

## ORIGINAL ARTICLE

# Low birth weight, family income and paternal absence as risk factors in neuropsychomotor development

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## Abstract

**Introduction:** The first years of life are crucial to neuropsychomotor development (NPMD), during this period children are susceptible to organic, environmental or activity-related influences that may represent protective or risk factors towards full development, with potential lifelong repercussions.

**Objective:** This study aimed to investigate and verify the risk factors in the NPMD of children aged from zero to three years, attending public early childhood education centers.

**Methods:** Cross-sectional study, contextual approach – based on ICF (International Classification of Functioning, Disability and Health) –, Denver II developmental screening test and additional assessments about nutritional status. For the analysis, a logistic regression was performed. The ICF concerning body functions and structure (evaluation questionnaire), activity and participation (evaluation of NPMD in school), personal factors (family characteristics), and environmental factors (characteristics of the ECECs) were considered for the evaluation phase. The instruments consisted of a questionnaire containing items to elicit information about the child, including current, neonatal and family traits. For the evaluation DPMD, the Denver II test was used. Inter- and intra-rater reliability was established using Cohen's kappa, and data subsequently submitted to stepwise (backward) regression analysis using a Logit model, using binary responses. The construction of an ROC (Receiver Operating Characteristic) to define the explanatory profile of the model built also was included, in addition to the calculation of the Odds Ratio (OR), the odds of chance occurrence the association of a given variable with DPMD.

**Results:** NPMD was within the normal parameters, in 68.8% (n = 53) and risk of delays was in 31.2% (n = 24). The area with the best performance was the fine motor-adaptive (3.75%) and the most questionable one was the language (57.5%). It was verified that 48% (n=37) of the children had normal weight while 52% (n = 40) presented some nutritional risk. Low birth weight (OR = 181), monthly family income (OR = 9) and paternal absence (OR = 34) were statistically significant factors on the risk of NPMD delays.

**Conclusion:** Low birth weight, family income and paternal absence are factors associated with risks of NPMD delays. These findings reinforce the systemic and multifactorial nature of NPMD and emphasize the need for monitoring and formulating public policies -- especially the ones dedicated to children with low income conditions --, which could contribute to the full development of children, since public early childhood education centers should be transforming agents in the quality of child development.

**Keywords:** physical therapy specialty, child development, early childhood education, health promotion

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## ■ INTRODUCTION

The first years of life are critical to the neuropsychomotor development (NPMD), during this period which children are more likely to be influenced by factors<sup>1</sup> that can be either risky or protective in the promotion of full development. Such factors can also impact their adulthood in the future<sup>2</sup>. Motor capacity is considered a good indicator for measuring child development<sup>3</sup> as it can express not only neurological integrity and motor development, but also aspects of affectivity, cognition and social interaction with the environment<sup>4</sup>. This dynamic and complex process is currently explained by the context model, which considers individual biological aspects, environmental conditions and tasks' characteristics as essential components to understanding NPMD. The World Health Organization (WHO) proposes this same perspective through the International Classification of Functioning, Disability and Health (ICF) model<sup>5</sup>.

There is plenty of evidence<sup>6-8</sup> that the environment in which the child is inserted, the stimuli provided and the biological characteristics impact NPMD leading to a cumulative effect of these factors<sup>9</sup>.

In Brazil – an developing country, where risks of NPMD delays are higher in children under five years old<sup>10</sup> because of economic<sup>11</sup> and social factors – full-time Early Childhood Education Centers (where children spend 8 to

10 hours a day) are chosen<sup>9</sup>. Although most of them have unsatisfactory quality<sup>12</sup>, they still give indications of having a possible protective effect on the child development<sup>2</sup>, especially for children at social risk<sup>13</sup>. Given this situation, it is necessary to investigate risk and protective factors that influence development in this initial and crucial stage, with the objective of identifying and screening children exposed to these factors. This investigation could serve as a way to promote a satisfactory development, with experience and optimization of all their capabilities<sup>14,15</sup>, especially in the home/school spheres<sup>9</sup>, which are close environments convenient to be investigated.

In addition, it is noteworthy that the assessment of children in their everyday environments values the “ecological validity” for its proximity to the real environment<sup>16</sup>, having the potential to explain the variation of 59% in NPMD in terms of activity and participation<sup>17</sup>. Activity is considered the execution of a task individually, while participation is related to such execution in a real environment<sup>18</sup>. Since the coastal region of Paraná has Human Development Index (HDI) of 0.73, which is considered average, it was an interesting scenario for the research.

Thus, the objective is to analyze the neuropsychomotor development of children with ages between zero and three years and the risk factors associated with their developments.

## ■ METHODS

This observational, analytical and cross-sectional study was approved by the Ethics Research Committee of the Health Sciences Sector of Federal University of Paraná (UFPR), registry CEP / SD: 531.068.08.05 CAAE: 1212.0.000.091-8.

This study included children aging from 0 to 3 years enrolled in public Early Childhood Education Centers (ECECs) in Matinhos (PR), whose parents or guardians signed the Informed Consent Term. Exclusion criteria were: 1) children with neurological alterations, genetic syndromes or congenital malformations; 2) three absences during the evaluation process and 3) impossibility of carrying out the study's assessment, prepared as suggested by other studies that analyzed NPMD<sup>19-21</sup>.

For the sample calculation<sup>22</sup>, 75 children with ages from 0 to 3 years enrolled in the early childhood education centers during the period of the study were considered. The estimated probability of finding alterations was 15%, with a sampling error of 5% and a confidence interval of 95%.

During the period of screening and evaluation, the ICF criteria about functions and structure (through evaluation questionnaire) were considered, as well as activities and participation (through NPMD evaluation by Denver II in the school environment), personal characteristics (through family questionnaire) and environmental factors (characteristics of Early Childhood Education Centers).

The evaluation tool was a questionnaire to parents and/or guardians about the children, their current characteristics, information about neonatal diseases and their families. To evaluate the neuropsychomotor development, the original version of Denver II<sup>23</sup>, adapted to Portuguese<sup>24</sup>, was used. This test was applied by three trained evaluators and

calibrated in accordance with the Kappa coefficient of intra-rater and inter-rater agreement. To assess the nutritional status, anthropometric measurements such as weight and height were used by an assessor with appropriate intra-rater agreement coefficient (ICC- Intraclass Correlation Coefficient). To classify the nutritional status, the WHO<sup>25</sup> reference standard, which is more updated and suitable for monitoring growth, was used through the Z score.

At the end of the study, all of the children's teachers and guardians attending the Early Childhood Education Centers were invited to participate in a meeting that aimed at showing and explaining the results without exposing any child participating in the research, who also received stimulation tips. The details of the individual assessments of each child were not considered. In the cases where the risk was identified, a meeting with the child's parents and/or guardians was requested so that the appropriate referrals were made. This step was divided into two phases, the first in which the intervention was held among educators and caretakers of the ECECs, and the second in which the intervention was held among family members and/or guardians of the children who frequented the ECECs study.

The statistical analysis was performed following the assessment of the development of participating children, in order to test the association between child development and the variables studied. In this step, logistic regression was applied using logit model selection with binary response and backward stepwise method, carrying out the maximization of the likelihood function with the Newton-Raphson algorithm, using the XLSTAT software (version 2012.1.01). For this analysis, the binary response variable used was normal neuropsychomotor development or questionable

neuropsychomotor development. The following information were regarded as explanatory variables: current characteristics of the child (age, sex, ECEC, the time spent on the ECEC – full or part-time – and nutritional status); neonatal and gestational characteristics (birth weight, gestational age, miscarriages and type of delivery); family features (monthly family income, parental education, amount of time the child spends with the father and the mother daily, single mother and absence of the father) and the ECECs’s characteristics (number of educators per child and time of activity of educators in ECECs).

Once the final logistic regression model was decided on, the odds were calculated from the formula  $Pr = 1/[1 + \text{and}-(\alpha + \sum (\beta_i x_i))]$ , with  $\alpha$  being the constant of the model. A ROC curve (Receiver Operating Characteristic) was built

to define the justifiability profile of the model. Also included in the calculation was the Odds Ratio (OR), that is, the odds ratio of occurrence of a variable to be associated with the neuropsychomotor development, estimated by confidence intervals of 95%. The analysis was completed with the calculation of the risk probability, by the estimate of the probability of occurrence of neuropsychomotor development delay, given the combination of the variables chosen for the predictive model. Significant explanatory variables with probability less than or equal to the significance level ( $p \leq 0.05$ ) were considered. Anthropometric data were analyzed using Epi-Info 6 software, version 6.04, which gives the exact value of the Z-score of each individual. Integrated to the previous sentence.

## RESULTS

This study included 77 children from 6 to 36 months of age of both sexes, who were enrolled in municipal public education in the town of Matinhos/Paraná and

frequented the ECECs A, B or C. The characteristics of the sample are shown in Table 1.

In this sample, 68.8% (n = 53) of children presented

**Table 1:** Frequencies of categories of variables of the sample characterization.

Variables		Categories	Frequencies (n)	%
Current characteristics of the child	Sex	Male	40	52
		Female	37	48
	Age	7 to 12 months	12	15.58
		13 to 18 months	19	24.68
		19 to 24 months	17	22.08
		25 to 30 months	13	16.88
		31 to 36 months	16	20.78
ECEC	A	22	28.6	
	B	12	15.6	
	C	43	55.8	
Period	Full-time on ECEC	39	50.65	
	Part-time on ECEC	38	49.35	
Neonatal and gestational characteristics	Birth weight*	> 2,500 Kg	70	90.91
		<= 2.500Kg	7	9.09
	Gestational age	> 37 weeks	62	80.52
		<= 37 weeks	15	19.48
	Abortions	Presence	13	16.88
		Absence	64	83.12
	Delivery type	Normal	24	31.17
Cesarean or other		53	68.83	
Family characteristics	Monthly household income*	< R\$ 2,000.00	46	59.74
		>= R\$ \$2,000.00	31	40.26
	Educational status of the father	<= Primary school concluded	33	42.86
		> Primary school concluded	44	57.14
	Educational status of the mother	<= Primary school concluded	16	20.78
		> Primary school concluded	61	79.22
	Daily time the child spent with the father	< 1 period	24	31.17
		>= 1 period	53	68.83
	Daily time the child spent with mother	< 1 period	8	10.39
		>= 1 period	64	89.61
	Single mother	Yes	21	27.27
No		56	72.73	
Absent father*	Yes	20	25.97	
	No	57	74.03	
Characteristics of ECEC	Number of educators per child	Suitable	2	20.00
		Inappropriate	8	80.00
	Time of activity of educators in ECECs	<= 1 year	3	30.00
		> 1 year	7	70.00

\*variables with interactions through the ROC curve (Figure 1). Source: the authors.

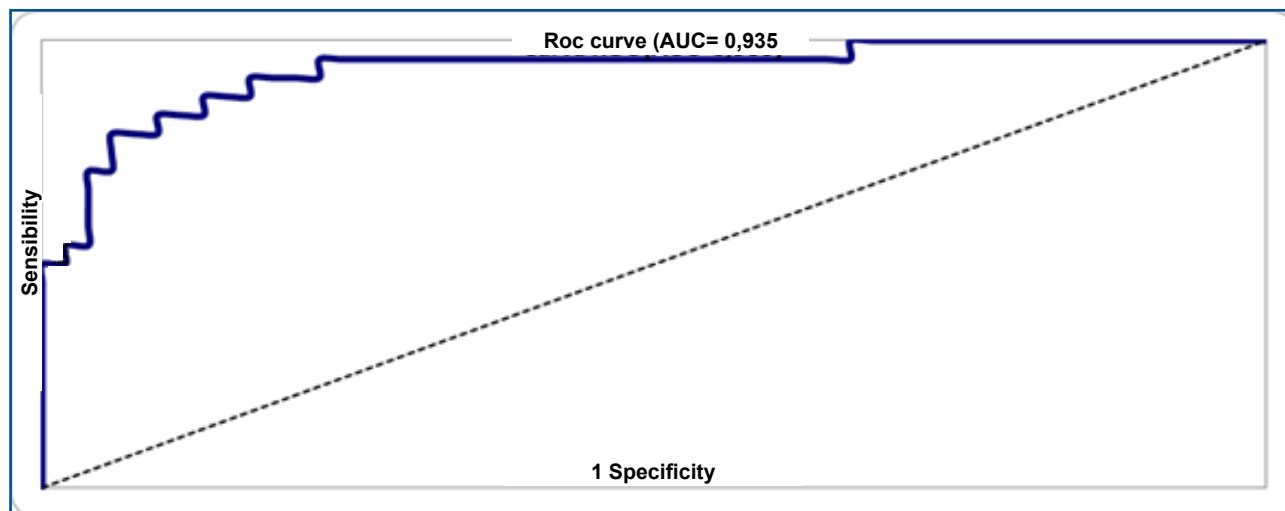
normal neuropsychomotor development while 31.2% (n = 24) presented questionable NPMD. From the 24 children with questionable development, 7 children (29.2%) presented a shift in only one area of development, 12 (50%) in two areas, 3 (12.5%) in three areas and 2 (8.3%) in all four areas. Analyzing the questionable sample and considering both the risks and delays, the language area was discovered as the most questionable (57.5%), followed by the personal-social area, with 28.75%, then the motor-gross (10%) area, and the least affected was the fine-adaptive motor area, with 3.75%.

In nutritional evaluation, it was determined that

48% (n=37) of children were eutrophic and 52% (n=40) presented some nutritional risk. 1 child (1.3%) presented early malnutrition, 25 children (32.5%) were at risk of overweight and 14 children (18.2%) were obese.

The results obtained by the combination of all the variables previously presented by means of logistic regression show that the model has a proper fit (AIC=82.739). The estimated probabilities were sorted and plotted on a chart, providing the ROC curve (Figure 1). The area under the ROC curve shows that the estimated probabilities model can predict approximately 93.5% of the events (Figure 1).

**Figure 1:** ROC curve (Receiver Operating Characteristics) generated by the validation of the logistic regression model.



Source: the authors.

After the inclusion of the variables, according to the method of backward stepwise logistic regression, the final model was defined regarding the set of variables which contributed significantly to explain why children presented a questionable screening test of Denver II.

In the tests performed to evaluate possible interactions among variables, there was an association among birth weight (OR = 181.0; IC 95% 1.902 – 17,229.589; p = 0.025), monthly household income (OR = 9.90; IC 95% 1.115 – 87.926; p = 0.040) and absence

of the father (OR = 34.51; IC 95% 1.033 – 1,153.490, p = 0.048). It can be interpreted that the interaction between birth weight, monthly household income and absence of the father proved to be highly associated with delayed neuropsychomotor development, indicating that children with low birth weight, monthly household income lower than R\$2,000.00 and absence of the father were approximately 181, 9 to 34 times, more likely to report questionable development (Table 2).

**Table 2:** Parameters obtained through the application of logistic regression to identify the Odds Ratio for suspected delay in neuropsychomotor development.

	Value	Standard error	$\chi^2$ of Wald	PR > $\chi^2$	Odds Ratio (OR)	OR Limit inf. (95%)	OR Limit sup. (95%)
Linear coefficient	-4.464	1.667	7.169	0.007			
Birth weight	5.199	2.324	5.001	0.025	181.004	1.902	17229.589
Monthly household income	2.293	1.114	4.234	0.040	9.901	1.115	87.926
Absent father	3.541	1.790	3.912	0.048	34.511	1.033	1153.490

OR= odds ratio. Source: the authors.

## DISCUSSION

During the analysis of NPMD, the biological component related to structure and functions, and the activity and participation, conducted through the Denver II test, a relevant portion of the sample (31.2%) presented questionable results. Such results were similar to other studies in ECECs (22.7%)<sup>26</sup> and in other environments

(27.3%)<sup>27</sup>, such as Halpern *et al.*<sup>11</sup> (34%) and Torquato *et al.*<sup>28</sup> (31.6%). Therefore, research of identification and monitoring of the NPMD and its associated factors in early stages of life is clearly relevant<sup>9</sup>.

When investigating personal and environmental components of each child, it was observed, by means

of logistic regression, that birth weight, monthly family income and paternal absence are risk factors influencing the neuropsychomotor development of the children evaluated. Although the proportions differed in each of the variables, the analysis demonstrated the relevance of these three variables in determining risk of delays in child development, reinforcing the multifactorial dimension of NPMD<sup>9</sup>.

Factors such as poverty and nutrition problems, highlighted in the present study as associated to NPMD, have already been mentioned in previous studies<sup>10,29</sup>.

In nutritional assessment, 52% (n = 40) of children showed some nutritional risk, with greater prevalence of obesity (50.7%) than of malnutrition (1.3%), validating previous studies<sup>30</sup>, but with an even higher proportion. These results confirm the nutritional transition process that has taken place, with a reduction in the prevalence of nutritional deficits and most expressive occurrences of overweight and obesity. Such overweight is occurring in developing countries, including Brazil<sup>31</sup>, and in different socioeconomic levels, even in children with lower economic conditions<sup>32</sup>.

Studies have confirmed the existence of a relation between low birth weight and changes in development<sup>33</sup>. This relation is considered a risk factor for changes in neuropsychomotor development, more pronounced when the newborn is exposed to unfavorable social conditions, such as parental education status, dysfunctional families, and family psychiatric problems<sup>34</sup>. These findings have already been indicated since 1996<sup>35</sup> and revealed that Brazilian children at 12 months of age weighing less than 2,500 Kg were three times more likely to present NPMD delays, as suggested by the Denver II test and confirmed in the study of Resegue *et al.*<sup>36</sup>. The same authors highlight this neonatal indicator as a necessary marker for the monitoring and supervision of the child development, and Caçola and Bobbio<sup>33</sup> claim that low birth weight is one of the main predictors of neonatal and perinatal morbidity and mortality.

Several studies<sup>6,7,37</sup> have shown evidence of the negative impact of poverty and poor socioeconomic conditions in the NPMD during early life in various countries. Hoff<sup>38</sup> states that the socioeconomic status of the family is a powerful predictor of many aspects of child development. Although studies use different methods to assess the socioeconomic level and the NPMD, they all indicate that such development is influenced by socioeconomic conditions. Thus, our study demonstrated that children with a monthly family income lower than R\$2,000.00 were approximately nine times more likely to present questionable development. These results legitimate the studies of Halpern *et al.*<sup>39</sup> and Paiva *et al.*<sup>40</sup>. The researchers Halpern *et al.*<sup>39</sup> evaluated the neuropsychomotor development of 1,363 children using the Denver II test, and found that children from low-income families were more likely (50%) to present a suspected delay in their development, probably because of the stimulation and varied opportunities that children with better socioeconomic conditions have in the first year of life.

The study of Paiva *et al.*<sup>40</sup> evaluated 136 children

between nine and 12 months of age and found that infants with low socioeconomic conditions present more often suspected delays in NPMD, especially regarding receptive communication. This can be justified by the fact that families with low socioeconomic conditions tend to read less to their children, depriving them of complex verbal strategies.

A cohort study conducted by Lima *et al.*<sup>41</sup> in the northeastern of Brazil aimed at identifying biological and environmental factors associated with mental and motor development in the first 12 months of life among the low-income population. It was found that environmental factors had a greater negative effect on the child's development and factors related to poverty had a greater influence on it. The results suggest that poverty directly affects the quality of domestic environment, mainly due to the lack of physical conditions and resources necessary to promote properly stimulation and child protection.

Halpern *et al.*<sup>35</sup> of the children evaluated at 12 months presented a development delay that was twice as frequent in the low-income children. To Grantham-McGregor *et al.*<sup>37</sup>, low-income children who do not reach all the potential of their development are less likely to become productive adults, mainly due to less years of schooling and less learning per year in school, which implies a decrease in income as adults, resulting in a cycle when forming their families, thus generating consequences to national development.

Although family income was presented as a risk factor in the present study, one might think that low-income children who do not attend daycare are at a larger risk. This lacks further explanation, considering daycare was identified in another study<sup>42</sup> as having a protective effect in development, promoting cognitive and academic aspects, and even serving to reduce the differences influenced by socioeconomic factors. Thus, we suggest to future studies the comparison of factors here surveyed between children who attend and who do not attend daycare.

Among the risk factors selected for the analysis of the development of the children examined in the ECECs, paternal absence presented a significant correlation with the risk of delay in development.

Similar to our research, some studies indicate that paternal absence can be considered a risk factor for delays in development<sup>43</sup>, with the father being a key component for the development of the child<sup>44</sup>.

The research done by Pilz and Schermann<sup>45</sup> in the city of Canoas/RS found, through the Denver II test, that 27% of the sample presented a suspected delay in neuropsychomotor development, which was seven times more likely in children whose mothers did not receive support from the fathers.

Yet, the study of Amorim *et al.*<sup>46</sup> showed that a daily time in the company of the father was also statistically associated with higher percentages of delayed motor development. The authors associated this finding with the fact that paternal presence is usually linked to unemployment, which has an impact on other social conditions. Our study concluded that paternal absence has a negative influence on child development, but not the number of hours spent in the company of the father, which

could be analyzed in future studies.

Anme *et al.*<sup>47</sup> have developed a longitudinal study in Japan and have concluded that fatherhood is a strong and consistent predictor of child development. In the referred study, the spousal support was considerably related to the development of the vocabulary of the children evaluated. This supports the findings of our study, since the paternal absence is linked to lack of family support.

The authors Manfroi, Macarini and Vieira<sup>44</sup> concluded that the influence of the father in child development (social and motor) is connected to several factors. One factor is family harmony, since it favors a more affectionate involvement between mother and children. Another one is family dynamic, once father influence is responsible for transmitting values and setting an example for cooperation through the assistance in domestic activities. There is also the involvement in the basic care of the children (hygiene, food), which brings the family closer together, and games that increase the interaction between father and child.

Thus, it is concluded that the presence of the father has a protective effect on child development, due to the interaction and relationship with the child, the support to the mother and also the assistance in the socioeconomic factors of the house<sup>43</sup>. In addition, it reinforces the need for an evaluation that considers the family context.

Considering the different areas of development, language presented the most remarkable delay in the present study. Although more precise statements cannot be made due to the model of the study, paternal absence is considered an influencer. There are studies<sup>48</sup> that show the paternal influence on the development of language and cognition, but further evidence is still needed.

During child development, situations of restraint, regardless of the reasons, can modify connections and superior functions in a deleterious way. Early assessment/intervention have a crucial role in critical periods and situations of development. This is due to the fact that neuroplasticity has critical periods that are directly related to the potential of a functional recovery and must be known and prioritized in early intervention. It is known

that, before the formation of neurons and glial cells, its migration, apoptosis' processes and formation of dendrites are fundamental events. After birth, during childhood, the formation of dendrites, the formation of synapses and the myelination process are the most important events<sup>49</sup>: at 2 years of age, the formation of synapses is doubled in comparison to the number of synapses in adults, being strongly influenced by environmental issues<sup>50</sup>.

Considering the intense neuroplasticity during the first years of life, the interaction between the individual aspects, the environment in which the child is inserted and the tasks proposed, as well as the susceptibility to stimulation in school and/or daycare, cause changes in the psychomotor behavior. All this results in a full motor development, improvement of all capabilities and expansion of the psychomotor background.

The majority (68.8%) of the children evaluated presented normal NPMD, but risks were identified in 31.2% of the children. These children could benefit from early intervention programs. The area that presented the best performance was fine motor-adaptive (3.75%) and the one that presented the most questionable performance was the language area (57.5%).

These findings can contribute to the field of public health through the systematization of strategies for health promotion and prevention. In addition, it can subsidize public policies for children's health.

Our study reinforces the systemic and multifactorial nature of NPMD, considering that low birth weight, monthly family income and paternal absence were the highest risk factors for the development of children in the daycare centers evaluated, which indicates the need for follow-up and monitoring.

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## Resumo

**Introdução:** Os primeiros anos de vida são fundamentais para o desenvolvimento neuropsicomotor (DNPM), neste período as crianças estão propensas a sofrer influências de fatores orgânicos, ambientais ou de atividades que podem ser protetores ou de risco para um desenvolvimento pleno com repercussões até a vida adulta.

**Objetivo:** O presente estudo teve como objetivo analisar o desenvolvimento neuropsicomotor (DNPM) de crianças de zero a três anos de idade e os fatores de risco associados ao desenvolvimento.

**Método:** Estudo transversal, abordagem contextual, baseada na CIF, por meio do Teste de Triagem de Denver II e avaliações complementares do estado nutricional. Na avaliação foram considerados os domínios da Classificação Internacional de Funcionalidade Incapacidade e Saúde (CIF) de funções e estrutura (questionário de avaliação), atividades e participação (avaliação do DNPM na escola), fatores pessoais (características familiares) e fatores ambientais (características dos CEIs). Os instrumentos de avaliação consistiram em um questionário com informações sobre a criança, características atuais, neonatais e familiares. Para avaliação do DNPM, utilizou-se o teste de Denver II. Na análise estatística realizou-se a calibração pelo índice Kappa de concordância intra e inter-avaliadores e posteriormente a regressão logística utilizando como seleção de modelo Logit com resposta binária e método Stepwise (Backward); a construção de uma curva ROC (Receiver Operating Characteristic) para definir o perfil de explicabilidade do modelo construído; o cálculo do Odds Ratio (OR), a razão de chances de ocorrência de uma variável estar associada com o DNPM.

**Resultados:** O DNPM encontrou-se dentro dos parâmetros de normalidade em 68,8% (n=53) e com riscos de atrasos em 31,2% (n=24). A área de melhor desempenho foi a motora fina –adaptativa (3,75%) e a mais questionável foi da linguagem (57,5%). Foi acurado que 52% (n=40) das crianças apresentaram algum risco nutricional. Verificou-se que o baixo peso ao nascer (OR= 181), a renda familiar mensal (OR=9) e a ausência do pai (OR=34) são fatores estatisticamente significantes sobre o risco de atrasos no DNPM.

**Conclusão:** O baixo peso ao nascer, a renda familiar e a ausência do pai estão associados com riscos de atraso do DNPM. Estes achados reforçam a natureza sistêmica e multifatorial do DNPM e comprova a necessidade de acompanhamento, monitoramento e criação de políticas públicas, especialmente em crianças com condições desfavoráveis, que contribuam para o desenvolvimento pleno das crianças, uma vez que instituições de educação infantil do ensino público devem ser agentes transformadoras na qualidade do desenvolvimento infantil.

**Palavras-chave:** fisioterapia, desenvolvimento infantil, educação infantil, promoção da saúde.

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