment opportunities such as child care and education, hospitality, housing construction and maintenance etc. At the same time, it is important to note that while attendance rates for Aboriginal students in very remote areas in Year 11 and 12 remain at 40%, the attendance rates of Year 12 Aboriginal students in outer regional and remote schools are almost the same as those of non-Aboriginal students.

5.7.4 Child health and attendance

Using data in childhood hospitalisation for infectious diseases (i.e. up to age 5.5 years) as a general indicator of child health status, the investigation of how this related to Year 1 attendance yielded some interesting observations. Given the much higher overall rate of hospitalisations of Aboriginal children it was not surprising this was found to be more prevalent for Aboriginal students across all bands of attendance. However, the most useful finding is the association between the infection-related hospitalisation rate and school attendance rate in Aboriginal students. This finding on the one hand provides indication for the association between child health status and school attendance, on the other hand, it also shows that, improving the health status of children also is an important measure for improving school attendance, which is especially important for the NT setting where rates of paediatric infection are high in Aboriginal children.

These findings are consistent with other Australian studies such as the Growing Up in Australia: The Longitudinal Study of Australian Children (LSAC) and the Longitudinal Study of Indigenous Children (LSIC) (Purdie and Buckley 2010). In the LSAC, child health was found to be one of the main reasons for non-attendance, as reported by both teachers (on average, 50% of absences at all ages) and parents (around 73% across different ages). Results from a multivariable regression analysis using wave three data from the LSIC (Biddle 2014) also identified child health as the factor most strongly associated with school attendance, after adjusting for other factors in the model (Biddle 2014).

5.7.5 Child development and attendance

The importance of children's early development and health have long been recognised as being of relevance to their making a successful transition into school learning (McTurk et al. 2008). The availability of Australian Early Development Census (AEDC) data collected in children's first year of full-time schooling enabled investigation of how children's developmental status on school entry was associated with their Year 1 attendance. The AEDC teacher rated measure has been culturally adapted to maximise its measurement equivalence and inclusive use for assessing Aboriginal and non-Aboriginal students (Silburn et al. 2009). However, its use as a measure of school readiness of Aboriginal students has been questioned (Li, D'Angiulli, and Kendall 2007).

Others have argued that it can also be used by teachers and schools to assess their own readiness to cater for the specific learning needs of its student population (Goldfeld et al. 2016). Our analysis showed that there was little difference between the attendance rates of non-Aboriginal students assessed as developmentally 'on track' and those who were developmentally 'vulnerable' on each of the AEDC scores. However, for Aboriginal students, the attendance of students assessed as developmentally 'vulnerable' were generally lower than those considered developmentally 'on-track'in particular for the AEDC scores on the 'Language and cognitive skills' domain (median school attendance rate of 65.3% vs. 82.7%) and 'Communication skills and general knowledge' domain (66.3% vs. 80.1%).

5.7.6 Limitations and future research

While the findings reported in this chapter have necessarily been confined to the types of analysis possible using the de-identified linked administrative data available in early 2017, these data have since been updated and linked with other data from additional NT administrative datasets. These new data include information on children's contact with the NT child protection system, their contact with primary health care services, and ear health and hearing status. It is important that future research uses information available from these new datasets to extend this investigation to make a more comprehensive analysis of the many factors affecting school attendance.

Another limitation of the present study is that fixed effects modelling used to identify the proportion of attendance variance attributable to specific factor groups was not able to separate out the extent to which school factors and community factors each contribute to the overall variation in student attendance. Future studies should therefore aim to include a range of community and school characteristics.

Community characteristics of possible relevance to school attendance which could be used in future studies include the number of usual residents, the ratio of children to adults, the ratio of Aboriginal to non-Aboriginal residents, the percentage of adults who speak English as a first language, the percentage of Adults with year 9 or more education, the percentage of adults employed, family food security, housing adequacy, and community safety.

School characteristics which should be considered in future studies of school attendance outcomes might include factors such as the school size and staffing, the teacher/student ratio, the ratio of Aboriginal to non-Aboriginal staff, the annual rate of teacher turnover, perceived curriculum relevance, ratings of teaching quality, teacher and parent ratings of parent and child engagement with school, and parent ratings of the school's engagement with the community.

5.8 References

ACARA. 2016. *National Assessment Program—Literacy and Numeracy Achievement in Reading, Writing, Language Conventions and Numeracy: National Report for 2016* (Australian Curriculum, Assessment and Reporting Authority (ACARA): Sydney).

Australian Government Department of Education and Training. 2015. *Australian Early Development Census – National Report 2015* (Australian Government Department of Education and Training: Canberra, ACT).

Australian Government Department of Education and Training. 2017. 'National Partnership Agreements', Australian Government Department of Education and Training, Accessed 8 December. https://www.education.gov.au/national-partnership-agreements.

Australian Government Department of Human Services. 2017. 'School Enrolment and Attendance Measure - Northern Territory', Australian Government Department of Human Services,, Accessed 20 November. https://www.humanservices.gov.au/individuals/enablers/school-enrolment-and-attendance-measure-northern-territory.

Australian Government Department of Prime Minister and Cabinet. 2014. 'Remote School Attendance Strategy', Commonwealth of Australia, Accessed 20 November. https://www.pmc.gov.au/indigenous-affairs/education/remote-school-attendance-strategy.

Biddle, N. 2014. *Developing a behavioural model of school attendance; Policy implications for Indigenous children and youth. CAEPR working paper no. 94/2014* (Centre for Aboriginal Economic Policy and Research: Canberra).

Biddle, N, and N Priest. 2014. 'Indigenous students skipping school to avoid bullying and racism', *The Conversation,* 11 April 2014.

Bodkin-Andrews, GH, N Denson, and P Bansel. 2013. 'The varying effects of academic self-concept, multiculturation and teacher discrimination as predictor of Indigenous and non-Indigenous Australian student academic self-sabotaging and disengagement', *Australian Psychologist*, 48: 226-37.

Bodkin-Andrews, GH, V O'Rourke, R Grant, N Denson, and RG Craven. 2010. 'Validating racism and cultural respect: testing the psychometric properties and educational impact of perceived discrimination and multiculturation for Indigenous and non-Indigenous students', *Educational Research and Evaluation*, 16: 471-93.

Bodkin-Andrews, GH. 2011. 'Appendix E: Review of Research on Racism and its Impact on Educational Retention and Attainment of Indigenous Young People in Australia.' in, *Analysis of Year 12 or Certificate II attainment of Indigenous young people - Stage 1: a report prepared for the Council of Australian Governments Reform Council* (Australian Council for Educational Research: Melbourne, VIC).

Bodkin-Andrews, GH., and R. Craven. 2014. "Bubalamai Bawa Gumada (Healing the Wounds of the Heart): The search for resiliency against racism for Aboriginal Australian students." In *Quality and Equity: What does Research Tell Us*, 49-58. Australian Council for Educational Research.

Boulden, K. 2006. *The school attendance of Indigenous students: A literature review* (Report prepared for the Alliance of Aboriginal Community Schools by the Department of Education Science and Training: Canberra).

Carlin, JB, P Chondros, P Masendycz, H Bugg, RF Bishop, and GL Barnes. 1998. 'Rotavirus infection and rates of hospitalisation for acute gastroenteritis in young children in Australia, 1993-1996', *The Medical journal of Australia*, 169: 252-56.

Clucas, DB, KS Carville, C Connors, BJ Currie, JR Carapetis, and RM Andrews. 2008. 'Disease burden and health-care clinic attendances for young children in remote Aboriginal communities of northern Australia', *Bulletin of the World Health Organization*, 86: 275-81.

Currie, BJ, and JR Carapetis. 2000. 'Skin infections and infestations in Aboriginal communities in northern Australia', *Australasian journal of dermatology*, 41: 139-43.

Education and Innovation Committee. 2014. 'Review of state school attendance rates: Report 42', Parliamentary Committee, Queensland Government, Accessed 20 November. http://www.parliament.qld.gov.au/documents/committees/EIC/2014/ARR2014/rpt-042-19Nov2014.pdf.

Goldfeld, S, E O'Connor, M O'Connor, M Sayers, T Moore, A Kvalsvig, and S Brinkman. 2016. 'The role of preschool in promoting children's healthy development: Evidence from an Australian population cohort', *Early Childhood Research Quarterly*, 35: 40-48.

Hancock, KJ, CJ Shepherd, D Lawrence, and SR Zubrick. 2013. 'Student attendance and educational outcomes: Every day counts', *Canberra, Australia: Department of Education, Employment and Workplace Relations. Retrieved August*, 28: 2015.

Hughes, M. 2015. 'School Years around the World-From Australia to South Korea', Accessed 8 December. https://www.infoplease.com/world/world-statistics/school-years-around-world.
Krakouer, J. 2016. 'Aboriginal Early Childhood Education: Why attendance and true engagement are equally important?', Australian Council for Education Research. https://research.acer.edu.au/cgi/viewcontent.cgi?referer=https://www.bing.com/&httpsredir=1&article=1044&context=indigenous_education.
Li, J, A D'Angiulli, and GE Kendall. 2007. 'The Early Development Index and children from culturally and linguistically diverse backgrounds', *Early Years*, 27: 221-35.
McTurk, N, G Nutton, T Lea, G Robinson, and J Carapetis. 2008. 'The School Readiness of Australian Indigenous Children: A Review of the Literature', Charles Darwin University and Menzies School of Health Research, Accessed 20 November. http://apo.org.au/research/school-readiness-australian-indigenous-children-review-literature.
Meghit, C., and SG. Rivkin. 2010. 'Econometric Methods for Research in Education. NBER Working Paper No. 16003', National Bureau for Economic Research, Accessed 20 November. http://www.nber.org/papers/w16003.pdf.
Miller, C. 2005. *Aspects of training that meet Indigenous Australians' aspirations: A systematic review of research* (National Centre for Vocational Education Research: Adelaide).
Northern Territory Department of Education. 2016. 'Attendance and participation policy', Accessed 20 November. https://education.nt.gov.au/__data/assets/pdf_file/0018/273141/attendance-and-participation-policy.pdf.
O'Grady, K-A F, PJ Torzillo, and AB Chang. 2010. 'Hospitalisation of Indigenous children in the Northern Territory for lower respiratory illness in the first year of life', *Medical Journal of Australia*, 192: 586.
Productivity Commission. 2014. *Childcare and Early Learning, Productivity Commission Draft Report* (Australian Government Productivity Commission: Canberra).
Purdie, N, and S Buckley. 2010. *School attendance and retention of Indigenous Australian students: An issues paper for the Closing the Gap Clearinghouse* (Australian Institute of Family Studies: Melbourne, VIC).
Santos, R, M Brownell, O Ekuma, T Mayer, and R-A Soodeen. 2012. *THE EARLY DEVELOPMENT INSTRUMENT (EDI) IN MANITOBA* (Manitoba Centre for Health Policy: Winnipeg, Manitoba, Canada).
Silburn, S, S Brinkman, S Ferguson-Hill, I Styles, R Walker, and C Shepherd. 2009. *The Australian Early Development Index (AEDI) Indigenous Adaptation Study* (Curtin University and Telethon Institute for Child Health Research: Perth, WA).
Spiers, H., and M. Spiers. 2007. 'Northern Territory Adult Lieracy and Numeracy Best Practice-innovative practice', Charles Darwin University, Accessed 8 December. http://www.cdu.edu.au/centres/ntalnbp/docs/innovative_practice.pdf.
Trevaskis, L. 2012. 'School rules in wet season', ABC Rural, Accessed 8 December. http://www.abc.net.au/site-archive/rural/content/2012/s3514242.htm.
Wilson, B. 2014. 'A share in the future: Review of Indigenous Education in the Northern Territory', NT Department of Education, Accessed 20 November. https://education.nt.gov.au/__data/assets/pdf_file/0020/229016/A-Share-in-the-Future-The-Review-of-Indigenous-Education-in-the-Northern-Territory.pdf.
Zubrick, SR, P Dudgeon, G Gee, B Glaskin, K Kelly, Y Paradies, C Scrine, and R Walker. 2010. 'Social determinants of Aboriginal and Torres Strait Islander social and emotional wellbeing.' in N Purdie, Dudgeon P and R Walker (eds.), *Working Together: Aboriginal and Torres Strait Islander Mental Health and Wellbeing Principles and Practice* (Commonwealth of Australia: Canberra).

5.9 Appendices

Table 5.A.1 Results of multivariable regression modelling on selected predictors for Year 1 school attendance

Predictor variables*	Aboriginal				Non-Aboriginal			
	days	95%	CI*	p	days	95%	CI*	p
Age < 6 yrs old	0.8	-1.6	3.2	0.493	-0.5	-1.3	0.4	0.291
Male	-2.0	-3.8	-0.2	0.031	-0.1	-0.8	0.6	0.835
Remote	-5.8	-10.9	-0.7	0.026	-0.7	-2.2	0.8	0.369
ESL	-11.0	-13.8	-8.2	0.000	-2.1	-2.9	-1.2	0.000
Changed School in 1 year	-9.1	-12.3	-5.9	0.000	-5.4	-7.8	-2.9	0.000
Preschool	17.8	12.9	22.6	0.000	2.0	0.0	4.0	0.054
First Child	-2.2	-4.0	-0.3	0.021	-0.9	-1.6	-0.3	0.006
Twin	7.9	-0.5	16.2	0.065	4.4	2.4	6.4	0.000
LBW	-3.4	-6.7	-0.1	0.045	-2.0	-3.8	-0.2	0.034
Teenage Mum	-3.1	-6.5	0.2	0.063	-3.9	-6.2	-1.6	0.001
Mum Smoking	-2.6	-5.0	-0.2	0.034	-1.6	-2.8	-0.4	0.007
< 7 Antenatal Visits	-2.0	-4.5	0.6	0.132	-2.7	-3.9	-1.5	0.000
Employed Carers	10.9	8.0	13.8	0.000	3.8	1.4	6.2	0.002
Carer Completed Y10	9.2	6.8	11.6	0.000	1.8	1.0	2.6	0.000
Infectious diseases Hospitalisations	-3.5	-6.3	-0.7	0.014	-0.3	-1.3	0.7	0.509
Lived in Communities with Overcrowded Housing	-35.2	-52.3	-18.2	0.000	9.7	4.5	15.0	0.000
R2	0.333				0.064			

*** Confidence interval**

Note: All coefficients are estimated with linear regression models where the dependent variable is the predicted annual Year 1 school attendance and standard errors are clustered at the school level.

Table 5.A.2 Percent contribution of block of variables to explained variation in Year 1 school attendance rates

Aboriginal status	Block of variables							
	Level of Remoteness	Child specific factors	ESL	Parent/ carer charac-teristics.	Preschool exposure	School mobility	School/ community fixed effects	Explained variation (R^2)
Non-Aboriginal	Outer Regional	18.3	6.0	14.1	27.3	5.9	28.4	0.083
Non-Aboriginal	Remote	32.7	0.8	1.9	25.4	18.7	20.6	0.132
Non-Aboriginal	Very Remote	18.9	0.2	0.6	2.7	0.4	79.5	0.183
Aboriginal	Outer Regional	13.4	6.7	21.2	30.5	16.3	11.9	0.318
Aboriginal	Remote	15.7	9.8	26.1	23.3	4.7	20.3	0.352
Aboriginal	Very Remote	3.4	2.9	5.4	20.6	1.1	66.6	0.415

Table 5.A.3. Proportion of children having hospitalisation history before age 5.5 years old, by school attendance band and principal diagnosis

Aboriginal children	School Attendance bands (n) <60% (n=3469)	60%-79% (n=2772)	80-89% (n=1900)	90-100% (n=1756)
Avoidable hospitalisation*	63.2	59.2	53.4	45.3
Hospitalised for 3 or more times	40.0	35.2	29.6	25.5
Total Length of Stay >=30 days	15.4	12.7	8.9	7.4
Infectious diseases	59.6	55.4	48.7	40.3
Respiratory Diseases	36.9	34.5	29.8	25.5
Acute lower respiratory tract infections	32.5	29.2	24.1	19.4
Acute upper respiratory tract infections	6.2	6.4	6.0	5.3
Urinary tract infection	2.9	2.8	2.5	1.5
Gastroenteritis	29.8	26.2	20.9	15.7
Bacterial/unspecified pneumonia	17.9	16.3	11.5	9.3
Injuries	11.6	12.2	10.0	12.3
Nutritional Deficiency	5.0	2.8	2.4	1.6
Dental (dental caries, pulp, periodontal)	7.4	6.7	7.9	6.3
Non-Aboriginal children	**School Attendance bands (n)** <60% (n=86)	60%-79% (n=521)	80-89% (n=2031)	90-100% (n=5905)
Avoidable hospitalisation	18.6	23.2	24.3	20.7
Hospitalised for 3 or more times	12.8	13.2	10.3	7.9
Total Length of Stay >=30 days	3.5	2.5	2.1	1.0
Infectious diseases	17.4	17.7	19.4	17.1
Respiratory Diseases	11.6	12.7	13.2	11.1
Acute lower respiratory tract infections	8.1	6.3	6.8	5.3
Acute upper respiratory tract infections	4.7	3.5	3.2	2.6
Urinary tract infection	0.0	1.2	1.2	0.9
Gastroenteritis	5.8	6.0	5.9	4.7
Bacterial/unspecified pneumonia	3.5	2.5	3.2	2.3
Injuries	3.5	9.8	7.3	6.7
Nutritional Deficiency	1.2	0.4	0.1	0.1
Dental (dental caries, pulp, periodontal)	2.3	3.5	3.1	2.0

*Definition used in Falster, K., E. Banks, S. Lujic, M. Falster, J. Lynch, K. Zwi, S. Eades, A. H. Leyland and L. Jorm (2016). "Inequalities in pediatric avoidable hospitalizations between Aboriginal and non-Aboriginal children in Australia: a population data linkage study." BMC pediatrics 16(1): 169. **https://bmcpediatr.biomedcentral.com/articles/10.1186/s12887-016-0706-7**

Table 5.A.4. Median attendance rate (%) of students having developmentally 'on-track' or 'vulnerable' outcome by individual AEDC domain

AEDC outcomes	Aboriginal % On track	Aboriginal % Vulnerable	Non-Aboriginal % On track	Non-Aboriginal % Vulnerable
Physical health and wellbeing	79.0	69.7	94.0	93.8
Social competence	78.4	70.9	94.1	92.1
Emotional maturity	78.3	70.5	94.0	93.4
Language and cognitive skills	82.7	65.3	94.0	92.9
Communication skills and general knowledge	80.1	66.3	94.1	90.8
Developmentally vulnerable on 1+ domains	84.6	70.4	94.1	93.1
Developmentally vulnerable on 2+ domains	81.6	67.2	94.1	92.4

6. Preschool participation, school attendance and academic achievement

Stefanie Schurer, Georgina Nutton, John McKenzie, Jiunn-Yih Su and Sven Silburn

Chapter overview

This chapter builds on the findings reported in Chapter 5 to investigate how children's participation in preschool is linked with their subsequent attendance and academic achievement in primary school. Understanding the nature of these relationships is of high policy relevance considering the increased investment of the Australian and Northern Territory (NT) governments in preschool education over the past decade through programs such as Universal Access to Preschool (Council of Australian Governments (COAG) 2009) and the National Partnership for Indigenous Early Childhood (COAG 2008). The series of analyses reported here describe the pattern of these associations separately for Aboriginal and non-Aboriginal children. They further investigate how the three main modes of remote preschool delivery in the NT (i.e. general preschools (including satellite preschools), early years (EY) classes, and mobile preschools) performed in improving children's propensity to have better attendance in their early primary school years, and how this differs for children in urban and remote settings. School fixed effects regression modelling, with appropriate adjustment for potential and available confounders, is used to predict how much Aboriginal children's levels of preschool attendance would need to be increased to lift their EY school attendance above the NT Aboriginal population mean. We then describe how different levels of preschool attendance of Aboriginal children in remote regions are associated with higher levels of school achievement (National Assessment Program – Literacy and Numeracy (NAPLAN)), and the extent to which this is mediated by their preschool attendance rates. The chapter concludes with a discussion of the policy implications of the findings, particularly on the evidence they provide for defining the minimum preschool attendance needed for longer-term educational benefits. This discussion also suggests areas for future data linkage and qualitative research.

6.1 Background

The last decade has witnessed extensive preschool expansion reforms in Australia including the NT. Significant policy and regulatory reforms initiated by COAG have increased investments in access and quality of preschool programs such as the National Partnerships for Early Childhood, Universal Access to Preschool (COAG 2009), and Indigenous Early Childhood Development (COAG 2008). These reforms are key components of the Australian and NT government responses to the *Ampe Akelyernemane Meke Mekarle "Little Children are Sacred" Report* (Wild and Anderson 2007), which recommended expansion of preschool provision as a systemic 'intervention' to reduce the disadvantage of low school attendance and subsequent life outcomes in the NT. Prior to 2007, the many (perceived) challenges to service provision and access in the NT due to geographic dispersion, small and diverse populations and socioeconomic disadvantage, led to new types of preschool delivery models that have not been seen elsewhere in the country. The expansion of preschool programs included multi-level early years classes, mobile preschools, or distance education (via School of the Air), and satellite preschools for very small communities where transporting children to standard onsite and standalone preschool services on a primary school site were not feasible (NT Department of Education 2017).

Other integrated service platforms were also co-funded as part of the NT Government's Closing the Gap strategy and the Indigenous Child

Development National Partnership Agreement (e.g. Families as First Teachers in 2009). Further social policy reforms have been implemented in response to the *Growing them Strong, Together: Promoting the safety and wellbeing of the Northern Territory's children* report (Bamblett, Bath and Roseby 2010), and in response to recommendations of *A Share in the Future: Review of Indigenous Education in the NT* (Wilson 2014) to address the limited progress in educational engagement and achievement.

These NT educational policy reforms follow an international trend in expanding children's preschool opportunities. A large international literature has demonstrated that participation in preschool plays a key role in helping children, particularly those from disadvantaged backgrounds, to prepare for the challenges of the formal school education system (Bennett and Tayler 2006; Fox and Geddes 2016; Goldfeld et al. 2016; Neuman and Bennett 2001). Because children from income- or education-poor backgrounds often start from lower developmental baselines, they are likely to experience greater gains in measures of school readiness as a result of attending high-quality preschool (Burchinal et al. 2006; Entwisle and Alexander 1998; Magnuson, Ruhm, and Waldfogel 2007). Unfortunately, children with the highest expected gains from preschool attendance are often also the ones who are least likely to attend preschool, and this holds true also for Aboriginal children (see Biddle 2007). Qualitative evidence from observational studies highlighted that many Aboriginal parents and carers had negative schooling experiences and subsequently mistrusted the education system, making it difficult for them to support their children's schooling experiences (Frigo et al. 2004; Hewitt and Walter 2014; Homel et al. 2006).

Preschools are one way to help children and parents engage early with and build trust in the education system in the NT. However, to date there is no population-based empirical evidence on whether preschool services provided in the NT indeed help children to better engage with the education system and thus facilitate school learning. Most Australian studies of Aboriginal children's transition to school learning comprise observational case studies, small-scale comparative studies and qualitative surveys (Silburn et al. 2011). In the early 2000s these studies focused on the development of 'school culture' skills such as following routines and classroom behaviours (Clancy, Simpson, and Howard 2001; Collins and Lea 1999; Simpson and Clancy 2000).

Subsequent studies emphasised the importance of these skills for Aboriginal children's successful transition to formal schooling (Dockett et al. 2008; Martin 2016; Townsend-Cross 2004). It is found that very remote NT communities often have limited resources to support parents in engaging their children with academic socialisation activities to support their transitioning from home to school (Collins and Lea 1999; Hanlen 2007; Hewitt and Walter 2014; Hill et al. 2002).

It has also been recognised that program quality—independent of costs—are key to parental engagement and academic success (Cloney et al. 2016; Hattie 2003), and this is also true in the Australian setting (Grace, Bowes, and Elcombe 2014). Shonkoff and Phillips (2000) identified five factors that determined quality in preschool: (1) personalised and responsive services in delivery method; (2) precise and explicit content and procedures; (3) timing, intensity and duration matched to the developmental needs of participants; (4) educators who were highly knowledgeable, skilled and expert in developing relationships with participants, and (5) programs that were centre-based or which combine centre and some home visiting, to enable family approaches with more community-based connections wrapped around families.

Culturally responsive and inclusive programs in which educators focus on engaging children have been found to improve attendance in Australia (Biddle 2007; Dockett et al. 2008; Leske et al. 2015; Martin 2016). In particular, warm and responsive care is a critical feature of quality programs (Arnold et al. 2007; Briggs and Potter 1999; Losey 1995; NAEYC 2005). Yet, although some Australian studies have focused on the development of program quality indicators (Cloney et al. 2016; Krieg et al. 2015), measuring quality with routine administrative data is inherently difficult.

This chapter examines the impact of children's preschool attendance and dosage on their subsequent attendance in the EY of primary school (i.e. Transition to Year 3) and school achievement between 2005 and 2014. In the NT there are alternative service delivery models for preschool programs, which are largely a function of community size and remoteness. There are some indications that the quality of preschool programs may be impacted by these service delivery models. It is hoped that the investigation in this chapter may shed light on the heterogeneity in the impact of preschool attendance by preschool type in very remote locations, where service delivery models vary the most. We further use the results of the statistical analysis to predict the optimal dosage in preschool attendance required to bring about improvements in the EY school attendance rates of Aboriginal children beyond the Aboriginal population average in very remote regions.

6.2 Preschool services, data and cohort selection

6.2.1 Preschool services in the NT

In 2013, the NT provided 143 preschool services and 33 preschool programs within long day care centres. These catered for over 3,500 students (almost 90% of their respective birth cohorts). Around 40% of these children were Aboriginal, most of whom were living in remote or very remote communities.

The majority of preschool programs (94%) were delivered free of charge for children aged from 4 years in provincial and remote areas and from 3 years in very remote areas by the NT Government. These preschools are usually integrated with a primary school and almost all are co-located on the primary school site. At that time there were 10 non-government providers (including long day care centres with a preschool program) which delivered preschool programs on a fee-for-service basis, with fees ranging from $1 to $19 per hour. A small number of remote non-government schools also provided a non-fee paying preschool program.

The delivery of the standard preschool model in remote and very remote communities presents special challenges due to the diversity of their geographic, cultural, and social contexts and how this is addressed by the allocation formula for national education funding. In 2013, the NT Government provided preschool services via a range of delivery models, including onsite and standalone preschools, multi-level early years classes, mobile early childhood education services, distance education (School of the Air), and satellite programs where transporting children to the nearest primary school was not feasible (Text Box 6.1).

6.2.2 Data

De-identified preschool and primary school attendance data were extracted from the attendance records of NT Government schools for children born on, or after 1 January 1994, who were enrolled to receive some form of preschool education between 2005 and 2014. These data comprise 310,213 individual records each corresponding to one child for each year of their schooling up to Year 3. The total number of individuals in these data was 64,673, of which 64,092 had records of sufficient completeness to include in the analysis cohort. The NT has a high proportion of Aboriginal children, almost 40% of each birth cohort.

Text Box 6.1 NT preschool types in 2013

General preschools are onsite and standalone services, which children enter at age 4 in urban and large remote areas. These preschools have general staffing formulae that require a minimum of 12 enrolments for the allocation of a full-time equivalent teacher or proportion thereof. Long-distance education programs are also provided to students in remote areas through the general preschool framework***.***

Satellite preschools have the same attributes as general preschools but are geographically separate from the primary school through which they are administered e.g. Binjari, Kilano and Rockhole are satellite preschools of Clyde Fenton Primary School.

Multi-level early years classes (EY classes) are characterised by mixed-age classes in which preschool children are taught alongside Transition, Year 1 and/or older primary school children. These are typically provided in small communities where the limited number of student enrolments is such that the provision via the standard general preschool model is not feasible.

The Mobile Preschool Program. This innovative preschool model caters for children in very small and remote communities who previously had no access to preschool. Piloted from 2000 to 2005 under the National Indigenous Literacy and Numeracy Strategy (NIELNS) and expanded through the Closing the Gap strategy in 2008, it involves the employment of a local assistant teacher to provide a daily preschool program under the supervision of a visiting and qualified preschool teacher. The program is offered to children aged 3–5 years, but does not exclude younger children. It is delivered in children's first language with scaffolding of oral Standard Australian English. It includes active family engagement through parent information and activities promoting health, development and nutrition (Nutton 2013).

As can be seen in Table 6.1, the greater majority of NT Aboriginal children enrolled in preschool live in remote and very remote communities. Although there were 762 (1.2%) missing records, full information was available on children's early-life education (Transition, Years 1, 2 or 3) for 45,833 children (72%). Preschool records are observed for 23,161 children—or 50% of the children for whom we observe EY school attendance.

For the analysis, we need to assume that none of the children in our data left the NT, and returned at a later date, or attended a private preschool provider during the relevant time. There are also other children whose last early primary school year (i.e. Year 3) was in 2014. The majority of these children were still in early primary classes in 2015. These children were retained in the analysis cohort since patterns of school attendance are relatively stable in the early primary years and there was no apparent selection bias for or against Aboriginal children.

Applying these cohort-selection criteria yielded a final analysis sample of 19,586 eligible children. Figure 6.A.1 in the Chapter Appendix summarises the cohort selection process, and the resulting sample size in each step. We also assume that these 19,586 children were residents in the NT from preschool to their early primary school years, and that, with few exceptions children with no recorded preschool attendance did not attend preschool. Given that non-Aboriginal children were more likely to move interstate or to attend non-government preschools, this sample definition unavoidably introduces a sample selection bias in favour of Aboriginal children and therefore children living in very remote areas (see Table 6.2 below).

Table 6.1 Number of children by Aboriginal status and geographic location

	Outer regional	Remote	Very remote	Missing	Total
Non-Aboriginal	29,338 *(83.2%)*	6,666 *(59.6%)*	3,340 *(19.3%)*	223 *(67.0%)*	39,567 *(61.7%)*
Aboriginal	5,360 *(15.25%)*	4,409 *(39.4%)*	13,890 *(80.2%)*	104 *(31.7%)*	23,763 *(37.1%)*
Missing	554 *(1.6%)*	109 *(1.0%)*	98 *(0.6%)*	1 *(0.3%)*	762 *(1.2%)*
Total	35,252	11,184	17,328	328	64,092

Table 6.2 Percentage representation of Aboriginal and non-Aboriginal students in the analysis sample

	Excluded %	Sample %	Combined %
Non-Aboriginal	67.3	49.3	61.7
Aboriginal	31.0	50.7	37.1
Not stated	1.7	0	1.2
Total	100	100	100

The proportion of children who participated in preschool is substantially greater (86%) in our final estimation sample than in the sample of excluded children (36%). This is likely due to missing information on out-of-state or non-government preschool attendance, which we do not observe. The final estimation sample was further reduced by restricting the analysis on children with no missing observations of all relevant control variables. This reduced the analysis sample of Aboriginal children to 6,792 and non-Aboriginal children to 9,112 observations.[12] Also, since the analyses reported in earlier chapters indicated that outcome and control variables differed significantly between the Aboriginal and non-Aboriginal cohorts, the analysis was conducted separately for each group.

6.3 Distribution of school and preschool attendance

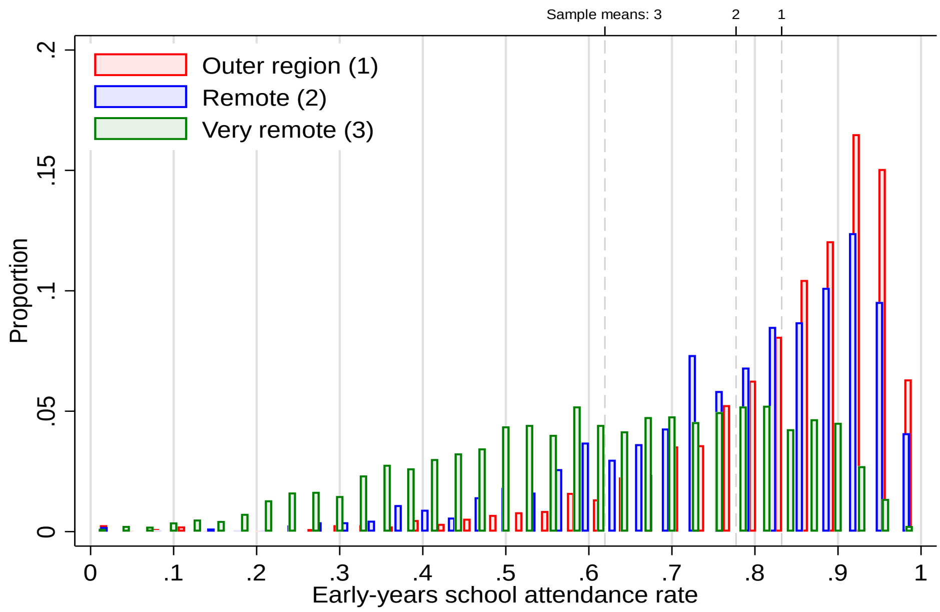
Children's attendance in the EY of primary school varies significantly across geographic regions. This can be seen in the distribution of school attendance rates for Aboriginal and non-Aboriginal children shown below in Figures 6.2(a) and 6.2(b). A significant gradient can be seen in the school attendance of Aboriginal children both within regions and across regions. For instance, average school attendance was significantly greater in outer regional schools (85%) than in remote (75%) and very remote schools (62%). The spread of school attendance rates varies widely across all regions, where some children never attended school whilst others attended 100% of the time.

In contrast, no obvious gradient by regional location was evident for non-Aboriginal children. Average attendance rates were almost 90% in all regions, although the spread of attendance rates was also high for non-Aboriginal children, covering the full distribution from 0% to 100% attendance rates.

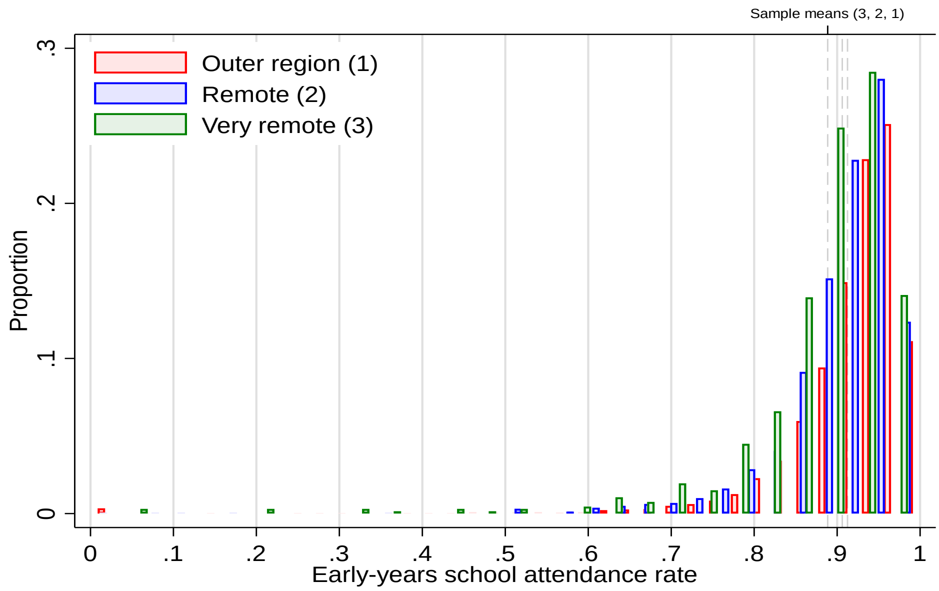
[12] Summary statistics of all relevant outcome and control variables are presented separately for Aboriginal and non-Aboriginal children in Appendix Table 6.A.2.

Figure 6.2 Distribution of EY school attendance (proportion of required days) for (a) Aboriginal children, and (b) non-Aboriginal children by area of remoteness (Accessibility Remoteness Index of Australia (ARIA))

(a) Aboriginal children (N = 6,792)



(b) Non-Aboriginal children (N = 9,112)



The majority of both Aboriginal and non-Aboriginal children attended some form of general preschool (63% and 87% respectively). A substantially larger proportion of Aboriginal children attended EY classes and mobile or satellite preschools than non-Aboriginal children. For instance, almost 10% of Aboriginal children attended an EY class and mobile preschool, while only 1% and less than 0.5% of non-Aboriginal children did so, respectively. Preschool attendance rates were 52% for Aboriginal and 79% for non-Aboriginal children.

6.4 Empirical framework and estimation results

6.4.1 Statistical modelling

Our key outcome of interest was EY school attendance rates (i.e. Transition and Years 1 to 3) measured as the proportion of the 200 school days able to be attended in a typical school year. In the analyses which follow we investigated the following questions:

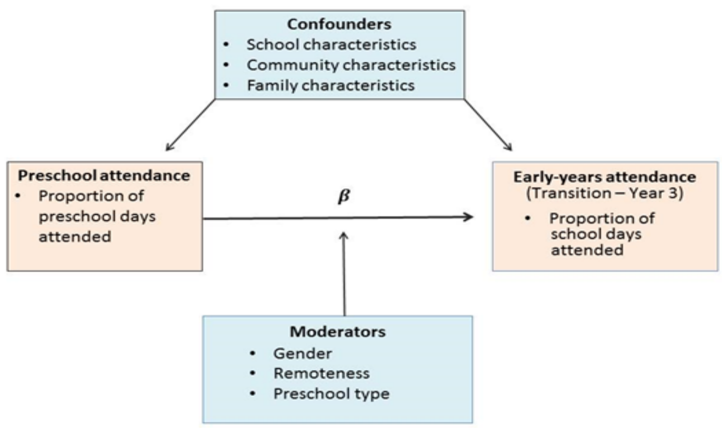
1. Regardless of Aboriginal status, are children who attended any preschool more likely to have higher EY school attendance rates than children who did not?
2. Do children who attended more days during a typical preschool year have higher EY school attendance rates?
3. To what extent do the type of preschool and geographic remoteness moderate the relationship between preschool attendance and EY school attendance rates?

The predictor variable in research question 1 is 'ever' attending any preschool while in question 2 it is the 'dose' of preschool attendance. Both are based on the assumption that preschool participation helps families and children establish regular attendance patterns (Attendance Works and Healthy Schools Campaign 2016). Question 3 is based on the evidence that some preschools are better equipped to deliver services, and that remoteness is a key barrier to the delivery of regular education services.

To investigate these questions, we estimated a non-linear model in which EY primary school attendance was the dependent variable and preschool attendance (any, by type) or dose (percentage of school days attended) was the main independent variable. To adjust for the non-normal, skewed distribution of the dependent variable evident in Figures 6.2(a) and 6.2(b) above, we utilised a general linear model (GLM) with a logit link function to estimate the relationships of interest (McCullagh and Nelder 1989). Figure 6.3 (below) describes the statistical model in theory.

In this model, β (beta) measures the association between preschool attendance and EY primary school attendance, but not necessarily an indication of causation. For the model to be robust, it also needs to take account of potential confounders, e.g. there could be factors at the school, community, family or individual level which were not in the pathway specified above but had influenced either the child's likelihood of attending preschool or the likelihood of the child's EY primary school attendance, or both.

Figure 6.3 Estimation model – confounders and moderators



Many of these potential confounders are observed in the analysis dataset, so we are able to control for them directly. For instance, some basic information about the socioeconomic and demographic background of the family was collected by the school at enrolment. The analysis dataset also includes Australian Bureau of Statistics (ABS) community-level statistical local area (SLA) proxies for economic deprivation (such as Socio-Economic Indexes for Areas (SEIFA) and housing overcrowding, see Chapters 4 and 5 for more information). In addition, the measure of geographic remoteness captures heterogeneity in communities' exposure to seasonal weather issues and travel distance to essential services.

Unfortunately, the analysis dataset did not include school-level information on school and teaching quality factors such as teacher/staff /student ratios, school/community relations, available resources, and peer group effects that are school district specific. However, it is possible to statistically control for school-specific factors (e.g. teaching quality, school-community engagement etc.) by the analysis including a 'fixed effects' indicator variable for each individual school. In effect, this variable operates as a proxy for these unmeasured factors specific to each school.

Under the assumption that there are no other confounders, and that the main school-specific effects are generally constant over time, the estimated coefficient β can be interpreted as showing the strength of the relationship.[13] Because we have data on individual students collected repeatedly over time at their school, it is necessary to cluster the standard errors (used for statistical inference) at the school level, a standard approach used in the literature.

6.4.2 Preschool attendance and early years school attendance

The model building process is summarised in Table 6.3 (below). This reports the estimated coefficient of β separately for Aboriginal children (Panel A) and non-Aboriginal children (Panel B).[14] Column (1) reports the direct association between preschool attendance (any) and EY school attendance rates without controlling for any potential confounders. Reading across the table from Model (1) to (5), it can be seen that each successive model increases the number of control variables taken into account—from no controls (Model 1), to a full set of controls including school fixed effects (Model 5). In this table it can also be seen that as each model includes an additional block of variables, this improved the Bayesian Information Criterion (BIC) measure of model fit i.e. including the additional control variable resulted in greater predictive precision.

The number of days it is possible for a child to attend school in a typical NT school year is around 200 days. The average EY school attendance among Aboriginal children was found to be 71%, while for non-Aboriginal children it was 91%. On average, Aboriginal children who attended any preschool spent 7.3 percentage points more days in EY school education than Aboriginal children who did not attend preschool. Since the average school attendance rate for Aboriginal children is 71%, this association is equivalent to 10% or 20 more days attendance in each of the school years from Transition to Year 3.

[13] Ideally, we would have preferred to control for individual or family-specific effects. However, this was not possible, because the predictor of main interest (preschool attendance) does not vary over time, and data were not yet available for siblings that would enable controlling for family-fixed effects.

[14] Positive β coefficients are interpreted as the increased proportion of days of EY attendance during a typical school year for a child who had attended preschool relative to the days of EY attendance of a comparable child that did not.

Table 6.3. Association between any preschool attendance and EY school attendance

Model	(1)	(2)	(3)	(4)	(5)
Panel A: Aboriginal (N = 6,792)					
Preschool	0.073***	0.041***	0.039***	0.045***	0.045***
	(0.013)	(0.011)	(0.012)	(0.012)	(0.008)
Model fit: BIC[a]	−2,349	−3,924	−4,576	−4,801	−6,496
Panel A1: Outer regional (N = 1,866)					
Preschool	0.068***	0.055***	--	0.059***	0.048***
	(0.015)	(0.012)	--	(0.012)	(0.012)
Panel A2: Remote and very remote (N = 4,926)					
Preschool	0.050***	0.033**	0.036**	0.044***	0.046***
	(0.014)	(0.014)	(0.015)	(0.015)	(0.010)
Panel B: Non-Aboriginal (N = 9,112)					
Preschool	0.011***	0.011***	0.011***	0.011***	0.012***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Model fit: BIC	−18,417	−18,501	−18,545	−18,589	−18,992
Panel B1: Outer regional (N = 6,836)					
Preschool	0.009**	0.009**	--	0.012**	0.010**
	(0.004)	(0.004)	--	(0.005)	(0.004)
Panel B2: Remote and very remote (N = 2,276)					
Preschool	0.017**	0.016**	0.016**	0.015**	0.020***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.005)
Control variables					
Family characteristics		✓	✓	✓	✓
Remoteness			✓	✓	✓
SEIFA/crowding				✓	✓
School fixed effects					✓

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Outcome variable is early years school attendance rate; Preschool is a dummy variable that takes the value 1 if the child attended any preschool, and 0 otherwise. Each column reports the estimated coefficient on preschool, adding subsequently a block of control variables such as family characteristics (mother's age at birth of cohort children, parental education, parental employment status), remoteness indicators (outer regional (base), remote, very remote), community characteristics (SEIFA index (natural logarithm), number of persons per room in household), and school fixed effects (dummy variable representing each one school). Standard errors are clustered at the school level to account for repeated observations in each school.
[a]BIC Bayesian Information Criteria is a measure of goodness of fit, which penalises increasing number of control variables. Smaller negative values indicate better model fit.

When controlling for all possible confounders, including fixed school characteristics (Table 6.3, column 5), this association is reduced, but still highly statistically significant with a 4.5 percentage point change equivalent to 12 additional days spent in school.

The impact of preschool attendance is approximately the same in absolute terms for Aboriginal children in outer regional areas and remote/very remote areas (Panel A1 vs Panel A2). However, the relative change—when measured as a percentage increase from the sample mean for the relevant group—is substantially larger for children in (very) remote areas. School attendance rates were only just above 60% in very remote areas; hence a 4.6 percentage point increase is equivalent to 15 additional days, while in outer regional areas, where school attendance is 82%, a 4.8 percentage point increase is equivalent to 11 more days. For non-Aboriginal children the impact of preschool attendance is weaker. Independent of the model specification, the association between preschool attendance and EY school attendance is only one percentage point (1% from mean 91%). This implies an increase of two additional days spent in EY; in very remote areas, the equivalent increase is four additional days (Panel B2, column 5).

6.4.3 The role of preschool attendance in very remote locations

In this section we investigate whether this association varied by the type of preschool attended (i.e. EY classes, general and mobile preschools) in very remote locations during the study period. Table 6.4 (below) reports the association between children's preschool attendance and EY school attendance for each of the three preschool types and Aboriginal status. For non-Aboriginal children, attendance at general preschools increased school attendance in very remote locations by about five additional school days each EY school year. However, for the 38 non-Aboriginal children who had attended a mobile preschool, this had no impact on their EY school attendance (i.e. a precise zero estimate). In practical terms, the percentage impacts equate to an average of 22, 13 and 11 more days of attendance respectively. As can be seen in column 2, all three preschool types had positive significant

Table 6.4 Association between preschool attendance (any) and EY school attendance, by preschool type in very remote areas

	(1) All	(2) Aboriginal	(3) Non-Aboriginal
Attendance			
EY class	0.036*	0.041**	--[a]
	(0.021)	(0.019)	--
General	0.064***	0.067***	0.024***
	(0.013)	(0.016)	(0.006)
Mobile	0.026*	0.033**	0.008
	(0.016)	(0.013)	(0.026)
Observations	4,052	3,385	667
- EY Class	506	497	9
- General	2,279	1,729	550
- Mobile	556	518	38

Notes: This model includes all control variables from column 5 of Table 6.2, including school fixed effects.[a] Due to small sample sizes, it was not possible to reliably estimate the relationship between EY class attendance and EY school attendance for non-Aboriginal children. Standard errors are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

associations ($p < 0.05$) with EY school attendance rates for Aboriginal children. The strongest impacts were for general preschools (6.7 percentage points), followed by EY classes (4.1 percentage points), and mobile preschools (3.3 percentage points) over each of the four early years of schooling.

6.5 Does the 'dose' of preschool matter?

This section reports an investigation of what preschool attendance percentage (i.e. 'dose' or exposure to preschool) is required for improving students' subsequent EY school attendance rates in very remote regions. This involved an experimental analysis which estimated the extent to which the EY school attendance rates of Aboriginal children increased for different 'doses' of preschool attendance.

6.5.1 Statistical methodology

The predictions were obtained from a GLM model in which the dependent variable is EY school attendance, and the main independent variables are the three indicators for each preschool type. Given the non-linear relationship between preschool and EY attendance, we introduced interactions between indicator variables and used a polynomial transformation of preschool attendance to improve predictive power of the model.

The model includes the same set of control variables as in the standard model used in Table 6.3, column 5, including school fixed effects.

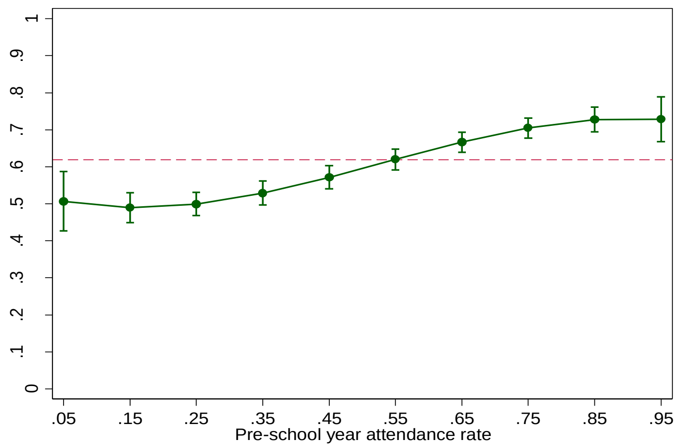
6.5.2 Analysis findings

Figure 6.4 (below) reports the EY school attendance rate for each selected preschool attendance rate as predicted from the statistical model described earlier in section 6.4, separately for each preschool type. The horizontal, red dashed line indicates the average EY school attendance rate in the sample of Aboriginal children in very remote areas (62%). The 'capped spikes' represent the 95% confidence interval around each of these estimates. The sample size for this estimation model included 3,385 Aboriginal children, of whom 641 did not attend any preschool (19%).

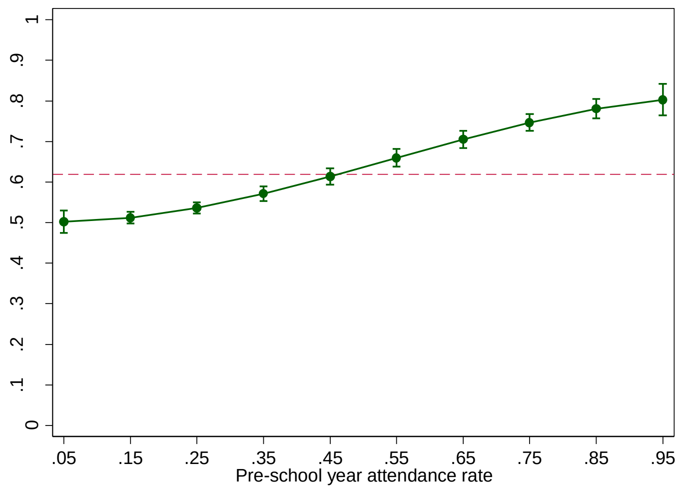
These findings have important policy implications. Firstly, in Figure 6.4(b) it can be seen that in comparison with the other preschool types, general preschool attendance has the greatest potential impact in increasing children's expected days of EY attendance. In other words, it takes fewer days of general preschool for a child to achieve above average EY school attendance. Secondly, Aboriginal children in very remote regions, who attend general preschool more than 45% of the required school days, can be expected to attend EY school beyond the sample average of 62%. Children who attended general preschool less than 45% of the yearly required days are predicted to attend EY school at significantly lower levels. Finally, for EY class preschools and mobile preschools, the corresponding minimum preschool attendance thresholds to lead to population average EY school attendance are 55% and 65%, respectively (Figures 6.4(a) and 6.4(c)). This finding is not surprising as general preschools are better resourced and professionally supported. At the same time, while less well resourced, EY classes and mobile preschools are both surprisingly successful in more days of attendance being associated with additional days attending primary school.

Figure 6.4 Association of preschool and EY school attendance rates for Aboriginal children in very remote areas, by preschool type

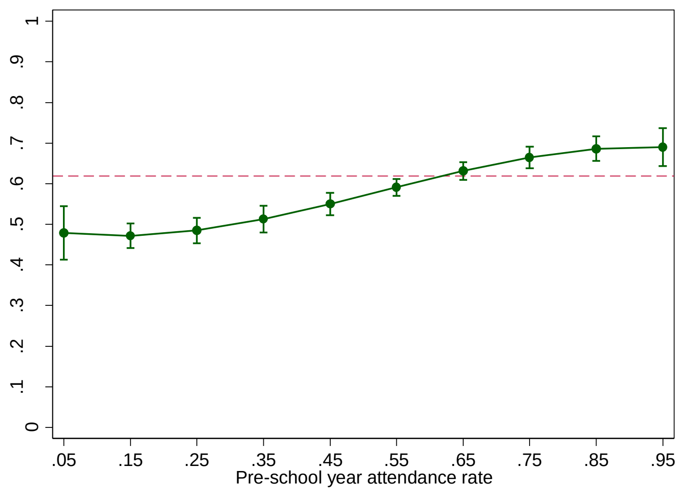
(a) Early years classes (N = 497)



(b) General preschool (N = 1,729)



(c) Mobile preschool (N = 518)



Another further insight from Figure 6.4 is that improvements in preschool attendance between 25% and 75% would have relatively greater impact in changing EY school attendance rates than similar improvements at the extreme ends of the preschool attendance distribution. This is evidenced by the slope of the prediction curve being steep between 25% and 75% but becoming flatter below 25% and above 75%.

6.6 Does preschool attendance improve school achievement outcomes?

Finally, to estimate the potential benefits of increasing Aboriginal children's preschool attendance for later academic outcomes, we considered the Year 3 NAPLAN outcomes of a subsample of 1,788 Aboriginal children living in very remote areas for whom data were available on their NAPLAN scores, preschool and EY school attendance. The dependent variable was a binary indicator of whether a child's NAPLAN scores ranked above the National Minimum Standard (NMS) on each of the NAPLAN scoring domains (i.e. reading, writing, spelling, grammar, numeracy). The main independent variable was a continuous measure of the preschool attendance rate. The model was estimated with a probit specification that is used in the analysis of dependent variables that are binary in nature. Adjustment was made for the same set of control variables as in the earlier reported models, including school fixed effects. Marginal effects were calculated at the mean of all control variables to estimate their effect on the probability of scoring above the NMS.

Figure 6.5(a) (below) shows the estimated effect of hypothetical increases in preschool attendance on the probability of scoring above the NMS for each of the NAPLAN domains. It illustrates that increasing a child's preschool attendance rate from 0% to 100% increases their probability of scoring above the NMS on four out of five Year 3 NAPLAN assessment domains.

Figure 6.5(a) Association between preschool attendance and NAPLAN achievement (Reading, Writing, Grammar, Spelling and Numeracy) not controlling for EY attendance, NT Aboriginal children in very remote areas (N = 1,788)

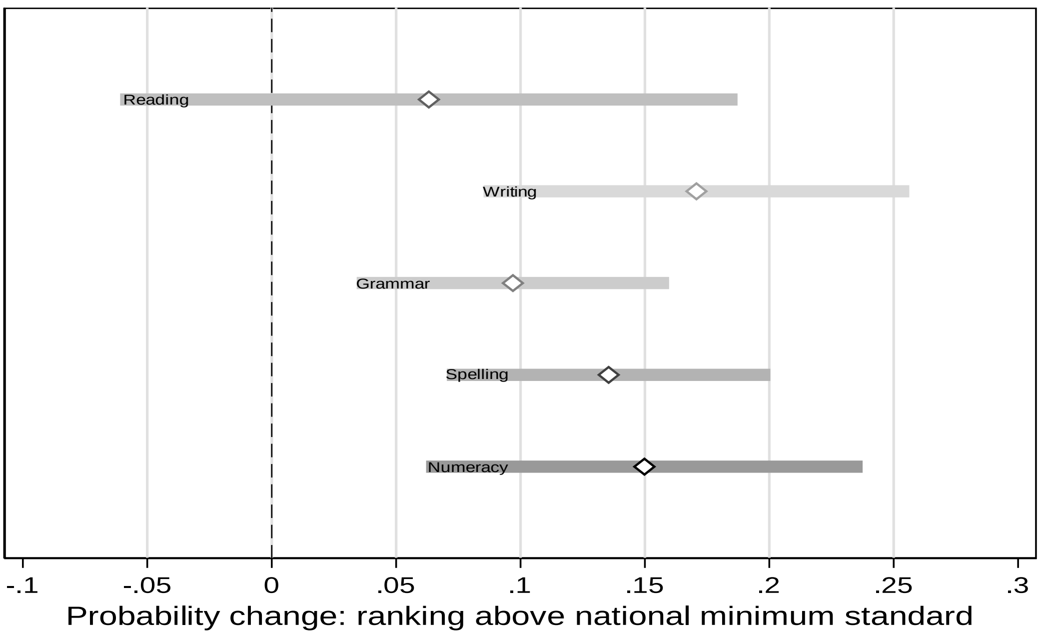
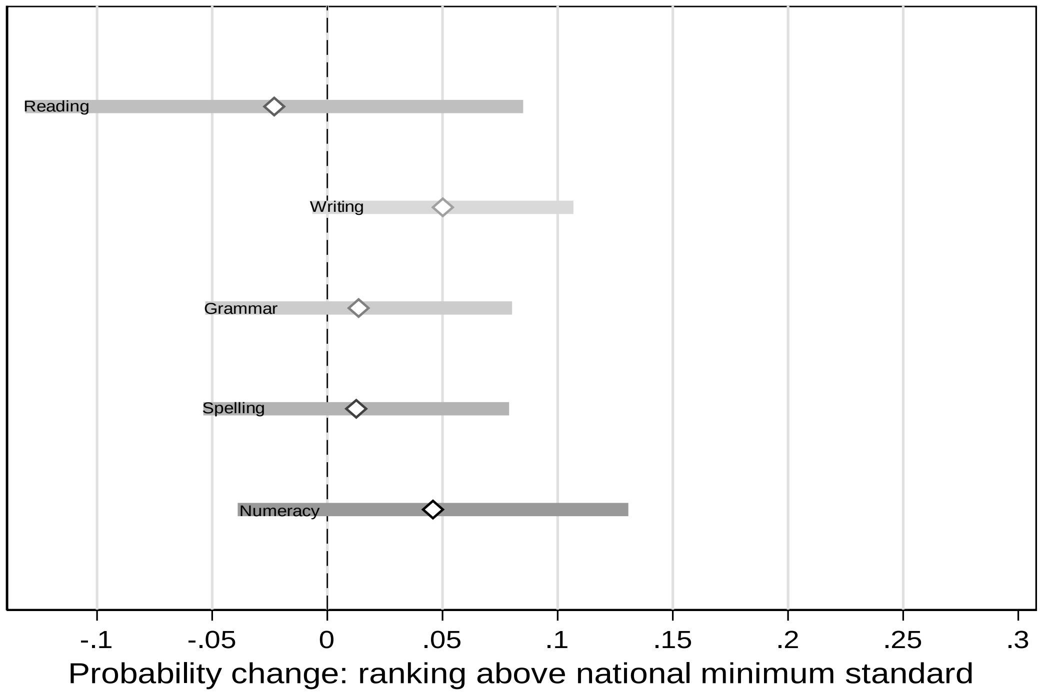


Figure 6.5(b) Association between preschool attendance and NAPLAN achievement (Reading, Writing, Grammar, Spelling and Numeracy) when controlling for EY attendance, NT Aboriginal children in very remote areas (N = 1,788)



Notes: 1. Grey bars represent 95% confidence intervals.
2. Base probability of reaching NMS for these children for each domain: Reading = 0.29; Writing = 0.24; Grammar = 0.24; Spelling = 0.21; and Numeracy = 0.32.

Figure 6.5(b) (above) shows the estimated marginal probability effect of increased preschool attendance from 0% to 100% when controlling for EY school attendance. As can be seen, these effects were all centred around zero, and thus no longer significant. This indicates that preschool attendance is associated with better EY school attendance, but is not associated with NAPLAN achievement over and above the effects of EY school attendance.

6.7 Discussion

The findings in this chapter provide encouraging empirical evidence for increased preschool attendance of Aboriginal children being associated with increased EY school attendance rates and thus better NAPLAN achievement outcomes. Where available, the general preschool model appears to be the optimal mode of preschool for lifting Aboriginal children's EY attendance rates above sample average and especially in very remote areas. Aboriginal children who attended at least 45% of the required preschool days, can be expected to have EY school attendance above the average attendance rate in these areas.

Importantly, the findings also show that alternative preschool delivery models such as early years classes and mobile preschools, although endowed with fewer resources and located in much more inaccessible areas, are associated with lifting EY school attendance rates, albeit less effectively than general preschools. These results hold over and above the influence of school/community-fixed factors—which for each school/community could either have an increasing or decreasing effect on both preschool and EY attendance.

Breakout box 6.1 The Congress Preschool Readiness Program

The Congress Preschool Readiness Program (PRP) is an award winning example of an innovative, locally developed program which has been highly effective in enabling Aboriginal children to make a successful transition into regular preschool attendance and early learning. The Congress Aboriginal Medical Service links its routine health screening to an outreach family and school support program. More than 300 Aboriginal families with young children use the medical services of the Congress each year. The PRP uses its patient medical records system to identify local Aboriginal families with three- and four-year-old children. All families are visited and offered free child health checks for their preschool-aged children. They are asked if they will be enrolling their children in preschool, and offered additional support if needed.

"The families we connect with want the best for their children, but many face challenges that limit their ability to support their children to get off to a good start. We focus on making sure we offer the right type of support for the right families. When I see the happy faces of these children and the proud faces of the parents who have gone through our program I have a lot of hope for their future" (PRP family support worker).

This model of providing a developmental out-reach program through a primary health service is unique in Australia. The Congress staff support families with preschool information and enrolment help, and work with families and children to help them become more confident in engaging with the school system. They assist with health checks and follow-ups, and also provide practical assistance at preschools to enable children's successful adjustment and regular attendance. The program has been acknowledged for its innovation and achievements within its first few years of operation, and was also cited as an example of excellence in practice in the Prime Minister's 2013 Closing the Gap report.

https://www.caac.org.au/news-events/news/2012/9/preschool-readiness-program-wins-chronic-disease-award

The findings concerning the longer-term effect of preschool attendance for subsequent school attendance and achievement can reasonably be interpreted as being more than just correlational evidence. This would support future research involving economic modelling of the medium- and longer-term cost benefits associated with percentage-point improvements in preschool attendance for each of the main preschool delivery models now operating in the NT. Such modelling would also need to take account of the feasibility of the different preschool delivery models according to the geographical and sociocultural community contexts in which they are delivered.

A limitation of our analysis is that it was not able to include data which would clarify the mechanisms through which higher preschool attendance has a greater effect on the ongoing school attendance rates for Aboriginal students than non-Aboriginal students. One of the possible explanations is that the universal access to preschool for Aboriginal children from age three onward may engage the family's interest and trust in the school education system from an earlier age, thus increasing parents' motivation to encourage their children going to school.

It may also be the case that children's preschool participation helps parents to build family routines which structure a typical day around their children's schooling. Preschools also play an important role in helping parents access other services that they and their children may require (e.g. breakfast programs, child care, and outreach medical services).

However, as Indigenous scholars such as Martin (2016) and others have pointed out, detailed qualitative investigation is needed into parents' perceptions of the experience they and their children have in engaging with preschool. Future studies of this kind are essential to advance policy understanding and service practices which optimise children's early learning opportunities.

The effectiveness of preschool programs in improving children's participation and outcomes is also dependent on the quality of their structural and process features, including those defined in the 'National Quality Framework for Early Childhood Education and Care' introduced in 2012. This framework includes a National Quality Standard (NQS) monitored by the regulatory authority in each state and territory. This is designed to ensure high quality and consistent early childhood education and care across Australia and applies to preschools, long day care, family day care, and outside school hours care (ACECQA 2017).

Under the National Quality Framework, long day care and preschool services must have an early childhood teacher in attendance, with specific requirements varying depending on the size of the service. While high standards are aspired to in the provision of preschool education for all NT children, it has not yet been possible for many preschools in remote and very remote areas of the NT to meet this teaching qualification requirement.

At the same time, the increasing availability of routinely reported NQS data for NT preschools means that these data could be utilised in future data-linkage research to identify the ways in which the 'quality' features of the various educational programs impact on children's outcomes. They could also be used in conjunction with qualitative research to assist in clarifying which aspects of teacher-child/family relationships are most critical to supporting children's longer-term educational engagement and achievement.

6.8 References

ACECQA. 2017. 'Guide to the National Quality Framework', Australian Children's Education & Care Quality Authority (ACECQA), Accessed 8 December 2017. http://files.acecqa.gov.au/files/National-Quality-Framework-Resources-Kit/NQF-Resource-03-Guide-to-NQS.pdf.

Arnold, C, K Bartlett, S Gowani, and R Merali. 2007. *Is Everybody Ready? Readiness, Transition and Continuity: Reflections and Moving Forward. Working Papers in Early Childhood Development, Number 41* (Bernard van Leer Foundation: The Hague, Netherlands).

Attendance Works and Healthy Schools Campaign. 2016 Mapping the early attendance gap: Charting a course for school success. Accessed 8 December 2017. http://www.attendanceworks.org/wp-content/uploads/2017/05/Mapping-the-Early-Attendance-Gap_Final-4.pdf

Bamblett, M, H Bath, and R Roseby. 2010. *Growing them Strong, Together: Promoting the safety and wellbeing of the Northern Territory's children* (Northern Territory Government: Darwin).

Bennett, J, and CP Tayler. 2006. *Starting strong II: Early childhood education and care* (Organisation for Economic Co-operation and Development (OECD): Paris).

Biddle, N. 2007. 'Indigenous Australians and preschool education: Who is attending?', *Aust J Early Child*, 32: 9-16.

Briggs, F, and GK Potter. 1999. *The early years of school: Teaching and learning* (Longman: Melbourne).

Burchinal, M, JE Roberts, SA Zeisel, EA Hennon, and S Hooper. 2006. 'Social risk and protective child, parenting, and child care factors in early elementary school years', *Parent Sci Pract*, 6: 79-113.

Clancy, S., L. Simpson, and P. Howard. 2001. 'Mutual Trust & Respect.' in, *Bringing School Together: Sharing Strengths* (Australian Early Childhood Association Inc.: Watson, ACT).

Cloney, D, C Tayler, J Hattie, G Cleveland, and R Adams. 2016. 'The selection of ECEC programs by Australian families: Quality, availability, usage and family demographics', *Aust J Early Child*, 41: 16.

COAG. 2008. 'Indigenous Early Childhood National Partnership', Council of Australian Governments (COAG), Accessed 8 December. www.coag.gov.au.

Council of Australian Governments (COAG). 2009. 'Early Childhood National Partnership', Council of Australian Governments (COAG), Accessed 8 December. www.coag.gov.au.

Collins, R., and T. Lea. 1999. "Learning lessons: an independent review of Indigenous education in the Northern Territory." In. Darwin: Northern Territory Department of Education.

Dockett, S, B Perry, T Mason, T Simpson, P Howard, D Whitton, S Gilbert, S Pearce, P Sanagavarapu, and J Skattebol. 2008. 'Successful transition programs from prior-to-school to school for Aboriginal and Torres Strait Islander children', University of Western Australia, Charles Sturt University & Australian Catholic University, Accessed 8 December 2017. http://www.curriculum.edu.au/verve/_resources/ATSI_Successful_Transition_programs_Report_Dec_2007.pdf.

Entwisle, DR, and KL Alexander. 1998. 'Facilitating the transition to first grade: The nature of transition and research on factors affecting it', *Elem Sch J*, 98: 351-64.

Fox, S, and M Geddes. 2016. *Preschool-Two Years are Better Than One: Developing a Preschool Program for Australian 3 Year Olds–Evidence, Policy and Implementation, Mitchell Report No. 03/2016* (Mitchell Institute: Melbourne).

Frigo, T, M Corrigan, I Adams, P Hughes, M Stephens, and D Woods. 2004. *Supporting English literacy and numeracy learning for Indigenous students in the early years* (Australian Council for Educational Research (ACER): Camberwell).

Goldfeld, S, E O'Connor, M O'Connor, M Sayers, T Moore, A Kvalsvig, and S Brinkman. 2016. 'The role of preschool in promoting children's healthy development: Evidence from an Australian population cohort', *Early Child Res Q*, 35: 40-48.

Grace, R, J Bowes, and E Elcombe. 2014. 'Child participation and family engagement with early childhood education and care services in disadvantaged Australian communities', *Int J Early Child*, 46: 271-98.

Hanlen, W. 2007. 'Indigenous literacies: Moving from social construction towards social justice.' in L Makin, C Jones-Diaz and C McLachlan (eds.), *Literacies in Childhood* (Elsevier: Marrickville, NSW).

Hattie, JAC. 2003. 'Teachers Make a Difference, What is the research evidence? Paper presented at the Building Teacher Quality: What does the research tell us ACER Research Conference', Australian Council for Educational Research (ACER), Accessed 8 December. https://research.acer.edu.au/research_conference_2003/4/.

Hewitt, B, and M Walter. 2014. 'Preschool participation among Indigenous children in Australia', *Family Matters*: 41-50.

Hill, S, B. Comber, W. Louden, J. Rivalland, and J.A. Reid. 2002. *100 children turn 10: A longitudinal study of literacy development from the year prior to school to the first four years of school* (Department of Education, Science & Training: Canberra).

Homel, R, K Freiberg, C Lamb, M Leech, A Carr, A Hampshire, I Hay, G Elias, M Manning, and R Teague. 2006. *The pathways to prevention project: the first five years 1999–2004* (Griffith University: Sydney).

Krieg, S, D Curtis, L Hall, and L Westenberg. 2015. 'Access, quality and equity in early childhood education and care: A South Australian study', *Aust J Educ*, 59: 119-32.

Leske, R, D Sarmardin, A Woods, and K Thorpe. 2015. 'What works and why?: Early childhood professionals' perspectives on effective early childhood education and care services for Indigenous families', *Aust J Early Child*, 40: 109-18.

Losey, Kay M. 1995. 'Mexican American students and classroom interaction: An overview and critique', *Rev Educ Res*, 65: 283-318.

Magnuson, KA, C Ruhm, and J Waldfogel. 2007. 'Does prekindergarten improve school preparation and performance?', *Econ Educ Rev*, 26: 33-51.

Martin, K. 2016. *Aboriginal Voices and Visions: Aboriginal Early Childhood Education in Australia* (Pademelon Press: Jamberoo, NSW).

McCullagh, P., and J.A. Nelder. 1989. *Generalized Linear Models* (Chapman and Hall: London).

NAEYC. 2005. 'Screening and assessment of young English-language learners', National Association for the Education of Young Children (NAEYC), Accessed 12 December 2017. https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/position-statements/ELL_SupplementLong.pdf.

Neuman, M, and J Bennett. 2001. *Starting strong I: Early childhood education and care* (Organisation for Economic Co-operation and Development (OECD): Paris).

Nutton, G. 2013. 'The effectiveness of Mobile Preschool (Northern Territory) in improving school readiness for very remote Indigenous children, PhD Thesis', Charles Darwin University.

Shonkoff, JP, and DA Phillips. 2000. *From neurons to neighborhoods: The science of early childhood development. Committee on Integrating the Science of Early Childhood Developement* (National Academy Press: Washington, D.C.).

Silburn, SR, G Nutton, J McKenzie, and M Landrigan. 2011. 'Early years English language acquisition and instructional approaches for Aboriginal students with home languages other than English: A systematic review of the Australian and international literature', *Darwin: Menzies School of Health Research*.

Simpson, L, and S Clancy. 2000. "Developing classroom discourse with young aboriginal learners." In *Australian Indigenous Education Conference proceedings*. Fremental, WA.

Townsend-Cross, M. 2004. 'Indigenous Australian perspectives in early childhood education [Taken from a keynote address at the Pacific Early-Childhood Education Research Association International Conference (5th: 2004: Melbourne).]', *Aust J Early Child*, 29: 1.

Wild, R, and P Anderson. 2007. *Ampe Akelyernemane Meke Mekarle:" Little Children are Sacred": Report of the Northern Territory Board of Inquiry Into the Protection of Aboriginal Children from Sexual Abuse* (Northern Territory Government: Darwin).

Wilson, B. 2014. *A share in the future: Review of Indigenous Education in the Northern Territory* (Northern Territory Government: Darwin).

7. Modelling key drivers of school education outcomes

John McKenzie, Bernard Leckning, Gawaian Bodkin Andrews, and Sven Silburn

Chapter overview

This chapter aims to unify the work of previous chapters in developing a deeper understanding of the complex interactions of children's early life circumstances, pre-school program exposure, developmental readiness for school learning and subsequent academic outcomes. Establishing the relative contribution of these influences in shaping children's educational progress is vital to the development and effective targeting of policy to enable population-level improvements in children's educational outcomes.

Structural equation modelling (SEM) is the statistical method used to 'unpack' the relative influence and interplay of key factors identified in earlier chapter as making important contributions to Northern Territory (NT) children's literacy and numeracy outcomes. The analysis is focused on the inter-relation of three child factors individually shown to be associated with Year 3 school achievement (NAPLAN) - preschool attendance (PSA), childhood development and school readiness at age 5 years (AEDC), and attendance during the early years of primary school (i.e. transition to Year 3) (EYA). It also considers how these relationships are shaped by key demographic factors which characterise the NT school population i.e. children's Aboriginal status, level of remote residence, having English as a second language (ESL), and parents' level of education.

The initial stages of the model building process indicated that the patterns of response to these factors were substantially different for Aboriginal and non-Aboriginal children, and varied by the remoteness of the communities in which they were living. Separate SEM analysis was therefore undertaken for Aboriginal and non-Aboriginal children in outer regional, remote and very remote areas of the NT.

The analysis findings provide unique empirical evidence of the extent to which education and other policy investments in the early years could expect to be associated with positive change in NT children's developmental readiness for school learning, improved school attendance, and literacy and numeracy outcomes. They particularly highlight how policy strategies and the delivery of school and other services could be tailored to be relevant and proportional to the developmental and early learning needs of different NT student cohorts.

7.1 Introduction

Understanding the relative importance of the range of influences on children's progress in school can help to inform the development of policies and the efforts of communities and families to improve children's school education outcomes. This chapter provides an empirical description of the interplay of key early childhood factors known to be associated with NT children's development of literacy and numeracy. It focuses on the way in children's scores on the year 3 National Program for Literacy and Numeracy (NAPLAN) assessment, are shaped by a) their level of preschool attendance (PSA); b) their developmental readiness for school learning (as assessed by the Australian Early Development Census (AEDC)), and c) their level of attendance in the early years of primary school (i.e. transition to Y3 (EYA)). We also describe the extent to which these are influenced by key demographic factors relevant to children's family and school learning circumstances.

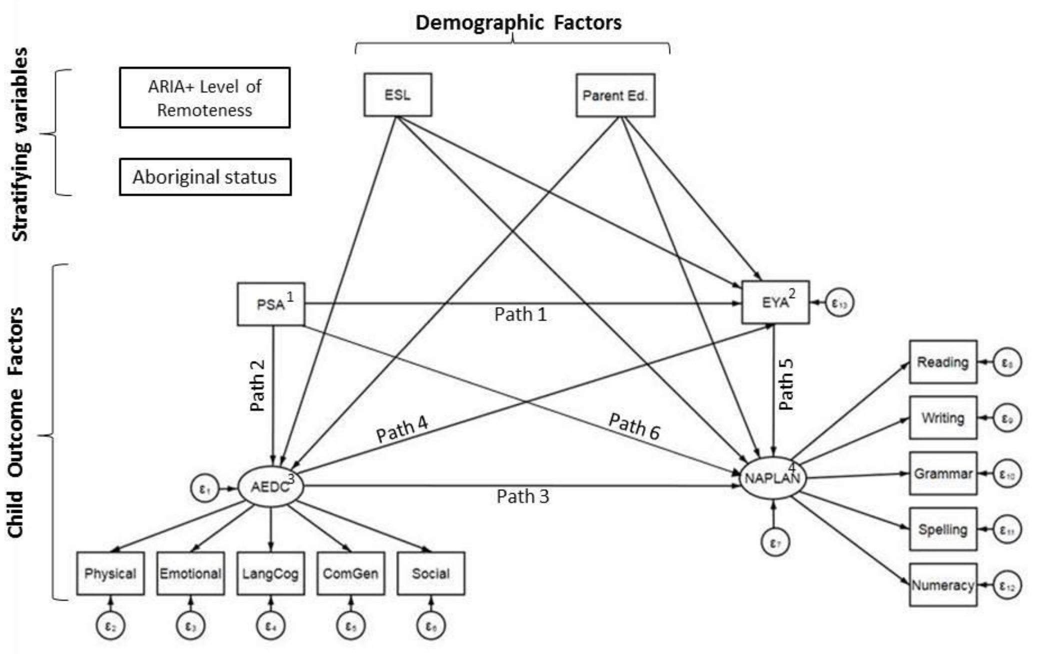
In earlier chapters (chapters 4, 5 & 6) we identified the benefits and factors associated with regular pre-school and primary school attendance, children's readiness for school learning (AEDC) and year 3 NAPLAN literacy and numeracy outcomes. Building on these findings, this chapter reports a Structural Equation Modelling (SEM) analysis undertaken to quantify how policy investments in the early years promoting children's healthy early development and readiness for school learning, could be associated with attendance in the pre- and early primary school years and their subsequent outcomes in literacy and numeracy.

7.2 Methods

Structural Equation Modelling (SEM) is a powerful analysis technique now increasingly used in social, behavioural, and educational research to investigate structural relationships between measured variables and 'latent' (unmeasured but analytically inferred) constructs (Duncan et al, 2011; Acock, 2013; Kline, 2013). It uses a confirmatory approach to the multivariate testing of a 'theory' developed by the researcher regarding the hypothesised interplay of factors thought to have a bearing on a particular phenomenon. This typically involves exploring a number of theoretically plausible models to identify which of the possible models offers the best fit with the data. The final hypothesised structural model we investigate is illustrated by the path diagram shown in Figure 7.1 below.

In this figure, the rectangular components are the directly measured data. The ovals represent the derived 'latent' variables e.g. in this model the value of the AEDC latent variable is derived from the measurement model associated with children's performance on the five AEDC domain

Figure 7.1 Hypothesised Structural Model



Notes: 1. PSA = Preschool Attendance Level
2. EYA = Early Years School Attendance
3. AEDC = Australian Early Development Census
4. NAPLAN = National Assessment Program for Literacy and Numeracy

scales which are represented diagrammatically in the five connecting rectangles. Similarly, the NAPLAN latent variable is derived from the five learning areas of NAPLAN represented in its connecting rectangles.

The SEM model building process was informed by an earlier investigation of the 'AEDC – EYA – NAPLAN' triangle (Paths 3, 4 and 5). This previous analysis used data of a smaller sample from the demonstration project (McKenzie, et al, unpublished 2012). That study established the necessity for the current analysis to be stratified by children's Aboriginal status. While it showed that the most direct path (i.e. Path 3) was important for all children, it also revealed that for Aboriginal children only, the combined effect of the indirect paths (i.e. Paths 4 and 5) was as strong an influence as the direct path (Path 3).

To enhance our understanding of the influence of children's preschool attendance (PSA) on Year 3 NAPLAN scores established in Chapter 6 (Path 6), the paths recommended by this earlier research (Paths 3, 4 and 5) were supplemented by paths reflective of findings from analyses in other chapters from the current Monograph. Path 1 was based on the findings reported in Chapter 5 regarding the association between children's level of preschool attendance (PSA) and their subsequent early years attendance (EYA). Findings from Chapter 5 confirmed results from earlier analyses of the need to account for the influence of AEDC outcomes on EYA (Path 4). Path 2 was informed by analysis in Chapter 4 describing the association between children's AEDC outcomes and their preschool attendance. The associations between demographic variables such as English as a second language and parents' level of education and AEDC, EYA and NAPLAN have also been established and reported in Chapter 5 and Chapter 6.

The structure of the final model shown in Figure 7.1 allows us to test the following hypotheses:

- Preschool attendance (PSA) positively influences early childhood development (AEDC) that in turn is associated with improvements in early academic achievement (Path 2 * Path 3).
- Preschool attendance (PSA) is positively associated with early primary school attendance (EYA), which, after adjusting for differences in early developmental outcomes (Path 4), has a positive influence on early academic achievement (NAPLAN) (Path 1 * Path 5).

7.2.1 Model specification

To ensure consistency in the interpretation of the influence of AEDC and NAPLAN by remoteness and Aboriginal status, the measurement models for these latent variables (i.e. items measuring AEDC outcomes and NAPLAN results, respectively) were first tested to ensure they were reflecting the same underlying construct across all strata. The required level of consistency was achieved across all strata and the appropriate constraints were applied to the measurement components of the full model. The other demographic variables included in the final stratified SEM models were: English as a Second Language (ESL) status, and parents' level of education.

A high proportion of NT Aboriginal students were identified in their school enrolment records as having English as their second or third language – particularly those in remote and very remote areas. These children typically require additional language support in making successful transition into a school learning context where English is the official language of instruction (Silburn et al, 2010). As the students' school enrolment records on parents' educational status had a high proportion of missing data, we used community-level Census data regarding adults' level of education in each child's community as a proxy (ABS, 2015). The analysis cohort was the same set of children investigated in the analysis of preschool outcomes reported in Chapter 6 (N=19,647). However, due to the potential reduction of the analysis cohort resulting from the linkage of multiple datasets, the requirement for each child to have complete data was relaxed. This was done by use of the 'maximum likelihood with missing values' (MLMV) convergence method.

7.3 Model fit and stratified modelling results

The full set of results from the stratified SEM analyses are shown separately for Aboriginal and non-Aboriginal children in each strata of remoteness in Appendix Figures 7.A.1, 7.A.2 and 7.A.3. These figures also include details of the measurement models from which the AEDC and NAPLAN latent variable scores were derived. For the structural component of the model (Paths 1 to 6), the path coefficients shown next to each path reflect its strength in predicting the path outcome. Because standardised coefficients are used throughout, this enables meaningful comparison to be made of the relative strength of the direct associations between different paths. Also, the combined influence of indirect (composite)paths can be established by multiplying the values of the individual path coefficients.

7.3.1 Model validity and fit

The validity of each of the six stratified SEM's was examined by establishing that the value of their chi-square test was insignificant, and that Goodness of Fit Indices and Root Mean Square Error of Approximation (RMSEA) tests met standard validity criteria.

The efficacy of the stratified SEM models in explaining the data is described by the value of their Coefficient of Determination (CoD). This model fit statistic is essentially equivalent to the R^2 parameter for linear regression and represents the proportion of variance in the data explained by the model. Table 7.1 below reports the strata cohort sizes and their corresponding CODs. It shows the models explain between 20 – 26% of the overall variance in the non-Aboriginal strata and over 45% of the variance for the Aboriginal strata.

Table 7.1 Stratified SEM models: Strata cohort sizes and CoDs[1]

	Non-Aboriginal		Aboriginal	
	N =	CoD	N =	CoD
Outer Regional	7,234	0.268	2,080	0.464
Remote	1,703	0.279	1,820	0.456
Very Remote	742	0.220	6,068	0.461

1. CoD = Coefficient of Determination.

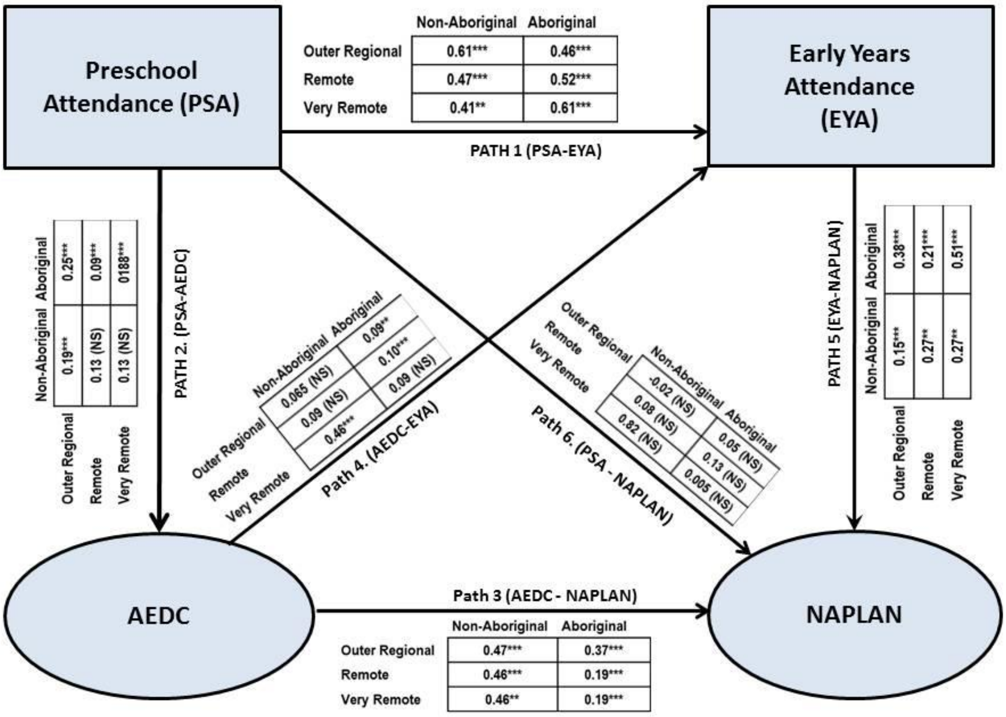
7.3.2 Direct path effects

Figure 7.2 (below) provides a diagrammatic summary of the direct path effects for Aboriginal and non-Aboriginal children in each of the three strata of remoteness.[15] These are described by their standardised path coefficients which can be interpreted as the effect-size contribution which a path makes to its outcome. In the tables adjacent to each of the path lines in Figure 7.1 it can be seen that the path coefficients for non-Aboriginal children were generally similar across all three levels of remoteness. In contrast, the path coefficients for Aboriginal children varied considerably with different levels of geographic remoteness[16]

Among the SEMs for all six analysis strata, the standardised path coefficients for Path 1 (i.e. preschool attendance to early years school attendance) the strongest of all path effects in the structural model. These were notably higher

[15] Details of these path effects are also provided in Table 7.A.4 in the chapter appendix.
[16] According to the location of the child's community within each of the three NT remoteness categories defined by the Australian Standard Geographic Classification (ASGC).

Figure 7.2 Direct path effects[1]: By level of remoteness and Aboriginal status



1. Reported as standardised path coefficients.
** Indicates $p \leq 0.05$; *** Indicates $p \leq 0.001$.

for Aboriginal children in remote and very remote areas. The standardised path coefficients for Path 5 (i.e. early years school attendance to NAPLAN) were all highly significant with their effects ranging from relatively weak for non-Aboriginal children in outer regional areas to a medium effect-size for Aboriginal children in very remote areas.

As expected, the AEDC to NAPLAN path (Path 3) had a medium effect-size strength across all non-Aboriginal analysis strata, but was weaker for remote and very remote Aboriginal children.

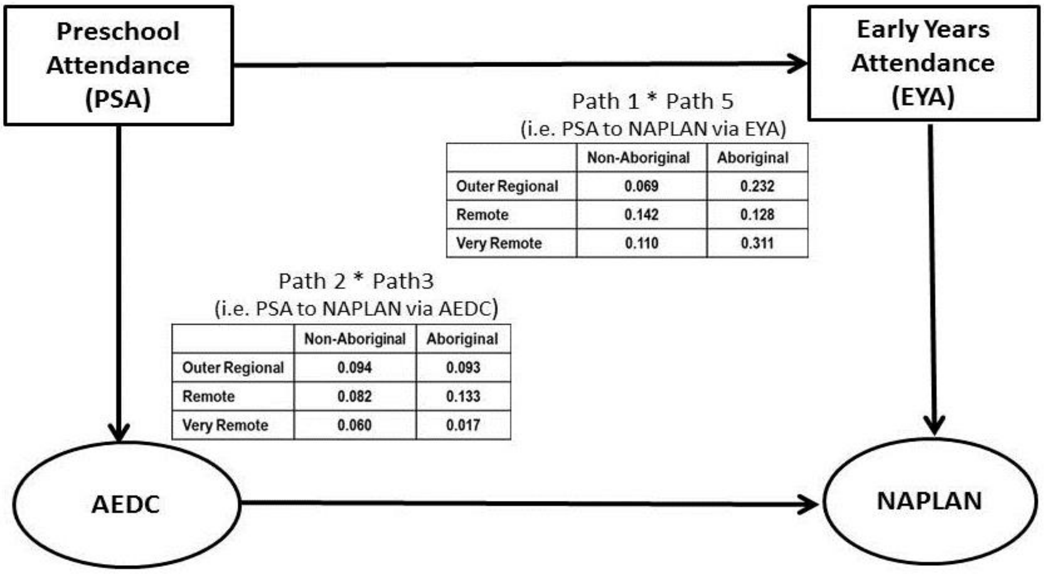
The Path 4 coefficients (i.e. the diagonal path from AEDC to attendance in the early years of school) were weak and non-significant for most strata cohorts, but surprisingly strong for very remote non-Aboriginal children. This finding may be due to these children having parents employed in the community (e.g. as nurses, teachers, police) and having higher education and household income than the community average.

The paths from preschool attendance to NAPLAN (Path 6) were mostly non-significant. This is not surprising as any learning benefits derived from preschool attendance must be sustained throughout the early years of primary school or are likely to experience a 'fade-out' effect, even when the initial gains appear substantial. Ways in which the effects of preschool may be sustained are highlighted by the analysis of indirect path effects discussed below.

7.3.2 Indirect path effects

Before describing the composite (indirect) path effects, it should be stressed that neither of the school attendance and AEDC outcomes, are determined by preschool attendance alone. Each is also influenced by a range of other factors outside the current model, many of

Figure 7.3 Indirect path effects by Aboriginality and level of remoteness[1]



Path 1 * Path 5 (i.e. PSA to NAPLAN via EYA)

	Non-Aboriginal	Aboriginal
Outer Regional	0.069	0.232
Remote	0.142	0.128
Very Remote	0.110	0.311

Path 2 * Path3 (i.e. PSA to NAPLAN via AEDC)

	Non-Aboriginal	Aboriginal
Outer Regional	0.094	0.093
Remote	0.082	0.133
Very Remote	0.060	0.017

1. Reported as standardised path coefficients.

which have been investigated in earlier chapters.

The two indirect (composite) paths in the structural model were: a) the path from preschool attendance via early years school attendance to NAPLAN (i.e. Path 2 * Path 3), and; b) the path from preschool attendance via AEDC to NAPLAN (i.e. Path 1 * Path 5). The composite contributions these indirect paths make to NAPLAN outcomes are reported in the 'tables within Figure 7.3 (above).

Because other Australian studies have shown that preschool can assist children's readiness for school learning (Nutton, 2013), and that AEDC outcomes have been shown to have a strong relationship with NAPLAN outcomes (Brinkman et al, 2013), we expected to find that AEDC would have a positive mediating effect for all children. However, the SEM analysis found this indirect path made only a weak positive contribution to NAPLAN outcomes for all six analysis strata. Whilst this indirect path effect was mostly similar for Aboriginal and non-Aboriginal children, it was much stronger for remote Aboriginal children compared to their non-Aboriginal counterparts (i.e. 0.133 compared to 0.082).

In contrast, for Aboriginal children, the indirect effect of their level of early years school attendance (EYA) had a relatively larger effect on NAPLAN outcomes than that found for non-Aboriginal children.

7.3.3 Demographic path effects

Lastly we investigated path effects of the two demographic variables included in each of the stratified SEM models i.e. English as a Second Language (ESL), and a binary measure of parents' level of education – whether they had completed six or more years of schooling. The standardised path coefficients for each of these paths to AEDC, early years attendance and NAPLAN for Aboriginal and non-Aboriginal children in each strata of remoteness are reported below in Table 7.4.

It is evident in this table that several of the path coefficients were not significant at the $p \leq 0.05$ confidence level. Parent's having six or more years of education appears to only have had a moderate positive association with AEDC

Table 7.4 Demographic path effects[1] by Aboriginal status and remoteness

	English as a second language (ESL)		Parent finished 6+ years of school	
a) AEDC	***Aboriginal***	***non-Aboriginal***	***Aboriginal***	***non-Aboriginal***
Outer Regional	-0.087*	-0.002 (NS)	0.097**	0.128**
Remote	-0.129**	-0.068 (NS)	0.111*	0.126**
Very Remote	-0.037 (NS)	-0.088 (NS)	0.029 (NS)	0.047**
b) EYA	***Aboriginal***	***non-Aboriginal***	***Aboriginal***	***non-Aboriginal***
Outer Regional	-0.071**	-0.032*	0.035 (NS)	-0.008 (NS)
Remote	-0.120**	-0.011 (NS)	0.073**	-0.26 (NS)
Very Remote	-0.071*	-0.075*	0.023 (NS)	0.071 (NS)
c) NAPLAN	***Aboriginal***	***non-Aboriginal***	***Aboriginal***	***non-Aboriginal***
Outer Regional	-0.039 (NS)	-0.03 (NS)	0.03 (NS)	0.126**
Remote	-0.079*	-0.053 (NS)	0.026 (NS)	0.084**
Very Remote	-0.210**	-0.056 (NS)	0.026 (NS)	0.29 (NS)

1. Reported as standardised path coefficients.

* Indicates $p \leq 0.05$; ** Indicates $p \leq 0.01$; *** Indicates $p \leq 0.001$.

outcomes for Aboriginal and non-Aboriginal children in outer urban and remote areas.

Somewhat surprisingly, the ESL status showed relatively small negative effects on the AEDC, EYA and NAPLAN outcomes of Aboriginal children. However, for Aboriginal children in very remote areas this path effect was equivalent a 0.21 effect size decrease in NAPLAN outcomes.

7.4 Discussion

A child's academic achievement as measured by their NAPLAN scores clearly depends on their early life circumstances and opportunities for learning (Guthridge et al, 2015). One of the key theoretical assumptions of this SEM analysis postulated that exposure to preschool might influence both a child's developmental readiness for school learning (measured by the AEDC) and also the extent of their subsequent engagement and participation in primary school as measured by their attendance in the early years of primary school), and that both would have some influence on a child's academic performance on Year 3 NAPLAN.

While the analysis findings support the validity of this hypothesis, they also identify substantial variations within and between the NT Aboriginal and non-Aboriginal student populations in the ways in which these processes play out over the course of their early development, preschool years and first few years of formal schooling.

School attendance has often been considered an indication of a child's engagement and involvement in schooling. However, attendance is at best only a weak proxy for engagement. Other factors not able to be included in this analysis (e.g. teaching quality, the schools cultural responsiveness and level of community engagement) are also known to be highly relevant to students' engagement and success in making a successful transition into school learning (Martin, 2016).

With that in mind, the strength of the positive associations we observe between children's level of preschool attendance and attendance in early years of formal schooling is notable. This effect was stronger for Aboriginal children – with similar effect sizes of 0.607, 0.517 and 0.606 in outer regional, remote and very remote areas respectively. For non-Aboriginal children this effect was smaller, but still substantial (0.455, 0.473 and 0.406 respectively). This finding is consistent with a recent Western Australian data linkage study of the school attendance of all students enrolled in WA schools over a two-year period which demonstrated that children's longer-term attendance patterns are established very early in their school careers (Hancock et al, 2015). Similar observations have also been made in recent Canadian data linkage studies investigating the impact of socioeconomic inequities early in children's lives (Santos, 2012; Brownwell, 2012). As an elaboration on the analyses from Chapter 6, these results provide further confirmation of the benefits of exposure to early childhood education to NT children.

The policy and practical importance of the association between preschool and early years school attendance cannot be overstated when it comes to 'closing the gap'. Not only does exposure to preschool attendance benefit non-Aboriginal children, when it comes to early years school attendance, the benefits are relatively greater for Aboriginal children who have generally lower rates of school attendance. Furthermore, this influence on early years school attendance also translates into positive educational outcomes.

As demonstrated in the analysis of indirect paths, the influence of preschool on NAPLAN scores mediated via early years attendance was substantially greater for Aboriginal students than the indirect path via AEDC outcomes. Put simply, this provides further confirmation of the benefits of investments in maximising children's engagement in early childhood education, especially for the high proportion of NT Aboriginal children who experience high levels of disadvantage.

The SEM analysis also shows that the benefits of preschool attendance extend to children's developmental readiness for school learning in terms of their AEDC outcomes. This effect was highly significant for both Aboriginal and non-Aboriginal children in outer regional areas where it was equivalent to effect size improvements of 0.255 and 0.195 respectively. Aboriginal children in remote areas also showed a significant benefit, with an associated 0.267 effect size increase in AEDC outcomes. In very remote areas, this association was also significant, but much smaller (0.090). Although, not as influential on NALPLAN outcomes as early years attendance, the developmental gains of preschool attendance evident on AEDC outcomes may signal benefits beyond formal schooling, such as reduced health and social risks (Anderson et al, 2003).

Again, it is notable that the beneficial influence of preschool attendance on AEDC outcomes was generally stronger for Aboriginal children. The immediate benefits include gains in language and communication skills, emotional maturity and pre-literacy skills. Beyond these, preschool provides an opportunity for children developing familiarity with more structured learning environments and routines of school.

An important limitation of this analysis was that we did not also stratify the analysis by gender. While it is well known that there are sizeable gender difference in children's early development and early school learning outcomes, we considered that to include gender as a stratifying variable would add an additional layer of complexity to an already highly involved investigation of the two main research hypotheses.

Another potential limitation of the SEM analysis was that while the results are consistent with the 'causal' processes posited in the hypotheses underpinning the final structural model, we cannot assume these to be proof that the associations are in fact causal (Denis and Legerski, 2006). The attribution of causality in epidemiological research requires a range of evidence criteria to be met (Bradley-Hill, 1965). Our model specification process, stratified SEM analysis and findings do, however, meet several of these indications of likely causality. These include: The temporality of the hypothesised causes and effects; the sizeable ‘effect sizes’; the differentially greater effects for Aboriginal children - especially those in remote communities and those having English as a second language, and; their comparability with the findings of the fixed regression analysis reported in Chapter 6. Together, these features of the analysis strongly indicate that the ‘down-stream’ benefits of preschool attendance are more likely to be causal (i.e. not simply correlational). However, this could only be conclusively established by a well-controlled experimental study.

It is necessary to acknowledge that there is a range of other child, family, school and community factors which are known to influence children’s development and learning, but suitable data on these were not available for inclusion in the SEM analysis. Despite this the variables included in the model were still able to account for between 20 – 26% of the overall variance in the non-Aboriginal strata and over 45% of the variance for the Aboriginal strata.

While the effects of some of those other factors (e.g. housing overcrowding) were considered in earlier chapters, the quality, strength and consistency of the evidence from this SEM analysis clearly shows that better levels of preschool participation have significant flow-on benefits for children’s school attendance and longer-term academic achievement – and especially so for Aboriginal children, those in more remote areas, and those not having English as their first language. This indicates that the recent national and NT Government policy investments to improve Aboriginal children’s participation in preschool are well placed and should be extended.

The analysis findings highlight the extent to which the learning and language support needs vary between the six NT demographic student cohorts we considered. The empirical evidence they provide could be useful in the targeting and weighting of resource allocations to achieve more equitable school attendance and learning outcomes. This is in line with international research demonstrating that one of the most promising strategies to achieve more equitable, long-term improvements in children’s outcomes, is for policy and investments in early years services (including health, child care and preschool) to be based on the principle of ‘proportionate universality’ (Kershaw et al, 2009; Marmot 2010: Carey et al, 2015). Delivering services in this manner would build a platform of universal early childhood support organised in ways that reduce many of the existing barriers to children’s participation in and benefit from preschool – especially those which affect children with the highest need.

Finally, further qualitative and quantitative studies are required to advance scientific and policy understanding of what can be done to maximise the benefits of preschool for Aboriginal and non-Aboriginal children (Nelson et al, 2011; Duncan et al 2011). Furthermore, and in line with other Australian research and Indigenous scholarship, such studies should investigate the school and community factors which enable child and family engagement with schooling. In particular, schools’ language learning environments and level of cultural responsiveness should be investigated with respect to the way curricula and approaches to teaching and learning align with local community circumstances and children’s language and specific learning needs (Martin 2016, Elliot et al, 2009; Silburn et al, 2011; Perso, 2014, Goldfeld et al, 2016; Page and Tailor, 2016; and Sparling et al. 2013).

7.5 References

ACARA (Australian Curriculum, Assessment and Reporting Authority). 2014. National Assessment Program- Literacy and Numeracy 2013: Technical Report, ACARA, Sydney.

Acock A, *Discovering Structural Equation Modelling Using Stata*, 2013, STATA Press.

Anderson, LM, Shinn MS, Fullilove MT, Scrimshaw SC, Fielding JE, Normand J, Carande-Kulis VG, Taskforce on Community Preventive Services. 2003. The effectiveness of early childhood programs : A systematic review. American Journal of Preventive Medicine. 24(3) Supplement: 32-46.

Bradford-Hill A. 1965. The Environment and Disease: Association or Causation?. *Proceedings of the Royal Society of Medicine*. 58 (5): 295–300.

Bentner P. 1990 Comparative Fit Indices in Structural Models. *Quantitative Methods in Psychology*. Vol 107 No. pp 238-246.

Bollen K. 1989. Structural equations with latent variables. New York: John Wiley & Sons.

Brinkman, S., Gregory, T., Harris, J., Hart, B., Blackmore, S. and Janus, M. 2013. *Associations Between the Early Development Instrument at Age 5, and Reading and Numeracy Skills at Ages 8, 10 and 12: a Prospective Linked Data Study*. Child Indicators Research, 6(4), pp.695-708.

Brownell M, Chartier M, Santos R, Ekuma O, Au W. 2012.How are Manitoba's Children Doing? Winnipeg MB: Manitoba Centre for Health Policy.

Byrne, BM. 1998. Structural Equation Modelling with LISREL, PRELIS, and SIMPLIS: Basic concepts, Applications and Programming. New York: Psychology Press.

Carey G, Crammond B, De Leeuw E. 2015. Towards health equity: a framework for the application of proportionate universalism. *International Journal for Equity in Health* 14:81.

Commonwealth of Australia. 2014. Improving School Enrolment and Attendance through Welfare Reform Measure (SEAM) Trial (2009-2012) Final Evaluation Report. Commonwealth of Australia (2014) ISBN 978-1-925237-76-4.

Denis D, Legerski J. 2006. Causal Modelling and the origins of path analysis, *Theory and Science* 2006: ISSN 1527-5558.

Duncan GJ, Murnane RJ (Eds). 2011. *Whither Opportunity: Rising Inequality, Schools, and Children's Life Chances*, pp 27–46. New York: Russell Sage Foundation.

Goldfeld S, O'Connor E, O'Connor M, Sayers M, Moore T, Kvalsvig A & Brinkman S. 2016. The role of preschool in promoting children's healthy development: Evidence from an Australian population cohort. Early Childhood Research Quarterly vol 35 40-48.

Guthridge S, Silburn S, Li SQ, McKenzie J, Lynch J. 2016. Early influences on developmental outcomes among children, at age 5, in Australia's Northern Territory. *Early Childhood Research Quarterly*. Vol 35 pp. 124–134.

Guthridge S, Li L, Silburn S, Li SQ, McKenzie J and Lynch J. 2015. 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. *Journal of Paediatrics and Child Health*, 51, 778–786. http://dx.doi.org/10.1111/jpc.12852.

Guo, B., Perron, B. and Gillespie, D. 2009. A Systematic Review of Structural Equation Models in Social Work Research. *British Journal of Social Work. Vol* 39, pp 1556-1574.

Hancock K, Shepherd C, Lawrence D and Zubrick S. 2013. *Child Attendance and Educational Outcomes: Every Day Counts*. Telethon Institute for Child Health Research and University of Western Australia.

Hermida R. 2015. The problem of allowing correlated errors in structural equation modelling: concerns and considerations. *Computational Methods in Social Sciences (CMSS)*, 3, issue 1, p. 05-17. (Available at: https://EconPapers.repec.org/RePEc:ntu:ntcmss:vol3-iss1-15-005).

Hooper D, Coughlan J, Mullen M. 2008. Structural Equation Modelling: Guidelines for Determining Model Fit. *Journal of Business Research Methods* vol 6 #1 pp. 53-60.

Kershaw P, Anderson L, Warburton B, Hertzman C. 2009. *15 by 15: A comprehensive policy framework for early human capital investment in Vancouver, British Columbia*: Business Council of British Columbia (BCBC) and the Human Early Learning Partnership (HELP); 2009. (Available from: http://www.earlylearning.ubc.ca/documents/2009/15by15- Full-Report.pdf)

Kline. RB. 2016. Principles and practice of Structural Equation Modeling. 4^{th} ed. New York: Guildford Press.

Marmot M. 2010. Fair Society, Healthy Lives: The Marmot Review. London: Strategic Review of Health Inequalities in England post-2010.

Martin, K (Ed). 2016.V*oices and Visions: Aboriginal Early Childhood Education in Australia*. Canberra: Early Childhood Australia.
McClelland M, Acock a & Morrison F. 2006. The impact of kindergarten learning-related skills on academic trajectories at the end of elementary school. Early Childhood Research Quarterly vol 21 471-4.
McKenzie, JM. 2012. *How are children's early development and engagement with school related to their year 3 NAPLAN outcomes?* Unpublished report from the NT Early Childhood Development Data linkage Demonstration Study. Darwin: Menzies School of Health Research.
Nelson C, Sheridan M. 2011. *Lessons from Neuroscience Research for Understanding Causal Links between Family and Neighborhood Characteristics and Educational Outcomes*. In GJ Duncan and RJ Murnane (Eds). Whither Opportunity: Rising Inequality, Schools, and Children's Life Chances, 27–46. New York: Russell Sage Foundation.
Nutton GD. 2013. *The effectiveness of mobile preschool (Northern Territory) in improving school readiness for very remote Indigenous children*. PhD Thesis, Charles Darwin University.
Santos R, Brownell M, Ekuma O, Mayer T, Soodeen R. 2012. The Early Development Instrument (EDI) in Manitoba: Linking Socioeconomic Adversity and Biological Vulnerability at Birth to Childrens' Outcomes at Age 5. Winnipeg MB: Manitoba Centre for Health Policy.
Silburn S, McKenzie J, Guthridge S, Li Land Li SQ et al. 2014. *Unpacking educational inequality in the Northern Territory*. Proceedings of the 2013 Australian Council for Education Research Conference. Melbourne: ACER. (Available on-line at: https://research.acer.edu.au/cgi/viewcontent.cgi?article=1234&context=research_conference.
Page J & Tayler C. (Eds). 2016. *Learning and Teaching in the Early Years*. Sydney: Cambridge University Press.
Perso T. 2012. Cultural Responsiveness and School Education: With Particular Focus on Australia's First Peoples. Menzies School of Health Research, Centre for Child Development and Education. Darwin Northern Territory.
Silburn S, Nutton G, McKenzie J & Landrigan M. 2011. Early Years Language acquisition and instructional approaches for Aboriginal students with home languages other than English. Menzies School of Health Research, Centre for Child Development and Education. Darwin Northern Territory.
Silburn S, Brinkman S, Ferguson-Hill S, Styles I, Walker R and Shepherd C. 2009. The Australian Early Development Index (AEDI) Indigenous Adaptation Study. Perth: Curtin University of Technology and Telethon Institute for Child Health Research.
Stata 14 Structural Equation Module Reference Manual. College Station, TX: Stata Press.
Sparling, J., Tayler, C., Hattie, J., Page, J., Scull, J., King, A., Piers-Blundell, A., Nossar, V., Ramey, C. (2013) *Building a bridge into preschool in remote Northern Territory Communities*. Australian Research Council Linkage Grant 2013 -2018.
Zubrick SR, Silburn SR, De Maio JA, Shepherd, C, Griffin J, Dalby RB, Mitrou FG, Lawrence DM, Hayward C, Pearson G, Milroy H, Milroy J & Cox A. 2006. *The Western Australian Aboriginal child health survey: Improving the educational experiences of Aboriginal children and young people*. Perth: Curtin University of Technology and Telethon Institute for Child Health Research.

7.6 Appendices

7.6.1 Model Structure and Parameters

The analysis was undertaken using the STATA14 SEM module (StataCorp, 2015). Structural Equation Modelling (SEM) typically requires large sample sizes and depending on the data quality of the available data it can be challenging to achieve a convergent solution (Acock, 2013). There were three possible choices of convergence method which could have been used: a) The default maximum likelihood (ML) approach; b) the asymptotic distribution free (ADF) method, and; c) the maximum likelihood with missing values (MLMV) method. ADF is considered the least sensitive to non-normally distributed data.

Both ML and ADF require complete data being available for all cases. Given the analysis involving the linkage of cases from a large number of separate datasets, the resulting level of sample loss would have meant restricting the analysis to just 1,238 of the 19,751 available observations. However, the MLMV analytic approach allows 'pathwise' complete case analysis – i.e. analysis of all cases with data available for the variables involved in defining each of the paths in the model.

All three convergence methods were tried and produced essentially similar results. The much larger case numbers able to be analysed with the MLMV approach produced greater model stability and narrower confidence intervals around path coefficient estimates. This made it our analytic method of choice.

Modification indices were used to investigate the benefits of increasing a model's complexity, e.g. by adding a path or allowing certain errors to be correlated. The SEM literature advises that this method should be used cautiously as any added complexity improves model fit incrementally (Hermida, 2015). Our approach therefore aimed to maximise parsimony in the number of model components.

A variety of fit indices are potentially available for testing SEM models (Byrne, 1998; Hooper et al, 2008; Bentner et al, 1990). We tested the final model using the 'estat stable' STATA command which confirmed it to be highly stable. The group level Coefficient of Determination is reported in section 7.3.2 in the chapter text. For technical reasons (i.e. stratification, constraining the measurement models and missing data) χ^2 and other indices of fit cannot be reported.

7.6.2 Measurement Models

AEDC domain scores are available both as a continuous scale and as a categorical score. Descriptive details of means, standard deviations (SD) and correlations among the five domain scales are provided in Table 7.A.1 below.

Table 7.A.1 Means, SD's, and correlations among AEDC domain scales

	AEDC (n=19,647)	*1*	*2*	*3*	*4*	*5*
1	Physical health & wellbeing	1.000				
2	Emotional maturity	0.520***	1.000			
3	Language & cognitive skills	0.571***	0.551***	1.000		
4	Communication skills	0.669***	0.559***	0.717***	1.000	
5	Social competence	0.630***	0.828***	0.662***	0.714***	1.000
	Mean	8.411	7.583	6.986	6.971	7.641
1	Standard deviation	1.754	2.028	2.425	2.965	2.263

* Indicates $p \leq 0.05$; ** Indicates $p \leq 0.01$; *** Indicates $p \leq 0.001$.

Table 7.A.2 Means, SD's, and correlations among NAPLAN scales

	NAPLAN (n=19,647)	*1*	*2*	*3*	*4*	*5*
1	Reading	1.000				
2	Writing	0.701***	1.000			
3	Grammar	0.793***	0.713***	1.000		
4	Spelling	0.741***	0.734***	0.751***	1.000	
5	Numeracy	0.737***	0.692***	0.7267***	0.706***	1.000
	Mean	-1.550	-4.950	-1.445	-3.686	-2.130
	Standard Deviation	1.893	3.696	2.016	2.448	1.541

** indicates $p \leq 0.05$; *** indicates $p \leq 0.01$; *** indicates $p \leq 0.001$.

The AEDC's domain scale score correlations and distributions with the overall NT study cohort were found to be broadly comparable to those reported in the national AEDI Indigenous Adaptation Study (Silburn et al, 2009).

Children's NAPLAN test results are reported as either raw test scores, logit transformed scores, scaled scores and band scores. The measurement models using each type of score were compared to determine which had the best distributive properties. While the raw scale score and logit scores were all strong (R^2 = 0.945, 0.936 and 0.937 respectively), we chose to use the logit score in the final SEM model for its superior distributional properties.

Table 7.A.2 (above) presents the means, standard deviations (SD's) and correlations among the NAPLAN logit scores for each scale.

To ensure the latent variables of AEDC scores and NAPLAN results can be used for meaningful comparisons across different strata, the Confirmatory Factor Analysis Framework was applied (Bollen, 1989) to determine the level of invariance within the measurement models. Testing of these measurement models across strata established strong factorial invariance, a requirement for stratified SEM analyses. Therefore, the full structural latent models were fit with constrained measurement models that involved fixing the estimated path coefficients and intercepts across all strata to ensure unbiased and meaningful comparisons across strata.

Finally, the stratified analysis enabled comparison of the relative strength of the various path loadings (i.e. standardised path coefficients) within each of the six NT demographic cohorts. These path loadings were found to be generally similar across strata with the notable exception of NAPLAN's 'Spelling' for very remote children. This loading was less than half that of the other strata paths.

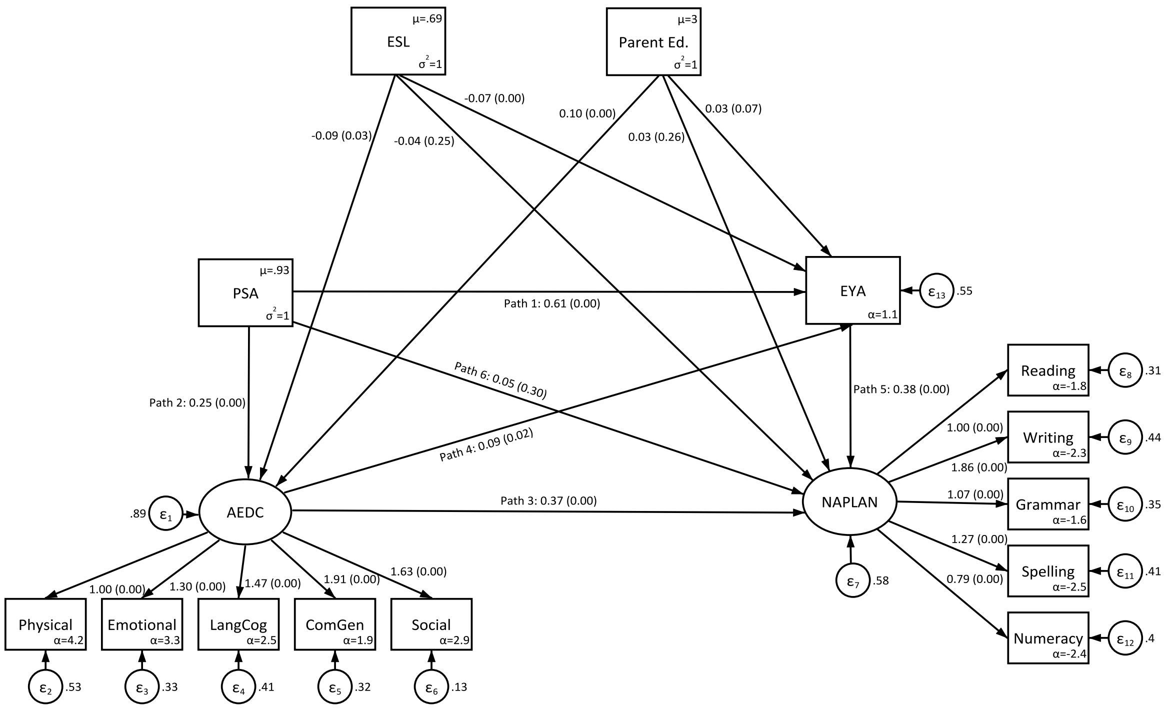
Figures 7.A.1 & 7.A.3 (below) display details of the structural path models for Aboriginal and non-Aboriginal children within each of the remoteness strata.

Table 7.A.3 reports descriptive statistics regarding the means, SD's and inter-correlations of the variables included in each of the stratified path models.

Tables 7.A.4 and 7.A.5 report in tabular format the direct and indirect path loadings which are shown diagrammatically within Figures 7.2 and 7.3 in the chapter text.

Figure 7.A.1 Structural Equation Models: NT Outer Regional areas

a) Aboriginal students



b) Non-Aboriginal students

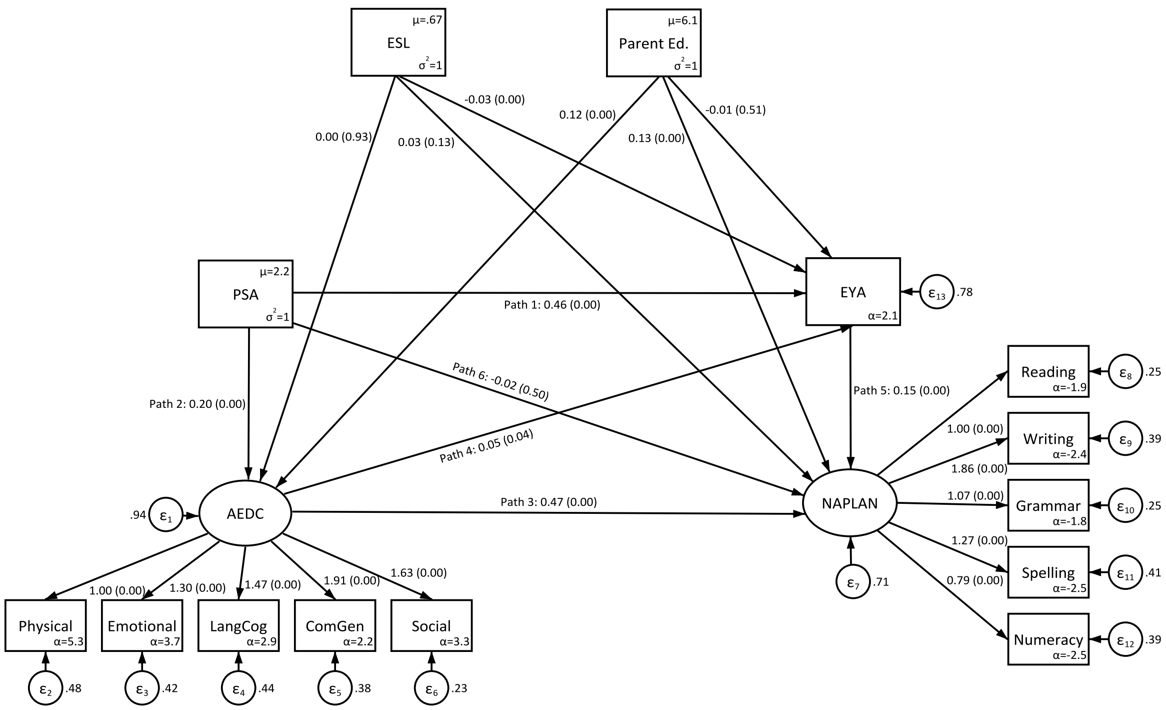
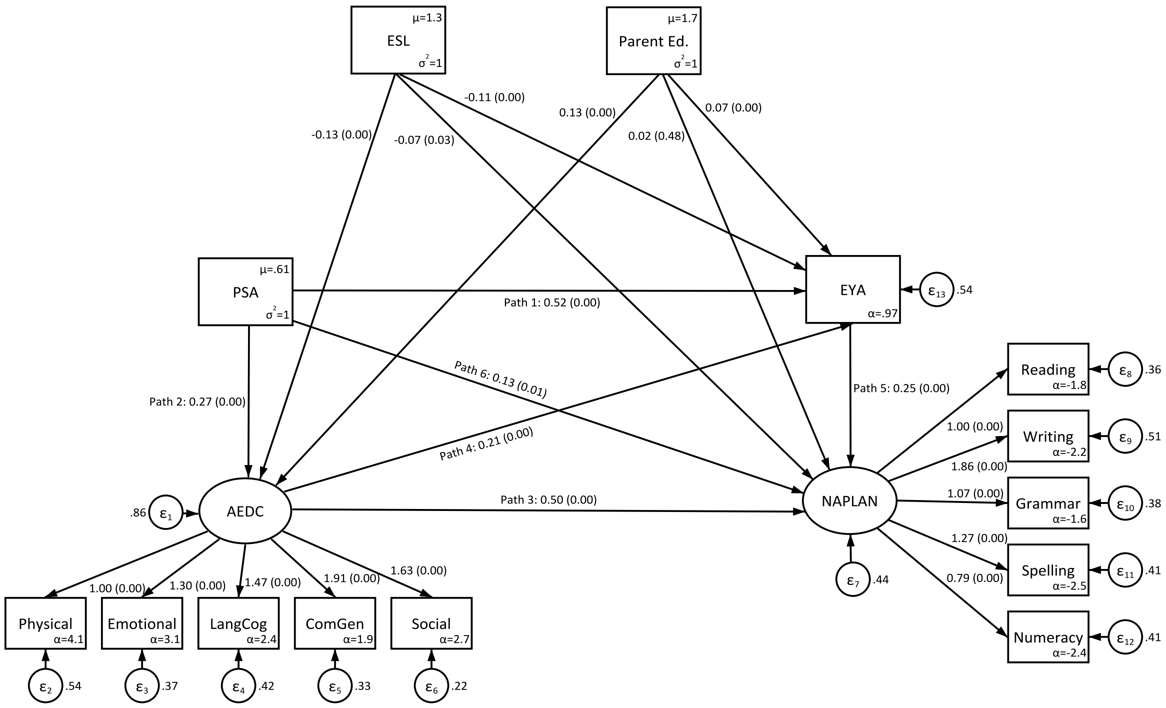


Figure 7.A.2 Structural Equation Models: NT <u>Remote</u> areas

a) Aboriginal students



b) Non-Aboriginal students

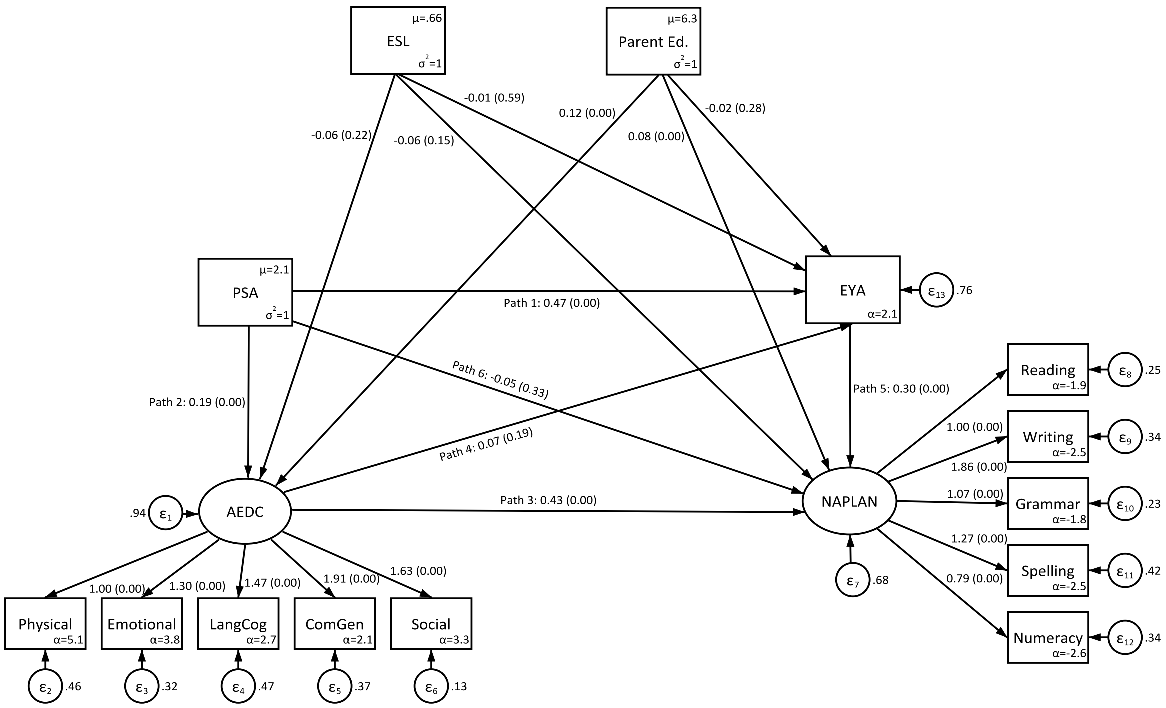
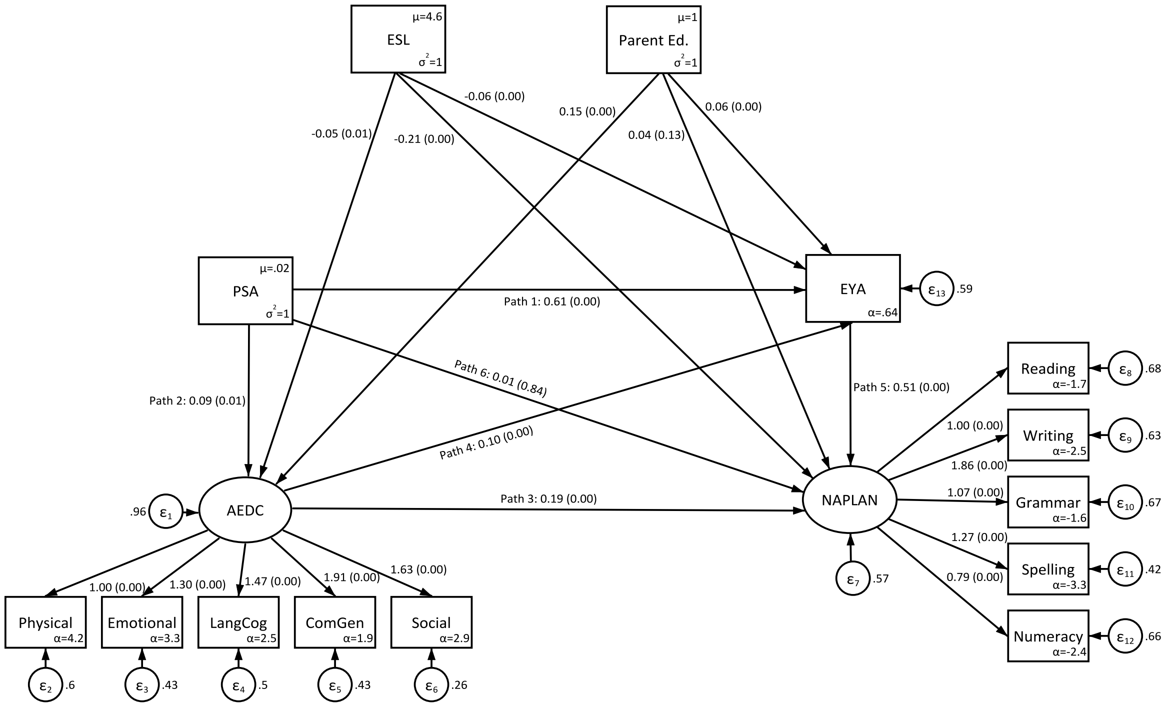


Figure 7.A.3 Structural Equation Models: NT <u>Very Remote</u> areas

a) Aboriginal students



b) Non-Aboriginal students

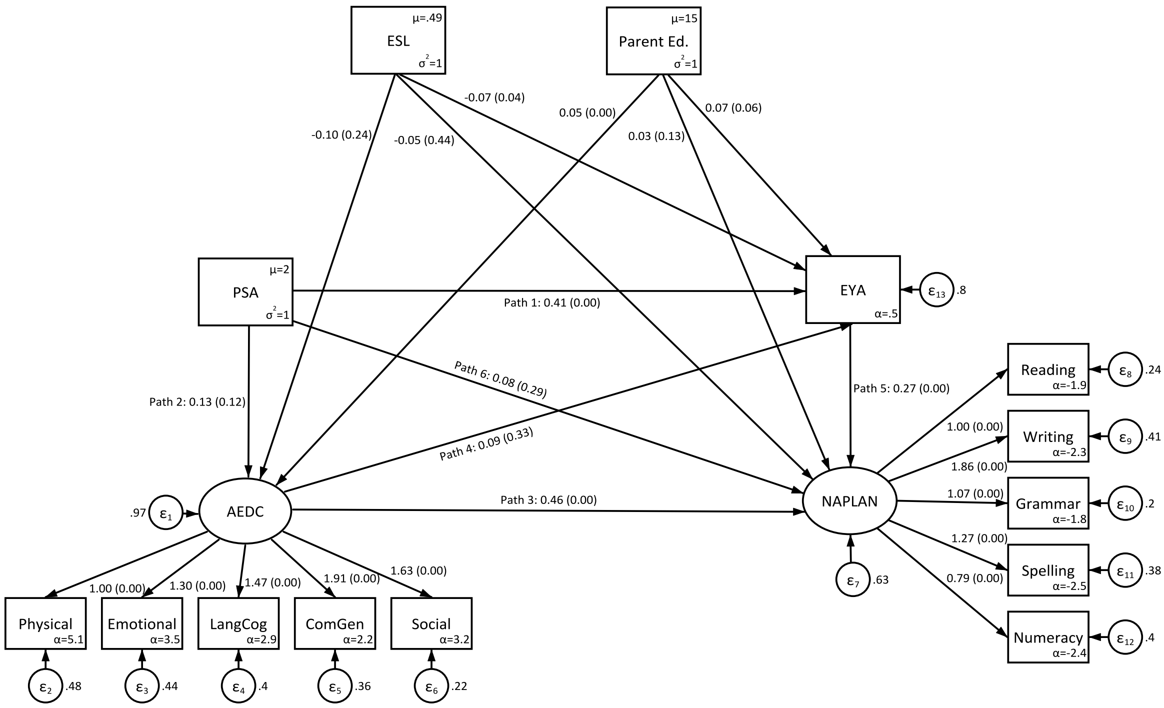


Table 7.A.3 Means, SD's, and correlations among observed variables:

a) NT Outer regional areas

	Aboriginal (n=2,080)	1 (PSA)[1]	2 (EYA)	3 (ESL)	4 (PEd)[2]
1	Preschool attendance (PSA)	1.000			
2	Early years attendance (EYA)	0.631***	1.000		
3	ESL	-0.187***	0.218***	1.000	
4	Parental education (PEd)	0.169***	0.177***	-0.139***	1.000
	Mean	1.312	1.878	0.323	0.898
	Standard Deviation	1.332	1.057	0.468	0.302

	Non-Aboriginal (n=7,234)	1 (PSA)[1]	2 (EYA)	3 (ESL)	4 (PEd)[2]
1	Preschool attendance (PSA)	1.000			
2	Early years attendance (EYA)	0.458***	1.000		
3	ESL	-0.090***	-0.073***	1.000	
4	Parental education (PEd)	0.073***	0.038**	-0.097***	1.000
	Mean	2.278	2.641	0.309	0.974
	Standard Deviation	1.048	0.853	0.462	0.159

b) NT Remote Areas

	Aboriginal (n=1,820)	1 (PSA)[1]	2 (EYA)	3 (ESL)	4 (PEd)[2]
1	Preschool attendance (PSA)	1.000			
2	Early years attendance (EYA)	0.609***	1.000		
3	ESL	-0.222***	-0.286***	1.000	
4	Parental education (PEd)	0.187***	0.222***	-0.183***	1.000
	Mean	0.820	1.403	0.645	0.747
	Standard Deviation	1.241	1.078	0.479	0.435

	Non-Aboriginal (n=1,703)	1 (PSA)[2]	2 (EYA)	3 (ESL)	4 (Ped)[2]
1	Preschool attendance (PSA)	1.000			
2	Early years attendance (EYA)	0.474***	1.000		
3	ESL	-0.089***	-0.058*	1.000	
4	Parental education (PEd)	0.086**	0.020	-0.025	1.000
	Mean	2.275	2.520	0.300	0.975
	Standard Deviation	1.078	0.853	0.458	0.155

c) NT Very remote areas

	Aboriginal (n=6,068)	1 (PSA)[1]	2 (EYA)	3 (ESL)	4 (PEd)[2]
1	Preschool attendance (PSA)	1.000			
2	Early years attendance (EYA)	0.618***	1.000		
3	ESL	-0.144***	-0.157***	1.000	
4	Parental education (PEd)	0.026	0.105***	-0.156***	1.000
	Mean	0.057	0.447	0.955	0.520
	Standard Deviation	1.245	1.033	0.207	0.500

	Non-Aboriginal (n=742)	1 (PSA)[1]	2 (EYA)	3 (ESL)	4 (PEd)[2]
1	Preschool attendance (PSA)	1.000			
2	Early years attendance (EYA)	0.424***	1.000		
3	ESL	-0.131**	-0.146***	1.000	
4	Parental education (PEd)	-0.051	0.065	-0.146***	1.000
	Mean	1.938	2.297	0.197	0.996
	Standard Deviation	0.978	0.962	0.398	0.067

1. Logit transformed preschool attendance rates were used.
2. Logit transformed early years attendance rates were used.
* Indicates $p \leq 0.05$; ** Indicates $p \leq 0.01$; *** Indicates $p \leq 0.001$.

Table 7.A.4 Direct path effects: By level of remoteness and Aboriginal status

a) Outer regional areas (e.g. Darwin)	**Aboriginal**	**non-Aboriginal**
Path 1. Preschool attendance to Early Years attendance	0.607***	0.455***
Path 2. Preschool attendance to AEDC	0.255***	0.195***
Path 3. AEDC to NAPLAN	0.374***	0.469***
Path 4. AEDC to Early years attendance	0.090**	0.051*
Path 5. Early Years Attendance to NAPLAN	0.379***	0.154***
Path 6. Preschool attendance to NAPLAN	0.047 (NS)	-0.016 (NS)
b) Remote areas (e.g. Alice Springs)	**Aboriginal**	**non-Aboriginal**
Path 1. Preschool attendance to Early Years attendance	0.517***	0.473***
Path 2. Preschool attendance to AEDC	0.267***	0.190***
Path 3. AEDC to NAPLAN	0.499***	0.433***
Path 4. AEDC to Early years attendance	0.213***	0.065 (NS)
Path 5. Early Years Attendance to NAPLAN	0.249***	0.300***
Path 6. Preschool attendance to NAPLAN	0.132*	0.065 (NS)
c) Very remote areas (e.g. Ngukurr)	**Aboriginal**	**non-Aboriginal**
Path 1. Preschool attendance to Early Years attendance	0.606***	0.406***
Path 2. Preschool attendance to AEDC	0.090**	0.131 (NS)
Path 3. AEDC to NAPLAN	0.189***	0.456***
Path 4. AEDC to Early years attendance	0.102***	0.089 (NS)
Path 5. Early Years Attendance to NAPLAN	0.513***	0.272**
Path 6. Preschool attendance to NAPLAN	0.006 (NS)	0.082 (NS)

* Indicates $p \leq 0.05$; ** Indicates $p \leq 0.01$; *** Indicates $p \leq 0.001$.

Table 7.A.5 Indirect path effects by Aboriginality and level of remoteness

a) Outer regional areas (e.g. Darwin)	**Aboriginal**	**non-Aboriginal**
PSA to NAPLAN via AEDC (Path 2 * Path 3)	0.093	0.094
PSA to NAPLAN via EYA (Path 1 * Path 5)	0.232	0.069
b) Remote areas (e.g. Alice Springs)	**Aboriginal**	**non-Aboriginal**
PSA to NAPLAN via AEDC (Path 2 * Path 3)	0.133	0.082
PSA to NAPLAN via EYA (Path 1 * Path 5)	0.128	0.142
a) Very remote areas (e.g. Ngukurr)	**Aboriginal**	**non-Aboriginal**
PSA to NAPLAN via AEDC (Path 2 * Path 3)	0.017	0.060
PSA to NAPLAN via EYA (Path 1 *Path 5)	0.311	0.110

* Indicates $p \leq 0.05$; ** Indicates $p \leq 0.01$; *** Indicates $p \leq 0.001$.

8. Summary and conclusions

This final chapter considers the overall implications of the findings reported in the earlier chapters. Each chapter was designed to progressively build a more comprehensive and nuanced understanding of the cumulative effects of the multiple, inter-acting factors shaping children's early health, development and school learning outcomes. Wherever possible, the findings have been contextualised in terms of the Northern Territory's diverse cultural, geographic and socioeconomic circumstances. The overall methodological approach and analysis strategy have also been informed by Aboriginal perspectives on the issues as they affect their lives. The conclusions arising from the study have a clear message for policy makers, government agencies and community service providers – there are substantial immediate and longer term benefits which can be realised from policy and service investment which increase children's access to, and participation in, quality preschool early learning. However, future efforts to improve the school attendance and learning outcomes of NT children will remain limited by the progress made by government and community action in addressing the modifiable early-life 'up-stream' determinants of these outcomes, and Aboriginal children's disproportionate exposure to high levels of disadvantage.

8.1 Summary

The NT Developmental Outcomes Study has provided a unique opportunity to assemble a comprehensive new source of evidence regarding early-life determinants of children's development and school learning. It has enabled types of research not previously possible to establish a more nuanced and holistic understanding of some of the main drivers of NT children's developmental readiness for school learning, their school attendance and longer-term literacy and numeracy outcomes. The study's findings add to the rapidly growing research literature from data linkage studies now being conducted around Australia and internationally.

An important indirect benefit of the study has been the contribution it has made to the NT's growing capacity to utilise de-identified data linkage research to make better use of its routinely collected administrative data holdings. These include the development of the technical infrastructure required for highly secure data management, as well as the research governance arrangements needed to support and oversee the conduct of ethics-approved research involving unit-record linkage and de-identified analysis of NT and other administrative data. Also, because data linkage is a relatively new concept, the study's communication strategy has given high priority to supporting government and community stakeholders gaining a shared understanding of its benefits for policy, service planning, program evaluation, and scientific research; as well as the safeguards in place to ensure the privacy of individuals and communities, and the confidentiality of the person-level information linked for the purposes of this study.

While the study population included all children born in the NT over a 20 year period, the design and reporting of findings has included a special focus on Aboriginal children, given that in 2011 they comprised 43% of the NT child population aged 0-17 years (ABS, 2016). This made it essential that the organisational partners in the research collaboration, the study's investigator team, and it's project governance and community advisory bodies, all included strong Aboriginal representation. This, together with the research partners' shared development of an overall methodological approach, assisted the study's implementation and reporting being carried out in a manner appropriate to the NT's cultural context and being properly inclusive of Aboriginal perspectives.

An initial challenge in planning the analysis of the study data concerning Aboriginal people's contact with different service agencies, came from the fact that the recording of a person's Aboriginal status can vary between agencies and over time with different episodes of service contact. The implication of this for analysis involving data from multiple data sources, is that with each additional dataset linked, the resulting number of cases with complete Aboriginal identifiers grows progressively smaller. This can restrict the number of cases available for complete case analysis resulting in biased or misleading findings.

In the methodology chapter (Chapter 2) we describe the approach taken to address this issue. This involved firstly investigating the completeness, consistency and quality of the Aboriginal status variables in each of the study datasets. That information was then used to develop and evaluate an algorithm (i.e. rule) which could be used for the selection of the optimum Aboriginal status identifier to use in the study analyses requiring data from two or more datasets. While the methodology used to develop this algorithm followed principles recommended from other Australian data linkage studies (Lawrence et al, 2012; Taylor et al, 2012; and Fremantle et al, 2012), we were also able to draw on several year's work which the NT Health Department has done with its Client Master Index to ensure that its personal health records are for the same individuals (Robbins, 1999). The algorithm we developed will be of value for other NT data linkage studies, as its validity and utility for use with NT population data has now been established.

One of the main strengths of the study was that the data linkage methodology enabled the assembly of population-level data on individual children's contact with health and education services over a 20 year period. This has permitted types of type of longitudinal analysis not previously possible for investigating the early life determinants shaping NT children's health, development and subsequent school learning outcomes. Also, the progressive sequence in which the different components of the study were conducted enabled the research team to build a cumulatively more layered and comprehensive description of the main factors shaping NT children's development and learning.

An important limitation of the study was that we were unable to secure all the permissions needed within the available timeframe to link all of the NT administrative datasets we had hoped to access for the analyses reported here. The additional datasets relevant to the study but not able to be linked in time included those concerning children's contact with: a) primary health services, including the Healthy Kids under 5 developmental health data; b) child hearing assessment services; c) the NT child protection system; d) the NT juvenile justice system; as well as NT Police data concerning community-level indicators community safety and rates of alcohol related harm.[17]

[17] Data extracted from these additional datasets were linked during 2017 and 2018. Findings from a preliminary analysis on NT children's contact with the NT child protection system were reported in a submission to the Royal Commission into the Protection and Detention of Children Northern Territory. Other publications reporting the analysis of data on children's contact with the child protection and juvenile justice systems, and child development and educational outcomes associated with ear health and hearing are now in preparation.

The inclusion of these data would clearly have improved the precision of the analyses reported in this publication. Nevertheless, using the data which were available, the regression models concerning predictors of children's early childhood development status (AEDC), and school attendance, achieved high predictive power and were able to account for large proportions of the variation in the these outcomes.

Another limitation of the study was that it was not possible to include sex as one of the stratifying variables in the analyses which were stratified by Aboriginal status and by areas of remoteness. This would have resulted in 12 separate analysis strata, some of which would not have sufficient case numbers for meaningful analysis. However, sex was included as a covariate in the regression analyses reported in chapters 4 and 5. These showed that, in comparison with girls and after adjustment for other factors, both Aboriginal and non-Aboriginal boys were more likely to be less developmentally ready for school learning, have more school absences, and poorer year 3 NAPLAN literacy and numeracy outcomes.

The documentation of recent population trends in key early life health indicators and early childhood development reported in Chapter 3 provide a descriptive overview of the study population as well as informing many of the analyses reported in subsequent chapters. The trend analysis clearly highlights the fact that disparities in the health status of Aboriginal children are evident from very early in life. They provide evidence concerning recent changes in live birth and fertility rates which have significant implications for projections of the NT's population growth and sustainability, as well as for the planning of services and social policy.

While there has been a small, but significant increasing trend (1.2% per year) in the total fertility rate (TFR) for non-Aboriginal women, the TFR for Aboriginal women has followed a significant decreasing trend, such that by 2013 it was the lowest on record, and close to the population replacement rate of the average 2.1.

Teenage birth rates for Aboriginal and non-Aboriginal mothers have also both shown significant decreasing trends in recent years. While this is encouraging, it is important that further research establishes whether this is associated with increasing rates of contraception use and/or other factors such the high NT rates of sexually transmitted infections and repeated episodes in this age group which could affect fertility.

The findings reported in Chapter 4 describe associations between the early life health factors, socio-demographic factors and children's subsequent developmental outcomes as measured by the AEDC at around age 5 years. These highlight the extent to which Aboriginal and non-Aboriginal children differ in their developmental readiness for school learning, and how this varies between different geographical areas.

The main predictive factors associated with positive early development of were similar for Aboriginal and non-Aboriginal children. they included: Female gender, having attended preschool, having mothers who did not smoke during pregnancy, and mothers who had at least seven antenatal health checks. Apart from female gender, all of these factors are potentially modifiable and should be key targets for preventive services.

While a few of the factors associated with an increased risk of AEDC scores indicative of 'developmental vulnerability' were common to both Aboriginal and non-Aboriginal children (e.g. male gender, not attending preschool, and having English as a second language), there were other notable differences. For Aboriginal children, key early life factors significantly associated with adverse developmental outcomes included: preterm birth (<37 weeks gestation), having has 2 or more hospitalisations by age 5 years, the child's primary carer being unemployed, and living in very remote areas. These findings identify areas for prevention and provide further evidence of the extent to which Aboriginal children's greater exposure to multiple adversities in early life affects their readiness for school learning.

Chapter 5's analysis of the school attendance of Aboriginal and non-Aboriginal students at government schools in urban, remote and very remote communities has several implications for policy to improve the current rates of Aboriginal school attendance.[18] While attendance rates for non-Aboriginal students are much the same regardless of their schools geographic location, Aboriginal students' attendance varies markedly by geographic region (e.g. 80% or higher for Aboriginal students in outer regional areas, and just 65% or less in very remote areas). Analysis of student's trajectories of attendance also show that enduring patterns of attendance are established very early in a child's school career - which is consistent with findings from a recent Western Australian data linkage study (Hancock et al, 2013).

The analysis of weekly average attendance rates over the school year show that there is substantially lower attendance in the first and last few weeks of each quarterly school term for both Aboriginal and non-Aboriginal students across all years of schooling. Given the current emphasis of the NT Department of Education's attendance policy that 'every day of school counts', this would seem to be a potentially fruitful area to target for combined school and community action.

Also, the attendance of Aboriginal students drops off markedly in the later years of compulsory schooling - from around 60% in the first quarter of Years 7-9, to less than 50% in the first quarter of Year 10, and then further to around 40% in the final two quarters of that year. This highlights the importance of middle schooling in maintaining student engagement, and why the transition to high school is such a critical point in the course of a student's school career. This represents a key opportunity for preventive intervention.

The fact that multivariable regression modelling of predictive factors associated with Aboriginal student's year 1 attendance found no less than 11 factors having a significant independent association highlights how generalised disadvantage in early childhood underlies the low rates of school attendance and why addressing this requires a 'whole-of-government' and community approach. The impact of these influences can be gauged from the proportion of school absence days which the analysis showed to be attributed to these factors. In a typical school year of 200 days, the average days of school absence independently associated with specific factors were: a) Living in a community with overcrowded housing - 35 more days absent; b) Having English as a second language - 11 more days absent; c) Living in a very remote location - 6 more days absent; d) Being hospitalised for an infectious disease by age 5.5 years - 4 more days absent, and; e) Having low-birthweight - 4 more days absent. Importantly, the main protective factors predicting better school attendance were: a) Having attended more than 30 days of pre-school - 18 more school days attended; b)

[18] These remoteness categories are those defined by the Australian Standard Geographic Classification (ASGC). In this system Outer Regional is Darwin & Palmerston, Remote includes the areas around Darwin extending to Katherine plus Alice Springs, the balance of the NT is Very remote.

Having a parent/carer that was employed - 11 more school days attended, and; c) Having a parent/carer with Year ten or higher education - 10 more school days attended. For non-Aboriginal students, the factors predictive of more days of school attended were: a) living in a community with overcrowded housing – 10 more days[19], b) being a twin -5 more days, and c) their parent/carers was employed – 4 more days. The combined effect on school attendance of students exposed to many of the above risk factors and few of the protective factors is therefore likely to result in extreme levels of school absence.

The influence of these early life factors also needs to be considered in conjunction with the other study findings concerning the link between early childhood health and educational outcomes, as well as the significant association observed between children's early development/school readiness and their year 1 school attendance. For Aboriginal children in particular, the greater extent to which their scores on the AEDC 'Language and cognitive skills' and 'Communication skills and general knowledge' domains are associated with their Year 1 attendance, emphasises the importance of ensuring they have access to the levels of learning and language support needed for a successful transition into primary school.

Given the well-established links between school attendance and educational attainment, the current NT and Australian Government's policy focus on improving school attendance is well founded. However, our findings suggest that these efforts can be expected to have only limited success unless they are accompanied by policy efforts to address their 'up-stream' determinants.

[19] This finding may be due to these children having parents employed in the community (e.g. as nurses, teachers, police) and having higher education and household income than the community average.

Such efforts should ideally be coordinated on the basis of 'proportionate universalism'. In other words, that all children have universal access to the basic services needed for their healthy development and learning, and; that more targeted and intensive services can also available in proportion to the identified needs of those children requiring additional support.

Another finding pointing to the need for a more differentiated and 'place-based' approach to addressing the early life determinants shaping Aboriginal school attendance, was from the 'variance decomposition' analysis described in Chapter 5. This compared the relative contribution to year 1 attendance made by specific child factors and the overall 'fixed effect' of their school/community characteristics. It showed that for Aboriginal children in all three geographical regions, the greatest modifiable protective factor in Aboriginal children's school attendance is their level of attendance at preschool. It also showed that school/community characteristics account for the majority of the explained variation attendance (67%) of Aboriginal children in very remote areas, while individual child factors explained relatively less of this variation (e.g. whether the child attended preschool (21%), parent's characteristics (5%), English as a second language (2%), child characteristics (3%), and student mobility between different schools (1%)).

In contrast, the same analysis showed that for Aboriginal students in remote and outer regional areas, the school/community fixed effect was much smaller (23% and 31% respectively). The findings of this analysis indicate that while improving Aboriginal children's preschool attendance should be a priority across all regions, in very remote areas the greatest gains are likely to derive from place-based intervention addressing community-level factors which impact all children in the community such as housing overcrowding, high rates of family unemployment and alcohol related harm.

The beneficial association between preschool participation and early years primary school attendance was investigated further to establish the relative efficacy of the three main modes of preschool delivery currently available in very remote areas (i.e. General Preschools, Early Years Classes, and Mobile Preschools). After adjustment for all possible confounders, it was found that Aboriginal children attending any of these types of preschool showed a significant positive association with their subsequent early years school attendance. On average, the children in very remote communities who attended a General Preschool attended 22 more school days per year, those who attended an Early Years Class attended 13 more days of school days per year, and those who attended a Mobile Preschool attended 11 more days of school each year. Thus in comparison with the other types of preschool, the General Preschool model offered the greatest potential benefit in increasing children's expected days of school attendance.

The final stage of that analysis also modelled the distribution of expected benefits of different levels of preschool attendance on early years school attendance. This showed that the minimum attendance at General Preschools necessary for this to be associated with children having a population average early years school attendance was 45%. The corresponding minimum preschool attendance in the other forms of preschool was 55% for Early Year Classes, and 65% for Mobile Preschools. These findings have implications for the setting of preschool attendance targets and promoting family, community and school understanding of longer-term benefits of regular preschool attendance for children's likely pathways of school attendance.

The final stage of the study, reported in Chapter 7, sought to unify the work of previous chapters in developing a deeper understanding of the complex interactions of children's early life circumstances, pre-school program exposure, developmental readiness for school learning and subsequent academic outcomes. This involved the use of structural equation modelling (SEM) to 'unpack' the relative strength of the influence and interplay of the key factors identified in earlier chapter as making important contributions to children's year 3 NAPLAN academic outcomes. This was used to test the following hypotheses separately for Aboriginal and non-Aboriginal children in outer regional, remote and very remote areas of the NT:

1. That preschool attendance is positively associated with attendance in the early years of primary school, which after adjusting for differences in AEDC outcomes, has a positive influence on NAPLAN outcomes, and;
2. That children's level of preschool attendance positively influences the early development outcomes (AEDC), which in turn is associated with early school achievement (NAPLAN).

The analysis showed that the strongest direct path associations were between children's level of preschool attendance and their subsequent school attendance across all remoteness strata. These direct path associations were equivalent to 'moderate' effect sizes of 0.61, 0.52 and 0.61 for Aboriginal students in outer regional, remote and very remote areas respectively. The equivalent path associations for non-Aboriginal students were 0.46, 0.47 and 0.41. Furthermore, the indirect (composite) path from preschool attendance to NAPLAN via early years school attendance for Aboriginal children were 0.23, 0.13 and 0.31 for outer regional, remote and very remote areas, and 0.07, 0.14 and 0.11 for non-Aboriginal children in these areas.

While the analysis also provided some support for Hypothesis 2, this was surprisingly less than expected. For Aboriginal children in outer regional, remote and very remote areas the respective effect sizes of the direct path from preschool attendance to AEDC were 0.26, 0.27 and 0.09. The equivalent effect sizes for non-Aboriginal children were 0.20, 0.19, and 0.13 respectively. Also, the indirect (composite) path from preschool attendance via AEDC to early years school attendance for Aboriginal children in outer regional and remote areas were just 0.09, 0.13 and 0.02; while for the few non-Aboriginal children in very remote areas this was 0.46, and not significant for those in outer regional or remote areas.

8.2 Conclusions

- The findings first and foremost demonstrate the extent to which socio-cultural and economic circumstances influence all children's early health, development and learning, and why it is essential that current efforts to improve school attendance and achievement also focus on addressing the known early determinants of these outcomes.
- They highlight the extent to which children's health status – especially from pre-birth through early childhood – and socioeconomic circumstances are associated with their developmental readiness for school learning.
- The findings provide evidence of the significant benefits of preschool and the vital importance of children attending preschool regularly. They suggest that improving children's access to, and participation in, preschool is one of the best immediately available strategies for improving the NT's concerning rates of Aboriginal school attendance and achievement.
- At the same time, they indicate that the initial benefits of preschool can easily 'fade out' unless they are reinforced by regular attendance and effective engagement with school learning in the early years of primary school. This underscores the necessity of that policy and services supporting children's transition into formal school learning extending through to at least Year 3.
- The findings are consistent with other research in identifying critical transition points in children's school careers which are opportunities for leveraging better outcomes: a) From preschool to Year 1 – especially for the Aboriginal students through targeted additional learning and language support, and; b) From Year 6 to Year 7 - through middle school programs which maintain student's engagement and facilitate their retention in high school and further learning.
- The overall findings strongly support the direction and potential benefits of the NT Government's recent investment of $35.6 million over four years to implement a whole-of-government plan in collaboration with community organisations to improve early childhood services and the lives of Territorian children (Northern Territory Government, 2018). They validate the plan's emphasis on developing a more integrated and place-based approach to the planning and delivery of universal and targeted services to young children and their families. They also provide a baseline against which many of its short- and longer-term performance outcomes could be monitored.

8.3 Implications for future research

Finally, the study findings suggest the need and potential value of future research in the following areas:

1. Investigating reasons for the recent decreasing trend in Aboriginal and non-Aboriginal teenage pregnancy e.g. whether this is associated with increased uptake of contraception in this age group and/or other health and social factors.
2. Investigating the implications of the declining Aboriginal total fertility rate which by 2013 was approaching the population replacement rate of 2.1 live births to women in their reproductive years.
3. Conducting qualitative studies to inform the development and evaluation of preventive public health strategies to reduce the continuing high proportion of Aboriginal women in remote and very remote who report smoking during pregnancy.
4. Investigating whether there are homogenous subgroups of students who share similar patterns of attendance over the course of their school career using newly available analytical methods, e.g. trajectory analysis (Nagin et al, 2010) and latent class analysis (Thompson et al, 2017; Hancock et al, 2018). This would assist in the early identification and targeted support for students at increased risk of adverse school outcomes.
5. Undertaking mixed-methods research to investigate family, community and school factors which explain why some communities have better early childhood development (AEDC) outcomes than would be predicted on the basis of their socioeconomic status.
6. Qualitative research into the child, school and curriculum factors which optimise children's engagement with school learnings in the early years of primary school. This should also include a focus on the specific learning and school adjustment needs of boys.

8.4 References

Australian Bureau of Statistics. 2016. *Australian Demographic Statistics*. ABS cat. No. 3101.0. Canberra: ABS.

Fremantle J, Ring I, Teshia G, Solomon A, Gachupin F, Smylie J, Cutler TL & Waldon JA. 2015. Indigenous Mortality (Revealed): The Invisible Illuminated. *American Journal of Public Health*, 105 (4) 644-652.

Hancock KJ, Shepherd CJ, Lawrence D and Zubrick SR. 2013. Student attendance and educational outcomes: Every day counts. Canberra, Australia: Department of Education, Employment and Workplace Relations. Available on-line at: https://www.telethonkids.org.au/globalassets/media/documents/research-topics/student-attendance-and-educational-outcomes-2015.pdf. Retrieved 8 May 2018.

Hancock KJ, Mitrou F, Taylor CL, Zubrick SR. The Diverse Risk Profiles of Persistently Absent Primary Students: Implications for Attendance Policies in Australia. Journal of Education for Students Placed at Risk (JESPAR). 2018;23(1-2):53-69.

Lawrence D, Christensen D, Mitrou F, Draper G, Davis G, McKeown S, et al. 2012. Adjusting for under-identification of Aboriginal and/or Torres Strait Islander births in time series produced from birth records: Using record linkage of survey data and administrative data sources. *BMC Medical Research Methodology.* 12(9). doi:10.1186/471-2288-12-90.

Nagin DS and Odgers CL. 2010. Group-Based Trajectory Modeling (Nearly) Two Decades Later. Journal of Quantative Criminology, 26(4): 445–453.

Northern Territory Government, 2018. Safe, *Thriving and Connected - Generational Change for Children and Families:* The Northern Territory Government's plan to implement reforms for better supporting children, young people and families experiencing vulnerability and delivering the recommendations of the Royal Commission into the Protection and Detention of Children in the Northern Territory 2018 – 2023. Available on-line at: http://newsroom.nt.gov.au/api/attachment/ById/10935.

Robbins J. The Northern territory client master index. *Health Information Management*. 1999;29(1):35-7.

Stewart A, Livingston M and Dennison S. 2008. Transitions and turning points: Examining the links between child maltreatment and juvenile offending. *Child Abuse & Neglect*. 32: 51–66.

Taylor LK, Bentley J, Hun J, Madden R, McKeown S, Brandt P and Baker D. 2012. Enhanced reporting of deaths among Aboriginal and Torres Strait Islander peoples using linked administrative health datasets. *BMC Medical Research Methodolo*gy, 12(1), 91-99.

Thomson KC, Guhn M, Richardson CG, Ark TK and Shoveller J. 2017. Profiles of children's social–emotional health at school entry and associated income, gender and language inequalities: a cross-sectional population-based study in British Columbia, Canada. *BMJ Open*;7:e015353. doi:10.1136/bmjopen-2016-015353.