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Research paper

Inequalities in child development at school entry: A repeated cross-sectional analysis of the Australian Early Development Census 2009–2018

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ABSTRACT

Background: Australia is the only developed country to consistently undertake a developmental census of its children nationwide. The repeated collection of the Australian Early Development Census (AEDC) has provided an unprecedented opportunity to examine the prevalence of developmental vulnerability across Australia's states and territories, the socio-economic distribution of developmental vulnerability across jurisdictions, and how these distributions might have changed over time.

Methods: This study employed multivariable logistic regressions to estimate the probability of developmental vulnerability within each jurisdiction and AEDC collection year (2009 to 2018), adjusting for jurisdictional differences in socio-demographic characteristics. To explore socio-economic inequalities in child development, adjusted slope index of inequality (SII) models were utilised.

Findings: The results of this study found reductions in the adjusted prevalence of developmental vulnerability over time in Western Australia (26% to 20%) and Queensland (30% to 25%), with an increase observed in the Australian Capital Territory (27% to 30%). Analysis also indicated an increase in socio-economic inequalities over time in the Northern Territory (+12%), the Australian Capital Territory (+6%) and Tasmania (+4%). Sensitivity analysis found these effects to be robust with an alternative measure of socio-economic position.

Interpretation: There is considerable variation in the prevalence and socio-economic inequalities in developmental vulnerability across Australia's jurisdictions. Future research should explore the policy drivers in early childhood education and health contributing to the findings of this study, with a particular focus on jurisdictions where there have been notable changes in developmental vulnerability and socio-economic inequality over time.

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Research in context

Evidence before this study

Our study builds on previous research conducted in Australia regarding the prevalence and socio-economic inequality in the development of Australian children at school entry. We searched PubMed, Web of Science and Google Scholar up until the 19th December 2019, using keywords ("child development" OR "developmental vulnerability") AND ("socio-economic inequality*" OR "socio-economic disadvantage") AND ("early childhood policy"). Database searches were supplemented with manual searching of reference lists, as well as searching of the grey literature using terms such as "child development", "socio-economic inequality" and "early childhood policy".

Added value of this study

Previous research conducted using the first collection of Australian Early Development Census (AEDC) data in 2009 highlighted considerable variation in the prevalence and socio-economic distribution of children classified as developmentally vulnerable in their first year of school. Our study builds on this previous evidence utilizing four collections of data (2009–2018) from the only triennial national census of child development in the world, with a sample of over one million children. This study quantifies differences in the prevalence and socio-economic distribution of developmental vulnerability across the states and territories of Australia, and discusses how and why these distributions may have shifted over time. The use of national developmental census data in this study provides not only a snapshot of how Australia's children have developed over the past decade, but also provides much needed reference data from which policymakers can design and measure the impact of government policies and programs at the community, state and national level.

Implications of all the available evidence

After considering socioeconomic differences, there should be little variation in the developmental vulnerabilities of children across the different jurisdictions of Australia. However, our analyses quantifies large differences within and between jurisdictions. These results provide an opportunity for jurisdictions to reflect upon how their policies and mix of services may be affecting children's development and inform future government policies and practices for closing gaps in developmental outcomes.

1. Introduction

Research has demonstrated the importance of both early life cognitive and non-cognitive abilities for healthy development throughout childhood and success into later adult life [1,2]. However, opportunities to develop these skills are not afforded to all children equally, with decades of evidence to highlight significant disparities in early development, health and academic achievement between children living in families with differing social positions [1,3–7].

Internationally, empirical research has shown that these social inequalities in early development persevere into adolescence and adulthood, resulting in a socio-economic divide in labour market outcomes, as well as social outcomes related to crime, substance abuse and physical and mental health [1,4,5,7,8]. However investment in high quality interventions, particularly for children who have experienced disadvantage early in life, can contribute to closing socio-economic gaps in child health and development [1,9,10]. Research shows that reducing these socio-economic gaps in child health and development can bring benefits to society through increased economic productivity and decreased social costs, as well as leading to a more equitable distribution of human capital and opportunity [1,11].

High quality early childhood health, education and care services have potential for reducing socio-economic inequalities early in life [1,12]. Decades of research has investigated the efficacy of community maternal and child health programs and early childhood education as interventions for improving the long-term outcomes of children living in more disadvantaged communities, with evidence from randomised controlled trials such as the Perry Preschool program demonstrating some positive individual and intergenerational outcomes for these children long after they leave the program [13–15]. However, the context of these studies is important, with the Perry Preschool program in particular comprising of a relatively small sample of children ($n = 123$) who attended an intensive preschool program over two years in the 1960s [16]. In Australia, non-experimental research indicates reduced odds of developmental vulnerability for children attending quality child care [17], playgroups [18] and preschool [19], particularly for those living in poorer socio-economic areas. Of the limited contemporary trial evidence, small or no effects are found for the effectiveness of interventions aiming to reduce socioeconomic gaps in child development [20,21].

Uniquely, Australia is the only developed nation that conducts a nation-wide developmental census of its children at the time they begin school, collected via the federally funded Australian Early Development Census (AEDC). This census, conducted every three years, provides an unprecedented opportunity to measure the development of successive cohorts of Australian children, while also providing comprehensive and nationally representative data that can be used to inform community planning and evaluate the efficacy of both federal and jurisdictional policies [22]. The AEDC also provides an opportunity to explore socio-economic inequalities in child development at a national and state/territory level, as well as monitoring changes in inequalities over time in successive birth cohorts who have been exposed to different health and education policies.

Socio-economic inequalities in developmental outcomes have been well documented in the Australian literature, with research conducted by Brinkman et al. (2012) using the first AEDC national census data (2009) demonstrating substantial disparities in the development outcomes of Australian children by socio-economic group and between jurisdictions. Specifically, analysis showed that in 2009 there was significant variation across jurisdictions in regard to levels of overall developmental vulnerability, with an absolute difference between children living in the most and least disadvantaged communities of 12.7 percentage points in males and 8.2 percentage points in females. The current study aims to extend this previous work quantifying the magnitude of socio-economic inequalities in child development across jurisdictions, and explores how levels of developmental vulnerability and social economic inequalities in development have changed over time since the first national census in 2009 to its most recent collection in 2018. In the Discussion, we postulate how some of the differences in universal service provision across the jurisdictions may be reflected in the results presented.

2. Method

2.1. Data

This study utilised repeated cross-sectional data from the Australian Early Development Census (AEDC). The AEDC is a triennial, nationwide census of children's development in their first year of full-time school. Schools across all sectors (public/government, Independent and Catholic) are invited to participate in the AEDC, and high school-level participation rates (>95%) have been achieved in all four cycles (2009, 2012, 2015, 2018) [23]. While the number of children in each AEDC has increased over time the percentage of

the estimated child population captured has decreased from 98% (2009) to 96% (2018).

Child development is measured using the 96-item, teacher completed Australian version of the Early Development Instrument (AvEDI) [24,25]. The AvEDI is designed to measure development across five domains of physical health and wellbeing, social competence, emotional maturity, language and cognitive skills, and communication skills and general knowledge.

2.2. Sample

Children with valid data on at least one AEDC domain in any of the four collections (2009, 2012, 2015 and 2018) (n = 1,162,076) formed the base sample for this study. AEDC domain scores are defined as non-valid if they have any of the following attributes: missing data on too many items (approximately 30–40% or more of items missing, varies across domains), the child is aged less than four years, the teacher knew the child for less than one month, or the child had special needs (based on a diagnosis of special needs recorded within school enrolment data).

Children were also excluded from the final sample if they had missing data on one or more of the confounders including Aboriginal and/or Torres Strait Islander status (n = 223), English as a Second Language (no missing data) and area-level socio-economic advantage/disadvantage (n = 2760). This resulted in a final analysis sample of 1,094,949 children across the four AEDC collection cycles.

2.3. Outcomes

2.3.1. Developmental vulnerability

Developmental vulnerability on each of the five AEDC domains was calculated based on norms established after the first census collection in 2009, which were set around the bottom 10th percentile of scores on that domain [22]. Developmental vulnerability on one or more domains (summary indicator) was used as the outcome for the primary analysis. Domain specific results are presented in supplementary tables S3.1 to S3.5 and S4.1 to S4.5.

2.4. Exposure

2.4.1. Jurisdiction/Jurisdictional socio-economic inequality

Australia is a large multi-cultural commonwealth nation, with a population of over 25 million people living across its six states and two territories (jurisdictions). Australia has diversity in its culture and traditions, with just over 25% of its population having been born overseas and close to 3% of the population identifying as being of Aboriginal and/or Torres Strait Islander descent [26]. The governance of Australia is represented across three tiers (federal, state/territory and local government), with health and education policies primarily managed at the state/territory level leading to differences in the implementation and funding of various policy objectives related to children's health and early childhood education. Jurisdictions in Australia also vary widely in their distribution of socio-economic disadvantage due to differences in both the geography and demographic composition of Australia's states and territories. For this reason, inequality analyses are stratified by jurisdiction, with an aim of investigating both inter-jurisdictional and intra-jurisdictional changes in development and socio-economic inequalities in child development over the four AEDC collections.

2.5. Confounders

2.5.1. Socio-economic indices for areas (SEIFA)

The SEIFA Index of Relative Advantage and Disadvantage (IRSAD) served as the primary measure of socio-economic position in this study. The SEIFA IRSAD is an area-based measure of socio-economic advantage and disadvantage published by the Australian Bureau of Statistics, calculated via principal components analysis on a selection of variables from the five-yearly Australian Census of Population and Housing. The SEIFA IRSAD index includes variables related to both socio-economic advantage and disadvantage such as education, income, occupation, and housing. For the purposes of our analysis, continuous SEIFA IRSAD scores (0–1000) were categorised into deciles, with a lower SEIFA IRSAD decile indicating that the child lived in a community with a higher relative level of socio-economic disadvantage, while a higher SEIFA IRSAD decile indicated the child lived in a community with a higher relative level of socio-economic advantage [27]. SEIFA IRSAD was applied to children at the smallest level of geography available, the Statistical Area 1 (SA1) level [28].

2.5.2. Child level demographics

Aboriginal and/or Torres Strait Islander background and English as a second language status were based on school enrolment records completed by the child's parent or guardian and these demographic variables were included as confounding factors in this study due to differences in the geographical distribution of these population groups across jurisdictions. Despite sex and age both being well established predictors of children's development, neither variable was included in the final regression models, as the distribution of sex did not vary across jurisdictions and so could not be considered a confounding factor, while the inclusion of age in the models was not necessary due to the age-standardisation of the AEDC developmental vulnerability outcome measure [22,23]. For more detail regarding the distribution of confounders across jurisdictions refer to supplementary tables S1.1 to S1.4.

2.6. Analysis

2.6.1. Multivariable logistic regression

To explore the association between jurisdiction and developmental vulnerability over time, unadjusted and adjusted multivariable logistic regressions were employed, stratified by AEDC collection year. Our first model predicts the probability of a child being developmentally vulnerable on one or more domains (DV1), with a categorical variable representing jurisdiction as the exposure variable.

$$\Pr(DV1 = 1) = \alpha + \beta_1(Jurisdiction) + \varepsilon \quad (1)$$

This model was run sequentially for children in each of the AEDC collection years (2009, 2012, 2015, and 2018). Following this, a second set of models were run adjusting for a binary indicator variable representing Aboriginal and/or Torres Strait Islander background (ATSI), ESL status and a categorical variable representing SEIFA IRSAD deciles, keeping jurisdiction as the exposure and developmental vulnerability as the outcome. This model is presented below.

$$\Pr(DV1 = 1) = \alpha + \beta_1(Jurisdiction) + \beta_2(ATSI) + \beta_3(ESL) + \beta_4(SEIFA) + \varepsilon \quad (2)$$

This model was run sequentially by AEDC collection year. New South Wales was employed as the reference category in all of the described analysis, as it is the largest Australian jurisdiction with relatively low levels of developmental vulnerability.

To allow the comparison of the prevalence of developmental vulnerability between jurisdictions, the *margins* command in Stata was implemented to generate adjusted prevalence (presented in Table 4) according to the method of marginal standardization [29].

2.6.2. Slope index of inequality

To examine socio-economic inequalities in developmental vulnerability, a slope index of inequality was calculated for each jurisdiction, stratified by AEDC collection year. The slope index of inequality (SII) is a weighted regression measure of socio-economic inequality that allows comparison of absolute socio-economic inequalities across sub-populations such as jurisdictions. To calculate the SII, children in each SEIFA IRSAD decile group were assigned a score, representing the midpoint of their range in the cumulative distribution of each respective SEIFA decile. For example, in NSW in 2009, 13.2% of children were in SEIFA IRSAD decile 1, and as such were assigned a score of 6.6% (i.e. 13.2/2). SEIFA decile 2 contained 24.6% of children, this decile was therefore assigned a score of 18.8% (i.e. 13.2 + (24.6/2) and so on. The SII was subsequently calculated using a generalised linear model (binomial regression with identity link function), whereby the outcome of developmental vulnerability was regressed against the SEIFA IRSAD midpoint score and adjusted by confounders consistent with the method described by Moreno-Betancur, Latouche [30]. This model is presented below.

$$g(DV1 = 1) = \alpha + \beta_1(SEIFA) + \beta_2(ATSI) + \beta_3(ESL) + \varepsilon \quad (3)$$

This model was run separately for each jurisdiction and stratified by AEDC collection year, with the SII coefficients (β_1) compared across jurisdictions and AEDC collection years. All analyses were undertaken using STATA V16.0 [31].

2.6.3. Sensitivity analysis

To ensure our analyses using SEIFA IRSAD as the measure of socio-economic position were robust, we conducted sensitivity analyses using parental education data that was available for the two most recent collections of AEDC data (2015 and 2018). Details of the sensitivity analyses are provided in the supplementary appendices.

2.7. Role of funding source

The funders of this research has no role in the study design, statistical analysis, interpretation of results or writing of the manuscript. The AEDC data collection is funded by the Australian Government. The corresponding author had full access to the data in the study and final responsibility for the decision to submit for publication.

3. Results

3.1. Descriptive statistics

Table 1 shows that there has been very little change in the national population distribution across jurisdictions over time, but there has been a steady increase in the number of children in each collection cycle, in line with small increases in the birth rate. Demographic changes in the Australian population of children from 2009 to 2018 are evident, with an increase in the percentage of children identified as being of Aboriginal and/or Torres Strait Islander background (4.5 to 6.0%), and an increase in the percentage of children with ESL status (12.6 to 17.7%). The distribution of sex has remained stable over time, with approximately equal proportions of girls and boys observed from 2009 to 2018. The majority of children in the sample were aged 5 years (~80%), with trends over time indicating there has been an increase in children aged 6–7 years from 2009 to 2018.

Table 2 presents the prevalence of developmental vulnerability within each jurisdiction, stratified by the AEDC collection year. In 2009, developmental vulnerability on one or more domains was highest in the Northern Territory (38.7%), followed by Queensland (29.6%), Western Australia (24.7%), South Australia (22.7%), Australian Capital Territory (22.1%), Tasmania (21.8%), New South Wales (21.3%), and Victoria (20.3%). This reflects an absolute difference of 18.4 percentage points between the Australian jurisdictions with the highest and lowest levels of developmental vulnerability. While national trends show a reduction in the proportion of children that are developmentally vulnerable from 23.5% in 2009 to 21.6% in 2018, patterns vary markedly across jurisdictions. For example, several jurisdictions recorded reductions in developmental vulnerability from 2009 to 2018, ranging from 5.3 percentage points in Western Australia to 0.2 percentage points in Tasmania, while increases in developmental vulnerability were seen in the Australian Capital Territory (+2.3%) and South Australia (+1.2%). Australia's largest jurisdiction New South Wales decreased from 21·3% of children developmentally vulnerable in 2009 to 19·9% in 2018, with these prevalence figures serving as the base category in the following logistic regressions.

3.2. Odds of developmental vulnerability between jurisdictions over time

Table 3 presents the odds of children being developmentally vulnerable on one or more domains in each AEDC collection year, before and after adjustment for confounders. In the 2009 adjusted model, children living in Queensland had the highest odds of being developmentally vulnerable (OR=1.70; 95% CI 1.66–1.74) while Victoria (OR=1.04; 95% CI 1.01–1.07) and Tasmania (OR=1.04; 95% CI 0.98–1.12) had the second lowest odds of developmental vulnerability behind New South Wales (reference category). Between 2009 and 2018, both Queensland (OR=1.70 to OR=1.38) and Western Australia (OR=1.37 to OR=1.03) experienced reductions in their adjusted odds of developmental vulnerability, while the Australian Capital Territory experienced increases in adjusted odds of developmental vulnerability (OR=1.45 to OR=1.78) over this same period.

3.3. Socio-economic inequality in developmental vulnerability over time

Table 4 presents the slope index of inequality (SII) coefficients within each jurisdiction, stratified by AEDC collection year. These results suggest that after adjusting for confounders South Australia had the highest level of absolute socio-economic inequality in 2009 (SII=−0.20; 95% CI −0.22, −0.17). This indicates that in 2009 South Australia had an adjusted difference of 20 percentage points in developmental vulnerability for children living in its least disadvantaged and most advantaged communities. Similar levels of socio-economic inequality in developmental vulnerability were also observed in Queensland and Tasmania in 2009, with lower levels of inequality seen in New South Wales, Victoria and Western Australia, and much lower levels of inequality in child development observed in the Northern Territory and the Australian Capital Territory.

Exploration of trends over time from Table 4 indicate that Tasmania showed an increase in inequality over time and had the (equal) highest level of socio-economic inequality in 2018. South Australia and Queensland showed consistently high levels of socio-economic inequality in child development over time. A marked increase in socio-economic inequality in child development was observed in the Northern Territory from 2009 to 2018, such that they had second lowest level of inequality in 2009 and the (equal) highest level of inequality in 2018. New South Wales and Victoria showed very minor increases in their level of inequality in child

Table 1
Demographics of children stratified by AEDC collection year.

	2009 (n = 245,655) n (%)	2012 (n = 271,666) n (%)	2015 (n = 285,451) n (%)	2018 (n = 292,177) n (%)
Sex				
Male	123,870 (50.4)	136,807 (50.4)	143,673 (50.3)	147,420 (50.5)
Female	121,785 (49.6)	134,859 (49.6)	141,778 (49.7)	144,757 (49.5)
Age				
4 years old	9761 (4.0)	7520 (2.8)	8467 (3.0)	7759 (2.7)
5 years old	195,369 (79.5)	218,660 (80.5)	229,589 (80.4)	229,454 (78.5)
6/7 years	40,525 (16.5)	45,486 (16.7)	47,395 (16.6)	54,964 (18.8)
Jurisdiction				
New South Wales	82,557 (33.6)	88,766 (32.7)	90,878 (31.8)	93,109 (31.9)
Victoria	57,131 (23.3)	63,461 (23.4)	67,627 (23.7)	71,618 (24.5)
Queensland	52,357 (21.3)	57,795 (21.3)	61,939 (21.7)	61,579 (21.1)
South Australia	14,956 (6.1)	17,304 (6.4)	18,429 (6.5)	19,081 (6.5)
Western Australia	25,987 (10.6)	30,605 (11.3)	32,324 (11.3)	32,595 (11.2)
Tasmania	5664 (2.3)	6066 (2.2)	6154 (2.2)	5814 (2.0)
Northern Territory	2828 (1.2)	3078 (1.1)	3211 (1.1)	3167 (1.1)
Australian Capital Territory	4175 (1.7)	4591 (1.7)	4889 (1.7)	5214 (1.8)
Aboriginal and/or Torres Strait Islander				
Yes	11,111 (4.5)	13,940 (5.1)	15,782 (5.5)	17,449 (6.0)
No	234,544 (95.5)	257,726 (94.9)	269,669 (94.5)	274,728 (94.0)
English as a Second Language				
Yes	30,899 (12.6)	38,602 (14.2)	42,698 (15.0)	51,836 (17.7)
No	214,756 (87.4)	233,064 (85.8)	242,753 (85.0)	240,341 (82.3)
SEIFA IRSAD Deciles				
1 (most disadvantaged)	26,215 (10.7)	27,290 (10.0)	28,317 (9.9)	27,539 (9.4)
2	24,180 (9.8)	25,824 (9.5)	27,965 (9.8)	27,724 (9.5)
3	23,787 (9.7)	26,160 (9.6)	27,485 (9.6)	27,260 (9.3)
4	23,818 (9.7)	26,061 (9.6)	28,446 (10.0)	28,728 (9.8)
5	23,539 (9.6)	25,854 (9.5)	28,500 (10.0)	29,362 (10.0)
6	23,898 (9.7)	26,662 (9.8)	29,065 (10.2)	30,495 (10.4)
7	23,978 (9.8)	27,078 (10.0)	29,046 (10.2)	30,518 (10.4)
8	24,326 (9.9)	27,818 (10.2)	28,511 (10.0)	30,551 (10.5)
9	24,923 (10.1)	28,272 (10.4)	29,350 (10.3)	31,140 (10.7)
10 (most advantaged)	26,991 (11.0)	30,647 (11.3)	28,766 (10.1)	28,860 (9.9)

Table 2
Prevalence of developmental vulnerability on one or more domains by jurisdiction, stratified by AEDC collection year.

Jurisdiction	2009 (n = 245,655) n (%)	2012 (n = 271,666) n (%)	2015 (n = 285,451) n (%)	2018 (n = 292,177) n (%)
New South Wales	17,622 (21.3)	17,680 (19.9)	18,357 (20.2)	18,536 (19.9)
Victoria	11,613 (20.3)	12,382 (19.5)	13,458 (19.9)	14,218 (19.9)
Queensland	15,508 (29.6)	15,168 (26.2)	16,199 (26.2)	15,920 (25.9)
South Australia	3397 (22.7)	4097 (23.7)	4329 (23.5)	4560 (23.9)
Western Australia	6430 (24.7)	7037 (23.0)	6880 (21.3)	6332 (19.4)
Tasmania	1236 (21.8)	1306 (21.5)	1295 (21.0)	1254 (21.6)
Northern Territory	1095 (38.7)	1088 (35.4)	1185 (36.9)	1129 (35.7)
Australian Capital Territory	924 (22.1)	1008 (22.0)	1074 (21.97)	1271 (24.4)
National	57,825 (23.5)	59,766 (22.0)	62,777 (22.0)	63,220 (21.6)

Table 3
Odds of developmental vulnerability on one or more domains before and after adjustment for confounders, stratified by AEDC collection year.

	2009 (n = 245,655)		2012 (n = 271,666)		2015 (n = 285,451)		2018 (n = 292,177)	
Jurisdiction	U-OR (95% CI)	A-OR (95% CI)	U-OR (95% CI)	A-OR (95% CI)	U-OR (95% CI)	A-OR (95% CI)	U-OR (95% CI)	A-OR (95% CI)
New South Wales	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Victoria	0.94 (0.92–0.97)	1.04 (1.01–1.07)	0.97 (0.95–1.00)	1.08 (1.05–1.11)	0.98 (0.96–1.01)	1.05 (1.03–1.08)	1.00 (0.97–1.02)	1.07 (1.04–1.09)
Queensland	1.55 (1.51–1.59)	1.70 (1.66–1.74)	1.43 (1.40–1.47)	1.56 (1.52–1.60)	1.40 (1.37–1.43)	1.41 (1.37–1.44)	1.40 (1.37–1.44)	1.38 (1.35–1.42)
South Australia	1.08 (1.04–1.13)	1.10 (1.06–1.15)	1.25 (1.20–1.30)	1.22 (1.18–1.27)	1.21 (1.17–1.26)	1.14 (1.09–1.18)	1.26 (1.22–1.31)	1.16 (1.12–1.21)
Western Australia	1.21 (1.17–1.25)	1.37 (1.33–1.42)	1.20 (1.16–1.24)	1.41 (1.37–1.46)	1.07 (1.04–1.10)	1.14 (1.10–1.17)	0.97 (0.94–1.00)	1.03 (0.99–1.06)
Tasmania	1.03 (0.96–1.10)	1.04 (0.98–1.12)	1.10 (1.04–1.18)	1.04 (0.98–1.11)	1.05 (0.99–1.12)	0.95 (0.89–1.02)	1.11 (1.04–1.18)	0.98 (0.92–1.05)
Northern Territory	2.33 (2.15–2.52)	1.45 (1.33–1.58)	2.20 (2.04–2.37)	1.47 (1.35–1.59)	2.31 (2.15–2.49)	1.59 (1.47–1.72)	2.23 (2.07–2.40)	1.60 (1.47–1.73)
Australian Capital Territory	1.05 (0.97–1.13)	1.45 (1.35–1.57)	1.13 (1.05–1.22)	1.68 (1.56–1.80)	1.11 (1.04–1.19)	1.51 (1.41–1.62)	1.30 (1.21–1.38)	1.78 (1.66–1.90)

Note: Adjusted for Aboriginal and/or Torres Strait Islander background, ESL and socio-economic position (SEIFA IRSAD), U-OR=unadjusted odds ratio, A-OR=adjusted odds ratio.

Table 4
Adjusted prevalence of developmental vulnerability on one or more domains and slope index of inequality coefficients by jurisdiction, stratified by AEDC collection year.

Jurisdiction	Adjusted SII (95% CI)				Adjusted Prevalence of Developmental Vulnerability (95% CI)			
	2009	2012	2015	2018	2009	2012	2015	2018
NSW	−0.13 (−0.14, −0.12)	−0.16 (−0.17, −0.15)	−0.13 (−0.14, −0.12)	−0.14 (−0.15, −0.13)	0.21 (0.20, 0.21)	0.19 (0.19, 0.19)	0.20 (0.20, 0.20)	0.20 (0.20, 0.20)
VIC	−0.14 (−0.15, −0.13)	−0.18 (−0.19, −0.17)	−0.18 (−0.19, −0.17)	−0.16 (−0.17, −0.15)	0.21 (0.21, 0.21)	0.20 (0.20, 0.21)	0.21 (0.20, 0.21)	0.21 (0.20, 0.21)
QLD	−0.18 (−0.19, −0.17)	−0.18 (−0.19, −0.16)	−0.18 (−0.19, −0.17)	−0.18 (−0.19, −0.17)	0.30 (0.30, 0.30)	0.27 (0.26, 0.27)	0.26 (0.25, 0.26)	0.25 (0.25, 0.26)
SA	−0.20 (−0.22, −0.17)	−0.22 (−0.24, −0.19)	−0.20 (−0.22, −0.18)	−0.20 (−0.22, −0.17)	0.22 (0.22, 0.23)	0.22 (0.22, 0.23)	0.22 (0.21, 0.23)	0.22 (0.22, 0.23)
WA	−0.15 (−0.17, −0.14)	−0.18 (−0.19, −0.16)	−0.14 (−0.16, −0.13)	−0.14 (−0.16, −0.13)	0.26 (0.25, 0.26)	0.25 (0.24, 0.25)	0.22 (0.22, 0.22)	0.20 (0.20, 0.21)
TAS	−0.17 (−0.21, −0.14)	−0.19 (−0.23, −0.16)	−0.17 (−0.21, −0.14)	−0.21 (−0.24, −0.17)	0.21 (0.20, 0.22)	0.20 (0.19, 0.21)	0.19 (0.18, 0.20)	0.19 (0.19, 0.20)
NT	−0.09 (−0.15, −0.03)	−0.19 (−0.26, −0.12)	−0.24 (−0.30, −0.17)	−0.21 (−0.27, −0.14)	0.27 (0.25, 0.29)	0.25 (0.24, 0.27)	0.28 (0.27, 0.30)	0.28 (0.26, 0.29)
ACT	−0.05 (−0.09, −0.00)	−0.12 (−0.16, −0.07)	−0.07 (−0.11, −0.28)	−0.11 (−0.15, −0.07)	0.27 (0.26, 0.28)	0.28 (0.27, 0.29)	0.27 (0.26, 0.28)	0.30 (0.29, 0.31)

Note: Adjusted for Aboriginal and/or Torres Strait Islander background, ESL and socio-economic position (SEIFA IRSAD), SII=Slope Index of Inequality.

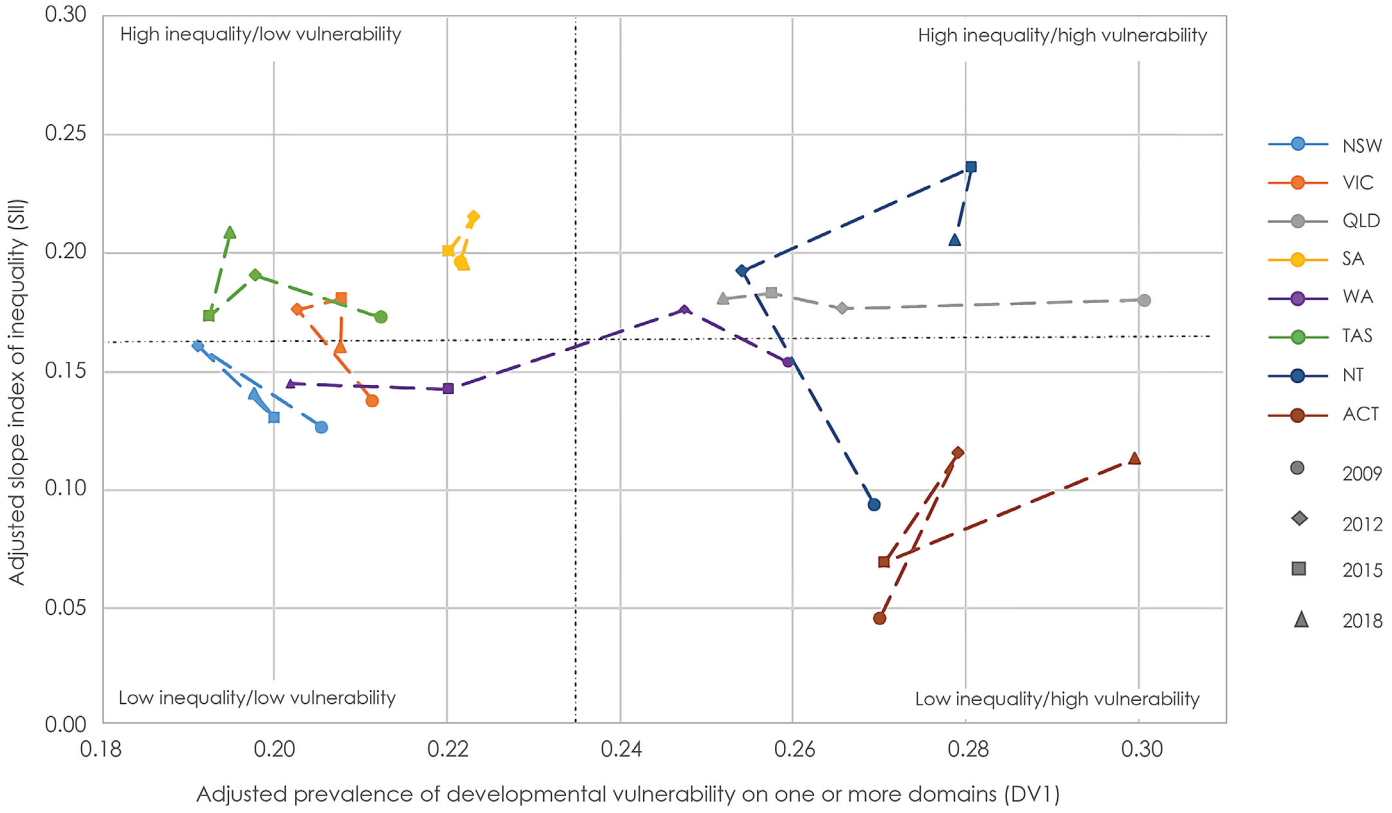

Fig. 1. Adjusted prevalence of developmental vulnerability on one or more domains by slope index of inequality, stratified by jurisdiction and AEDC collection year.
Note: SII coefficients are represented as an absolute (+) value for presentation purposes, whereby higher values indicate more inequality in child development. X-axis adjusted for Aboriginal and/or Torres Strait Islander, ESL and socio-economic position (SEIFA IRSAD), Y-axis adjusted for Aboriginal and/or Torres Strait Islander and ESL. Dotted lines represent the average adjusted prevalence of developmental vulnerability (x-axis) and average adjusted SII (y-axis). Dashed lines illustrate changes in adjusted developmental vulnerability and SII over time in the jurisdictions.

development over time, and Western Australia showed a very minor decrease over time. The Australian Capital Territory showed increased inequality in child development over time but was consistently the jurisdiction with the lowest level of inequality in each AEDC collection. Also presented in Table 4 is the adjusted prevalence of developmental vulnerability by jurisdiction and AEDC collection year. These results are explored further in the analysis of Fig. 1 below.

3.4. Adjusted socio-economic inequality and developmental vulnerability by jurisdiction and over time

Fig. 1 graphically presents the adjusted slope index of inequality coefficients (y-axis), plotted against the adjusted prevalence of developmental vulnerability (x-axis) for each jurisdiction in each AEDC collection year. The average adjusted prevalence of developmental vulnerability (x-axis) and the average adjusted SII (y-axis),

denoted by dotted lines, intersect to make quadrants representing the Australian average (across all cycles) in terms of socio-economic inequality and developmental vulnerability.

Fig. 1 indicates that jurisdictions such as Western Australia and Queensland have experienced reductions in adjusted developmental vulnerability over time (dashed lines). Despite the improvements in developmental outcomes in these jurisdictions, there has not been a reduction in socio-economic inequality in child development, with similar SII coefficients estimated for 2009 and 2018.

Other jurisdictions such as the Northern Territory and the Australian Capital Territory experienced increases in developmental vulnerability from 2009 to 2018, however with considerably different levels of inequality in child development estimated for the two territories. The Australian Capital Territory increased in socio-economic inequality in child development over this period, however remained below average relative to other jurisdictions, while the Northern Territory also increased in socio-economic inequality in child development moving from below to above average. Several jurisdictions were below average in terms of adjusted developmental vulnerability across this period including New South Wales, Victoria, South Australia, and Tasmania, however these states also differed widely in the extent of socio-economic inequality in child development outcomes. Fig. 1 indicates South Australia and Tasmania were above average in terms of socio-economic inequality in child development, with Tasmania in particular increasing in this respect in the period from 2009 to 2018.

4. Discussion

Whereas time trends in health inequality have been frequently reported for mortality and chronic health conditions [32,33], there has been little contribution from the field of child development. The present study aimed to examine differences within and between jurisdictions in development outcomes and socio-economic inequalities in the development of Australian children at school entry, using four collections of AEDC data from 2009 to 2018. The primary analysis of this study found there to be differences in developmental vulnerability and inequality within and between jurisdictions over time. Notably, the jurisdictions of Western Australia and Queensland both experienced reductions in the prevalence of developmental vulnerability over time, after adjustment for socio-demographic differences between jurisdictions. Most other jurisdictions remained stable in their prevalence of developmental vulnerability over this period, with the exception of the Australian Capital Territory which observed an increase in the prevalence of developmental vulnerability.

There are likely to be numerous drivers of these changes in developmental vulnerability, relating to unique changes in jurisdictional policies. For example, from 2009 to 2012 the Universal Access Entitlement (UAE) of 600 h of preschool was scaled up across Australia. While this policy was implemented at the federal level to provide all jurisdictions with comparable provision of preschool services, markedly different levels of availability and enrolment in preschool in the year before school were apparent prior to the introduction of UAE [34], and as such this policy likely had differential impacts on cohorts of children living in different jurisdictions. Queensland had very low levels of preschool participation before the implementation of the UAE, and as such experienced the largest increase in both preschool availability and enrolment following its introduction (increasing from 29% in 2008 to 100% in 2013) [34]. It is worth highlighting that between 2009 and 2012, when the UAE was scaled up, Queensland experienced its largest reduction in state-wide developmental vulnerability (from 29.6 to 26.2%).

Further, the reduction in developmental vulnerability in Queensland occurred largely in children's language and cognitive skills, with a fall in vulnerability from 16% to 9% between 2009 and 2012 (see Table S4.4 in supplementary tables). The likelihood that the fall in developmental vulnerability is attributable to an increase in preschool participation is supported by a study using longitudinal data on the removal of Queensland's public preschool program in 2007 finding five months of universal preschool to be associated with a 0.23 standard deviation increase in school readiness [35].

Less clear are associations between policy changes and developmental shifts across the jurisdictions of Western Australia and the Australian Capital Territory, which have generated widespread interest from policymakers and the research community. For example, although maternal and child health is considered a universal service in all jurisdictions, the approach to implementation, the screening tools used and the number and timing of child health and development checks differ. Both Western Australia and the Australian Capital Territory had a strong child and maternal health system of universal health checks for children over this time period, with six checks between birth and three years of age, with an additional health check at school entry offered in Western Australia. However, inconsistently reported data across jurisdictions makes it difficult to determine how uptake has changed over time. Both jurisdictions had high levels of preschool enrolment before the implementation of the UAE, yet the level of developmental vulnerability in these two jurisdictions moved in opposite directions from 2009 to 2018. So despite the improvement in Western Australia being mainly due to a reduction in developmental vulnerability on the Language and Cognitive Domain (supplementary table S3.4), unlike Queensland, this can't seem to be attributed to changes in preschool attendance. Further research is required to investigate other salient factors such as government resource allocation and policies that may have contributed to the variation in results observed across these jurisdictions.

This paper also focused on the socio-economic gap in child development between children from the most disadvantaged and most advantaged communities. Results suggested that socio-economic gaps also differed substantially across jurisdictions and over time. For example, the socio-economic gap in child development in the Northern Territory increased substantially in the period from 2009 to 2012, remaining high from 2012 to 2018. The socio-economic gradient in child development also became more pronounced in other jurisdictions such as the Australian Capital Territory and Tasmania. There are many reasons why socio-economic inequality in child development may have increased in some jurisdictions and not others. For example, previous research has shown families with high levels of disadvantage are less likely to access important services in early childhood, particularly those that may facilitate healthy child development [36]. A recent study by O'Connor (2020) and colleagues demonstrated that children living in disadvantaged communities had far greater odds of non-attendance at preschool, with a step-wise relationship observed between an increase in community disadvantage and lower preschool attendance. Such results reflect the importance of providing a mix of strong universal platforms (that limit barriers to access) with targeted services correctly balanced on top of the universal base to identify and support those at higher risk of poor development (progressive universalism) [8].

The findings of this study are subject to limitations. Firstly, in our analysis of the socio-economic inequalities in child development we made use of a community level measure of socio-economic position, namely the SEIFA IRSAD index, which was linked to each child at a geographical level. Further to this SEIFA is calculated on the basis of Australian Bureau of Statistics Population Census data which is undertaken once every 5 years. The AEDC is collected once every three years and thus the years do not always align. We have simply applied the closest ABS Census year to the AEDC year. To account for these limitations we conducted a sensi-

tivity analysis using family level socio-economic position (parental education) that was available for the two most recent AEDC data collections (see supplementary appendices). Using a measure of socioeconomic position at the family level resulted in greater socioeconomic inequalities within most jurisdictions, however did not change inferences regarding the positions of jurisdictions relative to one another. As such, our findings indicated broadly consistent results using both measures of socio-economic position.

Secondly, in this study we used the child's jurisdiction of residence measured when the child first entered the schooling system to represent the policy context that the child would have been exposed to from birth to school entry. However, it is possible that some children may have moved jurisdictions in this time period, and we do not have sufficient data to identify these children. Publically available data published on interstate migration by the Australian Bureau of Statistics (ABS), has shown that in 2015 < 2% of children aged zero to four moved interstate in a single year [37]. As such, we would suggest this would have limited impact on our findings. We also note the possibility of measurement error across our study confounders. For example, research has indicated that Aboriginal and/or Torres Strait Islander children are under-enumerated in single data sources, compared with multiple linked data sources [38].

In conclusion, Australia is the only developed country in the world that has conducted multiple population census collections of children's development, as such, the AEDC exists as an unparalleled resource for taking a national pulse of how Australia's children are developing. The differences in inequality in child development reported are likely to reflect service disparities and demonstrate the need for better evidence to inform early childhood policy. This study builds on previous research [39,40] and underscores the value of universal early childhood infrastructure and social supports. As policy makers search for ways of reducing inequality and flattening the social gradient in child development, we need to better utilise the AEDC data to monitor and evaluate policy changes on child development. The fact that programs are implemented differently across jurisdictions facilitates the future use of quasi-experimental approaches to test their efficacy on children's development.

Contributors

SB and TG conceived the original study design. LC conducted the statistical analysis and interpreted the results. LC wrote the original manuscript and SB, TG, YHS and AG provided feedback and revisions on the draft manuscript. All authors approved the final version.

Data sharing

De-identified AEDC microdata can be accessed by application or under agreement with the Australian Government Department of Education, Skills and Employment. For more information visit: https://www.aedc.gov.au/researchers/accessing-aedc-data

Ethics approval

This study was deemed as exempt from ethics review by the University of Western Australia Human Ethics committee.

Declaration of Competing Interest

Mr Collier, Dr. Gregory, Dr. Harman-Smith, and Dr. Brinkman report Research contract funding from Australian Government Department of Education, Skills and Employment, during the conduct of the study; Dr. Gialamas has nothing to disclose; Dr. Brinkman reports grants from National Health and Medical Research Council Australia during the conduct of the study.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.lanwpc.2020.100057.

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