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A macro-level approach to assess the early developmental vulnerabilities of children in Australia: A local government area-based analysis

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ABSTRACT

The spatial impact of socioeconomic determinants on the macro-level early developmental vulnerability of children was analyzed in this paper using Local Government Areas (LGAs) as samples. Five domains of developmental outcomes: physical, social, emotional, language and cognitive, and communication have been addressed as ordinal outcomes, and fitted by the proportional odds model. Areas with a high percentage of low-income, welfare dependent and single parent families significantly increased the proportion of vulnerable children in all five domains. Other factors that significantly affect some aspects of developmental vulnerability in children are participation of women in the labor market, availability of home Internet and unemployment rate in the locality. The macro-level results match with previous micro-level assessments showing the relationship between household socioeconomic features and childhood vulnerability.

1. Introduction

The effect of socioeconomic heterogeneity in various geographical locations of Australia on children is an important issue as social structures are increasingly complex (Mohanty, Edvardsson, Abello, & Eldridge, 2016; Murray & Skull, 2005). Early perception of social and economic determinants facilitates the understanding of early vulnerability of children and identify the vulnerable sections of the society (Marmot, Allen, Bell, Bloomer, & Goldblatt, 2012). This, in turn, also allows policy makers to invest in the most vulnerable domains. This paper focuses on the five developmental domains of children: physical, social, emotional, language and cognitive, and communication. By taking into account the literature that assesses the relationship between household socioeconomic features and childhood vulnerability (Chen & Paterson, 2006), this paper focuses on the macro-level Local Government Area (LGA) analysis to assess the macro-level relation between the domains of children's vulnerability and the socioeconomic condition of Australian families. Furthermore, we provide a brief overview of the most vulnerable LGAs; those that require attention from policy makers.

1.1. Literature gap

Several factors influence the early development of a child: poverty, parenting complexity, abuse and neglect, hostile environment and violent community (Brinkman et al., 2013; Gewirtz & Edleson, 2007; Margolin, 2005; Schneider & Phares, 2005). Children's exposure to violence or the effect of a toxic neighborhood may cause emotional damage and behavioral disorders, which can affect their perception of surroundings and restrict moral development (Antunes & Ahlin, 2014; Margolin & Gordis, 2000). The micro-level effect of violence or family instability on children is a regularly discussed issue (Fabricius & Luecken, 2007; Nicolotti, El-Sheikh, & Whitson, 2003). However, macro-level area based analysis on children's vulnerability has been less frequently examined (Kershaw, Forer, Irwin, Hertzman, & Lapointe, 2007). There exists a literature gap on the macro-level relationship between childhood vulnerability and the neighborhood's socioeconomic effect. This study fitted the LGAs of Australia as samples for the assessment.

1.2. Various forms of vulnerability

There are disparities in several areas of children's development, most of which become evident early in a child's life. According to the Australian Bureau of Statistics (ABS) in a survey undertaken in 2009, 3.4% of children aged 0–4 years and 8.8% of those aged 5–14 years have exhibited some forms of disability (Australian Government, 2009). The effect of *physical* activity on the mental health of children and adolescents is less discussed compared to that of adults (Whitelaw,

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Teuton, Swift, & Scobie, 2010). It is estimated that 6% of early life physical clumsiness, ignored by most parents and doctors, results in serious psychological stress that interferes with long-term academic performance and social integration (Hamilton, 2002). In a review, Biddle and Asare (2011) concluded that lack of physical activity or sedentary screen time is related to poorer mental health. Similar importance should be given to early development of *social* competence, which allows the child to interact with others and further continue to thrive in a social world (Baker, Fenning, & Crnic, 2011; Denham et al., 2003). The contribution of macro-level neighborhood on these physical and social vulnerabilities is analyzed in this study.

Linguistic and cognitive as well as communication vulnerabilities are common in children who are exposed to neighborhood violence (Aisenberg & Herrenkohl, 2008; Fowler, Tompsett, Braciszewski, Jacques-Tiura, & Baltes, 2009; Kershaw et al., 2007). Children with concomitant prevalence of *language* deficits exhibit antisocial behavior 10 times higher than that of the general population (Benner, Nelson, & Epstein, 2002). The early (by ages 4 to 6) emergence of the gap between *cognitive* and non-cognitive skills are due to family environment and low-income status, which persist throughout adolescence (Heckman, 2006; Krueger, Friedman, & Heckman, 2003). Lack of self-worth and negative self-esteem is common in children with difficult family life (Jones & Prinz, 2005; Neff & McGehee, 2010). Moreover, there are substantial achievement gaps between children from high-income and low-income families at primary schools, which widen over time and contribute to serious disparities in learning abilities, educational attainment, and long-term employment potential (Hanushek & Woessmann, 2008; Ryan, Fauth, & Brooks-Gunn, 2006). An assessment of the LGAs in Australia will reveal the effect of specific locations on children's vulnerabilities.

1.3. Australian context

Early detection of vulnerability as well as children and their families' cultural integration with the health system is necessary. Fantuzzo, McWayne, and Bulotsky (2003) claimed that the mental health system's inability to engage the most vulnerable groups of children and their families may lie with the provision of incongruent services that lack cultural sensitivity. The development of children requires understanding of their cultural adaptations which improves the intervention service delivered (Griner & Smith, 2006; Peek & Stough, 2010; Spencer, 2013). Considering the multicultural diversity in Australia (28.2% of the population born overseas and 3% Indigenous Australians), it is a challenge to understand whether these micro-level (household based) vulnerabilities are present in macro-level (location wise) paradigms. These information should assist in allocating government aid and investments accordingly (Australian Government, 2011; Australian Government, 2015). The Australian government has focused on ensuring the wellbeing of every child through prioritizing the policing and statutory role of the State and Territory Governments (Australian Government, 2008). 41.2% of the total health expenditure in Australia was contributed by the federal government and 26.6% by the state, territory and local governments in 2013–14; which demonstrates the responsibility of federal policy makers and their need to understand child development at the macro-level (Australian Government: AIHW, 2015; Brinkman et al., 2012).

2. Material and methods

2.1. Data details

The Australian Early Development Census (AEDC) collects data regarding early childhood development outcomes for Australia and this paper has applied their 2012 data set. 289,973 Australian children were sampled in their first year of full-time school during 2012 (Government, 2015). The data from the AEDC provide snapshots of children's development parameters in one locality at the time when they start school, across five disciplines of early childhood development: physical health and wellbeing; social competence; emotional maturity; language and cognitive skills (schools-based); and communication skills and general knowledge. The data was accessed from the Public Health Information Development Unit (PHIDU) located at Torrens University Australia (Public Health Information Development Unit (PHIDU), 2009). AEDC domain scores are calculated on the basis of 104 developmental questions for each child, completed by their teachers (Australian Government, 2016a). Domain scores are represented by a number between 0 and 10 where a higher domain score indicates a higher level of development. AEDC results are reported as proportions of children who are 'developmentally on track', 'developmentally at risk', and 'developmentally vulnerable', based on cut-offs for each domain. The domain cut-off is created based on the data from all survey participants and released for various geographical locations (like LGAs). It particularly takes into account the age variations in the population of children in their first year of schooling, which varied in age from just under five to over six years. The details of domain score calculations are the intellectual property of McMaster University in Canada (Australian Government, 2016a).

Another relevant feature developed by the Australian Bureau of Statistics (ABS) is the Socio-Economic Indexes for Areas (SEIFA), a scale that ranks areas in Australia according to relative socioeconomic advantage and disadvantage based on five-yearly census results (Pink, 2011). This study used the SEIFA 2011 from the 2011 census. Among the four indexes of SEIFA, we applied the Index of Relative Socio-Economic Disadvantage (IRSD) as a crosschecking measurement tool for evaluating the consistency of our results from AEDC with ABS. ISRD is a numerical score allocated to a geographical location, where a low score indicates a high proportion of relatively disadvantaged people in that area. This scale is constructed by applying principal component analysis (PCA) on demographic criteria like family income, employment status, marital status of parents, education, and occupational skills. These are some of the components that constitute socioeconomic diversity in Australia (Bowden & Doughney, 2010; McMillan, Beavis, & Jones, 2009; Turrell, Hewitt, Patterson, & Oldenburg, 2003).

2.2. Vulnerability illustration

The Australian version of the 'Early Development Instrument' provides information regarding five vulnerable domains as mentioned before (Australian Government, 2015). *Physical health and wellbeing* are measured by a child's health status, independence, and readiness for school each day. *Social competence* is determined by his/her capability of mingling in a group and playing alongside other children with similar temperament. A child's ability to concentrate, to help others and to demonstrate self-confidence are considered as his/her *emotional maturity*. Literacy and numeracy are marked as *language and cognitive skills*. *Communication skills* are demonstrated by a child's capability in telling stories, communicating with adults and children, and articulating by himself/herself.

2.3. Variables

The outcome variables considered for the study are the five parameters of development vulnerability: physical, social, emotional, language and cognitive, and communication. The proportion of 'developmentally vulnerable' (from AEDC) children in an LGA was considered for each vulnerability domain and they were trisected proportionately: low, moderate and high, as it would provide better model fitness and easier interpretation. All the LGAs were ranked based on the proportion of vulnerable children from five categories living in the areas. Then these areas were trisected into three categories: low, moderate and high vulnerable areas for each domain, which were the outcome variables. The covariates fitted in the models were the proportion of low-income

welfare dependent family, proportion of single parent families with children aged < 15 years, proportion of dwellings with no Internet connection, average wage & salary income, unemployment rate and proportion of female labor force participation in the LGA. These socioeconomic indicators (covariates) were also scaled into 3 groups: low, moderate and high. The primary sampling unit was LGA (total 564 in 2012), and after removing all the missing values from the available data in 2012 total sample size was 426. LGAs are legally designated parts of a state or territory in Australia incorporated by local governing bodies and their size vary from 1.5 km^2 to 380,000 km^2 and defined by ABS (detailed in Australian Bureau of Statistics (2011)). A good number of LGAs had missing values due to not maintaining data standards. For example, data are not available for areas where fewer than two teachers had completed the AEDC instrument for children in that location or fewer than fifteen children had valid AEDC scores (Public Health Information Development Unit (PHIDU), 2015).

2.4. Statistical algorithm

Bivariate analysis was conducted to provide an overview of the relationship between the covariates and five vulnerability scales. The significance of their association was determined by p-values from chi-square tests. To further understand the nature of their relationship and determine the size of the associations, we fitted the proportional odds model for each vulnerability scale with the mentioned covariates applying *R* package *polr*. As explained earlier, the outcome variables were trichotomies of areas with vulnerable domains. The covariates fitted with these outcomes were also from macro-level variables, which were independent. Thus, it was appropriate to fit the proportional odds model for these ranked outcomes.

ISRD was fitted with the vulnerability domains, again using the proportional odds model, to crosscheck the consistency of the results in five domains with ABS. The snap shot of the most compromised LGAs in Australia was demonstrated by applying maps package in *R* sourced from Google Maps. All the statistical computations were conducted in *R* (version 3.2.3).

3. Results

3.1. Bivariate results

The chi-square test results in Table 1 show that there exists significant (p value < 0.05) association between childhood vulnerability and selected socioeconomic indicators. Patterns between the environment around children and childhood vulnerability were visible. The LGAs with greater percentage of low-income families as well as high unemployment rate seemed to be home for a higher proportion of vulnerable children. The areas with a lower number of dwellings with no Internet connection and higher female participation in the labor force had a smaller number of vulnerable children. However, bivariate association does not confirm causal relationship.

3.2. Physical vulnerability

Physical vulnerability is the first of five domains discussed in the paper. For assessing the causal association, the proportional odds model was fitted. The model suggests that the economic state of the family seems to have an association with the physical vulnerability of children. Areas with moderate and high percentage of welfare dependent low-income families demonstrated 3.31 times and 5.21 times more vulnerability (p values < 0.01) in the physical domain compared to areas with relatively low proportions of such families (Table 2). Similarly, LGAs with high proportion of single parent families were shown to have 2.97 times more physically vulnerable children than areas with low percentage of such families.

3.3. Social vulnerability

Social vulnerability in children is significantly associated (p values < 0.01) with low-income families, single parent families and female labor force participation. Table 2 shows that high percentage of low-income families in an area tends to lead to 2.98 times more socially vulnerable children compared to the low percentage of such families. The odds of socially vulnerable children is 2.24 times more in the areas with a high proportion of single parent families than the low percentages of single parent families in the LGAs of Australia. Areas with high female participation in the labor force actually resulted in 2.37 times more social vulnerability in children compared to areas with low female participation. Other covariates fitted in the model did not exhibit any significant causal association with the social vulnerability of children.

3.4. Emotional vulnerability

Vulnerability in the emotional domain shows homogeneous outcomes as with physical and social domains. More than twice the vulnerability is evident in areas with a higher proportion of welfare dependent families and single parent families. However, Internet connection at home, average wage or unemployment status did not reflect any significant relation with children's emotional vulnerability.

3.5. Language and cognitive vulnerability

Language development and cognitive skills of children seem to be significantly associated with income capacity of the family, marital status of parents, Internet connection at home, and female participation in the labor force in the locality (Table 2). Odds of finding language and cognitive vulnerable children in moderate and high proportion of low-income families in an LGA were 6.1 and 19.7 times higher compared to locations with low proportions of low-income families respectively. Interestingly, areas with higher female participation in economic activities showed a greater chance (> 3.5 times) of language and cognitive vulnerability in children than localities with fewer women in the labor force.

3.6. Communication vulnerability

Communication vulnerability in children tends to be associated with low-income, welfare dependent families and unemployment status in the locality. Children from families with moderate and high percentage of unemployment in an LGA appeared to be 3.15 and 3.87 times more vulnerable in the commutation domain compared to LGAs with a low unemployment rate. Similar odds ratios (2.77 & 3.39) resulted for locations with a greater proportion of low-income families, showing a positive association between family solvency and communication vulnerability in children. Other covariates did not show any significant associations (p values < 0.01.

3.7. Index of relative socio-economic disadvantage

IRSD, a spatial disadvantage index devised by ABS, was applied to crosscheck the consistency of the attained results of different developmental domains with ABS. Table 3 shows that all the vulnerabilities have a significant association with ISRD. One unit increase in IRSD in any LGA resulted in approximately 2% decrease in the vulnerability of children, an expected association.

Figs. 1 and 2 shows the 10 most vulnerable LGAs for each developmental domain of children in Australia. At the same time, the 10 lowest IRSD scored LGA was also marked on the maps. The worst 10 locations in Australia with estimated highest childhood vulnerability were marked bright turquoise and the bottom 10 areas with lowest ISRD were denoted by light orange. The size of the marked circles, in both cases, displayed the vulnerability measure as well as ISRD score of

Table 1
Association of five domains of developmental vulnerability of children with the socioeconomic characteristics.

Variables	Physical domain			Social domain			Emotional domain			Language and Cognitive domain			Communication Domain		
	Low n (%)	Moderate n (%)	High n (%)	Low n (%)	Moderate n (%)	High n (%)	Low n (%)	Moderate n (%)	High n (%)	Low n (%)	Moderate n (%)	High n (%)	Low n (%)	Moderate n (%)	High n (%)
Proportion of low-income welfare-dependent families (with children)															
Low	87 (60.8%)	40 (28%)	16 (11.2%)	75 (52.4%)	50 (35%)	18 (12.6%)	72 (50.3%)	51 (35.7%)	20 (14%)	96 (67.1%)	32 (22.4%)	15 (10.5%)	82 (57.3%)	44 (30.8%)	17 (11.9%)
Moderate	44 (31.7%)	46 (33.1%)	49 (35.2%)	45 (32.4%)	52 (37.4%)	42 (30.2%)	45 (32.4%)	46 (33.1%)	48 (34.5%)	34 (24.5%)	63 (45.3%)	42 (30.2%)	37 (26.6%)	52 (37.4%)	50 (36%)
High	19 (13.6%)	48 (34.3%)	73 (52.1%)	23 (16.4%)	36 (25.7%)	81 (57.9%)	24 (17.1%)	44 (31.4%)	72 (51.4%)	15 (10.7%)	42 (30%)	83 (59.3%)	22 (15.7%)	45 (32.1%)	73 (52.2%)
P-value		< 0.001			< 0.001			< 0.001			< 0.001			< 0.001	
Proportion of Single parent families with children aged < 15 years															
Low	80 (55.9%)	39 (27.3%)	24 (16.8%)	74 (51.7%)	43 (30.1%)	26 (18.2%)	70 (49%)	48 (33.6%)	25 (17.4%)	83 (58%)	33 (23.1%)	27 (18.9%)	79 (55.2%)	37 (25.9%)	27 (18.9%)
Moderate	54 (38.3%)	45 (31.9%)	42 (29.8%)	55 (39%)	47 (33.3%)	39 (27.7%)	50 (35.5%)	49 (34.8%)	42 (29.7%)	42 (29.8%)	55 (39%)	44 (31.2%)	48 (34%)	48 (34%)	45 (32%)
High	17 (12%)	51 (35.9%)	74 (52.1%)	17 (12%)	48 (33.8%)	77 (54.2%)	22 (15.5%)	47 (33.1%)	73 (51.4%)	22 (15.5%)	51 (35.9%)	69 (48.6%)	16 (11.3%)	58 (40.8%)	68 (47.9%)
P-value		< 0.001			< 0.001			< 0.001			< 0.001			< 0.001	
Proportion of dwellings with no Internet connection															
Low	66 (46.5%)	52 (36.6%)	24 (16.9%)	66 (46.5%)	50 (35.2%)	26 (18.3%)	58 (40.8%)	60 (42.3%)	24 (16.9%)	75 (52.8%)	37 (26.1%)	30 (21.1%)	62 (43.7%)	41 (28.9%)	39 (27.4%)
Moderate	47 (32.8%)	51 (35.7%)	45 (31.5%)	44 (30.8%)	49 (34.2%)	50 (35%)	38 (26.5%)	60 (42%)	45 (31.5%)	43 (30.1%)	59 (41.2%)	41 (28.7%)	44 (30.8%)	59 (41.2%)	40 (28%)
High	38 (27%)	32 (22.6%)	71 (50.4%)	36 (25.5%)	39 (27.7%)	66 (46.8%)	46 (32.6%)	24 (17%)	71 (50.4%)	29 (20.6%)	43 (30.5%)	69 (48.9%)	37 (26.2%)	43 (30.5%)	61 (43.3%)
P-value		< 0.001			< 0.001			< 0.001			< 0.001			0.001	
Proportion of average wage & salary income (AUD$)															
Low	46 (32.4%)	36 (25.4%)	60 (42.2%)	44 (31%)	42 (29.6%)	56 (39.4%)	45 (31.7%)	36 (25.3%)	61 (43%)	33 (23.2%)	49 (34.5%)	60 (42.3%)	48 (33.8%)	44 (31%)	50 (35.2%)
Moderate	39 (27.5%)	51 (35.9%)	52 (36.6%)	37 (26.1%)	49 (34.5%)	56 (39.4%)	36 (25.4%)	58 (40.8%)	48 (33.8%)	44 (31%)	54 (38%)	44 (31%)	41 (28.9%)	51 (35.9%)	50 (35.2%)
High	66 (46.9%)	48 (34%)	27 (19.1%)	65 (46.1%)	47 (33.3%)	29 (20.6%)	61 (43.2%)	50 (35.5%)	30 (21.3%)	70 (49.7%)	36 (25.5%)	35 (24.8%)	54 (38.3%)	48 (34%)	39 (27.7%)
P-value		< 0.001			< 0.001			< 0.001			< 0.001			0.401	
Proportion of unemployed															
Low	74 (51.7%)	35 (24.5%)	34 (23.8%)	73 (51%)	39 (27.3%)	31 (21.7%)	67 (46.8%)	43 (30.1%)	33 (23.1%)	76 (53.1%)	33 (23.1%)	34 (23.8%)	88 (61.5%)	37 (25.9%)	18 (12.6%)
Moderate	53 (35.8%)	53 (35.8%)	42 (28.4%)	53 (35.8%)	58 (39.2%)	37 (25%)	52 (35.1%)	58 (39.2%)	38 (25.7%)	53 (35.8%)	57 (38.5%)	38 (25.7%)	37 (25%)	58 (39.2%)	53 (35.8%)
High	24 (17.8%)	47 (34.8%)	64 (47.4%)	20 (14.8%)	41 (30.4%)	74 (54.8%)	23 (17%)	43 (31.9%)	69 (51.1%)	18 (13.3%)	49 (36.3%)	68 (50.4%)	18 (13.3%)	48 (35.6%)	69 (51.1%)
P-value		< 0.001			< 0.001			< 0.001			< 0.001			< 0.001	
Proportion of female labor force participation															
Low	39 (27.3%)	40 (28%)	64 (44.7%)	38 (26.5%)	45 (31.5%)	60 (42%)	41 (28.7%)	36 (25.2%)	66 (46.1%)	33 (22.4%)	54 (37.8%)	56 (39.2%)	32 (22.4%)	50 (35%)	61 (42.7%)
Moderate	50 (35.2%)	49 (34.5%)	43 (30.3%)	49 (34.5%)	43 (30.3%)	50 (35.2%)	46 (32.4%)	56 (39.4%)	40 (28.2%)	48 (33.8%)	49 (34.5%)	45 (31.7%)	47 (33.1%)	47 (33.1%)	48 (33.8%)
High	62 (44%)	46 (32.6%)	33 (23.4%)	59 (41.8%)	50 (35.5%)	32 (22.7%)	55 (39%)	52 (36.9%)	34 (24.1%)	66 (46.8%)	36 (25.5%)	39 (27.7%)	64 (45.4%)	46 (32.6%)	31 (22%)
P-value		0.002			0.009			< 0.001			0.001			< 0.001	

Table 2
The proportional odds model fitted with the developmental vulnerability of children.

Variables (in proportions)	Scales	Odds (C.I.) in domains				
		Physical	Social	Emotional	Language and cognitive	Communication
Low income families	Moderate	3.31* (1.88, 5.83)	1.69 (0.97, 2.94)	1.86* (1.08, 3.21)	6.15* (3.40, 11.14)	2.78* (1.59, 4.83)
(Reference: Low)	High	5.21* (2.59, 10.51)	2.98* (1.48, 5.99)	2.52* (4.96, 1.28)	19.67* (9.24, 41.85)	3.39* (1.69, 6.79)
Single parent families	Moderate	1.45 (0.85, 2.46)	1.23 (0.72, 2.09)	1.44 (0.86, 2.42)	1.77* (1.02, 3.09)	1.27 (0.74, 2.19)
(Reference: Low)	High	2.97* (1.52, 5.77)	2.24* (1.15, 4.36)	2.39* (1.24, 4.59)	1.42 (0.72, 2.82)	1.69 (0.86, 3.32)
No Internet connection	Moderate	0.87 (0.48, 1.58)	1.38 (0.75, 2.52)	1.11 (0.62, 1.99)	1.37 (0.73, 2.58)	0.65 (0.35, 1.22)
(Reference: Low)	High	1.38 (0.65, 2.93)	1.88 (0.87, 4.06)	1.25 (0.59, 2.59)	2.22 (1.00, 4.93)	0.81 (0.38, 1.74)
Average wage (AUD$)	Moderate	1.14 (0.67, 1.95)	1.22 (0.72, 2.07)	0.95 (0.57, 1.58)	0.66 (0.39, 1.13)	1.16 (0.69, 1.94)
(Reference: Low)	High	0.98 (0.52, 1.84)	0.89 (0.48, 1.68)	0.82 (0.44, 1.52)	0.88 (0.45, 1.70)	1.83 (0.97, 3.45)
Unemployed	Moderate	0.74 (0.44, 1.25)	0.96 (0.58, 1.61)	0.87 (0.53, 1.43)	0.65 (0.38, 1.14)	3.15* (1.88, 5.27)
(Reference: Low)	High	0.77 (0.39, 1.51)	1.76 (0.90, 3.43)	1.43 (0.75, 2.73)	0.97 (0.49, 1.93)	3.87* (1.99, 7.52)
Female in labour	Moderate	1.09 (0.66, 1.81)	1.48 (0.89, 2.47)	1.05 (0.64, 1.72)	1.72* (1.02, 2.89)	0.89 (0.54, 1.47)
Force (Reference: Low)	High	1.55 (0.81, 2.95)	2.38 (1.22, 4.63)	1.66 (0.88, 3.15)	3.51* (1.74, 7.06)	0.88 (0.46, 1.69)

Table 3
Proportional odds model of developmental vulnerability of children fitted with IRSD.

Domains of vulnerability	Odds (C.I.)
Physical	0.983* (0.983 ~ 0.984)
Social	0.984* (0.983 ~ 0.984)
Emotional	0.987* (0.987 ~ 0.988)
Language and cognitive	0.981* (0.981 ~ 0.982)
Communication	0.984* (0.983 ~ 0.984)

the location; that is the greater the circle radius, the higher the score. That means, the bigger the circle, the higher the vulnerability and lower the ISRD. The five domains were illustrated in five maps sequentially, demonstrating the consistency of our results with ABS score ISRD. The maps also indicated the most vulnerable places in Australia for children to grow up.

4. Discussion

From the overall result, it is evident that financial status and family composition (single or couple) significantly affect the five domains of children's early development vulnerability. Participation of women in the job market significantly affect social and language and cognitive vulnerability of children. Language and cognitive development are also associated by the availability of Internet connection at home. Unemployment ratio in the locality is only significant in case of communication vulnerability. However, none of the domains is affected by average wage or salary income in the LGAs.

Income loss and lower financial status, neighborhood disadvantage and poverty-related stress affects all the family members, particularly early childhood development (Engle et al., 2011; Jiang, Ekono, & Skinner, 2015; Santiago, Wadsworth, & Stump, 2011). Children in poverty often face multiple risks, including inadequate and crowded living conditions; depleted and dangerous neighborhoods; inadequate schools; limited access to health care and childcare, which have important implications on long-term physical and mental health (Mistry, Benner, Biesanz, Clark, & Howes, 2010; Rogosch, Dackis, & Cicchetti, 2011). In our analysis, the local areas with higher low-income/welfare dependent families appeared to have greater amount of more vulnerable children in across five domains; which is consistent with individual respondent based research (Ridge, 2011).

Early childhood family environments represent vital links for understanding mental and physical health across the life span (Repetti, Taylor, & Seeman, 2002). Around 40% children all over the world experience parental divorce (Amato, 2000), which creates insecurity, and

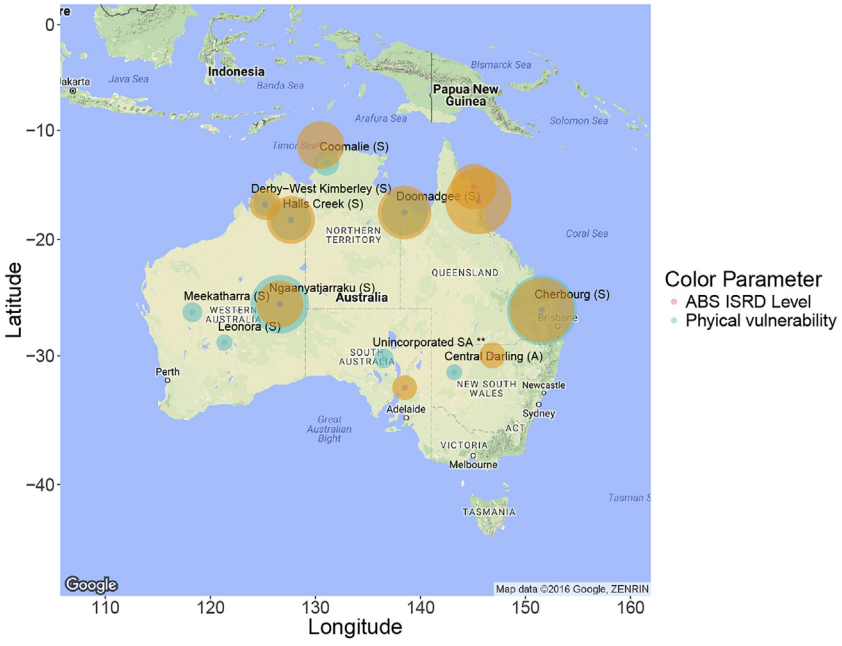

Fig. 1. Geographical position of areas with highest physical vulnerability and lowest IRSD.

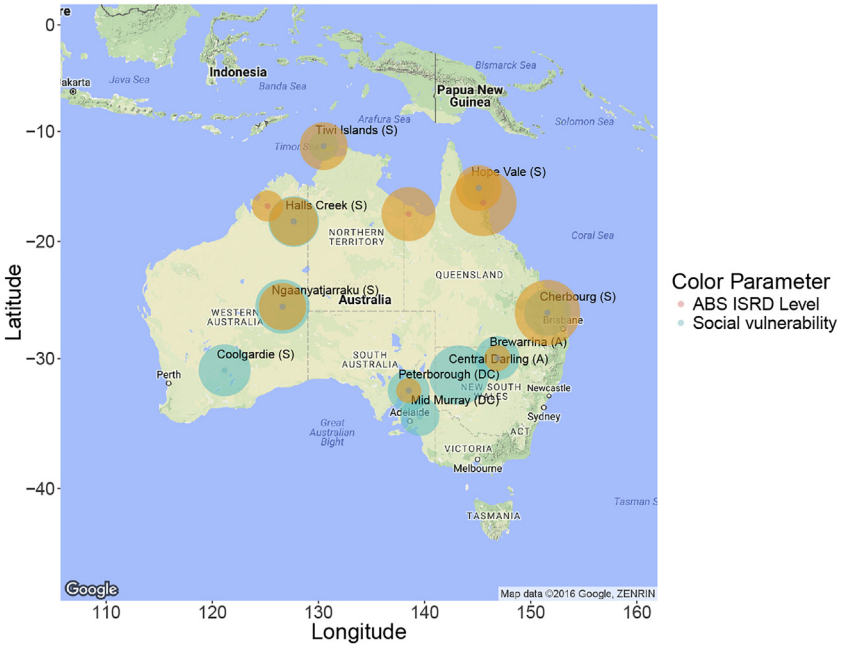

Fig. 2. Geographical position of areas with highest social vulnerability and lowest IRSD.

they are often victims of stress, social criticism and psychological control by the surroundings (Barber, 2002; Morris et al., 2002). In case of our area-based analysis, a similar conclusion was drawn, where we found that areas with a larger percentage of single parent families had higher amount of developmentally vulnerable children across all five domains, expect for communication vulnerability. Unfortunately, the number of single parent families is on the rise in Australia reaching up to 15% (961,000), and 67% of those families have dependents living with them (Australian Government, 2012). Moreover, 81% of the single parent families are led by mothers and female participation in the labor force is only 65.1%, which puts both psychological and financial burden on the single mothers (Australian Government, 2016b; Baxter & Alexander, 2008). This pressure on mothers subsequently affects the child's development (Li & Atkins, 2004; Turner, 2007).

The participation of women in the job market shows an interesting result. Children in areas where a higher proportion of women participate in the labor force were significantly affected in social (2.38 times) and language and cognitive (3.51 times) domains compared to other areas with low involvement of women in job sector. Explaining this complex scenario, Gerson (2010) showed the viewpoints of working mothers: “they want committed, enduring, and egalitarian partnerships that can help them fulfill their dual-centric (career and family) lifestyle. Yet... reality fails to live up to their ideals...”. The children are often caught between this work-family dilemma and ends up developmentally vulnerable. In a review, Moen, Mason, Ekman, Halpern, and Cheung (2010) showed that the balance between motherhood and high-powered careers is complex and often depends on the profession, while some women delay having a child. Literature in this area demonstrates that no ‘simple’ solution exists. Likewise, we found a dilemma in our results. The early vulnerabilities of children were highly associated by low-income status, family composition and the growing number of single mother families that encourages mothers to participate in the labor force. However, their involvement in career creates a vacuum in children's development process. This is a double-edged sword that cannot be solved by one policy or explained in one piece of research (Adda, Dustmann, & Stevens, 2017).

Internet access for children is growing fast (Soeters & Van Schaik, 2006; Valcke, Bonte, De Wever, & Rots, 2010), which brings concerns regarding its psychological effect (Gross, Juvonen, & Gable, 2002; Valcke, De Wever, Van Keer, & Schellens, 2011). While most studies showed the negative aspects of childhood exposure to computer and Internet use, Li and Atkins (2004) showed how early computer exposure before or during the preschool years is positively associated with development of preschool concepts and cognition among children; although frequency of usage did not generate any significant result. Jackson et al. (2006) concluded Internet users aged 10 to 18 years performed better in academic areas compared to the non-users. Our results show that early language and cognitive vulnerability in children is more prominent in areas with a higher percentage of homes with no Internet connection; suggesting that Internet, at the macro-level, works as a positive stimulant for cognitive development in children.

Parental unemployment adversely affects the children of a family; there is a risk of material, physical, educational and emotional stress on the developing stages of children due to inadequate income (Gershoff, Aber, Raver, & Lennon, 2007). Children's risk of behavioral and emotional problems is higher when parents are unemployed and so delinquent behaviors are common among them (Harland, Reijneveld, Brugman, Verloove-Vanhorick, & Verhulst, 2002). Children show improvement in the developmental spheres as they grow up; however, the effects of parental unemployment are never completely erased (Hetherington & Stanley-Hagan, 1999). Our result shows consistency with previous studies arguing that communication vulnerability of children was significant in areas with high unemployment rates.

Figs. 1 to 5 show the top 10 locations in Australia with highest physical, social, emotional, language and cognitive and communication vulnerability in children, along with 10 areas of lowest ISRD. The consistency of ISRD score with the various vulnerabilities were demonstrated spatially. However, there are some areas which were not at the bottom of the disadvantage list in ABS; for example, areas in South Australia and New South Wales displayed social vulnerability but were not the most vulnerable in the ISRD score (Fig. 2). Similarly, emotional vulnerability was prevalent in southern parts of Western Australia (Fig. 3). We suggest that instead of measuring the disadvantages in one scale or considering overall vulnerability of children, government policies should be implemented based upon different types of vulnerability as socioeconomic characteristics of all the vulnerabilities are not homogeneous.

The areas with low-income and fewer facilities tend to contain more vulnerable children. This is a much researched concept and our results are congruent with previous works (Galster & Santiago, 2006; Jaffee,

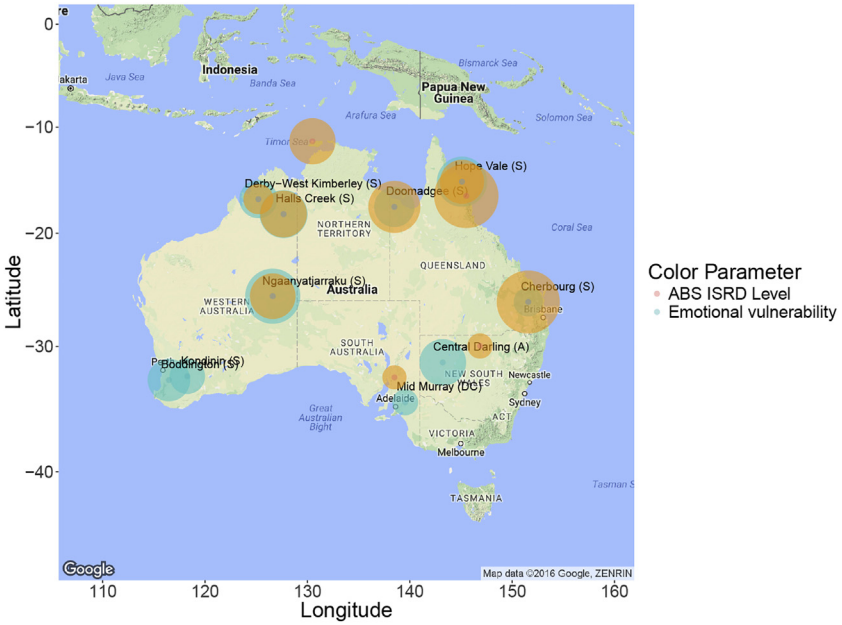

Fig. 3. Geographical position of areas with highest Emotional vulnerability and lowest IRSD.

Caspi, Moffitt, Polo-Tomas, & Taylor, 2007). A study on African-American children found that conduct disorders are strongest among children whose families were residing in the most disadvantaged neighborhoods (Brody et al., 2003). Wikström and Loeber (2000) showed that there exists a direct effect of neighborhood disadvantage on otherwise well-adjusted children, influencing them to be involved in serious criminal activities. These show the requirement of having a 'proper' environment for the upbringing of children preventing developmental vulnerability. Our conclusion agrees with a previous study (Mohanty et al., 2016), who found that the children's health outcomes are worse in remote parts of Australia.

Although the macro-level results of this study are consistent with previous research on individual-level outcomes and existing IRSD scores, care must be given while interpreting our results due to the borderline 'ecological fallacy'. As the aim of the study was to investigate the neighborhood disadvantage effect and due to lack of access to individual level data, our analyses were limited to only the macro-level risk factors. Along with the existing literature on micro-level risks, this result on overall Australian context confirms the need to further investigate the impact of neighborhood level risk factors, which is also important to ensure that the 'individual fallacy' is counterbalanced (Diez-Roux, 1998; Pearce, 2000). Furthermore, if micro-level data were available, future studies could fit a multi-level hierarchical model by considering individuals as level-one and provincial clusters as higher levels, which would adjust the underlying sources of variation at the area level.

The geographical results show that macro-level variation exists in childhood vulnerability and most of the vulnerable domains lie in remote areas, suggesting that the socioeconomic difference may have been an impact factor. However, more concise data of various cultures in same location is required to reach a more concrete conclusion. This study is further limited by the lack of data in some LGAs, which would

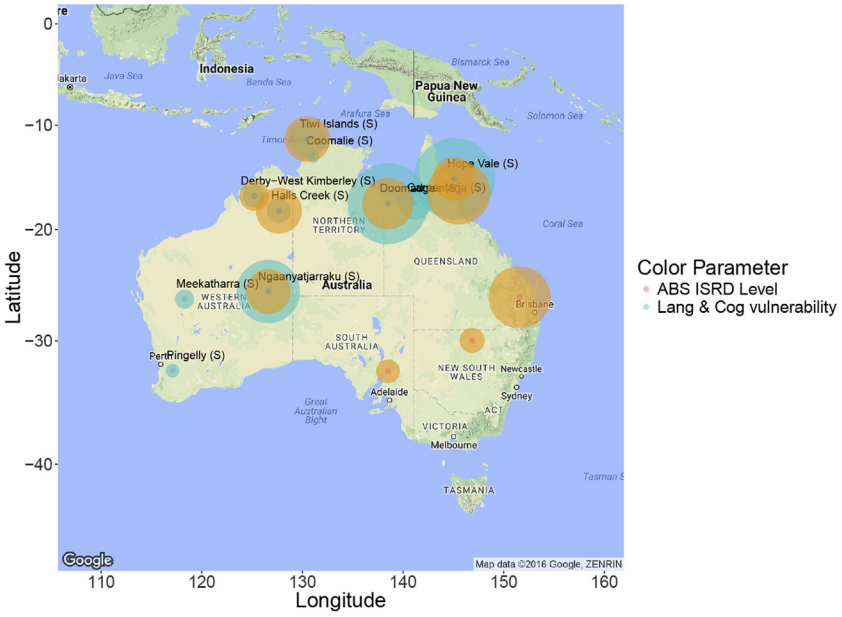

Fig. 4. Geographical position of areas with highest language and cognitive vulnerability and lowest IRSD.

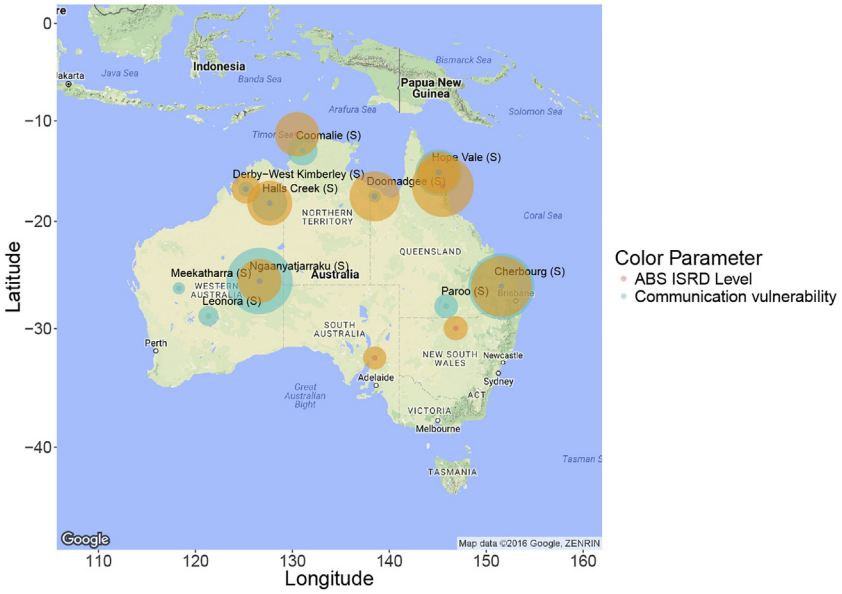

Fig. 5. Geographical position of areas with highest communication vulnerability and lowest IRSD.

have completed the whole scenario. Moreover, with a theoretical framework, future studies could collect information on local crime rates, population density, availability of mental health care centers, or distance from major urban zones, which might draw a complete picture.

5. Conclusion

This study analyzed the contribution of macro-level socioeconomic factors on the developmental vulnerability of children. It focused on five domains: physical, social, emotional, linguistic and cognitive, and communication. Local Government Areas (LGA) of Australia were taken as samples. The results suggest that areas with larger portion of low-income, welfare dependency and single parent families significantly affect all five vulnerable domains of children's early development. Several other aspects of early developmental outcomes were contributed (p values < 0.05 by women's participation in the labor market, availability of home Internet and unemployment rate in the locality. The impact of socioeconomic determinants varied over different domains of children's developmental vulnerability. The geographical analysis suggests the need for research on their vulnerabilities under multicultural atmosphere. The results match with the ABS's disadvantage index (IRSD). It is important for policymakers to consider the area-wise socioeconomic factors influencing specific vulnerability domains, which will ensure the best application of budget allocations.

Contributors

RK Biswas conceptualized the study, compiled the data, synthesized the analysis plan, performed statistical analysis and drafted the manuscript. The manuscript was critically reviewed and edited by E Kabir. All authors read and approved the manuscript.

Ethical standards

Conflict of interest

The authors declare that they have no competing interests.

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Ethical approval

The data is available online. Lenience for academic usage is available in: https://creativecommons.org/licenses/by-nc-sa/3.0/au/. The authors further contacted with the director of PHIDU for confirmation seeking permission which was granted.

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