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Longitudinal developmental profile of children from low socio-economic circumstances in Cape Town, using the 1996 Griffiths Mental Development Scales

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Abstract

Background—The Griffiths Mental Development Scales (GMDS) have not been standardised in South African children Neurodevelopmental scores of infants from deprived environments decline with age, but there is no evidence on how young South African children from such backgrounds perform on serial assessments.

Aim—To describe the longitudinal developmental profile of infants from low socio-economic backgrounds at Tygerberg Children's Hospital by comparing the GMDS scores performed at 10 - 12 months and 20 - 22 months.

Methods—Infants born to HIV-uninfected women attending the public service programme were recruited from a vaccine study in Cape Town, South Africa. The GMDS 0 - 2 years and a

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neurological examination were performed between 10 and 12 months and between 20 and 22 months.

Results—Thirty-one infants (14 girls, 17 boys) were assessed. Their mean (standard deviation (SD)) age was 11.6 (0.8) months and 21.0 (0.5) months at the first and second assessments, respectively. The mean (SD) general quotient decreased significantly from 107.3 (11.7) to 95.0 (11.0) ($p<0.001$). All sub-quotients decreased significantly except for locomotor. The hearing and language sub-quotient was most affected, with a decrease in mean quotients from 113.0 to 93.2 ($p<0.001$). There was no evidence of intercurrent events to explain the decline.

Interpretation—Scores on the GMDS of this group of children from low socio-economic backgrounds were normal at 11 months and, other than locomotor, decreased significantly at 21 months, with language the most affected. Further research is needed to determine the specific reasons for the decline.

The neurodevelopment of the young child is influenced by genetic determinants, the environment and both physical and emotional well-being.[1,2] Each child has a unique combination of factors that can influence the rapidly developing brain. Previous studies have shown that the home environment has a greater impact on development in the second year of life than in the first[3] and that socio-economic status has a greater influence than culture. In a multicultural society, cultural influences should also be recognised.[4] In addition, within the same socio-economic strata, maternal well-being and characteristics may have an effect.[3,5]

In the context of neurodevelopmental research in southern Africa, there may be specific influences on the sub-group of children under study that impact on developmental profiles. Tools for assessing early childhood development are limited in predicting long-term outcomes.[6] Since many tests have been normalised in developed countries, local physicians should understand the nuances and should know if these tests remain consistent for different ages. For example, previous studies from Cape Town showed a lower developmental profile in children from low socio-economic groups when compared with expected norms.[7,8]

The Griffiths Mental Development Scales (GMDS) are widely used in young South African children. There are five different sub-scales. The locomotor sub-scale measures the earliest motor milestones as the child moves from horizontal to vertical and becomes mobile. The personal-social sub-scale assesses early adaptive behaviour using interaction with the environment and skill in dressing and feeding as well as pointing out body parts as the child approaches 2 years of age. This sub-scale uses caregiver reports. The hearing and language sub-scale measures the earliest forms of expressive language such as babbling, the development of words with meaning, and receptive speech through the ability to follow commands and identify objects. The eye-hand co-ordination sub-scale measures the development of hand grasp, fine motor and visual abilities. The performance sub-scale measures fine motor manipulative skill as well as visual spatial orientation.

Although the GMDS has not been standardised for South African children, it has been extensively studied in numerous postgraduate dissertations. South African researchers have contributed to restructuring the items on the latest editions to make them more culturally fair. Scores show good correlation with British children from different race and language groups.[9] Unfortunately, results have not been published in peer-reviewed journals. One South African validation study on 45 black children (5 - 7 years) found the mean performance comparable to that of the original (1960) British normative sample.[10] There was a significant positive correlation between the general quotient and school performance, and no difference between children from higher or lower socio-economic groups. The inter-correlations between the Junior South African Intelligence Scales and the GMDS range from high to moderate.[11] Allan *et al.*[9] found that among 60 white 5-year-old normal preschool

South African children, upper-class children performed significantly better than middle- and lower-class children on the hearing and language, eye-hand co-ordination and performance sub-scales compared with British children. Using common factor analysis, Luiz *et al.*[12] showed that the GMDS tends to measure a single factor. When only common variables were included, the factor appeared to be similar across 430 South African children from four ethnic groups (white, mixed race, Asian and black). These studies used older versions of the GMDS 2 - 8 years.

The GMDS is made up of two separate scales, the GMDS 0 - 2 years[13] and the GMDS-ER 2 - 8 years.[14] The GMDS 0 - 2 years was revised and re-standardised on 665 British children in 1996.[13] The mean quotients and standard deviations (SDs) of the sub-scales were 100 and 16, and for the general quotient the mean was 100.5 with SD 11.8. The reliability coefficients at 10 - 12 months were 0.83 - 0.94 for the sub-scales and 0.96 for the general score. At 19 - 21 months these were 0.79 - 0.88 for the sub-scales and 0.94 for the general score. The standard error for an individual child was 3.9 - 6.6 for the sub-scales and 2.5 for the general score at 10 - 12 months, and 5.3 - 7.4 for the sub-scales and 3.0 for the general score at 19 - 21 months.

Three recent cross-sectional South African studies using the 1996 version of the GMDS 0 - 2 years found differing results. Among 19 control children from a maternal iron deficiency study in a Cape Town township, the mean scores at 9 months were significantly higher than the British norms, ranging from 0.5 to 2 SD above the mean of 100.[15] A study of 40 black South African infants aged between 13 and 16 months from urban Johannesburg showed significant differences in three sub-scales compared with the British norm group: scores were better on the eye-hand co-ordination and performance sub-scales and lower on the personal-social sub-scale.[16] In a study investigating the influence of maternal education in black infants between 13 and 16 months of age, those of low socio-economic status performed significantly more poorly on the locomotor sub-scale.[17]

The GMDS 0 - 2 years has not been validated and standardised for South African children. Our aim was to describe the longitudinal developmental profile of a cohort of children from a low socio-economic community in Cape Town.

Methods

The children were recruited as healthy controls for a vaccine study, one of two prospective interlinking studies through the Comprehensive International Programme of Research on AIDS in South Africa (CIPRA-SA) at the Children's Infectious Diseases Clinical Research Unit (KID-CRU), Tygerberg Children's Hospital, Cape Town.[18,19] Participants were recruited during 2005. Mothers were approached at public community antenatal and postnatal clinics within the greater Cape Town metropolitan area and invited to join the study. Participants' mothers tested negative for HIV at peripheral clinics. Infant HIV status was assessed between 4 and 6 weeks using the HIV-1 DNA polymerase chain reaction assay.

Inclusion criteria were: birth weight >2 000 g, enrolled on CHER[18] <6 weeks with normal neurological examination, mother and infant HIV negative, and two Griffiths assessments in required age range: 10 - 13 and 20 - 22 months. In this setting, gestational age is often inaccurate so we used birth weight >2 000 g as a surrogate for excluding prematurity. Children only attended the KID-CRU for study visits. They attended community health clinics for intercurrent illnesses and health visits. Written consent was obtained from the child's parent or guardian. The study protocol was approved by the Human Research Ethics Committee, Faculty of Health Sciences, Stellenbosch University.

Birth history, a record of adverse events and maternal demographics were obtained from the CIPRA-SA files. Head growth was plotted on Centers for Disease Control and Prevention (CDC) (USA) charts. A neurological examination was performed and vision was assessed clinically using tiny cake decorations ('hundreds and thousands'). A psychologist interviewed primary caregivers using the Edinburgh Postnatal Depression Scale (EPNDS),[20] the Center for Epidemiologic Studies Depression Scale (CES-D)[21] and the Alcohol Use Disorders Identification Test (AUDIT).[22]

The GMDS 0 - 2 years 1996 revision[13] was performed by four trained paediatricians. Quotients on the sub-scales and the general quotient were obtained from raw scores using data from the British norm group. Scores were calculated according to chronological age. Standardised instructions, questions and comments were prepared in English, Afrikaans and Xhosa according to the GMDS manual for the assessments. A single trained translator assisted with all Xhosa-speaking children and mothers using the standardised instructions, questions and comments. All four paediatricians performed the assessments. Initially, two or three paediatricians evaluated one patient and compared notes. Once there was consensus on discrepant pass or fail items, a final score was derived. The procedure was repeated until there was agreement that the scoring was of the same standard. In children from the CHER study, intra-class correlations were assessed by comparing independent scoring on the same patient at the same assessment. For the two main testers, the correlations ranged between 0.93 and 0.80 for all sub-scales except for the personal-social sub-scale, which was 0.18. This is the least objective sub-scale, relying on parent reporting of the child's ability.

Statistical analysis was performed using the Statistical Package for the Social Sciences version 14 (Chicago, Ill., USA). Frequencies, means and SDs of quantitative data were calculated. Comparisons between the groups were performed by using either the paired Student's *t*-test or the Mann-Whitney *U*-test for continuous variables and the chi-square test for discrete variables. A 95% confidence interval was calculated where applicable. Significance was established at $p<0.05$. A drop in 1 SD was set at 16 according to the GMDS standards. Multivariate analysis of variance (MANOVA) tests were used to compare the group whose scores declined by >1 SD with those whose scores declined by <1 SD.

Results

Among 38 infants enrolled in the vaccine study, 31 (17 boys and 14 girls) met the inclusion criteria for the present study. Of the 7 who were excluded, 4 had only the first assessment, and 3 had both assessments but were out of the age range. We included one infant tested at 9.9 months of age and infants who had not yet turned 23 months. The cohort is described in Table I and the GMDS scores in Table II. Table III summarises possible confounders.

The mean scores for the hearing and language sub-quotient declined by more than one SD set by the GMDS, from a mean of 113.0 to 93.2. Only 3 (10%) infants' quotients improved on this sub-scale, and their scores increased by 4, 3 and 24 points on this sub-scale. Eleven (36%) infants were identified as problem cases: one started with a quotient of 85 and dropped to 76, and the scores of the other 10 infants (32% of the cohort) dropped by 2 SDs or more (>32 points). Of these, 4 fell from >125 to within the average range, 2 fell from average to between 1 and 2 SD below the mean, and 4 fell from average to >2SD below the mean.

Gestational age

Owing to many recordings of 'term' on the child's birth records, gestational age was expressed as above or below 37 weeks. Two children with gestational ages recorded as 33 weeks (birth weights 2 240 g and 2 242 g) and 1 recorded as 31 weeks (birth weight 2 172 g)

were included in this study. According to the Keen and Pearse perinatal growth record charts,[23] these weights are just below the 97th percentile for gestational age, supporting our view that gestational ages were inaccurate.

Inter-tester correlations

We did not evaluate inter-tester correlations of the four testers for these assessments. Numbers are too small for meaningful comparison of scoring trends, but for the two main testers, there was no statistical difference in the mean scores of their assessments.

Primary caregivers' questionnaires

The EPDS and CES-D were completed on 27 (87%) caregivers at both assessments The AUDIT was completed for 24 mothers (77%) at the first assessment and 27 (87%) at the second assessment. Four mothers fulfilled the criteria for alcohol abuse at the first assessment, and 1 of these again at the second. Their infants had no features of fetal alcohol syndrome, but 2 were small for age (Table IV).

Maternal and infant characteristics

There was no significant difference between infants' gender, gestation above or below 37 weeks, and mothers' depression status (on the CES-D or EPNDS) at the first assessment. Infants of older mothers performed better than those <25 years of age for the locomotor (p=0.002) and personal-social sub-scales (p=0.019). On the performance sub-scale, infants of mothers who had >10 years of education performed better (p=0.003) than infants of mothers with <10 years of formal education. Children of mothers who scored in the clinical range for the EPNDS at the second assessment had significantly lower language scores (p=0.007). These results are interesting and descriptive, but should be interpreted with caution owing to the small numbers. Numbers were too small to meaningfully compare a drop in 2 SD.

There was no difference between the mean scores at the first assessment of the 7 excluded compared with the 31 included infants (p-values ranging from 0.14 to 0.8 for the various sub-scales).

Discussion

We present the first longitudinal study using the GMDS 0 - 2 years 1996 version in South African children. We documented a decline in developmental profiles in a group of children from low socio-economic circumstances in Cape Town. The scores were in the 'average' range at 11 months and below expected norms at 21 months. The decline in scores was unexpected and not noted in the British norms. Possible reasons may include the instability of the GMDS in the first year of life, the selection of the cohort from only low socio-economic groups, cultural bias for children in Cape Town, and our inclusion criteria.

Previous studies on South African children[9] showed comparability with UK norms. It therefore seems more likely that the selection of children affected their profile, rather than the instability of the GMDS as a measuring instrument. Our group were all of low socio-economic status, with the attendant problems of poverty, poor maternal education, increased incidence of maternal depression and overburdened health care services. Our findings are supported by previous studies from Cape Town showing a lower developmental profile in children from low socio-economic groups when compared with expected norms.[7,8] Molteno *et al.*[7] found a deceleration in development as assessed by the Reynell Language Scales and the Draw-a-Man Test and an increasing association between developmental abilities and social milieu. The 1996 standardisation in the UK also shows significantly better scores in

the highest social class groups. Test re-test reliability on the standardised sample suggests that the test has poor stability in the first year of life, but high stability in the second year. However, numbers in the reliability study were small.[13] We do not know how this group of children would perform on a different neurodevelopmental assessment e.g. the Bayley Intellectual Development Scales.

The hearing and language sub-scale was the most affected, with a decrease in the mean score of >1 SD. Many studies have shown that language development is linked to maternal education and socio-economic status.[7,24] Interestingly, in our cohort maternal education above or below 10 years was not significantly linked to a 1 SD drop in scores. The decrease in language scores was associated with depressed mothers at the second assessment, but this may have been confounded by other environmental factors. A disturbing finding is that only 2 of the 11 children referred for hearing tests were actually assessed.

It is possible that the GMDS is more discerning when testing language development at 21 months than at 11 months. For example, at 11 months a child is only expected to use 3 words with meaning, identify 2 objects and try to sing. However at 21 months the child is expected to use 20 words with meaning, identify 7 objects and use word combinations, which relies on maturation of the brain as well as external stimulation and feedback.

Our study has several limitations. First, the small sample size and selection criteria limit the inferences from this study. Second, owing to our inclusion criteria, children with subtle neurological signs were included. It is likely that these would have been missed in the public health system and the children would have passed as normal, healthy children. Third, the study did not include prospective, routinely planned hearing tests for each participant. However, undetected hearing impairment would not explain the decline in non-verbal sub-scales of eye-hand co-ordination and performance scores. Fourth, the study was not designed to assess nutrition and growth. Measurements were obtained from the parent study at the closest visit. It is plausible that nutritional factors may contribute to the increase in the number of stunted children between assessments. Finally, the cohort may have included more premature infants than identified. However, calculating the GMDS scores without correcting for prematurity would not have contributed to a decline in scores.

Conclusions

Children from a low socio-economic community scored poorly in the second year of life, especially in the hearing and language sub-scale. The GMDS 0 - 2 years is a useful tool for assessment in young South African children from poor socio-economic backgrounds, but may over-estimate scores in the first year of life. The study reflects the inaccuracies of predicting future function from the GMDS 0 - 2 years scores of children younger than 12 months in deprived settings. The diagnosis of acquired developmental delay should be made with caution, unless there is knowledge of the expected development trajectory in a particular patient population profile. This may be particularly relevant in medico-legal cases and shows that chronic illnesses such as HIV may not be the only reason for a decline in scores in this age group. Although standardisation may be useful, it is necessary to look at specific profiles on the GMDS of the various South African cultural/language/ethnic and socio-economic groups.

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TABLE I

DESCRIPTION OF THE COHORT (*N*=31)

Gender, male (*N*(%))	17 (54.8)
Median birth weight (g) (range)	3 190 (2 172 - 4 294)
Gestation (wks) (*N*(%))	
≥37	25 (80.6)
<37	6 (19.3)
Mode of delivery (*N*(%))	
Normal vaginal delivery	26 (83.9)
Caesarean section	5 (16.1)
Maternal age at delivery (yrs) (median (range))	26.8 (18.3 - 38.3)
Maternal education, years of formal schooling (*N*(%))	
7 or less	5 (16.1)
8 - 10	14 (45.1)
More than 10	12 (38.7)
Home language (*N*(%))	
Afrikaans	19 (61.2)
Xhosa	9 (29.0)
English	2 (6.4)
Sotho	1 (3.2)
Declared household income per year at first assessment (*N*(%))	
<R10 000 (US$1 100)	14 (48.3) (*N*=29)
R10 000 - 20 000	13 (44.8) (*N*=29)
>R20 000 (US$2 200)	2
Unknown	2

TABLE II

COMPARISON OF MEAN QUOTIENTS ON THE GRIFFITHS MENTAL DEVELOPMENT SCALES AT THE FIRST AND SECOND ASSESSMENTS AT MEAN AGES OF 11.6 AND 21.0 MONTHS

Griffiths scale	Assessment	Mean quotient	Median	Min. score	Max. score	Range	SD	*p*-value
General quotient	First	107.3	110	81	125	44	11.7	<0.001
	Second	95.0	95	64	118	54	11.0	
Locomotor	First	102.1	101	69	129	60	14.0	0.478
	Second	99.7	102	49	123	74	12.2	
Personal-social	First	107.2	113	60	136	76	17.9	0.005
	Second	95	98	66	121	55	14.6	
Hearing and language	First	113.0	111	85	139	54	13.6	<0.001
	Second	93.2	97	59	118	59	16.4	
Eye-hand co-ordination	First	109.3	111	63	133	70	15.5	0.007
	Second	99.6	100	73	120	47	11.5	
Performance	First	102.8	106	61	128	67	15.4	0.002
	Second	91.1	92	60	119	59	13.6	

TABLE III

POSSIBLE CONFOUNDERS (*N*=31)

Neurological findings	Mild spastic diplegia (*N*=1)	Subtle neurological signs insufficient for full diagnosis (*N*=4)	
Hospitalisation			
Overnight admissions (*N*=3)	IVI rehydration for gastro-enteritis (*N*=2)	Nebulised bronchodilators for bronchop-neumonia (*N* =1)	
Admission 2 days (*N*=1)	Oral rehydration – gastro-enteritis		
Day theatre (*N*=1)	Frenulectomy with no problems		
Otitis media	Before 1st assessment (*N* =5)	Between 1st and 2nd assessments (*N* =2)	Repeated episodes (*N* =1)
Hearing tests attended (*N*=2)	Both normal free-field audiograms		
Head growth			
1st assessment (*N* =30) 2nd (*N* =26)	2 infants <3rd percentile, caught up at 2nd assessment	1 infant fell from 7th percentile to <3rd	1 infant >97th percentile at both (presumed familial macrocephaly)
Stunting (height <-2 SD)	2 at both assessments	5 at 2nd assessment only	

TABLE IV

PRIMARY CAREGIVERS SCORING IN THE CLINICAL RANGE FOR DEPRESSION AND ALCOHOL USE

Scale used	1st assessment	2nd assessment (*N* 27 mothers)
Edinburgh Postnatal Depression Scale	14 (58%), (*N* = 24 mothers)	11 (22%)
Centre for Epide-miological Studies Depression Scale	14 (52%), (*N* =24 mothers, 3 grandmothers)	6 (22%)
Alcohol Use Disorders Identification Test	4 (17%), (*N*=24 mothers)	1 (4%)