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ARTICLE SUMMARY BOX:

Article Focus

- This study presents the first ever population wide census of child development across an entire country; Australia.
- There are large inequalities in child development across jurisdictions and socio-demographic groups, showing that disparities in child development emerge early in life.

Key Messages

- High quality population monitoring and data linkage systems are essential to inform progressive universalist policy approaches.
- Jurisdictional differences in child development persist after controlling for socio-economic and demographic factors. Differing jurisdictional policies, and levels of service provision that support children and their families from birth to school age may contribute to inequalities in child development across the country.

Strengths and limitations

- These results are based on a developmental census of Australian children, with a large sample of 261,147 children, representing approximately 97.5% of the estimated five-year-old population.
- Further research is needed to understand whether these jurisdictional differences in child development can be attributed to different government policies and service provision.

STRUCTURED ABSTRACT:

Objectives: Early child development may have important consequences for inequalities in health and wellbeing. This paper explores population level patterns of child development across Australian jurisdictions, considering socioeconomic and demographic characteristics.

Design: Census of child development across Australia.

Setting and participants: Teachers complete a developmental checklist, the Australian Early Development Index (AEDI), for all children in their first year of fulltime schooling. Between May and July 2009, the AEDI was collected by 14,628 teachers in primary schools (government and non-government) across Australia, providing information on 261,147 children (approximately 97.5% of the estimated five-year-old population).

Outcome measures: Level of developmental vulnerability in Australian children for five developmental domains: physical wellbeing, social competence, emotional maturity, language and cognitive skills, and communication skills and general knowledge.

Results: The results show demographic and socioeconomic inequalities in child development as well as within and between jurisdiction inequalities. The magnitude of the overall level of inequality in child development and the impact of covariates varies considerably both between and within jurisdiction by sex. For example, the difference in overall developmental vulnerability between the best and worst performing jurisdiction is 12.5% for males and 7.1% for females. Levels of absolute social inequality within jurisdictions range from 8.2% for females and 12.7% for males.

Conclusions: The different mix of universal and targeted services provided within jurisdictions from pregnancy to age 5 may contribute to inequality across the country. These results illustrate the potential utility of a developmental census to shed light on the impact of differences in universal and targeted services to support child development by school entry.

Introduction

Governments are becoming increasingly interested in the early determinants of children's health, development and wellbeing in order to inform services needed to better support children and their families. It is recognised that the opportunities for prevention and public health interventions will be enhanced the more we understand the early pathways to poorer health and development [1] and that to have an impact on health inequalities will require us to address the social determinants of early child health, development and wellbeing [2]. However, appropriate service and systemic improvements for reducing developmental inequalities requires an understanding of the patterns of child health and development across population groups and geographies in order to underpin a progressive universal portfolio of services [3].

Socioeconomic gradients in child health and development mean that providing services primarily to the disadvantaged will not eliminate population health burdens [4]. Children from all social and economic backgrounds may suffer poor health and development, albeit that those in the most disadvantaged circumstances have a disproportionate share of poor health and development. To reduce the steepness of the social gradient in health, actions to influence development must be universal, but be implemented with a scale and intensity that is proportionate to the level of disadvantage [2] – an approach termed progressive or proportionate universalism.

Measuring the developmental effects of proportionate universalism requires substantial effort in the form of establishing early and developmentally relevant baseline measures with ongoing capacity to monitor progress over time. An added challenge entails demonstrating that improvements in early development, translate into improvements in later human capability [5]. This requires longitudinal measurement to ascertain lifecourse developmental effects. An essential starting point is quantification of the overall level, and the absolute and relative inequality in child health and development across the population.

The global challenge to improve early child health and development requires an instrument that can be used across the population, be compared over time for monitoring and is sensitive

enough to evaluate programs. A measure used internationally would additionally enable such comparisons both within and across countries. The current basic health statistics collected early in life to compare the progress of countries include infant, maternal and child mortality rates, breastfeeding and immunisation rates [6]. Other measures of progress such as the Programme for International Student Assessment [7] provide cross-national comparisons of educational performances and are collected much later in child development. These efforts have contributed substantially to sustained cross-national financial and programmatic commitments to lift human development outcomes within nations [8].

Notwithstanding the significance of these measures, we should be seeking indicators that not only determine whether children are surviving but how well populations of children are actually developing between birth and school entry. This is now recognized by organizations such as the OECD and the World Bank which are promoting the use of internationally comparable instruments to measure child development and wellbeing [9, 10]. The implications for monitoring child development are also highlighted by the United Nations Convention on the Rights of the Child [11] as each of the signatory countries is responsible for providing children with the opportunities necessary to develop physical, cognitive, social and emotional capabilities in early life.

Transition to school is seen as one of the best stages in a child's life to measure child development and wellbeing [12-14]. Research has established that children at higher risk for suboptimal development can be better prepared for initial success at school through early childhood education, family support, paediatric and allied health care interventions and child health programs [15]. When children come to school with the developmental capacity to take advantage of the education system, coupled with a high quality education system, the initial positive effects persist into adolescence and adulthood [15].

In 2007, the Council of Australian Governments endorsed the Australian Early Development Index (AEDI) as a national progress measure of early childhood health and development [16]. The AEDI is a population measure of children's development covering five developmental domains:

physical health and well-being, social competence, emotional maturity, language and cognitive skills, and communication skills and general knowledge. The instrument is based on the Canadian Early Development Instrument and has been used in Australia since 2002 [17]. In 2009 the AEDI was collected for almost every child across Australia in their first year of full time schooling. This represents the first effort by any country to conduct a 'child development census' with information collected on more than 261,000 children representing 97.5% of the age-eligible population [18]. The Australian federal government has now committed to repeating the AEDI census every three years. The monitoring of child development and wellbeing over time and across the whole population enables local communities to determine if they are making improvements and fosters the relative comparison of communities and populations subgroups [19]. This commitment to tracking and reporting early childhood outcomes across the entire population, underlines the federal government's leadership role in providing communities and governments with evidence-based information for policy and service evaluation.

The Australian Context

Australia is a federated democracy that has three tiers of government: federal, state and local. Funding towards early child health and development at a federal level is delivered through various departments including the Department of Education, Employment and Workplace Relations, Department of Families, Housing, Community Services and Indigenous Affairs and the Department of Health and Ageing. The federal government has annual contract negotiations, passing monies over to the jurisdictions, for them to deliver agreed services and to assist with national health reform.

Although the six states join together to form the Commonwealth of Australia, they are constituted with the power to make laws and policies through their own legislative, executive and judicial functions. Australia also has two principal territories, the Australian Capital Territory (ACT) and the Northern Territory (NT), which constitutionally are directly subject to the

Commonwealth government. These eight State and Territory Governments provide the bulk of early childhood services, with differing levels and approaches to service delivery. Local governments make up the third tier and are established by state and territory governments to take responsibility for a number of community based services. Of the total health expenditure in Australia, 42.7% is contributed by the federal government, 25.3% by state, territory and local governments, and the remainder is covered by individuals, non-government agencies and private industry [20].

Australia is the earth's biggest island and the sixth-largest country in the world in land area. It is a culturally diverse society with a population of more than 22 million [21]. Australia's population includes Aboriginal and Torres Strait Islander peoples and migrants from some 200 countries with Indigenous Australian peoples representing 2.5% of the total population [22]. In over 60 years of planned post-war migration, Australia has accepted more than 6.5 million migrants and in the most recent census (2006), 3.1 million people (16% of the population) were reported to speak a language other than English at home [23]. The majority of the population lives in the cities mainly located around the coast, however many live in rural and remote areas ranging from dry arid land to tropical and a few live in what are arguably some of the most remote and untouched areas of the world.

Australia's income inequality has been steadily increasing [24] but it ranks second after Norway on the most recent Human Development Index (HDI) results [25]. The plight of the Aboriginal and Torres Strait Islander population however remains one of Australia's most concerning inequalities. Separate HDI estimates for Australian Aboriginal and Torres Strait Islanders ranked this subpopulation at about 104th – between Cape Verde and China [26]. The most recent report from Australia's Productivity Commission notes that there has been little change for Aboriginal people on measures of literacy and numeracy, most health indicators and in proportions living in overcrowded housing. Rates of child abuse and neglect substantiations and adult imprisonment have increased for Aboriginal people, but there has been recent improvement in

juvenile detention rates [22]. Low birth weight rates are two and a half times higher than for children born to non-Aboriginal mothers [22].

The multicultural context of Australia, its geographical size and climatic variation, along with multi-tiered political governance and service delivery highlights the complexity faced when aiming to both understand and reduce inequality in child health and development. The objective of this study is to use the national AEDI census data to examine jurisdictional, geographic, socioeconomic and gender inequality in child health and development across Australia.

Methods

To support broad access to the AEDI data the Australian Government through the Department of Education, Employment and Workplace Relations made available in 2011 a Confidentialised Unit Record File (CURF) for researchers. In order to protect the privacy of individual children the data were confidentialised by removing the child's name and date of birth, restricting potentially identifying information, and where the information was considered to present a risk of identifying individuals the data were restricted and/or "perturbed" however details of this process conducted by the Australian Bureau of Statistics are confidential [27]. This, in combination with the unavailability of a SEIFA indicator for the Northern Territory resulted in the removal of the territory from the analytical models. The AEDI CURF does not include the individual items that comprise the AEDI and only provides categorised data on the summary AEDI domain scores and a limited range of socio-demographic characteristics such as state of residence, gender, and remoteness [28].

Study population

Between May and July 2009, all schools (government and non-government) across all states and territories in Australia participated in the AEDI. As shown in Figure 1, information for 261,147 children (approximately 97.5% of the estimated five-year-old population) in their first year of full-

time school was collected by 14,628 teachers across Australia. Of those, 89.6% (n=233,960) contributed to the analysis with 117,937 males and 116,023 females, and their characteristics are provided in Table 1. The vast majority of children live in major cities, with the most populous states being New South Wales, Victoria and Queensland. Four per cent of the children were of Aboriginal or Torres Strait Islander descent and approximately 12% of all children spoke English as a second language. The AEDI was not completed for children whose parent/guardian opted-out or in the situation where the teacher had known the child for less than one month and felt that they didn't know the child well enough to complete the checklist [18].

Table 1: Socio-demographic characteristics of children for whom an AEDI was completed and contributed to the analysis

Characteristics	Male (n=117,937) n (column %)	Female (n=116,023) n (column %)
State		
New South Wales	41,465 (35.2)	40,657 (35.0)
Victoria	28,286 (23.9)	28,400 (24.5)
Tasmania	2,855 (2.4)	2,785 (2.4)
Australian Capital Territory	2,114 (1.8)	2,021 (1.7)
South Australia	7,282 (6.2)	7,221 (6.2)
Western Australia	13,112 (11.1)	12,633 (10.9)
Queensland	22,823 (19.4)	22,306 (19.2)
Aboriginal Torres Strait Islander		
Yes	4,668 (4.0)	4,766 (4.1)
No	113,269 (96.0)	111,257 (96.0)
English as a second language		
Yes	14,865 (12.6)	14,043 (12.1)
No	103,072 (87.4)	101,980 (87.9)
Mean SEIFA (±SD)	6.29 (2.98)	6.27 (2.99)

Outcome

The AEDI is the outcome measure used to assess children's development. The Index is an adapted version of the Canadian Early Development Instrument [16, 29]. Both the Canadian and the Australian version of the instrument have been shown to have sound validity [29-34]. The AEDI is an 95-item, teacher completed questionnaire designed to measure five domains of child development: Physical health and wellbeing, Language and cognitive skills, Emotional maturity, Social competence, and Communication skills and general knowledge [35].

Teachers complete the AEDI for each child in their class on the basis of their knowledge of the children. Children are not required to be present when the information is entered into the secure web-based data entry system. Each item on the checklist is either dichotomous (yes/no) or a Likert scale response (e.g. very good/good; average; poor/very poor). The data were collected across the country over a three month time period (May to July 2009).

Domain scores range between 0 and 10 and are calculated as a mean score of all valid answers. Higher scores indicate a higher level of development for that domain. Children who score below the 10th percentile of the national AEDI population for an individual domain (e.g. emotional maturity) are categorized as 'developmentally vulnerable' with all other children categorized as 'not developmentally vulnerable' for that domain. The National Progress Measure is the proportion of children who are developmentally vulnerable on one or more of the five domains.

Covariates

Index of Relative Socio-economic Advantage and Disadvantage

The Australian Bureau of Statistics releases on the basis of census information a series of four Socio-Economic Indices For Areas (SEIFA). The index utilised for this manuscript was the Index of Relative Socio-economic Advantage and Disadvantage [36]. The index reflects the average socio-economic status of people and households in the area, not individual people or households. SEIFA has been applied to the AEDI data file on the basis of the child's suburb

(neighbourhood) of residence [28]. In the rural and remote areas where suburbs do not exist, SEIFA was applied at the smallest level of geography on the basis of their address details provided by the teacher upon completing the AEDI [28]. The SEIFA index is calculated via Principal Components Analysis using 21 indicator variables. The index is ordinal and ranges from around 200 to 1200 with a mean of 1000 and standard deviation of 100, however, this score has been categorised to deciles as part of the confidentialisation process undertaken by the ABS with the lowest decile representing the most disadvantaged areas [36].

Aboriginal and Torres Strait Islander and English as a Second Language.

Aboriginal and Torres Strait Islander (ATSI) background and English as a Second Language (ESL) are collected with the AEDI. ATSI was recorded on the basis of school enrolment records. Teachers classified children as having English as a Second Language where English was not their first language and where they needed additional instruction in English or where their English was not yet proficient.

Statistical analyses

A dichotomous variable was created indicating whether the child was in the bottom 10^{th} percentile (developmentally vulnerable) or not for each of the five domains, and developmentally vulnerable on one or more domains. Children, who were identified as having special needs, were three years old, or had less than four valid domain scores (n=11,484) were not included in the calculation of developmentally vulnerable on one or more domain [18, 37].

As our primary interest was to investigate jurisdictional and socioeconomic inequality of child developmental vulnerability we utilised two nested fixed-effects logistic regression models. Model 1 considers only state as the covariate. For being developmentally vulnerable on one or more domain ($DV1^{+}$) variable the model is:

$$\text{logit}\left[p_{ij}\left(dv1^{+}=1\right)\right]=\alpha+\beta_j(state_{ij}), \quad (1)$$

where $p_{ij}\left(dv1^{+}=1\right)$ is the probability of a child being developmentally vulnerable on one or more domains for the i^{th} observation in the j^{th} class of the state variable, α is the intercept and β_j is the coefficient for the state. Model 2 considers three additional covariates for jurisdictional variation of child vulnerability. Again for same dependent variable $DV1^{+}$ the full model is defined as,

$$\text{logit}\left[p_{ij}\left(dv1^{+}=1\right)\right]=\alpha+\beta_{1j}(state_{ij})+\beta_{2j}(ATSI_{ij})+\beta_{3j}(ESL_{ij})+\beta_{4j}(SEIFA_{ij}), \quad (2)$$

where β_{1j}, β_{2j}, β_{3j}, and β_{4j} are the coefficients for four covariates: state, Aboriginal and Torres Strait Islander (ATSI) status, English as a second language (ESL) status and SEIFA, respectively. Models are estimated separately for males and females. Similar models are used for each of the domain specific outcomes.

To examine socioeconomic inequalities in developmental vulnerability we computed the slope index of inequality (SII) [38, 39]. In this circumstance we use the SII to measure the absolute developmental vulnerability gap between the lowest and highest SEIFA deciles within jurisdictions in Australia. The computational process of creating the SII is:

1) Compute the proportion of total children (t_i) for the ordered (lowest to highest) classes of SEIFA deciles $(i=1,2,...,10)$;
2) Compute the cumulative proportion of children for each SEIFA class (c_i) and then give a score based on the midpoint of its range in the cumulative distribution in the children $(i.e.\ x_i = c_{i-1} + t_i/2)$;
3) Compute the proportion of developmentally vulnerable children for i^{th} class (r_i); and

4) Values of r_i then are plotted against the values of x_i and a regression line is fitted to the data. Thus, the SII is the absolute value of the slope coefficient of the regression line from lowest to highest SEIFA score.

All analyses were carried out using SAS software Version 9.2.

Results

Table 2 shows the association between geographic and socio-demographic characteristics and the probability of being developmentally vulnerable on one or more AEDI domain by sex. Aboriginal and Torres Strait Islander children were more likely to be developmentally vulnerable compared to non-ATSI children (OR 2.16 males; 95% CI, 2.03-2.30 OR 2.42 females; 95% CI, 2.27-2.58); those for whom English was not their first language were more likely to be developmentally vulnerable (OR 2.06 males; 95% CI, 1.99-2.14 OR 2.43 females; 95% CI, 2.33-2.54); and for every decile increase in SEIFA there was a decreasing odds of being developmentally vulnerable (OR 0.92 males; 95% CI, 0.91-0.92 and OR 0.91 females; 95% CI, 0.90-0.91).

Model 1 in Table 2 shows that for both sexes, compared to New South Wales (reference group), children living in Queensland had the highest odds (OR 1.70 males; 95% CI, 1.64-1.75 and OR females1.42; 95% CI, 1.37-1.49) of being developmentally vulnerable followed by children living in Western Australia, South Australia, Australian Capital Territory, Tasmania and Victoria. After adjusting for ATSI, ESL and SEIFA (Model 2) Queensland children for both sexes remained the most developmentally vulnerable (OR 1.80 males; 95% CI, 1.74-1.87 and OR females 1.52; 95% CI, 1.46-1.59). However, after adjustment, compared to Model 1, there was a shift in the ranking of developmental vulnerability by jurisdiction, with the odds of vulnerability increasing substantially for children living in the Australian Capital Territory and Western Australia.

Table 2: Odd ratios (95% CI) estimates for children developmentally vulnerable on one or more domains by geographic and sociodemographic characteristics in Australia

	Developmentally vulnerable on one or more domains			
	Male (N=117937)		Female (N=116023)	
	Model 1	Model 2	Model 1	Model 2
Geographic variables				
State				
New South Wales	reference			
Australian Capital Territory	1.10 (1.00 - 1.21)	1.55 (1.41 - 1.71)	0.94 (0.83 - 1.07)	1.42 (1.25 - 1.61)
Queensland	1.70 (1.64 - 1.75)	1.80 (1.74 - 1.87)	1.42 (1.37 - 1.49)	1.52 (1.46 - 1.59)
South Australia	1.14 (1.08 - 1.20)	1.11 (1.04 - 1.17)	1.01 (0.95 - 1.09)	0.97 (0.90 - 1.04)
Tasmania	1.10 (1.02 - 1.20)	1.04 (0.96 - 1.14)	0.92 (0.83 - 1.03)	0.88 (0.79 - 0.98)
Victoria	0.98 (0.94 - 1.01)	1.06 (1.02 - 1.10)	0.88 (0.85 - 0.92)	0.98 (0.94 - 1.02)
Western Australia	1.26 (1.21 - 1.32)	1.38 (1.32 - 1.44)	1.12 (1.06 - 1.18)	1.24 (1.17 - 1.31)
Sociodemographic variables				
Aboriginal and Torres Strait Islander				
No	reference			
Yes		2.16 (2.03 - 2.30)		2.42 (2.27 - 2.58)
English second language				
No	reference			
Yes		2.06 (1.99 - 2.14)		2.43 (2.33 - 2.54)
Socioeconomic advantage & disadvantage index (SEIFA)		0.92 (0.91 - 0.92)		0.91 (0.90 - 0.91)

Results presented in Tables 3 and 4 show the association between geographic and socio-demographic characteristics and the probability of being developmentally vulnerable on each AEDI domain by sex. The general pattern showing large jurisdictional differences after controlling for the covariates is consistent across each of the five developmental domains with children in Queensland and the Australian Capital Territory showing higher vulnerability compared to children living in the other jurisdictions. In Queensland, when looking across the five domains, there is little difference found between the odds ratios in Models 1 and 2 for physical health and wellbeing, social competence and emotional maturity. However, controlling for the covariates increases the odds of vulnerability for both language and cognitive and communication and general skills. This pattern is consistent across males and females. Contrary to this, children living in the Australian Capital Territory show increased odds across all five developmental domains when controlling for covariates.

For all five domains, both Aboriginal and Torres Strait Islander (ATSI) and English as a Second Language (ESL) children have increased odds of vulnerability compared to non-ATSI and non-ESL children respectively. It is noteworthy that inequality between ATSI and non-ATSI children is greater for females than for males. For instance, on the physical health and wellbeing domain, the odds ratio for male ATSI children is 1.81 (CI 1.68-1.95) compared with 2.38 for female ATSI children (CI 2.19-2.58). For ATSI children the greatest inequality when compared to non-ATSI is for the Language and cognitive development domain (OR 2.59 males; 95% CI, 2.42-2.78 and OR females 3.01; 95% CI, 2.78-3.25). For children with ESL status the highest ORs were found for the Communication skills and general knowledge domain with 4.19 (95% CI, 4.01-4.37) for males and 5.16 (95% CI, 4.89-5.44) for females.

Table 3: Odd ratios (95% CI) for male children developmentally vulnerable on each domain by jurisdiction and sociodemographic characteristics (N=117937)

	Developmentally vulnerable on each sub-domain									
	Physical health & wellbeing		Social competence		Emotional maturity		Language & cognitive skills		Communication & general skills	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
State										
New South Wales (r)										
Australian Capital Territory	1.20 (1.05 - 1.37)	1.62 (1.42 - 1.86)	1.07 (0.94 - 1.22)	1.44 (1.26 - 1.64)	1.21 (1.07 - 1.38)	1.57 (1.37 - 1.78)	1.02 (0.87 - 1.21)	1.72 (1.45 - 2.04)	1.04 (0.90 - 1.19)	1.62 (1.40 - 1.86)
Queensland	1.39 (1.32 - 1.45)	1.37 (1.30 - 1.44)	1.50 (1.43 - 1.57)	1.52 (1.45 - 1.59)	1.60 (1.52 - 1.67)	1.57 (1.50 - 1.65)	3.27 (3.11 - 3.43)	3.46 (3.29 - 3.64)	1.27 (1.21 - 1.33)	1.52 (1.44 - 1.60)
South Australia	1.21 (1.12 - 1.30)	1.12 (1.04 - 1.21)	1.22 (1.13 - 1.31)	1.15 (1.07 - 1.24)	1.48 (1.38 - 1.59)	1.38 (1.29 - 1.49)	1.02 (0.93 - 1.12)	0.94 (0.85 - 1.04)	0.89 (0.82 - 0.97)	0.94 (0.86 - 1.02)
Tasmania	1.19 (1.06 - 1.33)	1.03 (0.92 - 1.16)	1.07 (0.95 - 1.20)	0.97 (0.86 - 1.09)	1.25 (1.12 - 1.40)	1.10 (1.98 - 1.23)	1.48 (1.30 - 1.67)	1.30 (1.14 - 1.48)	0.80 (0.70 - 0.91)	0.93 (0.81 - 1.06)
Victoria	0.90 (0.86 - 0.95)	0.95 (0.90 - 0.99)	0.98 (0.93 - 1.02)	1.03 (0.99 - 1.08)	1.15 (1.09 - 1.20)	1.19 (1.13 - 1.25)	1.06 (1.00 - 1.12)	1.18 (1.12 -1.25)	0.93 (0.89 - 0.98)	1.08 (1.02 - 1.13)
Western Australia	1.23 (1.16 - 1.30)	1.28 (1.20 - 1.36)	0.90 (0.84 - 0.96)	0.94 (0.88 - 1.00)	1.22 (1.15 - 1.29)	1.26 (1.19 - 1.34)	2.31 (2.17 - 2.45)	2.57 (2.41 - 2.73)	1.04 (0.98 - 1.10)	1.22 (1.14 - 1.30)
Aboriginal and Torres Strait Islander										
No (r)										
Yes		1.81 (1.68 - 1.95)		1.78 (1.66 - 1.92)		1.59 (1.48 - 1.71)		2.59 (2.42 - 2.78)		2.10 (1.95 - 2.27)
English second language										
No (r)										
Yes		1.29 (1.23 - 1.36)		1.48 (1.41 - 1.55)		1.19 (1.13 - 1.25)		1.94 (1.84 - 2.04)		4.19 (4.01 - 4.37)
Socioeconomic advantage & disadvantage index (SEIFA)		0.92 (0.92 - 0.93)		0.93 (0.92 - 0.93)		0.93 (0.92 - 0.94)		0.88 (0.88 - 0.89)		0.92 (0.91 - 0.92)

Table 4: Odd ratios (95% CI) for female children developmentally vulnerable on each domain by jurisdiction and sociodemographic characteristics (N=116023)

	Developmentally vulnerable on each sub-domain									
	Physical health & wellbeing		Social competence		Emotional maturity		Language & cognitive skills		Communication & general skills	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
State										
New South Wales (r)										
Australian Capital Territory	0.93 (0.77 - 1.13)	1.42 (1.87 - 1.72)	0.90 (0.73 - 1.10)	1.32 (1.08 - 1.63)	1.26 (1.01 - 1.57)	1.82 (1.46 - 2.28)	0.87 (0.69 - 1.09)	1.54 (1.22 - 1.95)	0.85 (0.70 - 1.03)	1.36 (1.12 - 1.65)
Queensland	1.22 (1.14 - 1.30)	1.16 (1.09 - 1.24)	1.36 (1.28 - 1.45)	1.35 (1.26 - 1.44)	1.53 (1.41 - 1.65)	1.47 (1.36 - 1.60)	2.59 (2.43 – 2.76)	2.67 (2.50 - 2.86)	1.01 (0.94 - 1.07)	1.23 (1.15 - 1.31)
South Australia	1.11 (1.01 - 1.23)	0.99 (0.90 - 1.10)	1.04 (0.94 - 1.16)	0.96 (0.86 - 1.07)	1.34 (1.18 - 1.51)	1.21 (1.07 - 1.36)	1.06 (0.94 - 1.20)	0.96 (0.85 - 1.09)	0.78 (0.70 - 0.87)	0.80 (0.72 - 0.90)
Tasmania	1.15 (0.99 - 1.33)	0.95 (0.81 - 1.10)	0.84 (0.70 - 1.00)	0.73 (0.61 - 0.88)	0.90 (0.73 - 1.12)	0.76 0.61 - 0.94)	1.16 (0.97 - 1.38)	1.02 (0.85 - 1.22)	0.63 (0.53 - 0.76)	0.77 (0.64 - 0.93)
Victoria	0.84 (0.79 - 0.90)	0.91 (0.85 - 0.97)	0.90 (0.84 - 0.96)	0.97 (0.90 - 1.03)	1.10 (1.01 - 1.19)	1.16 (1.07 - 1.26)	1.01 (0.93 - 1.08)	1.14 (1.06 -1.23)	0.84 (0.79 - 0.89)	0.98 (0.92 - 1.04)
Western Australia	1.13 (1.04 - 1.22)	1.16 (1.08 - 1.26)	0.77 (0.70 - 0.84)	0.80 (0.73 - 0.88)	1.15 (1.04 - 1.28)	1.19 (1.08 - 1.32)	1.99 (1.84 - 2.16)	2.19 (2.02 - 2.38)	0.83 (0.76 - 0.90)	0.98 (0.90 - 1.07)
Aboriginal and Torres Strait Islander										
No (r)										
Yes		2.38 (2.19 - 2.58)		2.01 (1.83 - 2.20)		1.88 (1.69 – 2.10)		3.01 (2.78 - 3.25)		2.21 (2.02 - 2.42)
English second language										
No (r)										
Yes		1.24 (1.16 - 1.32)		1.56 (1.46- 1.67)		1.23 (1.13 - 1.34)		2.13 (2.00 - 2.27)		5.16 (4.89 - 5.44)
Socioeconomic advantage & disadvantage index (SEIFA)		0.90 (0.89 - 0.91)		0.91 (0.90 - 0.91)		0.91 (0.90 - 0.92)		0.87 (0.86 - 0.88)		0.90 (0.90 - 0.91)

Figure 2 shows the joint variation across Australian states and territories of child vulnerability on one or more domain according to 1) adjusted predicted average levels of vulnerability in the state or territory and 2) the slope index of inequality (absolute) based on SEIFA. Ideally, jurisdictions should be in the bottom left-hand quadrant with lower overall levels of vulnerability and lower absolute social inequality. The scales of the X-axes are the same to show the lower overall vulnerability of females (median vulnerability about 15%) compared to males (median vulnerability about 29%). Across all jurisdictions males experience higher inequality and higher median levels of developmental vulnerability compared to females. For males and females, the smallest levels of inequality and developmental vulnerability are found in New South Wales and Tasmania whereas the largest inequalities and highest levels of developmental vulnerability are found in Western Australia and Queensland. Children in Victoria and South Australia have higher levels of inequality but lower vulnerability, while children in the Australian Capital Territory experience lower levels of inequality yet higher vulnerability.

The *inequality difference* between states varies significantly with the lowest and highest levels of inequality for males being 12.6 (lowest level of inequality in Tasmania and highest level in South Australia) and for females is 8.2 (lowest level of inequality found in the Australian Capital Territory and highest inequality in Western Australia). The difference in *overall developmental vulnerability* for males between the top (New South Wales) and bottom (Queensland) states is 12.5 percentage points and for females it is 7.1 (top=Tasmania and bottom=Queensland). The magnitude of these inequalities varies considerably between and within jurisdiction by sex. The difference in inequality between males and females is smallest in Tasmania (difference 1.24), then New South Wales (difference 2.03) followed by Victoria (difference 4.85), Queensland (difference 5.07), Western Australia (difference 5.83), and the Australian Capital Territory (difference 7.0) with the highest level of inequality between males and females found in South Australia (difference 10.82).

Children residing in the most disadvantaged areas (SEIFA decile 1) in New South Wales and Tasmania recorded the same proportion of children developmentally vulnerable (27%) as those children residing in the middle of the SEFIA range (decile 5) in Western Australia and the Australian Capital Territory and the lower end of the socioeconomic range (decile 8) in Queensland. Those children living in the most advantaged areas in Queensland (decile 10) recorded a similar proportion of children developmentally vulnerability as children residing in the poorer areas of NSW, Tasmania, South Australia and Victoria (deciles 2-3).

Despite acknowledged universal availability of health services in Australia, there is a marked variation in what the states and territories provide to families with young children. Table 5 shows the published schedules for maternal and child health services as well as preschool services offered within the different jurisdictions. These two services represent the main universal systems available to most Australian families. This table suggests that such services vary across the jurisdictions. While any statistical analyses of association are not possible with such broad data, a descriptive approach highlights the concordance with some of the results on the AEDI. Queensland, where the services are not universal, has the lowest preschool attendance and one of the highest children to staff ratios. New South Wales, Tasmania, and Victoria appear to have the most comprehensive universal early years' service coverage – and in two out of these three states (NSW and Tasmania) the level of inequality in child developmental vulnerability is the smallest.

Table 5: Documented universal services offered in each of the Australian jurisdictions prior to school.

	Child, Health and Parenting schedule of Universal services			**Preschool attendance in 2008**	**Preschool staff to child ratio**
	1-3 months	**4-12 months**	**1 – 5 years**		
New South Wales	<2 weeks (HV) 1-4 weeks 6-8 weeks	6-months 12 months	18-months 2 years 3 years 4 years	60.4%	1:10
Australian Capital Territory	1-4 weeks (HV) 6-8 weeks	6-9 months	18 -21 months 3 – 3.5 years	88.3%	1:11
Queensland	No universal service			26.6%	1:12
South Australia	< 2 weeks (HV)	-	-	87.9%	1:10
Tasmania	2 weeks (HV) 4 weeks 8 weeks	4 months 8 months 12 months	18 months 3 ½ years	101.6%	1:10
Victoria	< 2 weeks (HV) 2 weeks 4 weeks 8 weeks	4 months 8 months 12 months	18 months 2 years 3 ½ years	95.8%	1:15
Western Australia	<10 days (HV) 6-8 weeks	3-4 months 8 months	18 months 3 years	103.4%	1:10

HV = Home Visit. Note: States provide aggregated data for their preschool attendance rates and the Australian Bureau of Statistics provides data for the denominator, which is provided as the reason for percentages being over 100%. References for Table 5: [40-48].

Discussion

Population-wide data has enabled Australia to be the first nation to quantify patterns of early child health and development across its different jurisdictional boundaries with their associated socioeconomic and demographic diversity. The work here provides the first national population benchmarks of some aspects of early childhood development as this pertains to readiness to learn at school. The data illuminate striking differences in early capacities that are strongly associated with socioeconomic and demographic circumstances.

Controlling for socioeconomic and demographic covariates reveals significant variations in developmental vulnerabilities across the states and territories. At the outset we acknowledge that there are socioeconomic and demographic determinants that are not fully captured by the models presented owing to their limited availability in the CURF. Nonetheless, it is both heartening and disturbing to discover such differences across jurisdictions. It is heartening because it highlights that child health and development may be improved by factors other than socioeconomic and demographic factors. However, it is disturbing to note that in a wealthy country where universal health coverage, mandated education and public health provision are available, and where there is still a reasonable social safety net, there are nevertheless striking disparities in levels of early child development. Why is it, for example, that after controlling for the standard socioeconomic and demographic factors, a child residing in Queensland relative to a child residing in New South Wales, has an increased odds of being developmentally vulnerable by the time they reach school entry (males OR 1.80, CI 1.74-1.87; females OR 1.52 CI 1.46-1.59)? There is little doubt that these differences would be reduced by more extensive socioeconomic and demographic controls but this is unlikely to explain all the residual differences within and across jurisdictions. This raises the question of whether differing policies, contexts and mix of services that support children and their families from birth to school age across the jurisdictions in Australia contribute to such inequalities? The marked variation demonstrated in Table 5 suggests this is a possibility.

In South Australia (SA) the maternal and child health schedule moves quickly from a universal to an active targeted service; however all mothers not in the targeted service who wish to see a child health nurse can still visit the clinics. In SA almost all families have a Universal Contact Visit within the first two weeks after birth of their baby. Based on the nurse's assessment, mothers who have risk factors such as being young, socially isolated or having mental health issues are offered further intensive home visits. These visits are extensive with weekly sessions between week 3 and 8, followed by fortnightly visits up to 8 months, and then monthly visits until the child is two years old. The schedule includes a total of 34 visits in the first 2 years of the child's life [41]. In Tasmania, ACT and NSW a universal home visit is also conducted and then the state specific scheduled development checks for all families are offered. In Victoria, even though funded by the State government, the services are delivered by local governments adding a different context to the "shop front". NSW is the only state with an antenatal health check-up that identifies vulnerable families early. These families are then referred onto secondary services where necessary [49, 50]. In WA, a universal service is offered in the first 10 days after birth and then nurses aim to provide a total of six contacts [51]. In Queensland the government has no universal maternal and child health service and Queensland is also the state with the lowest preschool attendance [46, 48].

In addition to the variability across jurisdictions in the delivery of maternal and child health services and the level of access to these services there are also differences in the rate of investment in these services relative to population growth. For example in Western Australia service delivery has not kept pace with the population growth. The Western Australia Children's Commissioner in a submission to a Justice Standing Committee noted that although the birth rate had increased 16% over the previous years there had not been a concomitant increase in the number of child health nurses, school health nurses, Aboriginal health workers or investments in child health services. The Commissioner's figures revealed that despite the published Child and Maternal Health Schedule there was only one child health nurse for every 167 births (whereas most other jurisdictions had ratios between 1:78 – 1:98) [47].

While it may be tempting to make strong claims about the co-variation in AEDI results with models and levels of human service delivery in the various Australian jurisdictions, a much more extensive investigation is required to move toward any causal interpretation. For example, controlling for the covariates increases the odds of developmental vulnerability for children living within the Australian Capital Territory. Just why this should be so, given the shallower socioeconomic gradient in this jurisdiction (with no children recorded in the poorest 5 deciles of SEIFA), is unclear. Why then, despite the ACT being a relatively wealthy state with lower socioeconomic inequality, do we see increased odds for vulnerability across all five of the developmental domains?

Gender differences are evident in these data. There are well documented gender differences in brain development of young children [52, 53]. At early ages in particular, boys develop at a slower rate than girls [54], and there is evidence that different areas of the brain develop in a different sequence in girls compared with most boys [55]. This is consistently evident within the EDI [29] and AEDI results [18]. However within gender there are significant differences for boys and girls residing in different jurisdictions, and socioeconomic and demographic contexts. What are the contextual factors in South Australia that lead to both the greatest inequality difference between males and females and also the greatest degree of inequality within the male gender compared to other jurisdictions? This is in contrast to a smaller gap between boys and girls living in Tasmania and New South Wales, and both of these jurisdictions show the lowest level of inequality while still also maintaining lower levels of developmental vulnerability overall.

Worth noting is also the finding that inequality in vulnerability is higher for girls than boys, even though boys on average have poorer outcomes. This seems to be supported by evidence suggesting that girls are more susceptible to adverse external conditions than boys. Persistent poverty had a significantly larger effect on the cognitive scores of pre-school aged girls than boys [56]. In this study, income was more strongly associated with cognitive development for girls, who, when annual income increased by $10,000, experienced a larger improvement in cognitive scores

than boys. Additionally, girls' scores were worse than boys' when compared to controls in higher socioeconomic status, which is similar to our results.

Across all five of the AEDI domains both Aboriginal and ESL children have increased odds of vulnerability compared to non-Aboriginal and non-ESL children respectively. Of interest is that the inequality between Aboriginal and non-Aboriginal children is greater for females than for males particularly on the Physical health and wellbeing domain, where the odds ratio for male Aboriginal children is 1.81 (CI 1.68-1.95) compared with 2.38 for female Aboriginal children (CI 2.19-2.58). However the greatest inequality gap between Aboriginal and non-Aboriginal children is found on the language and cognitive development domain irrespective of gender (OR 2.59 males; 95% CI, 2.42-2.78 and OR females 3.01; 95% CI, 2.78-3.25). Interestingly, although SEIFA has a large impact on each of the five AEDI domains, it is the Language and cognitive domain that is influenced the greatest by the socio-economic index.

For children with ESL status the highest ORs for vulnerability were found for the Communication skills and general knowledge domain with an OR of 4.19 for males (CI 4.01-4.37) and an OR of 5.16 for females (CI 4.89-5.44). The results needs to be considered in light of the fact that the AEDI measures school based communication skills in English as English is the main language of instruction in Australian schools. Results reported elsewhere have shown that children who speak another language but are additionally proficient in English show the lowest levels of developmental vulnerabilities across each of the five domains, however those that are not proficient in English (independent of ESL status) show poorer results on the AEDI [18, 57, 58].

The AEDI will be repeated once every three years (i.e. 2012, 2015, 2018…). This will enable onward monitoring and surveillance and creates opportunities to examine the effects of policies and interventions. This will require political will and leadership as well as the capitalisation of this opportunity by the scientific community and those interested in human service evaluation. The onward implementation of the AEDI also encourages efforts in establishing a longitudinal capacity (i.e. following the same child/person over time) to illuminate the pathways leading to a

variety of human development outcomes. Among such life course outcomes are those pertaining to health/ill-health as well as wider outcomes pertaining to social, economic and civic participation.

In Australia there are robust administrative data linkage methodologies, some longstanding and well established, that are currently being assessed for their potential to use AEDI data to prospectively estimate the human development benefits of early childhood opportunities, environments and services on later life course outcomes. It is possible to construct crosswalks between health, early child development and education databases that integrate population-wide, person-specific data at national, provincial, and community levels [59]. As such it is possible to create a historical perspective of developmental trajectories for an entire population of children.

Australia is now progressing towards national data linkage with jurisdiction based "nodes" working together under a national network (the Population Health Research Network) that will allow researchers to access linked data that is de-identified. The systems will improve Australia's ability to monitor health and health inequalities using data already collected by social services including primarily health but also education and family and community services. In Western Australia and New South Wales data linkage systems have been operating for over 10 years [60], however the national network with significant infrastructure investment from the federal and state governments aims to provide the world's most comprehensive population health database to monitor and study health across the country [61]. The 2009 AEDI dataset is currently being linked into this national network of jurisdictional based nodes.

Currently there are a number of interventions aimed at improving child development that show demonstrated efficacy [15]. However, there is still insufficient data to inform policies and practices to reduce inequalities in early child development. With linked population data sets program/policy evaluation and economic models can also be investigated (such as the effectiveness of preventive interventions which are traditionally hard to quantify). Such systems will be invaluable tools for assessing the efficacy and effectiveness of policies and interventions that aim to reduce inequalities in health and development across populations [3].

The Early Development Instrument (EDI) is gaining attention internationally with the instrument now being utilized in over a dozen countries [34]. Part of the attraction is that the EDI is administered just like a census and is a holistic measure of child health and development. Regular monitoring of inequalities and use of these data for education, advocacy, and increased accountability among the general public and decision makers is urgently needed, but alone will not be sufficient [62]. Equity of opportunity and access must be a priority in the design of policies and interventions. The AEDI provides a critical measure in a developmental stage that is otherwise surprisingly uncharted in the life course trajectory given the contemporary claims placed on the importance of optimising development at early points in life.

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Contributor Authorship Statement: SB, JL, SS, VC and SZ conceived the original idea and structure of the paper. SB led and wrote the majority of the paper. AG and AR wrote the first draft of the methods and results section, with AR and MM undertaking responsibility for the analyses under direction by JL and SB. TG compiled the universal policy analyses. SG directed the 2009 AEDI data collection in conjunction with SB, SS and SZ. MJ is the original developer of the EDI on which the AEDI is based and was involved in the adaptation process, and both MJ and CH provide continuing advocacy and support for the population utility of the EDI and AEDI. All authors provided input to the paper.

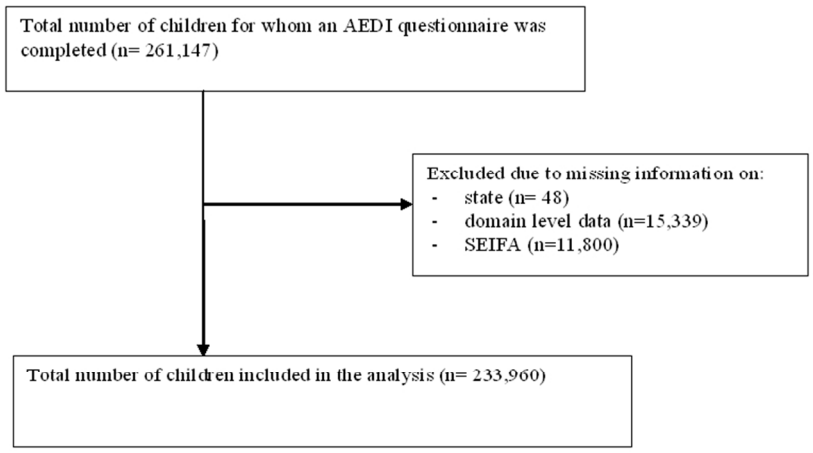
References

1 Lynch JW, Davey-Smith G. A Life Course Approach to Chronic Disease Epidemiology. Annu Rev Public Health 2005;**26**:1-35.
2 Marmot M. Fair Society, Healthy Lives: The Marmot Review: The Marmot Review; 2010. Available from: http://www.marmotreview.org/AssetLibrary/pdfs/Reports/FairSocietyHealthyLives.pdf.
3 Lynch JW, Law C., Brinkman S., et al. Inequalities in child healthy development: Some challenges for effective implementation. Soc Sci Med 2010;**71**:1219-374.
4 Hertzman C, Boyce T. How Experience Gets Under the Skin to Create Gradients in Developmental Health. Annu Rev Public Health 2010;**31**:329-47.
5 Heckman J. Schools, Skills, and Synapses. Econ Inq 2008;**46**:289-324.
6 UNICEF. The State of The Worlds Children: Downloadable Statistical Tables. UNICEF; 2010 [updated 11/8/2010]; Available from: http://www.unicef.org/rightsite/sowc/statistics.php.
7 OECD. OECD Programme for International Student Assessment (PISA). 2012; Available from: www.pisa.oecd.org.
8 United Nations Development Programme. The Millennium Development Goals: Progress Reversals and Challenges. New York2002.
9 UNESCO. Strong Foundations Early Childhood Care and Education. 2007; Available from: http://unesdoc.unesco.org/images/0014/001477/147785E.pdf.
10 Young ME. Early Child Development: From Measurement to Action. Washington DC., USA: The World Bank; 2007.
11 Status of the Convention on the Rights of the Child. Report of the Secretary-General: United Nations General Assembly, United Nations, Sixty-fifth session Sess. (2 August 2010, 2010).
12 Janus M, Duku E. The school entry gap: Socioeconomic, family, and health factors associated with children's school readiness to learn. Early Education & Development 2007;**18**:375-403.
13 Meisels SJ. Developmental Screening in Early Childhood: The Interaction of Research and Social Policy. Annu Rev Public Health 1988;**9**:527-50.
14 Meisels SJ. Can Developmental Screening Tests Identify Children Who Are Developmentally at Risk? Pediatrics 1989;**83**:578-85.
15 Barnett WS. Effectiveness of Early Educational Intervention. Science 2011 Aug;**333**:975-8.
16 Goldfeld S, Sayers M, Brinkman S, et al. The process and policy challenges of adapting and implementing the Early Development Instrument in Australia. Early Education and Development 2009;**20**:978-91.
17 Janus M, Brinkman S, Duku E, et al. The Early Development Instrument: A population-based measure for communities. A handbook on development, properties and use. Hamilton, Ontario: Offord Centre for Child Studies; 2007.
18 Centre for Community Child Health and Telethon Institute for Child Health Research. A Snapshot of Early Childhood Development in Australia. Australian Early Development Index (AEDI) National Report 2009. Canberra: Australian Government2009.
19 Hertzman C, Williams R. Making Early Childhood Count. Can Med Assoc J 2009;**180**:68-71.
20 OECD. OECD.StatExtracts. Health Expenditure and Financing: OECD; 2008.
21 Australian Bureau of Statistics. 3101.0 - Australian Demographic Statistics. June 2011. Canberra: Australian Bureau of Statistics; 2011.
22 Steering Committee for the Review of Government Service Provision. Overcoming Indigenous Disadvantage: Key Indicators 2011.2011: Available from: http://www.pc.gov.au/__data/assets/pdf_file/0018/111609/key-indicators-2011-report.pdf.

23 Australian Bureau of Statistics. 1301.0 - Year Book Australia, 2009-10. Canberra: Australian Bureau of Statistics; 2010.
24 Atkinson AB, Piketty P, Saez E. Top Incomes in the Long Run History. J Econ Lit 2011;**49**:3-71.
25 United Nations Development Programme. Human Development Report 2011. New York: Palgrave Macmillan; 2011. Available from: http://hdr.undp.org/en/media/HDR_2011_EN_Complete.pdf.
26 Silburn S, Zubrick S.R., De Maio JA, et al. The Western Australian Aboriginal Child Health Survey: Strengthining the Capacity of Aboriginal Children, Families and Communities. Perth: Curtin University of Technology and the Telethon Institute for Child Health Research.2006.
27 Centre for Community Child Health. AEDI Research CURF. Australian Government; 2011.
28 Centre for Community Child Health. Australian Early Development Index: Data Users Guide. Australian Government; 2010.
29 Janus M, Offord D. Development and psychometric properties of the Early Development Instrument (EDI): A measure of children's school readiness. Canadian Journal of Behavioural Science 2007;**39**:1-22.
30 Brinkman S, Gregory T, Harris J, et al. 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. Aust N Z J Public Health 2012;**in press**.
31 Brinkman S, Silburn S, Lawrence D, et al. Investigating the validity of the Australian Early Development Index. Early Education and Development 2007;**18**:427-51.
32 Brinkman S, Zubrick S, Silburn S. Predictive Validity of a school readiness assessment on later cognitive and behavioral outcomes. . Journal of Early Education and Development 2012;**in press**.
33 Forget-Dubois N, Lemelin, J.P. Boivin, M., Dionne, G. Predicting early school achievement with the EDI: A longitudinal population-based study. Early Education and Development 2007;**18**:405-26.
34 Janus M, Brinkman SA, Duku E. Validity and psychometric properties of the Early Development Instrument in Canada, Australia, United States and Jamaica. Soc Ind Res 2011;**103**:283-97.
35 Centre for Community Child Health and Telethon Institute for Child Health Research. AEDI Guide for Teachers. Canberra: Centre for Community Child Health and Telethon Institute for Child Health Research2009.
36 Australian Bureau of Statistics. Information Paper: An Introduction to Socio-Economic Indexes for Areas (SEIFA). Australian Government,; 2008.
37 Centre for Community Child Health and Telethon Institute for Child Health Research. AEDI Technical Paper No 1: Children developmentally vulnerable on one or more and two or more, AEDI domains. Australian Government; 2011.
38 Wagstaff A, Paci P, van Doorslaer E. On the measurement of inequalities in health. Social Science & Medicine 1991;**33**:545-57.
39 Harper S, Lynch JW. Methods for Measuring Cancer Disparities: Using Data Relevant to Healthy People 2010 Cancer-Related Objectives. Bethesda: National Cancer Institute2005.
40 ACT Health. Australian Capital Territory Immunisation Strategy (2007-2010) 2007. Available from: http://www.health.act.gov.au/policies-and-plans/find-policy-documents/.
41 Children Youth and Women's Health Service. Family Home Visiting: Service Outline 2005. Available from: http://www.cyh.com/SubContent.aspx?p=134.
42 Department of Education and Early Childhood Development. Your Maternal and Child Health Service Visits. 2011; Available from: http://www.education.vic.gov.au/earlychildhood/mch/visits.htm.
43 Department of Health and Human Services. Child Health Centres. 2011; Available from: http://www.dhhs.tas.gov.au/service_information/services_files/child_health_centres.

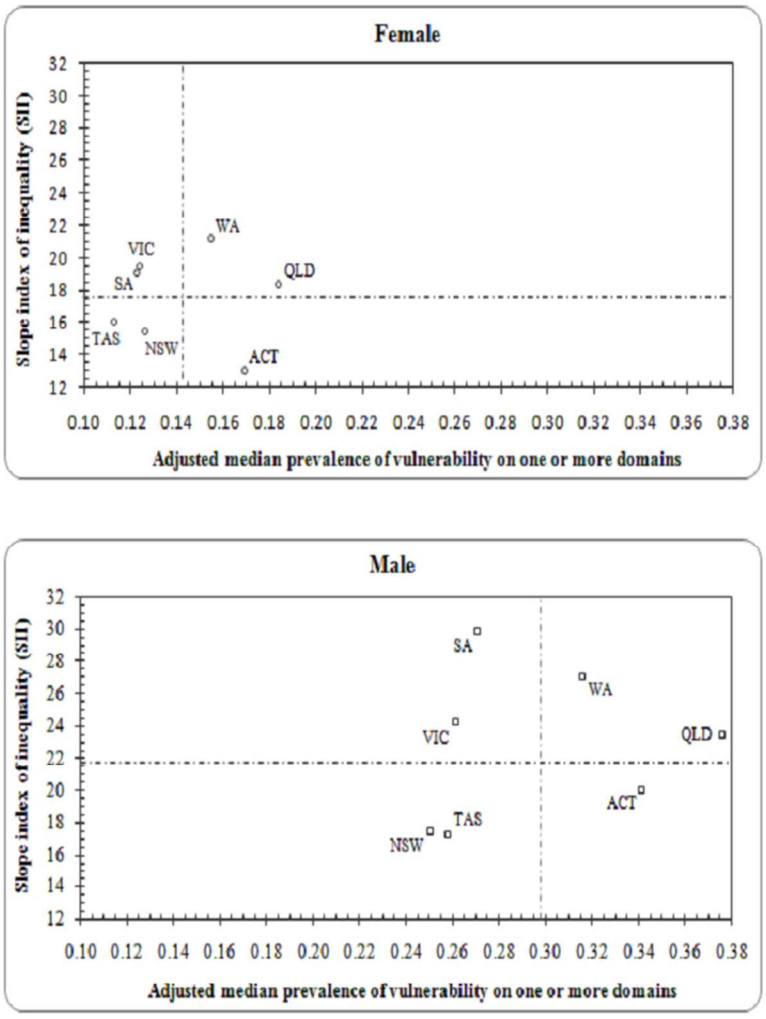
44 NSW Department of Health. Personal Health Record (The Blue Book). 2011; Available from: http://www.health.nsw.gov.au/policies/ib/2007/IB2007_008.html.
45 Office of Early Childhood Education and Care. Child and Family Support Hubs. 2011; Available from: http://deta.qld.gov.au/earlychildhood/families/ey-services/support-hubs.html.
46 Dowling A, O'Malley K. Preschool Education in Australia. Melbourne: Australian Council for Educational Research,2009.
47 Commisioner for Children and Young People. Submission to the Community Development and Justice Standing Committee; Inquiry into the Adequacy of Services to Meet the Developmental Needs of Western Australia's Children. Perth2009.
48 Hirst C. Re-Birthing. Report of the Review of Maternity Services in Queensland. Brisbane: Department of Health, Queensland2005.
49 Families NSW. Safe Start. 2011; Available from: http://www.families.nsw.gov.au/getting_help_and_support/safe_start.html.
50 Families NSW. Health home visiting & early childhood health services. 2011; Available from: http://www.families.nsw.gov.au/getting_help_and_support/health_home_visiting.html.
51 Commisioner for Children and Young People. Submission to the Education and Health Standing Committee: Review of WA's Current and Future Hospital and Community Health Care Services. Perth: Government of Western Australia.; 2009.
52 Anokhin AP, Lutzenberger W, Nikolaev A, et al. Complexity of electrocortical dynamics in children: developmental aspects. Dev Psychobiol 2000;**36**:9-22.
53 Hanlon H, Thatcher R, Cline M. Gender differences in the development of EEG coherence in normal children. . Dev Neuropsychol 1999;**16**:479-506.
54 Bornstein M, Hahn C, Haynes O. Specific and general language performance across early childhood: Stability and gender considerations. First Language 2004;**24**:267-304.
55 Weinberg MK, Tronick EZ, Cohn JF, et al. Gender differences in emotional expressivity and self-regulation during early infancy. Dev Psychol 1999;**35**:175-88.
56 Petterson SM, Albers AB. Effects of poverty and maternal depression on early child development. Child Dev 2001;**72**:1794-813.
57 Brinkman S, Sayers M, Goldfeld S, et al. Population monitoring of language and cognitive development in Australia: The Australian Early Development Index. International Journal of Speech-Language Pathology 2009;**11**:1-12.
58 Janus M, Hertzman C, Guhn M, et al. Reply to Li, D'Angiulli and Kendall: The Early Development Index and children from culturally and linguistically diverse backgrounds. Early Years: An International Journal of Research and Development 2009;**29**:31-5.
59 Jutte DP, Roos, L.L., Brownell, M.D. Administrative Record Linkage as a Tool for Public Health Research. Annu Rev Public Health 2011;**32**:91-108.
60 Holman C, Bass A, Rosman D, et al. A decade of data linkage in Western Australia: strategic design, applications and benefits of the WA data linkage system. Aust Health Rev 2008;**32**:766 - 77.
61 PHRN. Population Health Research Network. Perth: Population Health Research Network; 2011; Available from: www.phrn.org.au.
62 Victora CG, Wagstaff A, Schellenberg JA, et al. Applying an equity lens to child health and mortality: more of the same is not enough. Lancet 2003;**362**:233-41.

Figure1: Flow chart of participants



248x173mm (96 x 96 DPI)

Figure 2: Adjusted prevalence of vulnerabliity (%) on one or more AEDI domains and absolute socioeconomic inequality (%) by jurisdiction.



*Dotted lines indicate national median vulnerability (%) and absolute socioeconomic inequality (%).

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract Completed - Census of child development	1 & 4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Completed	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Completed	5-9
Objectives	3	State specific objectives, including any prespecified hypotheses Objectives stated	9
Methods			
Study design	4	Present key elements of study design early in the paper Census of child development	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Completed	9-10
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants Completed	9-10
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Completed	12-13
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Completed	12-13
Bias	9	Describe any efforts to address potential sources of bias No attempt has been made to address any potential source of bias – the census collected an estimated 97.5% of the 5 year old population.	n/a

Section/Topic	Item #	Recommendation	Reported on page #
Study size	10	Explain how the study size was arrived at Not applicable - census	n/a
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Completed	13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Completed	13-15
		(*b*) Describe any methods used to examine subgroups and interactions Completed	13-15
		(*c*) Explain how missing data were addressed Completed	13
		(*d*) If applicable, describe analytical methods taking account of sampling strategy Not applicable - census	n/a
		(*e*) Describe any sensitivity analyses None	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-11
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram Flow diagram presented	Figure file
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Completed	10
		(b) Indicate number of participants with missing data for each variable of interest Completed	
Outcome data	15*	Report numbers of outcome events or summary measures Completed	

Section/Topic	Item #	Recommendation	Reported on page #
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Completed	16, 18 & 19
		(*b*) Report category boundaries when continuous variables were categorized Completed	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not applicable	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Completed	20-21
Discussion			
Key results	18	Summarise key results with reference to study objectives Completed	23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Completed	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Completed	
Generalisability	21	Discuss the generalisability (external validity) of the study results Completed	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Completed	29

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Jurisdictional, socioeconomic and gender inequalities in child health and development: Analysis of a national census of 5 year olds in Australia.

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TITLE: Jurisdictional, socioeconomic and gender inequalities in child health and development: Analysis of a national census of 5 year olds in Australia

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ARTICLE SUMMARY BOX:

Article Focus

- This study presents the first ever population wide census of child development across an entire country; Australia.
- There are large inequalities in child development across jurisdictions and socio-demographic groups, showing that disparities in child development emerge early in life.

Key Messages

- High quality population monitoring and data linkage systems are essential to inform progressive universalist policy approaches.
- Jurisdictional differences in child development persist after controlling for socio-economic and demographic factors. Differing jurisdictional policies, and levels of service provision that support children and their families from birth to school age may contribute to inequalities in child development across the country.

Strengths and limitations

- These results are based on a developmental census of Australian children, with a large sample of 261,147 children, representing approximately 97.5% of the estimated five-year-old population.
- Further research is needed to understand whether these jurisdictional differences in child development can be attributed to different government policies and service provision.

STRUCTURED ABSTRACT:

Objectives: Early child development may have important consequences for inequalities in health and wellbeing. This paper explores population level patterns of child development across Australian jurisdictions, considering socioeconomic and demographic characteristics.

Design: Census of child development across Australia.

Setting and participants: Teachers complete a developmental checklist, the Australian Early Development Index (AEDI), for all children in their first year of fulltime schooling. Between May and July 2009, the AEDI was collected by 14,628 teachers in primary schools (government and non-government) across Australia, providing information on 261,147 children (approximately 97.5% of the estimated five-year-old population).

Outcome measures: Level of developmental vulnerability in Australian children for five developmental domains: physical wellbeing, social competence, emotional maturity, language and cognitive skills, and communication skills and general knowledge.

Results: The results show demographic and socioeconomic inequalities in child development as well as within and between jurisdiction inequalities. The magnitude of the overall level of inequality in child development and the impact of covariates varies considerably both between and within jurisdiction by sex. For example, the difference in overall developmental vulnerability between the best and worst performing jurisdiction is 12.5% for males and 7.1% for females. Levels of absolute social inequality within jurisdictions range from 8.2% for females and 12.7% for males.

Conclusions: The different mix of universal and targeted services provided within jurisdictions from pregnancy to age 5 may contribute to inequality across the country. These results illustrate the potential utility of a developmental census to shed light on the impact of differences in universal and targeted services to support child development by school entry.

Introduction

Governments are becoming increasingly interested in the early determinants of children's health, development and wellbeing in order to inform services needed to better support children and their families. It is recognised that the opportunities for prevention and public health interventions will be enhanced the more we understand the early pathways to poorer health and development [1] and that to have an impact on health inequalities will require us to address the social determinants of early child health, development and wellbeing [2]. However, appropriate service and systemic improvements for reducing developmental inequalities requires an understanding of the patterns of child health and development across population groups and geographies in order to underpin a progressive universal portfolio of services [3].

Socioeconomic gradients in child health and development mean that providing services primarily to the disadvantaged will not eliminate population health burdens [4]. Children from all social and economic backgrounds may suffer poor health and development, albeit that those in the most disadvantaged circumstances have a disproportionate share of poor health and development. To reduce the steepness of the social gradient in health, actions to influence development must be universal, but be implemented with a scale and intensity that is proportionate to the level of disadvantage [2] – an approach termed progressive or proportionate universalism.

Measuring the developmental effects of proportionate universalism requires substantial effort in the form of establishing early and developmentally relevant baseline measures with ongoing capacity to monitor progress over time. An added challenge entails demonstrating that improvements in early development, translate into improvements in later human capability [5]. This requires longitudinal measurement to ascertain lifecourse developmental effects. An essential starting point is quantification of the overall level, and the absolute and relative inequality in child health and development across the population.

The global challenge to improve early child health and development requires an instrument that can be used across the population, be compared over time for monitoring and is sensitive

enough to evaluate programs. A measure used internationally would additionally enable such comparisons both within and across countries. The current basic health statistics collected early in life to compare the progress of countries include infant, maternal and child mortality rates, breastfeeding and immunisation rates [6]. Other measures of progress such as the Programme for International Student Assessment [7] provide cross-national comparisons of educational performances and are collected much later in child development. These efforts have contributed substantially to sustained cross-national financial and programmatic commitments to lift human development outcomes within nations [8].

Notwithstanding the significance of these measures, we should be seeking indicators that not only determine whether children are surviving but how well populations of children are actually developing between birth and school entry. This is now recognized by organizations such as the OECD and the World Bank which are promoting the use of internationally comparable instruments to measure child development and wellbeing [9 10]. The implications for monitoring child development are also highlighted by the United Nations Convention on the Rights of the Child [11] as each of the signatory countries is responsible for providing children with the opportunities necessary to develop physical, cognitive, social and emotional capabilities in early life.

Transition to school is seen as one of the best stages in a child's life to measure child development and wellbeing [12-14]. Research has established that children at higher risk for suboptimal development can be better prepared for initial success at school through early childhood education, family support, paediatric and allied health care interventions and child health programs [15]. When children come to school with the developmental capacity to take advantage of the education system, coupled with a high quality education system, the initial positive effects persist into adolescence and adulthood [15].

In 2007, the Council of Australian Governments endorsed the Australian Early Development Index (AEDI) as a national progress measure of early childhood health and development [16]. The AEDI is a population measure of children's development covering five developmental domains:

physical health and well-being, social competence, emotional maturity, language and cognitive skills, and communication skills and general knowledge. The instrument is based on the Canadian Early Development Instrument and has been used in Australia since 2002 [17]. In 2009 the AEDI was collected for almost every child across Australia in their first year of full time schooling. This represents the first effort by any country to conduct a 'child development census' with information collected on more than 261,000 children representing 97.5% of the age-eligible population [18]. The Australian federal government has now committed to repeating the AEDI census every three years. The monitoring of child development and wellbeing over time and across the whole population enables local communities to determine if they are making improvements and fosters the relative comparison of communities and populations subgroups [19]. This commitment to tracking and reporting early childhood outcomes across the entire population, underlines the federal government's leadership role in providing communities and governments with evidence-based information for policy and service evaluation.

The Australian Context

Australia is a federated democracy that has three tiers of government: federal, state and local. Funding towards early child health and development at a federal level is delivered through various departments including the Department of Education, Employment and Workplace Relations, Department of Families, Housing, Community Services and Indigenous Affairs and the Department of Health and Ageing. The federal government has annual contract negotiations, passing monies over to the jurisdictions, for them to deliver agreed services and to assist with national health reform.

Although the six states join together to form the Commonwealth of Australia, they are constituted with the power to make laws and policies through their own legislative, executive and judicial functions. Australia also has two principal territories, the Australian Capital Territory (ACT) and the Northern Territory (NT), which constitutionally are directly subject to the

Commonwealth government. These eight State and Territory Governments provide the bulk of early childhood services, with differing levels and approaches to service delivery. Local governments make up the third tier and are established by state and territory governments to take responsibility for a number of community based services. Of the total health expenditure in Australia, 42.7% is contributed by the federal government, 25.3% by state, territory and local governments, and the remainder is covered by individuals, non-government agencies and private industry [20].

Australia is the earth's biggest island and the sixth-largest country in the world in land area. It is a culturally diverse society with a population of more than 22 million [21]. Australia's population includes Aboriginal and Torres Strait Islander peoples and migrants from some 200 countries with Indigenous Australian peoples representing 2.5% of the total population [22]. In over 60 years of planned post-war migration, Australia has accepted more than 6.5 million migrants and in the most recent census (2006), 3.1 million people (16% of the population) were reported to speak a language other than English at home [23]. The majority of the population lives in the cities mainly located around the coast, however many live in rural and remote areas ranging from dry arid land to tropical and a few live in what are arguably some of the most remote and untouched areas of the world.

Australia's income inequality has been steadily increasing [24] but it ranks second after Norway on the most recent Human Development Index (HDI) results [25]. The plight of the Aboriginal and Torres Strait Islander population however remains one of Australia's most concerning inequalities. Separate HDI estimates for Australian Aboriginal and Torres Strait Islanders ranked this subpopulation at about 104th – between Cape Verde and China [26]. The most recent report from Australia's Productivity Commission notes that there has been little change for Aboriginal people on measures of literacy and numeracy, most health indicators and in proportions living in overcrowded housing. Rates of child abuse and neglect substantiations and adult imprisonment have increased for Aboriginal people, but there has been recent improvement in

juvenile detention rates [22]. Low birth weight rates are two and a half times higher than for children born to non-Aboriginal mothers [22].

The multicultural context of Australia, its geographical size and climatic variation, along with multi-tiered political governance and service delivery highlights the complexity faced when aiming to both understand and reduce inequality in child health and development. The objective of this study is to use the national AEDI census data to examine jurisdictional, geographic, socioeconomic and gender inequality in child health and development across Australia.

Methods

To support broad access to the AEDI data the Australian Government through the Department of Education, Employment and Workplace Relations made available in 2011 a Confidentialised Unit Record File (CURF) for researchers. In order to protect the privacy of individual children the data were confidentialised by removing the child's name and date of birth, restricting potentially identifying information, and where the information was considered to present a risk of identifying individuals the data were restricted and/or "perturbed" however details of this process conducted by the Australian Bureau of Statistics are confidential [27]. This, in combination with the unavailability of a socio-economic indicator for the Northern Territory resulted in the removal of the territory from the analytical models. The AEDI CURF does not include the individual items that comprise the AEDI and only provides categorised data on the summary AEDI domain scores and a limited range of socio-demographic characteristics such as state of residence, gender, and remoteness [28].

Study population

Between May and July 2009, all schools (government and non-government) across all states and territories in Australia participated in the AEDI. As shown in Figure 1, information for 261,147 children in their first year of full-time school was collected by 14,628 teachers across Australia.

This number of children represents a 97.5% participation rate when compared to the expected population of 5 year olds. The number of children we were expecting (267,843) was based on the Australian Bureau of Statistics Estimated Resident Population for five-year-olds, 31 March 2009 [29]. Of the children that did participate in the AEDI data collection, 89.6% (n=233,960) contributed to the analysis with 117,937 males and 116,023 females, and their characteristics are provided in Table 1. The sample analysed thus represents 87.3% of the total population. The vast majority of children live in major cities, with the most populous states being New South Wales, Victoria and Queensland. Four per cent of the children were of Aboriginal or Torres Strait Islander descent and approximately 12% of all children spoke English as a second language. The AEDI was not completed for children whose parent/guardian opted-out or in the situation where the teacher had known the child for less than one month and felt that they didn't know the child well enough to complete the checklist [18].

Table 1: Socio-demographic characteristics of children for whom an AEDI was completed and contributed to the analysis

Characteristics	Male (n=117,937) n (column %)	Female (n=116,023) n (column %)
State		
New South Wales	41,465 (35.2)	40,657 (35.0)
Victoria	28,286 (23.9)	28,400 (24.5)
Tasmania	2,855 (2.4)	2,785 (2.4)
Australian Capital Territory	2,114 (1.8)	2,021 (1.7)
South Australia	7,282 (6.2)	7,221 (6.2)
Western Australia	13,112 (11.1)	12,633 (10.9)
Queensland	22,823 (19.4)	22,306 (19.2)
Aboriginal Torres Strait Islander		
Yes	4,668 (4.0)	4,766 (4.1)
No	113,269 (96.0)	111,257 (96.0)
English as a second language		
Yes	14,865 (12.6)	14,043 (12.1)
No	103,072 (87.4)	101,980 (87.9)
Mean SEIFA IRSAD (±SD)	6.29 (2.98)	6.27 (2.99)

Outcome

The AEDI is the outcome measure used to assess children's development. The Index is an adapted version of the Canadian Early Development Instrument [16 30]. Both the Canadian and the Australian version of the instrument have been shown to have sound validity [30-35]. The AEDI is an 95-item, teacher completed questionnaire designed to measure five domains of child development: Physical health and wellbeing, Language and cognitive skills, Emotional maturity, Social competence, and Communication skills and general knowledge [36].

Teachers complete the AEDI for each child in their class on the basis of their knowledge of the children. Children are not required to be present when the information is entered into the secure web-based data entry system. Each item on the checklist is either dichotomous (yes/no) or a Likert scale response (e.g. very good/good; average; poor/very poor). The data were collected across the country over a three month time period (May to July 2009).

Domain scores range between 0 and 10 and are calculated as a mean score of all valid answers. Higher scores indicate a higher level of development for that domain. Children who score below the 10th percentile of the national AEDI population for an individual domain (e.g. emotional maturity) are categorized as 'developmentally vulnerable' with all other children categorized as 'not developmentally vulnerable' for that domain. The classification of developmentally vulnerable is age standardized, with the 10th percentile calculated for 4 year olds, 5 year olds and 6 year olds separately. The National Progress Measure is the proportion of children who are developmentally vulnerable on one or more of the five domains.

Covariates

Index of Relative Socio-economic Advantage and Disadvantage (SEIFA IRSAD)

The Australian Bureau of Statistics releases on the basis of census information four different Socio-Economic Indices For Areas (SEIFA). The SEIFA indices are generally known as an indicator of people's "access to material and social resources and their ability to participate in

society; relative to what is commonly experienced or accepted by the wider community" [36]. The index utilised for this manuscript was the Index of Relative Socio-economic Advantage and Disadvantage (SEIFA IRSAD) [37]. The SEIFA IRSAD index is calculated via Principal Components Analysis using 21 indicator variables from the census. The index is ordinal and ranges from around 200 to 1200 with a mean of 1000 and standard deviation of 100, however, this score has been categorised to deciles as part of the confidentialisation process undertaken by the ABS with the lowest decile representing the most disadvantaged areas [37].

The index reflects the average socio-economic status of people and households in the area. SEIFA IRSAD has been applied to the AEDI data file on the basis of the child's suburb (neighbourhood) of residence [28]. A suburb is determined by the Local Council and helps define a household's address. Suburbs vary widely in population density, depending on the housing types and distance from the central city. In general, when a person is asked where they live by another person residing within that same State, they generally respond to the question with their suburb of residence. In the rural and remote areas where suburbs do not exist, SEIFA IRSAD was applied at the smallest level of geography on the basis of their address details provided by the teacher upon completing the AEDI [28]. Where possible the Australian Bureau of Statistic's Geospatial unit called Collection Districts were assigned to the address details of the child. Collection Districts have no meaning to people as they are simply the collection district in which a census collector works. The geographical size of Collection Districts (CDs) varies across Australia particularly in the rural and remote areas; however a technical report published by the Australian Bureau of Statistics shows the robustness of SEIFA [37].

Aboriginal and Torres Strait Islander.

Aboriginal and Torres Strait Islander (ATSI) background is collected with the AEDI. ATSI was recorded on the basis of school enrolment records, and thus reflects the parent/guardian's report of their child's ATSI status.

English as a Second Language

Teachers classified children as having English as a Second Language (ESL) where English was not their first language and where they needed additional instruction in English or where their English was not yet proficient.

Statistical analyses

A dichotomous variable was created indicating whether the child was in the bottom 10th percentile (developmentally vulnerable) or not for each of the five domains, and developmentally vulnerable on one or more domains. Children, were excluded in the calculation of developmentally vulnerable on one or more domain if they were; identified as having special needs, were recorded as three years old, or had less than four valid domain scores (n=11,484) [18 39]. In Australia, children should not be attending full time schooling if they are only three years old, and were therefore excluded.

As our primary interest was to investigate jurisdictional and socioeconomic inequality of child developmental vulnerability we utilised two nested fixed-effects logistic regression models. Model 1 considers only state as the covariate. For being developmentally vulnerable on one or more domain (DV1^{+}) variable the model is:

$$\text{logit}\left[p_{ij}\left(dv1^{+}=1 \right) \right]=\alpha+\beta_j(state_{ij}), \qquad (1)$$

where $p_{ij}\left(dv1^{+}=1 \right)$ is the probability of a child being developmentally vulnerable on one or more domains for the i^{th} observation in the j^{th} class of the state variable, α is the intercept and β_j is the coefficient for the state. Model 2 considers three additional covariates for jurisdictional variation of child vulnerability. Again for same dependent variable DV1^{+} the full model is defined as,

$$\text{logit}\left[p_{ij}\left(dvl^{+}=1 \right) \right]=\alpha+\beta_{1j}(state_{ij})+\beta_{2j}(ATSI_{ij})+\beta_{3j}(ESL_{ij})+\beta_{4j}(SEIFA_{ij}), \quad (2)$$

where β_{1j}, β_{2j}, β_{3j}, and β_{4j} are the coefficients for four covariates: state, Aboriginal and Torres Strait Islander (ATSI) status, English as a second language (ESL) status and SEIFA IRSAD, respectively. All models are estimated separately for males and females. Similar models are used for each of the domain specific outcomes.

To examine socioeconomic inequalities in developmental vulnerability we computed the slope index of inequality (SII) [40 41]. In this circumstance we use the SII to measure the absolute developmental vulnerability gap between the lowest and highest SEIFA IRSAD deciles within jurisdictions in Australia. The computational process of creating the SII is:

1) Compute the proportion of total children (t_i) for the ordered (lowest to highest) classes of SEIFA IRSAD deciles $(i=1,2,...,10)$;
2) Compute the cumulative proportion of children for each SEIFA IRSAD class (c_i) and then give a score based on the midpoint of its range in the cumulative distribution in the children $(i.e.\ x_i = c_{i-1} + t_i/2)$;
3) Compute the proportion of developmentally vulnerable children for i^{th} class (r_i); and
4) Values of r_i then are plotted against the values of x_i and a regression line is fitted to the data. Thus, the SII is the absolute value of the slope coefficient of the regression line from lowest to highest SEIFA IRSAD score.

The SII was calculated separately for males and females. All analyses were carried out using SAS software Version 9.2.

Results

Table 2 shows the association between geographic and socio-demographic characteristics and the probability of being developmentally vulnerable on one or more AEDI domain by sex. Aboriginal and Torres Strait Islander children were more likely to be developmentally vulnerable compared to non-ATSI children (OR 2.16 males; 95% CI, 2.03-2.30 OR 2.42 females; 95% CI, 2.27-2.58); those for whom English was not their first language were more likely to be developmentally vulnerable (OR 2.06 males; 95% CI, 1.99-2.14 OR 2.43 females; 95% CI, 2.33-2.54); and for every decile increase in SEIFA IRSAD there was a decreasing odds of being developmentally vulnerable (OR 0.92 males; 95% CI, 0.91-0.92 and OR 0.91 females; 95% CI, 0.90-0.91).

Model 1 in Table 2 shows that for both sexes, compared to New South Wales (reference group), children living in Queensland had the highest odds (OR 1.70 males; 95% CI, 1.64-1.75 and OR females1.42; 95% CI, 1.37-1.49) of being developmentally vulnerable followed by children living in Western Australia, South Australia, Australian Capital Territory, Tasmania and Victoria. After adjusting for ATSI, ESL and SEIFA IRSAD (Model 2) Queensland children for both sexes remained the most developmentally vulnerable (OR 1.80 males; 95% CI, 1.74-1.87 and OR females 1.52; 95% CI, 1.46-1.59). However, after adjustment, compared to Model 1, there was a shift in the ranking of developmental vulnerability by jurisdiction, with the odds of vulnerability increasing substantially for children living in the Australian Capital Territory and Western Australia.

Table 2: Odd ratios (95% CI) estimates for children developmentally vulnerable on one or more domains by geographic and sociodemographic characteristics in Australia

	Developmentally vulnerable on one or more domains			
	Male (N=117937)		Female (N=116023)	
	Model 1	Model 2	Model 1	Model 2
Geographic variables				
State				
New South Wales	reference			
Australian Capital Territory	1.10 (1.00 - 1.21)	1.55 (1.41 - 1.71)	0.94 (0.83 - 1.07)	1.42 (1.25 - 1.61)
Queensland	1.70 (1.64 - 1.75)	1.80 (1.74 - 1.87)	1.42 (1.37 - 1.49)	1.52 (1.46 - 1.59)
South Australia	1.14 (1.08 - 1.20)	1.11 (1.04 - 1.17)	1.01 (0.95 - 1.09)	0.97 (0.90 - 1.04)
Tasmania	1.10 (1.02 - 1.20)	1.04 (0.96 - 1.14)	0.92 (0.83 - 1.03)	0.88 (0.79 - 0.98)
Victoria	0.98 (0.94 - 1.01)	1.06 (1.02 - 1.10)	0.88 (0.85 - 0.92)	0.98 (0.94 - 1.02)
Western Australia	1.26 (1.21 - 1.32)	1.38 (1.32 - 1.44)	1.12 (1.06 - 1.18)	1.24 (1.17 - 1.31)
Sociodemographic variables				
Aboriginal and Torres Strait Islander				
No	reference			
Yes		2.16 (2.03 - 2.30)		2.42 (2.27 - 2.58)
English second language				
No	reference			
Yes		2.06 (1.99 - 2.14)		2.43 (2.33 - 2.54)
Socioeconomic advantage & disadvantage index (SEIFA IRSAD)		0.92 (0.91 - 0.92)		0.91 (0.90 - 0.91)

Results presented in Tables 3 and 4 show the association between geographic and socio-demographic characteristics and the probability of being developmentally vulnerable on each AEDI domain by sex. The general pattern showing large jurisdictional differences after controlling for the covariates is consistent across each of the five developmental domains with children in Queensland and the Australian Capital Territory showing higher vulnerability compared to children living in the other jurisdictions. In Queensland, when looking across the five domains, there is little difference found between the odds ratios in Models 1 and 2 for physical health and wellbeing, social competence and emotional maturity. However, controlling for the covariates increases the odds of vulnerability for both language and cognitive and communication and general skills. This pattern is consistent across males and females. Contrary to this, children living in the Australian Capital Territory show increased odds across all five developmental domains when controlling for covariates.

For all five domains, both Aboriginal and Torres Strait Islander (ATSI) and English as a Second Language (ESL) children have increased odds of vulnerability compared to non-ATSI and non-ESL children respectively. It is noteworthy that inequality between ATSI and non-ATSI children is greater for females than for males. For instance, on the physical health and wellbeing domain, the odds ratio for male ATSI children is 1.81 (CI 1.68-1.95) compared with 2.38 for female ATSI children (CI 2.19-2.58). For ATSI children the greatest inequality when compared to non-ATSI is for the Language and cognitive development domain (OR 2.59 males; 95% CI, 2.42-2.78 and OR females 3.01; 95% CI, 2.78-3.25). For children with ESL status the highest ORs were found for the Communication skills and general knowledge domain with 4.19 (95% CI, 4.01-4.37) for males and 5.16 (95% CI, 4.89-5.44) for females.

Table 3: Odd ratios (95% CI) for male children developmentally vulnerable on each domain by jurisdiction and sociodemographic characteristics (N=117937)

	Developmentally vulnerable on each sub-domain									
	Physical health & wellbeing		Social competence		Emotional maturity		Language & cognitive skills		Communication & general skills	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
State										
New South Wales (r)										
Australian Capital Territory	1.20 (1.05 - 1.37)	1.62 (1.42 - 1.86)	1.07 (0.94 - 1.22)	1.44 (1.26 - 1.64)	1.21 (1.07 - 1.38)	1.57 (1.37 - 1.78)	1.02 (0.87 - 1.21)	1.72 (1.45 - 2.04)	1.04 (0.90 - 1.19)	1.62 (1.40 - 1.86)
Queensland	1.39 (1.32 - 1.45)	1.37 (1.30 - 1.44)	1.50 (1.43 - 1.57)	1.52 (1.45 - 1.59)	1.60 (1.52 - 1.67)	1.57 (1.50 - 1.65)	3.27 (3.11 - 3.43)	3.46 (3.29 - 3.64)	1.27 (1.21 - 1.33)	1.52 (1.44 - 1.60)
South Australia	1.21 (1.12 - 1.30)	1.12 (1.04 - 1.21)	1.22 (1.13 - 1.31)	1.15 (1.07 - 1.24)	1.48 (1.38 - 1.59)	1.38 (1.29 - 1.49)	1.02 (0.93 - 1.12)	0.94 (0.85 - 1.04)	0.89 (0.82 - 0.97)	0.94 (0.86 - 1.02)
Tasmania	1.19 (1.06 - 1.33)	1.03 (0.92 - 1.16)	1.07 (0.95 - 1.20)	0.97 (0.86 - 1.09)	1.25 (1.12 - 1.40)	1.10 (1.98 - 1.23)	1.48 (1.30 - 1.67)	1.30 (1.14 - 1.48)	0.80 (0.70 - 0.91)	0.93 (0.81 - 1.06)
Victoria	0.90 (0.86 - 0.95)	0.95 (0.90 - 0.99)	0.98 (0.93 - 1.02)	1.03 (0.99 - 1.08)	1.15 (1.09 - 1.20)	1.19 (1.13 - 1.25)	1.06 (1.00 - 1.12)	1.18 (1.12 -1.25)	0.93 (0.89 - 0.98)	1.08 (1.02 - 1.13)
Western Australia	1.23 (1.16 - 1.30)	1.28 (1.20 - 1.36)	0.90 (0.84 - 0.96)	0.94 (0.88 - 1.00)	1.22 (1.15 - 1.29)	1.26 (1.19 - 1.34)	2.31 (2.17 - 2.45)	2.57 (2.41 - 2.73)	1.04 (0.98 - 1.10)	1.22 (1.14 - 1.30)
Aboriginal and Torres Strait Islander										
No (r)										
Yes		1.81 (1.68 - 1.95)		1.78 (1.66 - 1.92)		1.59 (1.48 - 1.71)		2.59 (2.42 - 2.78)		2.10 (1.95 - 2.27)
English second language										
No (r)										
Yes		1.29 (1.23 - 1.36)		1.48 (1.41 - 1.55)		1.19 (1.13 - 1.25)		1.94 (1.84 - 2.04)		4.19 (4.01 - 4.37)
Socioeconomic advantage & disadvantage index (SEIFA IRSAD)		0.92 (0.92 - 0.93)		0.93 (0.92 - 0.93)		0.93 (0.92 - 0.94)		0.88 (0.88 - 0.89)		0.92 (0.91 - 0.92)

Table 4: Odd ratios (95% CI) for female children developmentally vulnerable on each domain by jurisdiction and sociodemographic characteristics (N=116023)

	Developmentally vulnerable on each sub-domain									
	Physical health & wellbeing		Social competence		Emotional maturity		Language & cognitive skills		Communication & general skills	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
State										
New South Wales (r)										
Australian Capital Territory	0.93 (0.77 - 1.13)	1.42 (1.87 - 1.72)	0.90 (0.73 - 1.10)	1.32 (1.08 - 1.63)	1.26 (1.01 - 1.57)	1.82 (1.46 - 2.28)	0.87 (0.69 - 1.09)	1.54 (1.22 - 1.95)	0.85 (0.70 - 1.03)	1.36 (1.12 - 1.65)
Queensland	1.22 (1.14 - 1.30)	1.16 (1.09 - 1.24)	1.36 (1.28 - 1.45)	1.35 (1.26 - 1.44)	1.53 (1.41 - 1.65)	1.47 (1.36 - 1.60)	2.59 (2.43 – 2.76)	2.67 (2.50 - 2.86)	1.01 (0.94 - 1.07)	1.23 (1.15 - 1.31)
South Australia	1.11 (1.01 - 1.23)	0.99 (0.90 - 1.10)	1.04 (0.94 - 1.16)	0.96 (0.86 - 1.07)	1.34 (1.18 - 1.51)	1.21 (1.07 - 1.36)	1.06 (0.94 - 1.20)	0.96 (0.85 - 1.09)	0.78 (0.70 - 0.87)	0.80 (0.72 - 0.90)
Tasmania	1.15 (0.99 - 1.33)	0.95 (0.81 - 1.10)	0.84 (0.70 - 1.00)	0.73 (0.61 - 0.88)	0.90 (0.73 - 1.12)	0.76 0.61 - 0.94)	1.16 (0.97 - 1.38)	1.02 (0.85 - 1.22)	0.63 (0.53 - 0.76)	0.77 (0.64 - 0.93)
Victoria	0.84 (0.79 - 0.90)	0.91 (0.85 - 0.97)	0.90 (0.84 - 0.96)	0.97 (0.90 - 1.03)	1.10 (1.01 - 1.19)	1.16 (1.07 - 1.26)	1.01 (0.93 - 1.08)	1.14 (1.06 -1.23)	0.84 (0.79 - 0.89)	0.98 (0.92 - 1.04)
Western Australia	1.13 (1.04 - 1.22)	1.16 (1.08 - 1.26)	0.77 (0.70 - 0.84)	0.80 (0.73 - 0.88)	1.15 (1.04 - 1.28)	1.19 (1.08 - 1.32)	1.99 (1.84 - 2.16)	2.19 (2.02 - 2.38)	0.83 (0.76 - 0.90)	0.98 (0.90 - 1.07)
Aboriginal and Torres Strait Islander										
No (r)										
Yes		2.38 (2.19 - 2.58)		2.01 (1.83 - 2.20)		1.88 (1.69 – 2.10)		3.01 (2.78 - 3.25)		2.21 (2.02 - 2.42)
English second language										
No (r)										
Yes		1.24 (1.16 - 1.32)		1.56 (1.46- 1.67)		1.23 (1.13 - 1.34)		2.13 (2.00 - 2.27)		5.16 (4.89 - 5.44)
Socioeconomic advantage & disadvantage index (SEIFA IRSAD)		0.90 (0.89 - 0.91)		0.91 (0.90 - 0.91)		0.91 (0.90 - 0.92)		0.87 (0.86 - 0.88)		0.90 (0.90 - 0.91)

Figure 2 shows the joint variation across Australian states and territories of child vulnerability on one or more domain according to 1) adjusted predicted average levels of vulnerability in the state or territory and 2) the slope index of inequality (absolute) based on SEIFA IRSAD. The predicted average levels of vulnerability were adjusted by ESL, ATSI and SEIFA IRSAD. Ideally, jurisdictions should be in the bottom left-hand quadrant with lower overall levels of vulnerability and lower absolute social inequality. A slope index of inequality (SII) figure of say 22 indicates that there is an absolute difference of 22 percentage point in developmental vulnerability from the lowest to the highest SEIFA IRSAD decile. Thus the higher the SII value the greater the absolute level of inequality within the State. The scales of the X-axes are the same to show the lower overall vulnerability of females (median vulnerability about 15%) compared to males (median vulnerability about 29%). Across all jurisdictions males experience higher inequality and higher median levels of developmental vulnerability compared to females. For males and females, the smallest levels of inequality and developmental vulnerability are found in New South Wales and Tasmania whereas the largest inequalities and highest levels of developmental vulnerability are found in Western Australia and Queensland. Children in Victoria and South Australia have higher levels of inequality but lower vulnerability, while children in the Australian Capital Territory experience lower levels of inequality yet higher vulnerability.

The *inequality difference* between states varies significantly with the lowest and highest levels of inequality for males being 12.6 (lowest level of inequality in Tasmania and highest level in South Australia) and for females is 8.2 (lowest level of inequality found in the Australian Capital Territory and highest inequality in Western Australia). The difference in *overall developmental vulnerability* for males between the top (New South Wales) and bottom (Queensland) states is 12.5 percentage points and for females it is 7.1 (top=Tasmania and bottom=Queensland). The magnitude of these inequalities varies considerably between and within jurisdiction by sex. The difference in inequality between males and females is smallest in Tasmania (difference 1.24), then

New South Wales (difference 2.03) followed by Victoria (difference 4.85), Queensland (difference 5.07), Western Australia (difference 5.83), and the Australian Capital Territory (difference 7.0) with the highest level of inequality between males and females found in South Australia (difference 10.82).

Children residing in the most disadvantaged areas (SEIFA IRSAD decile 1) in New South Wales and Tasmania recorded the same proportion of children developmentally vulnerable (27%) as those children residing in the middle of the SEIFA IRSAD range (decile 5) in Western Australia and the Australian Capital Territory and the lower end of the socioeconomic range (decile 8) in Queensland. Those children living in the most advantaged areas in Queensland (decile 10) recorded a similar proportion of children developmentally vulnerability as children residing in the poorer areas of NSW, Tasmania, South Australia and Victoria (deciles 2-3).

Despite acknowledged universal availability of health services in Australia, there is a marked variation in what the states and territories provide to families with young children. Table 5 shows the published schedules for maternal and child health services as well as preschool services offered within the different jurisdictions. These two services represent the main universal systems available to most Australian families. This table suggests that such services vary across the jurisdictions. While any statistical analyses of association are not possible with such broad data, a descriptive approach highlights the concordance with some of the results on the AEDI. Queensland, where the services are not universal, has the lowest preschool attendance and one of the highest children to staff ratios. New South Wales, Tasmania, and Victoria appear to have the most comprehensive universal early years' service coverage – and in two out of these three states (NSW and Tasmania) the level of inequality in child developmental vulnerability is the smallest.

Table 5: Documented universal services offered in each of the Australian jurisdictions prior to school.

	Child, Health and Parenting schedule of Universal services			**Preschool attendance in 2008**	**Preschool staff to child ratio**
	1-3 months	**4-12 months**	**1 – 5 years**		
New South Wales	<2 weeks (HV) 1-4 weeks 6-8 weeks	6-months 12 months	18-months 2 years 3 years 4 years	60.4%	1:10
Australian Capital Territory	1-4 weeks (HV) 6-8 weeks	6-9 months	18 -21 months 3 – 3.5 years	88.3%	1:11
Queensland	No universal service			26.6%	1:12
South Australia	< 2 weeks (HV)	- available by request	- available by request	87.9%	1:10
Tasmania	2 weeks (HV) 4 weeks 8 weeks	4 months 8 months 12 months	18 months 3 ½ years	101.6%	1:10
Victoria	< 2 weeks (HV) 2 weeks 4 weeks 8 weeks	4 months 8 months 12 months	18 months 2 years 3 ½ years	95.8%	1:15
Western Australia	<10 days (HV) 6-8 weeks	3-4 months 8 months	18 months 3 years	103.4%	1:10

HV = Home Visit. Note: States provide aggregated data for their preschool attendance rates and the Australian Bureau of Statistics provides data for the denominator, which is provided as the reason for percentages being over 100%. References for Table 5: [42-50].

Discussion

Population-wide data has enabled Australia to be the first nation to quantify patterns of early child health and development across its different jurisdictional boundaries with their associated socioeconomic and demographic diversity. The work here provides the first national population benchmarks of some aspects of early childhood development as this pertains to readiness to learn at school. The data illuminate striking differences in early capacities that are strongly associated with socioeconomic and demographic circumstances.

Controlling for socioeconomic and demographic covariates reveals significant variations in developmental vulnerabilities across the states and territories. At the outset we acknowledge that there are socioeconomic and demographic determinants that are not fully captured by the models presented owing to their limited availability in the CURF. Nonetheless, it is both heartening and disturbing to discover such differences across jurisdictions. It is heartening because it highlights that child health and development may be improved by factors other than socioeconomic and demographic factors. However, it is disturbing to note that in a wealthy country where universal health coverage, mandated education and public health provision are available, and where there is still a reasonable social safety net, there are nevertheless striking disparities in levels of early child development. Why is it, for example, that after controlling for the standard socioeconomic and demographic factors, a child residing in Queensland relative to a child residing in New South Wales, has an increased odds of being developmentally vulnerable by the time they reach school entry (males OR 1.80, CI 1.74-1.87; females OR 1.52 CI 1.46-1.59)? There is little doubt that these differences would be reduced by more extensive socioeconomic and demographic controls but this is unlikely to explain all the residual differences within and across jurisdictions. This raises the question of whether differing policies, contexts and mix of services that support children and their families from birth to school age across the jurisdictions in Australia contribute to such inequalities? The marked variation demonstrated in Table 5 suggests this is a possibility.

In South Australia (SA) the maternal and child health schedule moves quickly from a universal to an active targeted service; however all mothers not in the targeted service who wish to see a child health nurse can still visit the clinics. In SA almost all families have a Universal Contact Visit within the first two weeks after birth of their baby. Based on the nurse's assessment, mothers who have risk factors such as being young, socially isolated or having mental health issues are offered further intensive home visits. These visits are extensive with weekly sessions between week 3 and 8, followed by fortnightly visits up to 8 months, and then monthly visits until the child is two years old. The targeted schedule includes a total of 34 visits in the first 2 years of the child's life [43]. In Tasmania, ACT and NSW a universal home visit is also conducted and then the state specific scheduled development checks for all families are offered. In Victoria, even though funded by the State government, the services are delivered by local governments adding a different context to the "shop front". NSW is the only state with an antenatal health check-up that identifies vulnerable families early. These families are then referred onto secondary services where necessary [51 52]. In WA, a universal service is offered in the first 10 days after birth and then nurses aim to provide a total of six contacts [53]. In Queensland the government has no universal maternal and child health service and Queensland is also the state with the lowest preschool attendance [48 50].

In addition to the variability across jurisdictions in the delivery of maternal and child health services and the level of access to these services there are also differences in the rate of investment in these services relative to population growth. For example in Western Australia service delivery has not kept pace with the population growth. The Western Australia Children's Commissioner in a submission to a Justice Standing Committee noted that although the birth rate had increased 16% over the previous years there had not been a concomitant increase in the number of child health nurses, school health nurses, Aboriginal health workers or investments in child health services. The Commissioner's figures revealed that despite the published Child and Maternal Health Schedule there was only one child health nurse for every 167 births (whereas most other jurisdictions had ratios between 1:78 – 1:98) [49].

While it may be tempting to make strong claims about the co-variation in AEDI results with models and levels of human service delivery in the various Australian jurisdictions, a much more extensive investigation is required to move toward any causal interpretation. For example, controlling for the covariates increases the odds of developmental vulnerability for children living within the Australian Capital Territory. Just why this should be so, given the shallower socioeconomic gradient in this jurisdiction (with no children recorded in the poorest 5 deciles of SEIFA IRSAD), is unclear. Why then, despite the ACT being a relatively wealthy state with lower socioeconomic inequality, do we see increased odds for vulnerability across all five of the developmental domains?

Gender differences are evident in these data. There are well documented gender differences in brain development of young children [54 55]. At early ages in particular, boys develop at a slower rate than girls [56], and there is evidence that different areas of the brain develop in a different sequence in girls compared with most boys [57]. This is consistently evident within the EDI [30] and AEDI results [18]. However within gender there are significant differences for boys and girls residing in different jurisdictions, and socioeconomic and demographic contexts. What are the contextual factors in South Australia that lead to both the greatest inequality difference between males and females and also the greatest degree of inequality within the male gender compared to other jurisdictions? This is in contrast to a smaller gap between boys and girls living in Tasmania and New South Wales, and both of these jurisdictions show the lowest level of inequality while still also maintaining lower levels of developmental vulnerability overall.

Across all five of the AEDI domains both Aboriginal and ESL children have increased odds of vulnerability compared to non-Aboriginal and non-ESL children respectively. Of interest is that the inequality between Aboriginal and non-Aboriginal children is greater for females than for males particularly on the Physical health and wellbeing domain, where the odds ratio for male Aboriginal children is 1.81 (CI 1.68-1.95) compared with 2.38 for female Aboriginal children (CI 2.19-2.58). However the greatest inequality gap between Aboriginal and non-Aboriginal children is found on

the language and cognitive development domain irrespective of gender (OR 2.59 males; 95% CI, 2.42-2.78 and OR females 3.01; 95% CI, 2.78-3.25). Interestingly, although SEIFA IRSAD has a large impact on each of the five AEDI domains, it is the Language and cognitive domain that is influenced the greatest by the socio-economic index.

For children with ESL status the highest ORs for vulnerability were found for the Communication skills and general knowledge domain with an OR of 4.19 for males (CI 4.01-4.37) and an OR of 5.16 for females (CI 4.89-5.44). The results need to be considered in light of the fact that the AEDI measures school based communication skills in English as English is the main language of instruction in Australian schools. Results reported elsewhere have shown that children who speak another language but are additionally proficient in English show the lowest levels of developmental vulnerabilities across each of the five domains, however those that are not proficient in English (independent of ESL status) show poorer results on the AEDI [18 58 59].

It is worth mentioning that the covariates ATSI and ESL do not show significant overlap. Of those children who are defined as ATSI, only 20% are classified as ESL. Whereas, of those children classified as ESL by the teacher, only 7% are defined as having ATSI status. In total less than 1% of the entire sample were both of ATSI decent and classified by the teachers as having English as a Second Language.

The AEDI will be repeated once every three years (i.e. 2012, 2015, 2018…). This will enable onward monitoring and surveillance and creates opportunities to examine the effects of policies and interventions. This will require political will and leadership as well as the capitalisation of this opportunity by the scientific community and those interested in human service evaluation. The onward implementation of the AEDI also encourages efforts in establishing a longitudinal capacity (i.e. following the same child/person over time) to illuminate the pathways leading to a variety of human development outcomes. Among such life course outcomes are those pertaining to health/ill-health as well as wider outcomes pertaining to social, economic and civic participation.

In Australia there are robust administrative data linkage methodologies, some longstanding and well established, that are currently being assessed for their potential to use AEDI data to prospectively estimate the human development benefits of early childhood opportunities, environments and services on later life course outcomes. It is possible to construct crosswalks between health, early child development and education databases that integrate population-wide, person-specific data at national, provincial, and community levels [60]. As such it is possible to create a historical perspective of developmental trajectories for an entire population of children.

Australia is now progressing towards national data linkage with jurisdiction based "nodes" working together under a national network (the Population Health Research Network) that will allow researchers to access linked data that is de-identified. The systems will improve Australia's ability to monitor health and health inequalities using data already collected by social services including primarily health but also education and family and community services. In Western Australia and New South Wales data linkage systems have been operating for over 10 years [61], however the national network with significant infrastructure investment from the federal and state governments aims to provide the world's most comprehensive population health database to monitor and study health across the country [62]. The 2009 AEDI dataset is currently being linked into this national network of jurisdictional based nodes.

Currently there are a number of interventions aimed at improving child development that show demonstrated efficacy [15]. However, there is still insufficient data to inform policies and practices to reduce inequalities in early child development. With linked population data sets program/policy evaluation and economic models can also be investigated (such as the effectiveness of preventive interventions which are traditionally hard to quantify). Such systems will be invaluable tools for assessing the efficacy and effectiveness of policies and interventions that aim to reduce inequalities in health and development across populations [3].

The Early Development Instrument (EDI) is gaining attention internationally with the instrument now being utilized in over a dozen countries [35]. Part of the attraction is that the EDI is

administered just like a census and is a holistic measure of child health and development. Regular monitoring of inequalities and use of these data for education, advocacy, and increased accountability among the general public and decision makers is urgently needed, but alone will not be sufficient [63]. Equity of opportunity and access must be a priority in the design of policies and interventions. The AEDI provides a critical measure in a developmental stage that is otherwise surprisingly uncharted in the life course trajectory given the contemporary claims placed on the importance of optimising development at early points in life.

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References

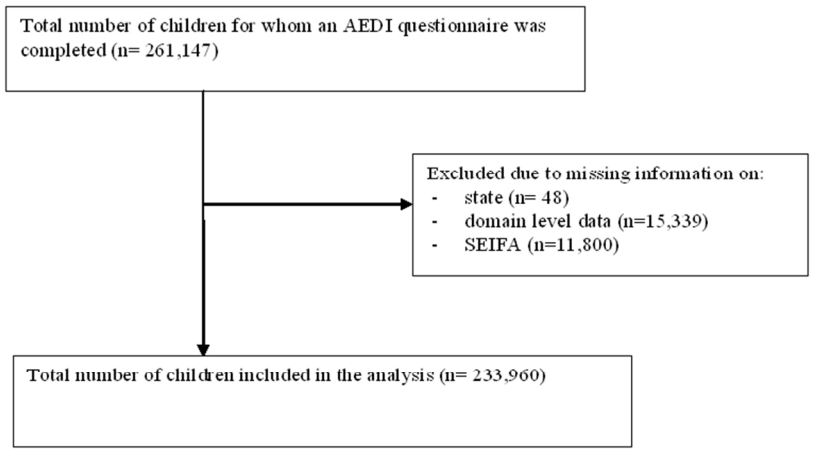
1. Lynch JW, Davey-Smith G. A Life Course Approach to Chronic Disease Epiemiology. Annu. Rev. Public Health 2005;**26**(1):1-35 doi: doi:10.1146/annurev.publhealth.26.021304.144505[published Online First: Epub Date]|.
2. Marmot M. Fair Society, Healthy Lives: The Marmot Review: The Marmot Review, 2010.
3. Lynch JW, Law C, Brinkman S, et al. Inequalities in child healthy development: Some challenges for effective implementation. Soc. Sci. Med. 2010;**71**(7):1219-374
4. Hertzman C, Boyce T. How Experience Gets Under the Skin to Create Gradients in Developmental Health. Annu. Rev. Public Health 2010;**31**:329-47 doi: 10.1146/annurev.publhealth.012809.103538[published Online First: Epub Date]|.
5. Heckman J. Schools, Skills, and Synapses. Economic Inquiry 2008;**46**(3):289-324
6. UNICEF. The State of The Worlds Children: Downloadable Statistical Tables. Secondary The State of The Worlds Children: Downloadable Statistical Tables 11/8/2010 2010. http://www.unicef.org/rightsite/sowc/statistics.php.
7. OECD. OECD Programme for International Student Assessment (PISA). Secondary OECD Programme for International Student Assessment (PISA) 2012. www.pisa.oecd.org.
8. United Nations Development Programme. The Millennium Development Goals: Progress Reversals and Challenges. New York, 2002.
9. UNESCO. Strong Foundations Early Childhood Care and Education. Secondary Strong Foundations Early Childhood Care and Education 2007. http://unesdoc.unesco.org/images/0014/001477/147785E.pdf.
10. Young ME. *Early Child Development: From Measurement to Action.* Washington DC., USA: The World Bank, 2007.
11. Status of the Convention on the Rights of the Child. Report of the Secretary-General. United Nations General Assembly. Sixty-fifth session ed: United Nations, 2010:18.
12. Janus M, Duku E. The school entry gap: Socioeconomic, family, and health factors associated with children's school readiness to learn. Early Education & Development 2007;**18**(3):375-403
13. Meisels SJ. Developmental Screening in Early Childhood: The Interaction of Research and Social Policy. Annu. Rev. Public Health 1988;**9**(1):527-50 doi: doi:10.1146/annurev.pu.09.050188.002523[published Online First: Epub Date]|.
14. Meisels SJ. Can Developmental Screening Tests Identify Children Who Are Developmentally at Risk? Pediatrics 1989;**83**(4):578-85
15. Barnett WS. Effectiveness of Early Educational Intervention. Science 2011;**333**(6045):975-78 doi: 10.1126/science.1204534[published Online First: Epub Date]|.
16. Goldfeld S, Sayers M, Brinkman S, et al. The process and policy challenges of adapting and implementing the Early Development Instrument in Australia. Early Education and Development 2009;**20**(6):978-91
17. Janus M, Brinkman S, Duku E, et al. *The Early Development Instrument: A population-based measure for communities. A handbook on development, properties and use.* Hamilton, Ontario, Canada: Offord Centre for Child Studies, 2007.
18. Centre for Community Child Health and Telethon Institute for Child Health Research. *A Snapshot of Early Childhood Development in Australia. Australian Early Development Index (AEDI) National Report 2009*. Canberra: Australian Government, 2009.
19. Hertzman C, Williams R. Making Early Childhood Count. Can. Med. Assoc. J. 2009;**180**:68-71
20. OECD. OECD.StatExtracts. Health Expenditure and Financing: OECD, 2008.
21. Australian Bureau of Statistics. 3101.0 - Australian Demographic Statistics. June 2011. Canberra: Australian Bureau of Statistics, 2011.

22. Steering Committee for the Review of Government Service Provision. Overcoming Indigenous Disadvantage: Key Indicators 2011. 2011. http://www.pc.gov.au/__data/assets/pdf_file/0018/111609/key-indicators-2011-report.pdf (accessed 1/1/2012).
23. Australian Bureau of Statistics. 1301.0 - Year Book Australia, 2009-10. Canberra: Australian Bureau of Statistics, 2010.
24. Atkinson AB, Piketty P, Saez E. Top Incomes in the Long Run History. Journal of Economic Literature 2011;**49**(1):3-71
25. United Nations Development Programme. Human Development Report 2011. Sustainability and Equity: A Better Future for All. New York: Palgrave Macmillan, 2011.
26. Silburn S, Zubrick SR, De Maio JA, et al. The Western Australian Aboriginal Child Health Survey: Strengthining the Capacity of Aboriginal Children, Families and Communities. Perth: Curtin University of Technology and the Telethon Institute for Child Health Research., 2006.
27. Centre for Community Child Health. AEDI Research CURF: Australian Government, 2011.
28. Centre for Community Child Health. Australian Early Development Index: Data Users Guide: Australian Government, 2010.
29. Australian Bureau of Statistics. 3201.0 - Population by Age and Sex, Australian States and Territories, Jun 2009. Canbera: Australian Bureau of Statistics, 2009.
30. Janus M, Offord D. Development and psychometric properties of the Early Development Instrument (EDI): A measure of children's school readiness. Canadian Journal of Behavioural Science 2007;**39**:1-22
31. Brinkman S, Gregory T, Harris J, et al. 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. Australian and New Zealand Journal of Public Health 2012;**in press**
32. Brinkman S, Silburn S, Lawrence D, et al. Investigating the validity of the Australian Early Development Index. Early Education and Development 2007;**18 (3)**:427-51
33. Brinkman S, Zubrick S, Silburn S. Predictive Validity of a school readiness assessment on later cognitive and behavioral outcomes. Journal of Early Education and Development 2012;**in press**
34. Forget-Dubois N, Lemelin JP, Boivin M, et al. Predicting early school achievement with the EDI: A longitudinal population-based study. Early Education and Development 2007;**18**(3):405-26
35. Janus M, Brinkman SA, Duku E. Validity and psychometric properties of the Early Development Instrument in Canada, Australia, United States and Jamaica. Social Indicators Research 2011;**103**(2):283-97
36. Centre for Community Child Health and Telethon Institute for Child Health Research. AEDI Guide for Teachers. Canberra: Centre for Community Child Health and Telethon Institute for Child Health Research, 2009.
37. Australian Bureau of Statistics. Information Paper: An Introduction to Socio-Economic Indexes for Areas (SEIFA): Australian Government, 2008.
38. Radisich P, Wise P. Socio-Economic Indexes For Areas: Robustness, Diversity Within Larger Areas and the New Geography Standard. Research Paper. Canberra: Australian Bureau of Statistics,, 2012.
39. Centre for Community Child Health and Telethon Institute for Child Health Research. AEDI Technical Paper No 1: Children developmentally vulnerable on one or more and two or more, AEDI domains: Australian Government, 2011.
40. Wagstaff A, Paci P, van Doorslaer E. On the measurement of inequalities in health. Soc. Sci. Med. 1991;**33**(5):545-57 doi: 10.1016/0277-9536(91)90212-u[published Online First: Epub Date]|.

41. Harper S, Lynch JW. Methods for Measuring Cancer Disparities: Using Data Relevant to Healthy People 2010 Cancer-Related Objectives. NCI Cancer Surveillance Monograph Series, Number 6. Bethesda: National Cancer Institute, 2005:1-80.
42. ACT Health. Australian Capital Territory Immunisation Strategy (2007-2010), 2007.
43. Children Youth and Women's Health Service. Family Home Visiting: Service Outline, 2005.
44. Department of Education and Early Childhood Development. Your Maternal and Child Health Service Visits. Secondary Your Maternal and Child Health Service Visits 2011. http://www.education.vic.gov.au/earlychildhood/mch/visits.htm.
45. Department of Health and Human Services. Child Health Centres. Secondary Child Health Centres 2011. http://www.dhhs.tas.gov.au/service_information/services_files/child_health_centres.
46. NSW Department of Health. Personal Health Record (The Blue Book). Secondary Personal Health Record (The Blue Book) 2011. http://www.health.nsw.gov.au/policies/ib/2007/IB2007_008.html.
47. Office of Early Childhood Education and Care. Child and Family Support Hubs. Secondary Child and Family Support Hubs 2011. http://deta.qld.gov.au/earlychildhood/families/ey-services/support-hubs.html.
48. Dowling A, O'Malley K. Preschool Education in Australia. Melbourne: Australian Council for Educational Research, 2009.
49. Commisioner for Children and Young People. Submission to the Community Development and Justice Standing Committee; Inquiry into the Adequacy of Services to Meet the Developmental Needs of Western Australia's Children. Perth, 2009.
50. Hirst C. Re-Birthing. Report of the Review of Maternity Services in Queensland. Brisbane: Department of Health, Queensland, 2005.
51. Families NSW. Safe Start. Secondary Safe Start 2011. http://www.families.nsw.gov.au/getting_help_and_support/safe_start.html.
52. Families NSW. Health home visiting & early childhood health services. Secondary Health home visiting & early childhood health services 2011. http://www.families.nsw.gov.au/getting_help_and_support/health_home_visiting.html.
53. Commisioner for Children and Young People. Submission to the Education and Health Standing Committee: Review of WA's Current and Future Hospital and Community Health Care Services. Perth: Government of Western Australia., 2009.
54. Anokhin AP, Lutzenberger W, Nikolaev A, Birbaumer N. Complexity of electrocortical dynamics in children: developmental aspects. Developmental Psychobiology 2000;**36**(1):9-22
55. Hanlon H, Thatcher R, Cline M. Gender differences in the development of EEG coherence in normal children. Developmental Neuropsychology 1999;**16**(3):479-506
56. Bornstein M, Hahn C, Haynes O. Specific and general language performance across early childhood: Stability and gender considerations. First Language 2004;**24**(3):267-304
57. Weinberg MK, Tronick EZ, Cohn JF, et al. Gender differences in emotional expressivity and self-regulation during early infancy. Developmental Psychology 1999;**35**:175-88
58. Brinkman S, Sayers M, Goldfeld S,et al. Population monitoring of language and cognitive development in Australia: The Australian Early Development Index. International Journal of Speech-Language Pathology 2009;**11 (5)**:1-12
59. Janus M, Hertzman C, Guhn M, Brinkman S, Goldfeld S. Reply to Li, D'Angiulli and Kendall: The Early Development Index and children from culturally and linguistically diverse backgrounds. Early Years: An International Journal of Research and Development 2009;**29**(1):31-35
60. Jutte DP, Roos LL, Brownell MD. Administrative Record Linkage as a Tool for Public Health Research. Annu. Rev. Public Health 2011;**32**:91-108

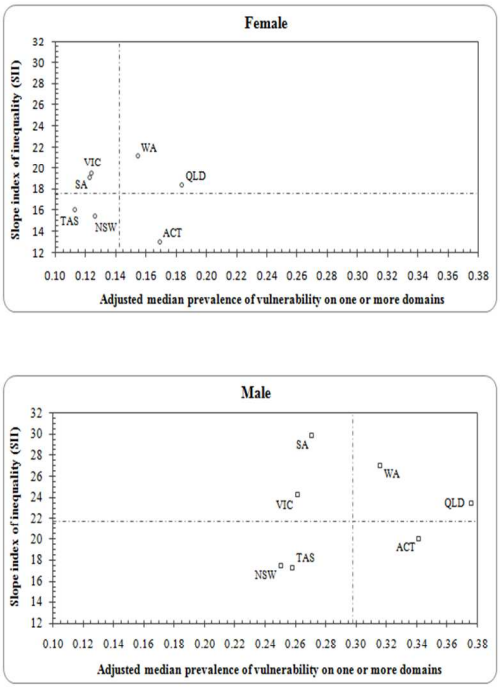
61. Holman C, Bass A, Rosman D, et al. A decade of data linkage in Western Australia: strategic design, applications and benefits of the WA data linkage system. Aust. Health Rev. 2008;**32**:766 - 77
62. PHRN. Population Health Research Network. Secondary Population Health Research Network 2011. www.phrn.org.au.
63. Victora CG, Wagstaff A, Schellenberg JA, Gwatkin D, Claeson M, Habicht J. Applying an equity lens to child health and mortality: more of the same is not enough. Lancet 2003;**362**(9379):233-41 doi: 10.1016/s0140-6736(03)13917-7[published Online First: Epub Date]|.

Figure1: Flow chart of participants



248x173mm (96 x 96 DPI)

Figure 2: Adjusted* prevalence of vulnerabliity (%) on one or more AEDI domains and absolute socioeconomic inequality (%) by jurisdiction.



* Mean prevalence is adjusted for ATSI, ESL and SEIFA IRSAD

**Dotted lines indicate national median vulnerability (%) and absolute socioeconomic inequality (%).

209x297mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract Completed - Census of child development	1 & 4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Completed	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Completed	5-9
Objectives	3	State specific objectives, including any prespecified hypotheses Objectives stated	9
Methods			
Study design	4	Present key elements of study design early in the paper Census of child development	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Completed	9-10
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants Completed	9-10
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Completed	12-13
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Completed	12-13
Bias	9	Describe any efforts to address potential sources of bias No attempt has been made to address any potential source of bias – the census collected an estimated 97.5% of the 5 year old population.	n/a

Section/Topic	Item #	Recommendation	Reported on page #
Study size	10	Explain how the study size was arrived at Not applicable - census	n/a
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Completed	13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Completed	13-15
		(*b*) Describe any methods used to examine subgroups and interactions Completed	13-15
		(*c*) Explain how missing data were addressed Completed	13
		(*d*) If applicable, describe analytical methods taking account of sampling strategy Not applicable - census	n/a
		(*e*) Describe any sensitivity analyses None	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-11
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram Flow diagram presented	Figure file
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Completed	10
		(b) Indicate number of participants with missing data for each variable of interest Completed	
Outcome data	15*	Report numbers of outcome events or summary measures Completed	

Section/Topic	Item #	Recommendation	Reported on page #
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Completed	16, 18 & 19
		(*b*) Report category boundaries when continuous variables were categorized Completed	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not applicable	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Completed	20-21
Discussion			
Key results	18	Summarise key results with reference to study objectives Completed	23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Completed	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Completed	
Generalisability	21	Discuss the generalisability (external validity) of the study results Completed	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Completed	29

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.