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ORIGINAL ARTICLE

Relationship between very low birth weight, environmental factors, and motor and cognitive development of children of 5 and 6 years old

Relação entre muito baixo peso ao nascimento, fatores ambientais e o desenvolvimento motor e o cognitivo de crianças aos 5 e 6 anos

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Abstract

Objective: To examine the relationships between birth weight, preterm birth, environmental factors and the motor and cognitive development of 5 to 6 year-old children. **Methods:** A case control study in which the motor and cognitive performance, as well as the home environment of children aged 5-6 years, born pre-term and weighing ≤1.500 grams, were compared to peers born full-term and with normal weight. The following testes were used: Movement Assessment Battery for Children (MABC), the Developmental Coordination Disorder Questionnaire (DCDQ), the vocabulary and cube tests of the Weschsler Intelligence Test for Children-III (WISC), the Swanson, Nolan and Pelham IV Scale (SNAP IV) and the Home Observation for Measurement of the Environment (HOME). **Results:** 50.54% of the very low birth weight (VLBW) children died and 15.2% of them demonstrated severe impairments. The scores (±SD) of the VLBW and normal birth weight (NBW) groups were: HOME 33.83±7.81(VLBW), 39.61±8.75(NBW); MABC 8.17±7,10(VLBW), 3.06±3.80(NBW); DCDQ 54.0±11.3(VLBW), 63.0±7.5(NBW); WISC Cubes 8.35±2.15(VLBW), 10.57±2.25(NBW); WISC Vocabulary 9.61±2.62(VLBW), 13.48±2.45(NBW); SNAP IV 4.04±4.95(VLBW), 1.57±3.27(NBW). Significant differences between the groups were found, with higher scores on all measures for the NBW group. The results of the motor and cognitive tests demonstrated correlations with birth weight ($p<0.01$) and HOME scores ($p<0.05$). **Conclusions:** The findings reaffirmed the evidences that children born pre-term and with VLBW were more vulnerable to have motor and cognitive impairments, compared to those born full-term. Environmental factors appeared to interfere with development of these children.

Keywords: low birth weight; child development; motor skills; cognition; social conditions.

Resumo

Objetivo: Examinar as relações entre baixo peso ao nascimento, prematuridade, fatores ambientais e os desenvolvimentos motor e cognitivo de crianças aos 5 e 6 anos de idade. **Métodos:** Estudo caso-controle no qual os desempenhos motor e cognitivo e o ambiente domiciliar de crianças com idade de 5-6 anos, nascidas pré-termo e com peso ≤ 1.500 gramas, foram comparados com os de pares nascidos a termo e com peso adequado (PA). Foram utilizados os testes Movement Assessment Battery for Children (MABC), Developmental Coordination Disorder Questionnaire (DCDQ), as provas de vocabulário e de cubos do Weschsler Intelligence Test for Children-III (WISC), o Swanson, Nolan and Pelham IV Scale (SNAP IV) e o Observation for Measurement of the Environment (HOME). **Resultados:** 50,54% das crianças nascidas com muito baixo peso (MBP) foram a óbito, e 15,2% deste grupo desenvolveram sequelas severas. Os escores para os grupos de MBP e de PA foram: HOME 33,83±7,81(MBP), 39,61±8,75(PA); MABC 8,17±7,10(MBP), 3,06±3,80(PA); DCDQ 54,0±11,3(MBP), 63,0±7,5(PA); WISC Cubos 8,35±2,15(MBP), 10,57±2,25(PA); WISC Vocabulário 9,61±2,62(MBP), 13,48±2,45(PA); SNAP IV 4,04±4,95(MBP), 1,57±3,27(PA). Foram encontradas diferenças significativas entre os grupos, com melhor desempenho em todos os testes no grupo de PA. Os resultados dos testes motores e cognitivos tiveram correlação com o peso ao nascer ($p<0,01$) e com o HOME ($p<0,05$). **Conclusões:** Os resultados reforçaram as evidências de que crianças nascidas prematuras e de MBP são mais propensas a apresentar dificuldades motoras e cognitivas que seus pares nascidos a termo e de PA. Fatores ambientais parecem interferir no desenvolvimento dessas crianças.

Palavras-chave: recém-nascido de baixo peso; desenvolvimento infantil; desenvolvimento motor; cognição; condições sociais.

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Introduction

The Information System of Live Births of the Ministry of Health/DATASUS-Brazil indicates the increasing survival of children born preterm with very low birth weight (VLBW). In the Brazilian state of Minas Gerais, in 2005, from 277,468 live births, 19,354 were pre-term and 3,676 with birth weight ≤1.499 grams. It is estimated, in that population, a prevalence from 7 to 20% of severe neurological disorders, such as cerebral palsy and sensory disabilities, and from 30 to 40% of moderate to mild motor problems will occur[1]. With the improvement in life expectancy of these children, the risk for developmental disabilities has become a growing focus for research and intervention, with a move from the quantitative interest related to survival, to a more qualitative interest, in regards to the consequences of prematurity and low birth weight in the child's development[2].

There is evidence that, when compared with their peers, these children exhibit difficulties in several areas of development, including problems with motor coordination, attention, academic performance and behavior[3]. Despite the relevance of biological risk factors, environmental conditions also act in a decisive manner and may aggravate or mitigate the impact of biological risk in the child development[1]. Several national studies[4-8] have focused on motor, cognitive and behavioral aspects of children born preterm and with low birth weight, however, the association with environmental factors is hardly examined, while, paradoxically, the impact of environmental risk in the development may be greater in developing countries[9], since more children are exposed to impoverished environments.

Considering the importance of examining the relationship between biological and environmental risk factors, this study aimed to describe the motor and cognitive development of a group of children with birth weight ≤1,500 grams, in 2001 and 2002, in the city of Divinópolis, MG, Brazil, and to examine the relationship between VLBW, environmental factors and the motor and cognitive development of 5 to 6 year-old children.

Methods

This is a case control study, which the target population consisted of 5990 live births from Divinópolis, MG, Brazil, born between 2001 and 2002. Upon approval of the Municipal Department of Health of Divinópolis, screening was performed in the Live Birth Certificates data. Children with birth weight ≤1,500 grams were identified and the data were compared with the death certificates. Then, contact was made with families, by phone or home visit, for location of survivors that met the following inclusion criteria: absence of neurological and/or orthopedic problems, malformations, genetic syndromes, sensory deficits or other evident disabilities. These children constituted the group of preterm infants with VLBW, which was matched, by age and social level, with full-term infants with birth weight ≥2,500 grams, which constituted the group with normal birth weight (NBW). For matching for age, a variability of up to 30 days was allowed. To try to maintain equivalence of social level, the children were matched according to the school attended (public or private) and it was also applied a sociodemographic questionnaire to help the comparison of the groups.

After signing the consent form, the home visit was scheduled. Children from both groups were assessed in their own home by a single examiner with extensive experience in the field of child development.

Motor function was assessed using the Developmental Coordination Disorder Questionnaire - Brazilian version (DCDQ-Brazil)[10], a parent questionnaire specific for screening for Developmental Coordination Disorder (DCD). The DCDQ assess the performance of children in situations of daily life, and the items are rated on a five point scale: the higher the score, the better the motor performance of children. The Movement Assessment Battery for Children (MABC)[11] was also used, a motor coordination test, widely used for identification of DCD. The MABC assess manual dexterity, static and dynamic balance and ball skills. Each item is scored from zero to five and, the higher the score, the worse the motor performance. The total score is converted into a percentile. Both DCDQ-Brazil and the MABC adopt the 5th percentile as a cutoff point for identification of DCD.

Cognitive function was assessed with the Weschsler Intelligence Test for Children III (WISC III)[12], traditional test of intelligence, translated and standardized for the Brazilian children. The cubes and vocabulary tests were utilized, as they show good correlation with the total score[13].

With the authorization of the Local Department of Education and after signing an informed consent, the children's teachers answered to the Swanson, Nolan and Pelham IV Scale (SNAP-IV)[14,15], questionnaire adapted into Portuguese[15] and used to screen for Attention Deficit Hyperactivity Disorder (ADHD) in schoolchildren. The SNAP-IV is interpreted according to the score achieved on the criteria for ADHD and the higher the score, the worse the performance. The home environment was assessed by the Home Observation for Measurement of the Environment (HOME)[16], observational inventory for systematic assessment of the quality and quantity of stimuli available in the home environment. Higher scores indicate more enriched environments and more suitable for child development. The HOME includes a questionnaire with

sociodemographic data of the family, which were used for comparison between groups.

In addition to standardized instruments, two protocols for data collection were developed: (a) structured interview with parents about important aspects of child development and (b) a questionnaire for teachers about the children's school performance.

Before data collection, the examiner was trained in the use of the tests and the reliability with another examiner was verified. The intraclass correlation coefficient (ICC), with absolute agreement and confidence interval of 95% was used to verify inter-rater reliability, obtaining an $ICC_{3,2}$ of 0.99 for HOME, MABC and WISC-III tests.

For data analysis, the Statistical Package for the Social Sciences - SPSS (version 13.0) was used. Descriptive statistics with measures of mean, standard deviation and median was used to describe the sample. Variables were examined for normal distribution using the Shapiro Wilk test. As normality was not confirmed for most variables, the nonparametric Mann-Whitney test was used to compare the performance of both groups on the tests. The association between the two groups, and the variables income salary, mother's and father's level of education were assessed using the chi-square test.

Finally, the nonparametric correlation coefficient of Spearman was calculated to examine the strength of association between the total scores of the tests and the following quantitative variables: birth weight, income salary, mother's and father's level of education. For all analysis, a significance level $\alpha<0.05$ was considered.

This study was approved by the Committee of Ethics in Research of the Universidade Federal de Minas Gerais (COEP/UFMG), Belo Horizonte, MG, Brazil, Nº. ETIC 332/07.

Results

From a total of 5,990 children, 93 were born with birth weight ≤1,500 grams. Among these 93 children, 47 have died, 13 were not located, three refused to participate in the study and seven were excluded; lasting 23 for the study, being 14 females and nine males. Of the seven excluded children, five had cerebral palsy and two had sensory impairments.

The sample description is summarized in Table 1. In relation to global development, as reported by the mothers, 43.5% of children in VLBW group had motor and/or language delay, and 60.9% were referred to stimulation programs in the first year of life. In the NBW group, there were reports of motor delay of only one child (4.3%). In the VLBW group, 30.4% of mothers reported perceiving differences between the current development of their child and other children with the same age; while in the NBW group, only one mother (4.3%) had the same perception. Except for one child in the VLBW group who did not attend school, the others were attending regular schools, and teachers of 60.8% of the children in the VLBW group and one (4.3%) in NBW group reported concerns about children's school performance.

Although it is possible to identify small differences in family characteristics, the chi-square test indicated no significant differences between groups in the income salary (p=1.00), mother's level of education (p=0.17) and father's level of education (p=0.81) variables.

Table 1. Participants' characteristics (mean±sd, median, and range [min-max]) of the descriptive variables for the very low birth weight (n=23) and the normal body weight (n=23) Groups.

Variable	Group	Mean±SD	Median	Range (min-max)
Age (months)	VLBW	69.39±7.37	69	60-81
	NBW	70.30±7.28	70	60-81
Gestational age (Weeks)	VLBW	30.04±2.18	29	27-34
	NBW	38.91±0.42	39	38-40
Birth weight (grams)	VLBW	1,201.30±177.51	1,180	930-1,500
	NBW	3,273.48±348.53	3,265	2,670-3,840
Apgar (scores)	VLBW	6.83±2.87	8	1-10
	NBW	8.91±0.79	9	7-10
Hospitalization (days)	VLBW	42.96±17.07	41	18-90
	NBW	0.04±0.21	0	0-1

VLBW = very low body weight; NBW = normal body weight.

The scores of each group and results of the Mann-Whitney test for the HOME Inventory are shown in Table 2. Significant differences were observed, with a higher score for the NBW group in the HOME total score and in the subscales learning material, language stimulation and modeling.

Table 3 shows the results of each group in the motor tests MABC and DCDQ, in cubes and vocabulary subtests of the WISC-III and in the SNAP-IV. There were significant differences in performance between groups in all tests, with better results for the NBW group, except in areas of manual dexterity and balance of the MABC, and of the SNAP-IV in the total score and items related to hyperactivity. With regards to the cutoff point for motor tests, in DCDQ-Brazil, which reflects the views of parents, 21.7% of the VLBW group showed results suggestive of difficulties with motor coordination in contrast to only 4.3% in NBW group. In the MABC, 8.7% of children from the VLBW group showed performance below the fifth percentile, which indicates definite problem of motor coordination, and 21.7% scored below the 15th percentile, which is considered "suspicious" motor performance. In the NBW group, only one child (4.3%) had the "suspicious" score.

Table 4 shows the results of the Spearman correlation between the total score in MABC, DCDQ, HOME, WISC Cubes and Vocabulary and SNAP-IV tests with the variables birth weight, income salary, mother's level of education and father's level of education.

Discussion

The results of the present study showed that a considerable number of children with birth weight ≤1,500 grams have died, and that, among the survivors who were located, 15.2% developed severe sequelae. Furthermore, among children who had no major sequelae, there was a higher frequency of motor coordination and attention problems. These results are consistent with national and international studies that show worse motor and cognitive performance in children born preterm and with low birth weight[17-21]. The mortality rate was 50.54%. According to SINASC/DATASUS, in Minas Gerais State, Brazil, in the same period, the mortality rate for children with birth weight ≤1,499 grams was 34.64%. Méio, Lopes and Morsch[17] showed a rate of 35.38% of mortality among children born with birth weight ≤1,500 grams. The highest rate of mortality observed in this study suggests that, in small and medium size cities, the survival of VLBW preterm children is still a challenge.

Table 2. Descriptive statistics (mean±sd, median, and range [min-max] of the sub-scale and total scores of the home observation for measure of the environment (HOME) for the very low birth weight (n=23) and the normal body weight (n=23) Groups.

Variable	Group	Mean±SD	Median	Range (min-máx)	Mann-Whitney U	p value
Learning material	VLBW	4.57±3.10	4	0-11	168.5	0.03
	NBW	6.57±3.14	7	0-11		
Language stimulation	VLBW	5.39±1.12	5	2-7	154.0	0.01
	NBW	6.17±0.89	6	4-7		
Physical environment	VLBW	6.09±1.65	7	1-7	209.0	0.18
	NBW	5.74±1.54	6	2-7		
Responsivity	VLBW	3.74±1.76	4	0-6	256.0	0.85
	NBW	4.00±1.13	4	0-5		
Academical stimulation	VLBW	2.78±2.15	3	0-5	196.5	0.18
	NBW	3.87±1.42	4	0-5		
Modelling	VLBW	2.26±1.29	2	0-4	170.0	0.03
	NBW	3.09±1.16	3	1-5		
Variety	VLBW	5.35±1.23	6	2-7	178.0	0.051
	NBW	6.39±1.62	6	4-9		
Acceptance	VLBW	3.65±0.57	4	2-4	239.0	0.46
	NBW	3.78±0.42	4	3-4		
Total	VLBW	33.83±7.81	31	16-45	161.5	0.02
	NBW	39.61±8.75	42	20-51		

VLBW = very low body weight; NBW = normal body weight.

Table 3. Descriptive statistics (mean ± sd, median, and range [min-max] of the motor tests: Movement Assessment Battery for Children (MABC) and Developmental Coordination Disorder Questionnaire (DCDQ), as well as the Cognitive Tests: Weschsler Intelligence Test for Children-III (WISC) and the Swanson, Nolan, and Pelham IV Scale (SNAP IV) for the very low birth weight (n=23) and the normal body weight (n=23).

Variable	Group	Mean±SD	Median	Range (min-max)	Mann Whitney U	p value
MABC* manual dexterity	VLBW	3.33±3.84	1.5	0-14	181.0	0.056
	NBW	1.46±2.06	0	0-6		
MABC* Ball skills	VLBW	1.87±1.66	1	0-5	105.5	<0.0001
	NBW	0.39±0.89	0	0-3		
MABC* Balance	VLBW	2.98±3.48	2	0-12	194.0	0.10
	NBW	1.22±1.84	0	0-6		
MABC * Total scores	VLBW	8.17±7.10	7	1-29	125.0	0.002
	NBW	3.06±3.80	1.5	0-14		
DCDQ Total scores	VLBW	54.0±11.3	55	33-72	139.5	0.006
	NBW	63.0±7.5	65	42-73		
WISC-III Cubes	VLBW	8.35±2.15	8	6-17	86.5	<0.0001
	NBW	10.57±2.25	10	7-15		
WISC- III Vocabulary	VLBW	9.61±2.62	10	5-15	67.0	<0.0001
	NBW	13.48±2.45	13	10-19		
SNAP- IV Attention deficits	VLBW	2.04±2.60	1	0-9	165.5	0.01
	NBW	0.52±1.56	0	0-7		
SNAP- IV Hiperactivity	VLBW	2.0±3.01	0	0-9	215.0	0.20
	NBW	1.04±2.16	0	0-7		
SNAP- IV Total scores	VLBW	4.04±4.95	2	0-13	198.0	0.11
	NBW	1.57±3.27	0	0-14		

VLBW = very low body weight; NBW = normal body weight; *High scores indicate poor performance.

Table 4. Spearman correlation coefficients amongst the Home Observation for Measure of the Environment (HOME), the Movement Assessment Battery for Children (MABC), the Developmental Coordination Disorder Questionnaire (DCDQ), the Weschsler Intelligence Test for Children-III (WISC), and the Swanson, Nolan, and Pelham IV Scale (SNAP IV) total scores and the variables related to birth weight, parents' level of education, and income salary.

Variable	Birth weight	Mother's level of education	Father's level of education	Income salary	HOME-Total scores	MABC-Total scores	DCDQ- Total scores	WISC - Cubes	WISC-Vocabulary
Mother's level of education	0.144	-							
Father's level of education	0.089	0.741**	-						
Income Salary	0.116	0.416**	0.431**	-					
HOME –Total scores	0.235	0.636**	0.598**	0.520**	-				
MABC – Total scores	-0.547**	-0.048	-0.043	-0.209	-0.308*	-			
DCDQ – Total scores	0.437 **	0.165	0.301*	0.203	0.347*	-0.259	-		
WISC - Cubes	0.615**	0.410**	0.355*	0.242	0.382**	-0.498**	0.370*	-	
WISC – Vocabulary	0.588**	0.238	0.186	0.142	0.348*	-0.292*	0.511**	0.575**	-
SNAP-IV – Total scores	-0.170	0.054	-0.018	0.129	-0.209	0.297*	-0.232	-0.289	-0.196

*p<0.05; **p<0.01.

The number of children who developed severe sequelae, such as cerebral palsy and sensory deficits (15.2%), was higher than that found in the literature. Davis et al.[18] and Jongmans et al.[22] found rates of 8.23 and 9.07%, while Mikkola et al.[23] found a similar rate of 14%, but with preterm children with birth weight ≤1,000 grams. One factor that may have contributed to a higher rate of sequelae in our sample are the conditions of perinatal care, especially considering a small city.

Regarding motor assessment, the children of VLBW group had significantly lower scores on MABC and DCDQ-Brazil tests, suggesting global motor difficulties, consistent with the criteria of motor performance below than that expected for

the age[24], necessary for the diagnosis of DCD. The frequency of scores suggestive of DCD identified in the present study (8.7%) was lower than the ones reported in the literature. Davis et al.[18], in a similar study, observed a rate of 10%. Other studies observed even higher rates, as Foulder-Hughes and Cooke[19] and Jongmans et al.[22] reported rates of 30.7% and 19% below the 5th percentile and 47.8% and 44% below the 15th percentile, respectively. This variability in the findings cannot be attributed to the assessment tools, as in all these studies, the 5th percentile of MABC was adopted as the cutoff point for identification of DCD. However, these studies used different criteria for recruitment of samples, which limits further comparisons.

Although the results of the DCDQ-Brazil and MABC show significant between groups differences, unexpectedly the correlation between these tests was low (r=-0.259, p=0.082) and not significant, suggesting that the objective data collected with the MABC did not coincide with the observations of parents. Wilson et al.[25], examining the concurrent validity between the DCDQ and MABC, reported a moderate and significant correlation (r=-0.59, p<0.0001), while Schoemaker et al.[26] reported a significant correlation, but similar to the value observed in the present study (r=-0.24, p=0.001). These data support the idea that the two instruments measure different aspects of motor performance, with the DCDQ focusing more on functional skills observed by parents and the MABC on the formal aspects of speed and quality of movements. Although the use of questionnaires is widespread in other countries, in Brazil, they are hardly used and some parents may have had difficulties in the use of scoring criteria, which affects the accuracy of scoring.

As expected, the negative correlation (r=-0.547, p<0.001) between birth weight and results of the MABC, as well as the positive correlation with the DCDQ (r=0.437, p=0.002), indicated that children born with lower weight and lower gestational age were those that showed worse motor performance, which demonstrates the high influence of biological factors in motor development in the first years of life. It should be emphasized that even with the exclusion of children with severe sequelae, these correlations persist at least until the beginning of schooling, which emphasizes the insidious character of prematurity.

Environmental factors seem to play an important role in the cognitive development[27], but the findings in relation to the environmental influence on motor aspects are scarse and inconsistent. Goyen and Lui[20] examined the influence of home environment in the development of motor skills, and the results showed that children aged 18 months and 5 years, with lower scores on the HOME, consistently had worse performance in gross motor skills. Chen, Jeng and Tsou[28], on the other hand, considered that sociodemographic factors, therefore environmental, are more associated with fine motor performance. In the present study, the correlations between the HOME and all the motor tests were weak, but statistically significant, suggesting that the quality of home environment has some influence on motor development. Another interesting point of this study is that both the education of parents and the income salary had moderate correlation with results of the HOME, which possibly resulted in greater availability of resources to purchase of toys and educational materials, with the provision of a more stimulating home environment.

In cognitive tests, children in the VLBW group had worse performance than the children in NBW group, but in both subtests of WISC-III, mean performance was within normal limits for age. These results confirm findings from other authors who found a level of intelligence within normal limits in different samples of preterm children and with low birth weight[19,29]. Méio, Lopes and Morsch[17], on the other hand, checking the cognitive development of children with birth weight ≤1,500 grams at preschool age, found that the mean Intelligence Quotient of these children were below the normal range. While Martins et al.[29] found no cognitive differences between children born preterm and with low birth weight with full-term children aged 6 years. Because of the complexity of the factors involved and the impact of cognitive development in various aspects of children's lives, this is an area that merits further research.

Considering the quality of home environment, significant differences between groups were found, with better results for the NBW group in the HOME total score and in the subscales learning material, language stimulation and modeling. Despite the differences in other areas of the HOME were not significant, the VLBW group scored lower in all areas, except in the physical environment. Thus, paradoxically, the results point to a less stimulating environment for the VLBW group, in which the biological risks to development are already pronounced. Children exposed to both risk factors are more likely to have developmental disorders; furthermore, children with biological risks may be more vulnerable to the influence of unfavorable environments if compared to full-term children with NBW[9].

With regards to behavior, the results of the SNAP-IV showed a significant between-group difference, with signs of poorer attention and worse results for the VLBW group. McGrath et al.[30] documented a significant increase, around four times more, of the prevalence of ADHD in children born preterm and with low birth weight, compared to their peers with NBW. Hemgren and Persson[21] and Seitz et al.[1] investigated the correlation between motor performance, attention deficits and cognitive functions in children with low birth weight, and in both studies, children with low birth weight

showed deficits in attention and coordination, associated with perceptual-motor delays important for the development of academic skills. Although age and the instruments used in the present study did not permit precise identification, the results point to greater difficulty in attention in VLBW group, which may be predictive of future diagnosis of ADHD at school age.

This study has limitations, since the sample was severely reduced due to the high mortality rate and losses due to changes of address. It is noteworthy; however, that it was possible to locate 71.74% of the surviving children, and the difference between groups was evident, even with the relatively small sample. The data are consistent with the literature, but it is important to invest in multicenter studies, as a strategy to obtain larger samples that allow a better characterization of the impact of prematurity among Brazilian children. Another limitation was that, due to the lack of standardized instruments for Brazilian children, it was necessary to use imported tests. However, comparisons were made only with the control group of Brazilian children, tested under the same conditions, without the use of normative data.

The present study contributes to support the evidence that children born preterm and with low birth weight are more likely to have motor and cognitive difficulties than their peers born full-term and with NBW. Environmental factors seem to contribute negatively to enhance the biological risks in the development outcome of these children. As most of them show apparently normal development, their difficulties are often more evident only at school age, when motor and cognitive demands are greater. The results of this study indicate the importance of public policies of post-natal assistance and implementation of longitudinal development follow up services, to follow these children until school age.

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