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ORIGINAL ARTICLE

Prevalence and risk factors of gross motor delay in pre-schoolers

Sanne LC Veldman ,[1] Rachel A Jones,[1] Paul Chandler,[1] Leah E Robinson[2] and Anthony D Okely[1,3]

[1]Early Start, Faculty of Social Sciences, [3]Illawarra Health and Medical Research Institute, University of Wollongong, Wollongong, New South Wales, Australia and [2]School of Kinesiology, University of Michigan, Ann Arbor, Michigan, United States

Aim: Gross motor skills are important for children's health and development. Delays in these skills are a concern for healthy developmental trajectories and therefore early identification of delay is important. This study screened for gross motor delay in children from low-income communities and investigated potential risk factors associated with gross motor delay.

Methods: This cross-sectional study involved 701 pre-schoolers (M_{age} = 54.1 ± 8.6 months, 52.8% boys) from childcare services in low-income and remote communities in Australia. Gross motor delay was assessed using the Ages and Stages Questionnaire – third edition. Potential risk factors included: sex, age, birthweight, prematurity status, weight status, childcare service, postcode, parent's education, parent's marital status, parent's employment and family income.

Results: Results showed 4.4% of the children were delayed in gross motor skills and 8.8% were at risk of delay. Logistic regression showed being a boy (odds ratio (OR) 1.78, 95% confidence interval (CI) 1.12–2.84), underweight (OR 2.72, 95% CI 1.18–6.30) or overweight (OR 1.83, 95% CI 1.00–3.33), and parental unemployment (OR 1.79, 95% CI 1.01–3.16) were factors associated with a higher odds of children being delayed or at risk of gross motor delay. A higher family income (OR 0.35, 95% CI 0.13–0.93) was associated with lower odds of delay.

Conclusion: This unique study demonstrated children in low-income communities, especially boys, underweight and overweight children, have higher odds of being at risk of gross motor delay. Therefore, early screening is vital in this population in order to identify delays and potentially intervene with appropriate motor skill interventions.

Key words: children; developmental delay; motor development; screening.

What is already known on this topic

1. Gross motor skill development is important for health and development.
2. Delays in gross motor skills are concerning.
3. Limited studies are available on the prevalence of motor delays and these differ by country and age

What this paper adds

1. This study reports prevalence rates of gross motor delays in pre-school-aged children in low-income communities in Australia with a high proportion of Australian Aboriginal children.
2. This study reports on socio-demographic risk factors associated with motor delay in these communities; being a boy, being underweight or overweight, parental unemployment or a lower family income.
3. This study suggests early screening is vital in order to identify delays and potentially intervene with appropriate motor skill interventions.

Poor gross motor skill competency among children is a growing concern, as gross motor skills are an important contributor to healthy growth and development.[1–3] Gross motor skills are seen as the building blocks of advanced motor behaviour and sport-specific skills.[4] They can be divided into locomotor skills (e.g. jumping and running), object control skills (e.g. catching and kicking) and stability or balance skills. Gross motor skills have been linked to several positive outcomes such as improved cognitive abilities, better cardio-respiratory fitness, higher self-perceptions, increased physical activity and better weight status.[1–3] Additionally, motor development is one of the key domains of early learning and development together with cognitive and social–emotional development which are essential for school readiness and contribute to long-term academic success and well-being.[5]

Given the significant role of gross motor skills for children's health and development, delays in the normal developmental trajectories of these skills are a cause for concern. Early screening may be beneficial in identifying gross motor delays and for potential intervention. Both in Australia and internationally, limited

Correspondence: Dr Sanne LC Veldman, Child Health and Care Research, Department of Public and Occupational Health, Amsterdam Public Health Research Institute, Amsterdam UMC, Van der Boechorststraat 7, 1081 BT Amsterdam, The Netherlands; email: s.veldman1@amsterdamumc.nl

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data are available on the prevalence of gross motor delays in typically developing children, with most screening studies focusing on children with additional needs (e.g. cerebral palsy or autism). In Norway, the highest prevalence of developmental delay among typically developing children was in gross motor skills (9% at age 12 months) compared to communication, problem-solving or fine motor skills.[6] Three studies conducted in Iran (age range 4–60 months) reported between 3 and 6% of children were delayed in gross motor skills.[7–9] In Ghana, 7% of the 330 children screened were delayed in the gross motor domain and in France, this was 5% (age 36 months).[10] Saccani *et al*. concluded that 11% of the 184 children aged 13–18 months were delayed in their motor development.[11] A study conducted in China reported 11% of children aged 24–35 months were delayed or at risk of delay.[12] Overall, between 3 and 11% of the children in these studies demonstrated gross motor delay.

Within Australia, the Australian Early Development Census collects nationwide data to track the development of young Australian children when they enter school.[13,14] This census consists of five domains: physical health and wellbeing, social competence, emotional maturity, language and cognitive skills, and communication skills and general knowledge. The physical health and wellbeing domain comprises 12 items covering how ready (e.g. well-dressed), healthy (e.g. hungry, tired or sick) and independent (e.g. toileting habits) a child is to cope with a school day as well as their gross (e.g. ability to climb stairs) and fine (e.g. holding a pen) motor skills. Data are collected via questionnaires by the child's classroom teacher. Results from 2015 show 22.7% (n = 64 458) of children (aged 5 years) were either developmentally 'at risk' or 'vulnerable' in the domain of physical wellbeing and health. However, what part of these results can be attributed to gross motor delay specifically is unknown.

In addition to the importance of early screening for gross motor delay, it is also essential to examine the potential risk factors that may contribute to gross motor delays. Factors associated with gross motor delay among typically developing children aged 0–5 years include in part, child characteristics (e.g. low birthweight[11] and prematurity[11,15,16]) and family characteristics (e.g. low parental education[11,16] and low familial socio-economic status[11,12]). One of the publications resulting from the Australian Early Development Census data examined socio-demographic factors associated with the physical health and wellbeing domain in the Northern Territory.[17] This is a region of Australia with a high proportion of children from Aboriginal backgrounds. Results showed that being of Australian Aboriginal descent, having English as their second language, not attending day care or preschool, mother's smoking during pregnancy and a lower care giver's educational level was associated with higher odds of developmental vulnerability.[17] Similar results were observed in a study showing over half of Australian Aboriginal children are considered to have developmental vulnerabilities limiting their school readiness at age 5.[18] These findings provide an example of how young Aboriginal children have been left behind and are experiencing developmental delay in their own country. It is therefore important to examine if these patterns also exist in other states.

Studies investigating both prevalence and risk factors of gross motor delay are scarce, especially in low-income communities and communities with a high proportion of people from Australian Aboriginal descent. Given the higher prevalence of developmental delay (including motor delay) in these communities, further research is needed. Therefore, this study screened for gross motor delay in children from low-income communities in Australia and investigated the presence of selected socio-demographic risk factors and their associations with motor delay in these communities.

Methods

The study involved 34 early childhood education and care services from low-income communities situated across New South Wales and the Australian Capital Territory. A number of these services had high proportions of children from Australian Aboriginal descent. These services were selected based on recognised indexes for socio-economic disadvantage and early development.[19] All children attending these services aged 3–5 years on the dates of data collection were eligible and invited to participate. Data were collected during scheduled weeklong visits at the early childhood education and care services between October 2014 and April 2015. Data collectors undertook 3 days of training and practice in standardised measurement procedures, protocols and appropriate communication skills for working with preschool-aged children and families from these communities.

The gross motor skill subtest of the Ages and Stages Questionnaire (ASQ), third edition,[21] was used to screen for motor delay (age categories 36, 42, 48, 54 and 60 months). This is a valid (sensitivity 82.5–89.2% and specificity 77.9–92.1%) and reliable (test–retest reliability coefficients 0.75–0.82 and inter-rater reliability coefficients 0.43–0.69) screening tool that covers 21 age groups from 1 month to 5.5 years.[22] The ASQ was considered the most cost-effective and appropriate tool to screen for gross motor delays in this large sample as it is easy to administer, requires little training for data collectors, little equipment and has a short duration to complete. The gross motor skill subtest consists of six items that were administered by trained data collectors instead of answered by parents. Examples of items include 'Does your child jump with both feet leaving the floor at the same time?', 'Does your child catch a large ball with both hands?' and 'Does your child walk on his tiptoes for 15 feet?'. Children were assessed individually and preferably in a space/room with less distractions (e.g. on the outside playground while the other children were inside). Children scored points based on ability to complete an item: 10 points = yes, 5 points = sometimes and 0 points = not yet. Using the manual, the sum of scores was converted into an age-specific 'risk of delay': 1 = developmental delay, 2 = at risk for developmental delay, and 3 = on track developmentally.

Height was measured to the nearest 0.1 cm using a Seca 217 portable stadiometer. The child was positioned fully upright without shoes and with their head in the Frankfort Plane. The average of two measurements was used for analysis. Weight was measured to the nearest 0.1 kg using a portable Seca 874 Scale. The child wore light clothing while heavy coats, heavy pocket items and shoes were removed. The average of two measurements was used for analysis. Body mass index (body mass (kg)/ height (m^2)) was calculated using the height and weight measures. The proportion on children classified as underweight, normal, overweight and obese was based on the international (IOTF) childhood BMI cut-offs.[23,24]

Parents were asked to complete a questionnaire to gather information on both their child's and their own demographics. The questionnaire could be completed on paper, online, face-to-face interview, or over the phone and took approximately 20 min to complete. The following variables from the questionnaire were included in this study as these are considered to be related to developmental and/or motor delay: child's sex, date of birth (age), Aboriginal status, child's birthweight, prematurity status, childcare service, postcode (the Index of Relative Socio-economic Disadvantage category), parent's education, parent's marital status, parent's employment and family income.

SPSS version 21 (IBM Corp, Armonk, NY, USA) and STATA version 13 (StataCorp, College Station, TX, USA) were used for analysis. Descriptive analyses were completed in SPSS. Children with developmental delay or who were at risk of developmental delay were grouped together for analyses examining associations since potential gross motor skill interventions would target both groups. This new group was referred to as 'At risk of delay or delayed'. Associations were examined using survey logistic procedures in STATA to allow for clustering by childcare services, which was the unit of recruitment. All selected variables were examined for independent associations with being at risk of gross motor delay using multilevel logistic regression models. Logistic regression models were then adjusted for sex and age since they are known to have an influence on gross motor skills. The significance level was set at $P < 0.05$. Ethics approval was obtained from the University of Wollongong Human Research Ethics Committee (HE14/015). Prior to data collection, all participants and main care givers of underage participants gave written informed consent and all underage participants assented. Reporting was done following the STROBE Statement.[20]

Results

Across the 34 early childhood education and care services consent forms were collected from 802 out of 1525 eligible children (52.6%) and eventually 701 (87.4%) children were included in this study. There were slightly more boys than girls (n = 370, 52.8%, mean age = 54.1 ± 8.6 months). Almost one third of the children was identified as being of Australian Aboriginal descent (n = 232, 33.1%). Most children had normal birthweight (n = 175, 82.5%) and weight status (n = 536, 77.9%; Table 1).

Results showed that 4.4% of the children were delayed and 8.8% were at risk of gross motor delay, meaning 13.2% of the children were not on track developmentally. Within the group who were delayed or at risk of delay, 64.5% were boys and 43.0% were identified as being of Australian Aboriginal descent. The sample of respondent parents represented ~40% of the total included children with most data missing from families living in the most remote areas. Around one third of parents had an income that was below the national average (<$49 999, 31.4%), one fourth had a highest education level of grade 10 or equivalent (22.8%) and 37% of the parents reported being unemployed).

Logistic regression revealed higher odds of being delayed or at risk of gross motor delay for sex, weight status, family income and employment status after adjusting for age and/or sex (Table 2). Boys were 78% more likely to be delayed or at risk of motor delay compared to girls (odds ratio (OR) 1.78, 95% confidence interval (CI) 1.19–2.84) as well as children who were underweight (OR 2.72, 95% CI 1.18–6.30) or overweight (OR 1.83, 95% CI 1.00–3.33). Parental unemployment was also associated with higher odds at delay (OR 1.79, 95% CI 1.01–3.16). Higher family income was associated with lower odds of gross motor delay (OR 0.35, 95% CI 0.13–0.93).

Discussion

The aim of this study was to screen for gross motor delay in socially disadvantaged and low-income communities in Australia. Results revealed approximately 13% of the children assessed were not on track developmentally for gross motor skills. Two other studies were conducted in similar settings, being low-income communities, and used the ASQ to screen for gross motor delay. These studies reported 15% of the children aged 3–5 months[16] and 11% of the children aged 24–35 months[12] were not on track developmentally. In Brazil, the Alberta Infant Motor Scale was used to assesses motor development in children aged 13–18 months.[11] They reported 18% of the children were not on track developmentally. Literature shows the prevalence of gross motor delay decreases with age,[11,12] implying results from the current study are higher than expected and compared to the other studies. Even though some studies report comparable results, the children in these studies were either younger compared to our participants (e.g. 3–5 months) or a lower percentage was not on track developmentally (13 vs. 11%). A few studies only reported the percentage of children who were delayed in gross motor skills. Prevalence rates in these studies varied between 3 and 5% and the age range was between 4 and 60 months.[6–10] All of these studies used the ASQ, second or third edition, to assess gross motor delay. Our results show that 4.4% of the children were delayed in gross motor skills and results are therefore comparable.

In this study, boys were more delayed compared to girls (Table 2). Overall boys have higher odds than girls to experience developmental delays in one or more areas (e.g. language, cognition, social, fine or gross motor skills),[17,25,26] but no sex differences have been reported before in the area of gross motor skills.[6–8,12] A potential explanation could be the presence of sex differences in gross motor skill development in pre-school-aged children. Literature shows boys tend to outperform girls in ball skills,[27–29] whereas girls seem to perform better at locomotor skills[28,29] and balance skills.[30,31] Most screening tools, including the ASQ, are not suitable for examining differences between types of skills as these are not tested separately. However, when examining the items that make up the gross motor skills subtest (two questions per category: ball skills, locomotor skills and balance skills), girls might have an advantage in four of the six items.

Our findings indicate that children who were underweight have higher odds of being at risk of gross motor delay. Only a few studies have investigated weight status in relation to developmental delay and these studies indicated underweight children have higher odds of developmental delay due to an inadequate nutritional intake.[32,33] Explanations include financial restrictions or availability for healthy food in remote areas. However, further research is needed to explain these results.

Table 1 Child and family characteristics and Ages and Stages Questionnaire (ASQ) outcomes: Descriptive data

Variable	Units of analysis	Total, *n* (%)	On track developmentally, *n* (%)	At risk of delay or delayed, *n* (%)
ASQ score (*n* = 701)	On track developmentally	608 (86.7)		
	At risk of gross motor delay	62 (8.8)		
	Delayed	31 (4.4)		
	At risk of delay or delayed	93 (13.3)		
Sex (*n* = 701)	Girls	331 (47.2)	298 (49.0)	33 (35.5)
	Boys	370 (52.8)	310 (51.0)	60 (64.5)
Aboriginal status (*n* = 700)	Not Aboriginal	468 (66.8)	415 (68.4)	53 (57.0)
	Aboriginal	232 (33.1)	196 (31.6)	40 (43.0)
Weight status (*n* = 688)	Underweight (grade −2 and −1)	32 (4.7)	24 (4.0)	8 (9.0)
	Normal weight (grade 0)	536 (77.9)	477 (79.6)	59 (66.3)
	Overweight (grade 1 and 2)	120 (17.4)	98 (16.4)	22 (24.7)
Birthweight (*n* = 212)	Low birthweight (<2500 g)	20 (9.4)	17 (9.0)	3 (13.0)
	Normal birthweight (2500–4200 g)	175 (82.5)	158 (83.6)	17 (74.0)
	High birthweight (>4200 g)	17 (8.0)	14 (7.4)	3 (13.0)
Prematurity status (*n* = 269)	No	241 (89.6)	212 (89.8)	29 (87.9)
	Yes	28 (10.4)	24 (10.2)	4 (12.1)
IRSD category (*n* = 286)	<927	61 (21.3)	53 (21.2)	8 (22.2)
	927–965.8	66 (23.1)	57 (22.8)	9 (25.0)
	965.8–1001.8	109 (38.1)	94 (37.6)	15 (41.7)
	>1001.8	50 (17.5)	46 (18.4)	4 (11.1)
Marital status (*n* = 280)	Never married, single parent	42 (15.0)	33 (13.4)	9 (26.5)
	Separated, divorced or widowed	31 (11.1)	28 (11.4)	3 (8.8)
	Never married/Married, live with partner	207 (73.9)	185 (75.2)	22 (64.7)
Education level (*n* = 281)	Primary school, year 10 or equivalent	64 (22.8)	55 (22.4)	9 (25.7)
	Year 12 or equivalent	51 (18.1)	41 (16.7)	10 (28.6)
	Trade/Apprenticeship/Certificate or diploma	77 (27.4)	68 (27.6)	9 (25.7)
	University degree or post-graduate qualification	89 (31.7)	82 (33.3)	7 (20.0)
Income (*n* = 264)	$AUS 0–49 999	83 (31.4)	67 (28.9)	16 (50.0)
	$AUS 50000–74 999	47 (17.8)	42 (18.1)	5 (15.6)
	$AUS 75000 or more	134 (50.8)	123 (53.0)	11 (34.4)
Employment (*n* = 281)	Employed	177 (63.0)	159 (64.6)	18 (51.4)
	Not employed	104 (37.0)	87 (35.4)	17 (48.6)

IRSD, the Index of Relative Socio-economic Disadvantage.

Family characteristics that have an influence on gross motor delay in this sample include parental income and employment status. This is in line with literature supporting associations between a low socio-economic background and gross motor delays[11,12] as well as developmental delays.[25,34] Childhood poverty can limit the amount of available resources (e.g. toys) and opportunities for children to develop motor skills.[35] Additionally, it can cause stress within the household which has a negative influence on a child's development and the amount of meaningful and functional learning experiences during parent–child interactions.[35]

This study included a high proportion of Australian Aboriginal children (~33%) compared to the nationwide average (12.4% of children 0–4 years).[36] Even though results were not significant, it is worth mentioning 43% of the children identified as being at risk of delay or delayed in gross motor skills were of Australian Aboriginal descent. This percentage is higher than the representation of Australian Aboriginal children in this study population. Communities with a high proportion of Aboriginal families could potentially benefit from early screening as this is a developmental outcome that Australia has committed to in closing the gap between Aboriginal and non-Aboriginal children.[37] Providing adequate resources to support the development of gross motor skills among Aboriginal children should however be guided by the community and be culturally appropriate.

The strengths of this study include the unique sample of pre-school-aged children from socially disadvantaged and low-income communities across New South Wales and Australian Capital Territory; specifically, the high proportion of Australian Aboriginal children. It is one of few studies to investigate the prevalence of motor delay and the associated risk factors in low-income populations. Additionally, the ASQ was administered by trained data collectors rather than parents which has contributed to a more reliable and valid outcome of motor delay. For future studies, it would be interesting to compare scores between data collectors and parents to examine perceptions of competence.

The limitations of this study include the cross-sectional design, the use of US-based norms for the ASQ-3 and the low

Table 2 Child and family characteristics associated with the likelihood of being delayed or at risk of gross motor delay

Variable	Unadjusted		Adjusted‡	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Sex				
Girls (reference)				
Boys	1.75 (1.094–2.793)	0.021*	1.78 (1.119–2.836)†	0.017*
Aboriginal status				
Not Aboriginal (reference)				
Aboriginal	1.63 (0.893–2.979)	0.108	1.63 (0.986–2.961)	0.107
Weight status				
Normal weight (reference)				
Underweight	2.70 (1.139–6.374)	0.025*	2.72 (1.178–6.297)	0.021*
Overweight	1.82 (0.988–3.3320	0.054	1.83 (1.000–3.330)	0.050*
Birthweight				
Normal birthweight (reference)				
Low birthweight	1.64 (0.470–5.719)	0.425	1.99 (0.548–7.229)	0.285
High birthweight	1.99 (0.522–7.595)	0.302	1.62 (0.388–6.795)	0.494
Prematurity status				
No (reference)				
Yes	0.82 (0.216–3.114)	0.765	0.74 (0.181–3.064)	0.673
IRSD category				
<927 (reference)				
927–965.8	1.05 (0.253–4.322)	0.949	1.19 (0.278–5.050)	0.813
965.8–1001.8	1.06 (0.355–3.147)	0.918	1.12 (0.337–3.729)	0.848
>1001.8	0.58 (0.137–2.421)	0.439	0.52 (0.127–2.169)	0.361
Marital status				
Never married, single parent (reference)				
Separated, divorced or Widowed	0.39 (0.107–1.436)	0.152	0.40 (0.115–1.382)	0.141
Never married/Married, live with partner	0.44 (0.167–1.137)	0.087	0.42 (0.156–1.105)	0.077
Education level				
Primary school, year 10 or equivalent (reference)				
Year 12 or equivalent	1.49 (0.465–4.778)	0.490	1.50 (0.459–4.907)	0.490
Trade/Apprenticeship/Certificate or diploma	0.81 (0.196–3.334)	0.762	0.79 (0.199–3.138)	0.729
University degree or post-graduate qualification	0.52 (0.179–1.518)	0.223	0.51 (0.168–1.567)	0.232
Total family income				
$0–49 999 (reference)				
$50 000–74 999	0.50(0.129–1.925)	0.301	0.49 (0.134–1.755)	0.260
$75 000 or more	0.37 (0.144–0.971)	0.044*	0.35 (0.133–0.929)	0.036*
Employment				
Employed (reference)				
Not employed	1.73 (0.991–3.006)	0.054	1.79 (1.012–3.156)	0.046*

*$P < 0.05$. †Adjusted for age. ‡Adjusted for age and sex. CI, confidence interval; IRSD, the Index of Relative Socio-economic Disadvantage; OR, odds ratio.

proportion of parents completing the questionnaire. The sample of respondent parents represented ∼40% of the total included children with most data missing from families with the lowest socio-economic background and/or those living in the most remote areas. The low response rates and ASQ-3 norms used mean results regarding associations should be viewed with caution in this sample of Australian children from low-income communities.

Conclusion

This study was unique in reporting prevalence and risk factors associated with gross motor delay in socially disadvantaged, low-income and remote communities. Results show especially boys, underweight and overweight children, and children from low-income families and unemployed parents have higher odds to be at risk of gross motor delay and can guide policy on where to invest in early screening and potential interventions. We recommend implementing early screening programmes for gross motor delay in socially disadvantaged and low-income communities. Early identification will enable the possibility for effective interventions that can prevent children from being behind on their peers when entering primary school and could prevent or minimise further delay. This will in turn improve children's and their family's health and well-being and promotes positive development.

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References

1 Robinson LE, Stodden DF, Barnett LM *et al*. Motor competence and its effect on positive developmental trajectories of health. *Sports Med.* 2015; **45**: 1273–84.
2 Lubans DR, Morgan PJ, Cliff DP, Barnett LM, Okely AD. Fundamental movement skills in children and adolescents: Review of associated health benefits. *Sports Med.* 2010; **40**: 1019–35.
3 van der Fels IM, Te Wierike SC, Hartman E *et al*. The relationship between motor skills and cognitive skills in 4–16 year old typically developing children: A systematic review. *J. Sci. Med. Sport* 2015; **18**: 697–703.
4 Payne VG, Isaacs LD. *Human Motor Development: A Lifespan Approach*, 9th edn, 438. Scottsdale, Arizona: McGraw-Hill Education; 2016.
5 Office of Head Start. *Head Start Early Learning Outcomes Framework: Ages Birth to Five*. In: Administration for Children and Families, ed. Washington, DC: US Department of Health and Human Services; 2015.
6 Valla L, Wentzel-Larsen T, Hofoss D, Slinning K. Prevalence of suspected developmental delays in early infancy: Results from a regional population-based longitudinal study. *BMC Pediatr.* 2015; **15**: 215.
7 Sajedi F, Vameghi R, Kraskian Mujembari A. Prevalence of undetected developmental delays in Iranian children. *Child Care Health Dev.* 2014; **40**: 379–88.
8 Yaghini O, Kelishadi R, Keikha M *et al*. Prevalence of developmental delay in apparently normal preschool children in Isfahan, Central Iran. *Iran J. Child Neurol.* 2015; **9**: 17–23.
9 Ghazavi Z, Abdeyazdan Z, Shiravi E *et al*. Developmental skills of 36-60-month-old children in Isfahan daycare centers in 2013. *Iran. J. Nurs. Midwifery Res.* 2015; **20**: 594–8.
10 Troude P, Squires J, L'Helias LF *et al*. Ages and Stages Questionnaires: Feasibility of postal surveys for child follow-up. *Early Hum. Dev.* 2011; **87**: 671–6.
11 Saccani R, Valentini NC, Pereira KR, Müller AB, Gabbard C. Associations of biological factors and affordances in the home with infant motor development. *Pediatr. Int.* 2013; **55**: 197–203.
12 Wei QW, Zhang JX, Scherpbier RW *et al*. High prevalence of developmental delay among children under three years of age in poverty-stricken areas of China. *Public Health* 2015; **129**: 1610–7.
13 Brinkman SA, Gregory TA, Goldfeld S, Lynch JW, Hardy M. Data resource profile: The Australian early development index (AEDI). *Int. J. Epidemiol.* 2014; **43**: 1089–96.
14 Sayers M, Coutts M, Goldfeld S, Oberklaid F, Brinkman S, Silburn S. Building better communities for children: Community implementation and evaluation of the Australian early development index. *Early Educ. Dev.* 2007; **18**: 519–34.
15 Kerstjens JM, de Winter AF, Bocca-Tjeertes IF, ten Vergert EMJ, Reijneveld SA, Bos AF. Developmental delay in moderately preterm-born children at school entry. *J. Pediatr.* 2011; **159**: 92–8.
16 Bello AI, Quartey JNA, Appiah LA. Screening for developmental delay among children attending a rural community welfare clinic in Ghana. *BMC Pediatr.* 2013; **13**: 119.
17 Guthridge S, Li L, Silburn S, Li SQ, McKenzie J, Lynch J. Early influences on developmental outcomes among children, at age 5, in Australia's Northern Territory. *Early Child Res. Q.* 2016; **35**: 124–34.
18 Silburn S, McKenzie J, Moss B. *Northern Territory results for the Australian Early Development Index 2009*. Darwin: Menzies School of Health Research & Northern Territory; 2010.
19 Australian Bureau of Statistics. *Socio-Economic Indexes for Areas (SEIFA)*. Canberra: The Bureau; 2013.
20 von Elm E, Altman DG, Egger M *et al*. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. *J. Clin. Epidemiol.* 2008; **51**: 344–9.
21 Squires J, Bricker D. *Ages & Stages Questionnaires (ASQ-3): A Parent-Completed Child-Monitoring System*. Baltimore, MD: Brookes Publishing Company; 2009.
22 Squires J, Twombly E, Bricker D, et al. *ASQ-3 Technical Report*. Baltimore, MD: Brookes Publishing Company; 2009.
23 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ* 2000; **320**: 1240–3.
24 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr. Obes.* 2012; **7**: 284–94.
25 To T, Guttmann A, Dick PT *et al*. Risk markers for poor developmental attainment in young children: Results from a longitudinal national survey. *Arch. Pediatr. Adolesc. Med.* 2004; **158**: 643–9.
26 Nishimura T, Takei N, Tsuchiya KJ, Asano R, Mori N. Identification of neurodevelopmental trajectories in infancy and of risk factors affecting deviant development: A longitudinal birth cohort study. *Int. J. Epidemiol.* 2016; **45**: 543–53.
27 Barnett LM, Lai SK, Veldman SL *et al*. Correlates of gross motor competence in children and adolescents: A systematic review and meta-analysis. *Sports Med.* 2016; **46**: 1663–88.
28 Hardy LL, King L, Farrell L, Macniven R, Howlett S. Fundamental movement skills among Australian preschool children. *J. Sci. Med. Sport* 2010; **13**: 503–8.
29 Okely AD, Booth ML. Mastery of fundamental movement skills among children in New South Wales: Prevalence and sociodemographic distribution. *J. Sci. Med. Sport* 2004; **7**: 358–72.
30 Venetsanou F, Kambas A. The effects of age and gender on balance skills in preschool children. *Phys. Educ. Sport* 2011; **9**: 81–90.
31 Krombholz H. Physical performance in relation to age, sex, birth order, social class, and sports activities of preschool children. *Percept. Mot. Skills* 2006; **102**: 477–84.
32 Abubakar A, Holding P, Van de Vijver FJ, Newton C, Van Baar A. Children at risk for developmental delay can be recognised by stunting, being underweight, ill health, little maternal schooling or high gravidity. *J. Child Psychol. Psychiatry* 2010; **51**: 652–9.
33 Halpern R, Giugliani ERJ, Victora CG, Barros FC, Horta BL. Risk factors for suspicion of developmental delays at 12 months of age. *J. Pediatr. (Rio J)* 2000; **76**: 421–8.
34 Najman JM, Bor W, Morrison J, Andersen M, Williams G. Child developmental delay and socio-economic disadvantage in Australia: A longitudinal study. *Soc. Sci. Med.* 1992; **34**: 829–35.
35 Shonkoff JP, Phillips DA. *From Neurons to Neighborhoods: The Science of Early Childhood Development*, 612. Washington, DC: National Academy Press; 2000.
36 Australian Institute of Health and Welfare, ed. *The Health and Welfare of Australia's Aboriginal and Torres Strait Islander Peoples: 2015*. Canberra: The Institute; 2015.
37 Commonwealth of Australia and Department of the Prime Minister and Cabinet. *Closing the Gap Prime Minister's Report*. Canberra, ACT: Department of Prime Minister and Cabinet; 2018.