ORIGINAL ARTICLE

RISK AND PROTECTIVE FACTORS FOR THE NEUROPSYCHOMOTOR DEVELOPMENT OF BABIES FROM THE SUSTAINABLE DEVELOPMENT GOALS

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Highlights: (1) 45.3% of the children showed risk or delay in neuropsychomotor development. (2) Low maternal education increases the risk of delayed child development. (3) The quality of stimulation at home directly influences child development.

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RISK AND PROTECTIVE FACTORS FOR THE NEUROPSYCHOMOTOR DEVELOPMENT OF BABIES FROM THE SUSTAINABLE DEVELOPMENT GOALS

ABSTRACT

This research approached 4- to 18-month-old children who attended daycare centers aiming to identify their neuropsychomotor development (NPMD) and home stimulation and verify the association of neonatal, socioeconomic, and environmental variables with NPMD, from the perspective of the sustainable development goals (SDGs). Cross-sectional study in 181 children, assessing their NPMD (Alberta Infant Motor Scale – AIMS and Denver II screening test) and contexts (Affordances in the Home Environment for Motor Development Infant Scale – AHEMD-IS). The data were analyzed with chi-square independence tests. The NPMD of 45.3% of the children were at risk/delayed; 31.5% had little home stimulation. There was an association with NPMD perceived as typical by parents (p=0.005), who were 7.5 times more likely to correctly identify NPMD. There was an association with maternal educational attainment (p=0.011); mothers with lower educational attainment were up to 3.8 times more likely to have at-risk babies. Better AHMED-IS Physical Space (p=0.006), Variety of Stimulation, and Total scores (p<0.001) were protective to NPMD. The results showed that SGD 3 and 4 are threatened by the lack of home stimulation and low maternal educational attainment; hence, the parental perception must be given importance. These findings may optimize NPMD protective measures proposed by SDGs, providing services and actions to improve early childhood development.

Keywords: Child; Child Development; Sustainable Development Goals; Child Day Care Centers; Risk Factors.

INTRODUCTION

Neuropsychomotor development (NPMD) is a complex multifactorial process with lifelong consequences[1].

For children, social factors or social determinants are “causes of the causes” and have a profound impact on their health[2]. Many of these could be risks for child NPMD[3–5].

The established risk to the development of babies is influenced by various factors, from biological and social disadvantages to stimulation quality, as well as a combination

of these factors[6-7]. Likewise, adequate health and variated stimuli are protective factors, favoring wholesome child development[8–9]. Hence, stimulating and limiting situations impact neural connections in a period particularly relevant to child brain development[10].

Aiming to optimize protective measures for NPMD, the United Nations listed in 2015 the sustainable development goals (SDGs). They are a global initiative plan with 17 goals and 169 targets to eliminate extreme poverty and hunger, provide lifelong quality education for all, protect the planet, and promote peaceful and inclusive societies by 2030. These goals include objectives related to child and adolescent protection, child education, and reduced inequalities, focusing on the most disadvantaged groups and providing fair opportunities to all children and adolescents[11]. SDG 3 is related to health and well-being, and SDG 4 addresses quality education. In this regard,[12] highlight that services and interventions addressing early childhood development are essential to reach the SDGs.

The interaction of contextual and/or environmental influences also include the broadened human health concept of biopsychosocial (BPS) health, present in the International Classification of Functioning, Disability, and Health (ICF)[13]. It approaches child health from a broadened perspective, enabling early identification and intervention measures for them[14], thus putting the SDGs into practice.

Therefore, the present research is justified. It investigated the NPMD of children in an optimal development phase, who attended public schools and were exposed to various risk and protective factors with lifelong consequences[10,15].

This study approached 4- to 18-month-old children who attended public daycare centers in Curitiba, Paraná, Brazil, aiming to identify their NPMD and home stimulation and verify the relationship and/or association between neonatal, socioeconomic, and environmental variables concerning NPMD from the perspective of the SDGs.

METHODS

Cross-sectional, observational, analytical study, approved by the Research Ethics Committee of the Department of Health Sciences at the Universidade Federal do Paraná (UFPR), under CAAE no. 57193516.6.0000.0102 and evaluation report no. 1.714.810. It

complied with the human research guidelines and regulating norms in Resolution 466/2012/CNS of the National Health Council.

Children of both sexes aged 4 to 18 months and attending public daycare centers in Curitiba, Paraná, Brazil, participated in the research with permission of their parents and/or guardians, who signed an informed consent form. Infants with congenital musculoskeletal malformations, signs of neurological changes (convulsions, nervous system infections, neonatal asphyxia, nervous system hemorrhage, atypical reflexes), genetical syndromes, sensory changes, history of congenital infections (TORCH) diagnosed in the neonatal period, malformations that might influence speech, and visual and/or hearing changes were excluded from the sample.

Child development was analyzed through DNPM screening and assessment of the child, family and school context with the following instruments: Alberta Infant Motor Scale (AIMS), an instrument composed of 58 items distributed in four subscales: prone, bench press, sitting and standing. The behaviors observed at the time of the assessment are part of the "motor window" and are scored as 0 (not observed – NO) or 1 (observed – O) [4]. The Denver II screening test, with 125 items divided into four domains: personal social, adaptive fine motor, gross motor and language, in which the action of each item on the scale is classified as: passed; not observed; refused; failed; caution. Children's questionnaire, personal child health record and Affordances in the Home Environment for Motor Development - Children's Scale (AHEMD-IS), behavior by 35 items that evaluate: physical space, variety of stimulation and fine and gross motor toys, the scores classify the environment between less than adequate, moderately adequate, adequate or excellent [16].

The data collection instruments are related to SDG 3 (health and well-being) and 4 (quality education) and were systematized according to the BPS model and ICF domains. The health and NPMD statuses were assessed with the personal child health record, child questionnaire, and development scales (AIMS and Denver II). The child questionnaire, personal child health record, AIMS, and Denver II are related to the Body Functions and Structures domains. Activities and Participation are related to AIMS and Denver II. The Contextual Factors are classified with the socioeconomic questionnaire of the Brazilian Association of Research Companies (ABEP, in Portuguese), AHEMD-IS

and child questionnaire. The Environmental and Personal Factors are related to the child questionnaire (Figure 1).

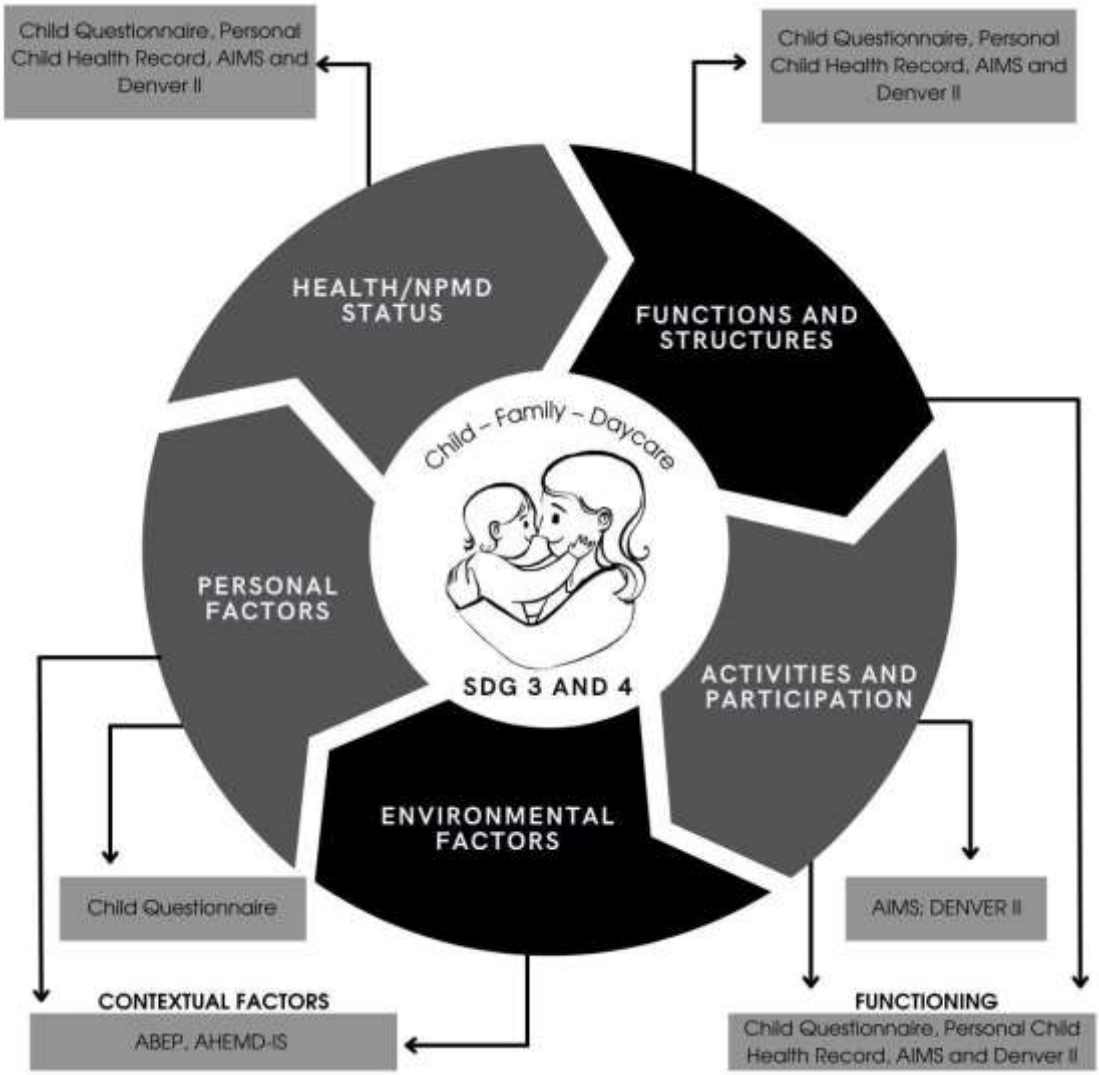

Figure 1 – Systematization of the data collection instruments according to the domains in the International Classification of Functioning, Disability and Health.

Source: the authors, adapted from WHO (2015).

*CAPTION: AIMS = Alberta Infant Motor Scale; AHEMD-IS = Affordances in the Home Environment for Motor Development Infant Scale; ABEP = Brazilian Association of Research Companies; NPMD = neuropsychomotor development; SDG = sustainable development goals.

After surveying the participating children's profile and contexts, the relationship between the variables and the NPMD was analyzed. The variables were organized into five major domains: 1. the children's current characteristics; 2. pregnancy and neonatal characteristics; 3. family characteristics; 4. NPMD characteristics; 5. home stimulation characteristics.

The Shapiro-Wilk test of normality with quantitative variables presented non-parametric distribution. The chi-square (χ^2) adherence test analyzed the proportion between risk and delay in relation to an estimate (33%) based on previous studies[3,19]. Chi-square independence tests investigated whether there were significant associations between the overall prevalence of NPMD (risk/delay or typical) and the variables of interest. For dichotomous variables – birth weight (adequate or inadequate), prematurity (yes or no), type of delivery (normal or cesarean section), single mother (yes or no) and absent father (yes or no), income (adequate or low), AIMS (risk/delay or typical), and Denver II (risk/delay or typical) – the chi-square independence test was used (2X2), verifying significance with the Fisher exact statistics, effect size with the phi-test (φ), and calculating the odds ratio for the variables of interest (significant variables). For variables with three or more categories – paternal and maternal educational attainment (below high school, high school graduate, higher education, or above), ABEP socioeconomic class (A, B1, B2, C1, C2, D-E), householder (mother, father, mother and father, or others), number of adults (1, 2, 3 or more), and AHEMD-IS for Physical Space (PS), Variety of Stimulation (VS), Gross Motor Control (GM), Fine Motor Control (FM), and Total (less than adequate, moderately adequate, adequate, excellent) – the chi-square independence test (nxk) was used, verifying the effect size with Cramer's V-test and analyzing the odds ratio based on adjusted residuals ($> \pm 2$).

Pearson's point-biserial correlation was used for the quantitative variables – age, time in daycare center, age at first daycare attendance, birth weight, birth length, gestational age, head circumference, paternal and maternal age, number of children, and paternal and maternal daily time with the children – in relation to NPMD (dichotomous).

RESULTS

The research sample comprised 181 children (Table 1); 59.1% (n = 107) were males, with a mean age 12.08 months; 47.5% (n = 86) were 13 to 18 months old. Ten daycare centers participated in the study; 32.6% (n = 59) of the children belonged to daycare center "A". The mean age at first daycare attendance was 8.29 months, and the mean time of attendance was 3.7 months.

The children's mean birth weight was 3.24 kg; 11 children (6.1%) had low birth weight. The mean birth length was 48.42 cm, and the mean head circumference was 33.91 cm. The mean gestational age was 38.87 weeks; 7.7% (n = 14) of the children were premature. More than half the children – 53.6% (n = 97) – were born by cesarean section.

Most participating families (37.6%) belonged to socioeconomic class B2. The mean income was R$ 2,935.42; 33.7% (n = 61) of the families had a low income. The father was the householder (highest income) in 48.6% (n = 88) of the families.

The predominating paternal and maternal educational attainment was high school graduate, respectively 55.8% and 54.1%. The mean age of the participating children's fathers was 29.36 years, and that of the mothers was 27.07 years. The number of adults and children in the home ranged from 1 to 5; their mean was respectively 2.35 and 1.62. The mean time the children spent per day with their fathers was 3 hours and with their mothers, more than 5 hours. There were 22.7% (n = 41) single mothers and 19.3% (n = 35) absent fathers. Most parents (91.2%) perceived their children's NPMD as typical.

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TABLE 1 – SAMPLE CHARACTERIZATION AND ASSOCIATIONS WITH NEUROPSYCHOMOTOR DEVELOPMENT

	Variable	Categories	n	%	CI	Mean±SD	p
Current characteristics of the children	Sex[a]	Males	107	59.1			p= 1
		Females	74	40.9			
	Age (months)[a]	4 to 8	42	23.2			
		9 to 12	53	29.3	4-18	12.08±3.61	p= 0.194
		13 to 18	86	47.5			
	Daycare center [a]	A	59	32.6			
		B	22	12.2			
		C	7	3.9			
		D	20	11.0			
		E	31	17.1			
		F	1	0.6			
		G	8	4.4			
		H	6	3.3			
		I	16	8.8			
		J	11	6.1			
	Age at first daycare attendance (months)[b]		181		2-17	8.29±3.54	p= 0.785
	Time in daycare (months) [b]		181		0-13	3.7±2.39	p= 0.489
Neonatal and pregnancy characteristics	Birth weight (kg) [a]	Adequate >2.5 kg	160	88.4	1-5.05	3.24±0.54	p= 0.546
		Low weight ≤ 2.5 kg	11	6.1			
		Not reported	10	5.5			
	Birth length (cm) [b]		171		34.5-56	48.42±2.83	p= 0.681
	Head circumference (cm) [b]		133		25.5-38	33.91±1.71	p= 0.330
	Prematurity [a]	Yes	14	7.7			p= 0.786
		No	167	92.3			
	Gestational age (months) [b]		180		30-42	38.87±1.6	p= 0.883
	Type of delivery [a]	Normal	80	44.2			p= 0.763
		Cesarean	97	53.6			
Family characteristics	ABEP [a]	A	5	2.8			p= 0.193
		B1	11	6.1			
		B2	68	37.6			
		C1	53	29.3			
		C2	32	17.7			
		D-E	12	6.6			

	Income R$ [a]	Adequate (> 2,000.00)	116	64.1	0-11,000	2,935.42±1,875.91	p= 0.753
		Low (≤ 2,000.00)	61	33.7			
		Not reported	4	2.2			
	Householder [a]	Mother	70	38.7			p= 0.547
		Father	88	48.6			
		Father and mother	11	6.1			
		Others	8	4.4			
		Not reported	4	2.2			
	Paternal educational attainment [a]	< HS graduate	42	23.2			p= 0.182
		HS graduate	101	55.8			
		HE degree or +	29	16.0			
		Not reported	9	5.0			
	Maternal educational attainment [a]	< HS graduate	34	18.8			P= 0.011*
		HS graduate	98	54.1			
		HE degree or +	48	26.5			
		Not reported	1	0.6			
	Paternal age (years) [b]		178		16-54	30.80±7.39	p= 0.689
	Maternal age (years) [b]		180		15-43	28.10±6.45	p= 0.404
	No. adults [a]		181		1-3ou+	2.35±0.98	p= 0.646
	No. children [b]		181		1-5	1.62±0.78	p= 0.321
	Paternal daily time (hours) [b]		181		0-10	3.09±2.24	p= 0.749
	Maternal daily time (hours) [b]		181		0-24	5.13±2.73	p= 0.472
	Single mother [a]	Yes	41	22.7			p= 0.594
		No	140	77.3			
	Absent father [a]	Yes	35	19.3			p= 0.264
		No	146	80.7			
	NPMD according to parents [a]	Delay	13	7.2			p= 0.004*
		Typical	165	91.2			
		Not reported	3	1.2			

LEGEND: p-value test in the relationship between variables and NPMD; NPMD = neuropsychomotor development; n = number; CI = confidence interval; SD = standard deviation; cm = centimeters; kg = kilograms; HS = high school; HE = higher education. [a]chi-square test (χ^2); [b]Pearson's point-biserial correlation; *p < 0.05

In the study sample, 54.7% of the children were classified with a typical NPMD and 45.3%, at risk/delay. In AIMS, 65.2% were considered typical and 34.8%, at risk/delay. In Denver II, 66.9% were considered typical and 24.1%, at risk/delay.

However, less than 8% of the parents/guardians indicated that their children were at risk/delay (Table 2).

TABLE 2 – CHARACTERIZATION OF NEUROPSYCHOMOTOR DEVELOPMENT

	Variable	**Categories**	**n**	**%**
NPMD	Overall (AIMS + Denver II)	Typical	99	54.7
		At risk	42	23.2
		Delayed	40	22.1
		At risk/delayed	82	45.3
	AIMS	Typical	118	65.2
		At risk	48	26.5
		Delayed	15	8.3
		At risk/delayed	63	34.8
	Denver II	Typical	121	66.9
		At risk	24	13.3
		Delayed	36	19.9
		At risk/delayed	60	33.1
	Perception of the parents/guardians	Typical	165	91.2
		Delayed	13	7.2
		Not reported	3	1.2

LEGEND: n = number; NPMD = neuropsychomotor development; AIMS = Alberta Infant Motor Scale.

Almost 70% of the children were classified as excellent or adequate in AHEMD-IS total score. The most frequent PS classification was moderately adequate (30.4%); on the other hand, VS was classified as excellent in 44.8% of the sample. GM and FM had the highest representation (respectively 45.3% and 36.5%) among children with adequate home stimulation (Table 3).

TABLE 3 – CHARACTERIZATION OF HOME STIMULATION AND ASSOCIATIONS

	Variable	Categories	n (%)	p
Home stimulation (AHEMD)	Physical space	Excellent	32 (17.7)	p= 0.006*
		Adequate	53 (29.3)	
		Moderately adequate	55 (30.4)	
		Less than adequate	41 (22.7)	
	Variety of stimulation	Excellent	81 (44.8)	p<0.001*
		Adequate	52 (28.7)	
		Moderately adequate	32 (17.7)	
		Less than adequate	16 (8.8)	
	Gross motor function	Excellent	24 (13.3)	p= 0.106
		Adequate	82 (45.3)	
		Moderately adequate	39 (21.5)	
		Less than adequate	36 (19.9)	
	Fine motor function	Excellent	39 (21.5)	p= 0.159
		Adequate	66 (36.5)	
		Moderately adequate	45 (24.9)	
		Less than adequate	31 (17.1)	
	Total score	Excellent	62 (34.3)	p<0.001*
		Adequate	62 (34.3)	
		Moderately adequate	42 (23.2)	
		Less than adequate	15 (8.3)	

LEGEND: p-value test in the relationship between variables and NPMD; n = number.
Chi-square test (χ^2); *p < 0.05

Overall NPMD was not associated with sex (female or male), birth weight (adequate or inadequate), prematurity, type of delivery, single mother, absent father, or income (adequate or low). There was a difference in relation to parental perception of NPMD (χ^2 [1] = 8.850, p = 0.005, φ = 0.220) with a small effect size and an odds ratio (OR) 7.5 times greater of typical babies' parents correctly identifying the NPMD than delayed babies' parents. Only 11 (13.6%) out of the 81 cases of risk/delay were identified by the parents, whereas the typical babies' parents correctly identified it in 97.9% of the cases (95 out of 97).

NPMD was significantly associated with maternal educational attainment (χ^2 [2] = 8.967, p = 0.011, φ = 0.223). Standardized adjusted residual analyses demonstrated that maternal education attainment lower than high school was associated with greater risk of

NPMD. Mothers whose educational attainment was lower than high school were 2.8 times more likely to have babies with at-risk NPMD than mothers who graduated from high school; they were also 3.8 times more likely to have babies with at-risk NPMD than mothers who had a higher education degree or above. Paternal educational attainment, ABEP socioeconomic class, householder, and number of adults were not associated with NPMD.

The following quantitative variables were not correlated with NPMD: age, time in daycare center, age at first daycare attendance, birth weight, birth length, gestational age, head circumference, paternal and maternal age, number of children, and paternal and maternal daily time with the children.

The association analysis between NPMD and AHEMD-IS found significant PS (χ^2 [3] = 12.461, p = 0.006, φ = 0.262), VS (χ^2 [3] = 24.575, $p < 0.001$, φ = 0.368), and total score (χ^2 [3] = 17.390, $p < 0.001$, φ = 0.310). Better AHEMD-IS scores (adequate and excellent) were protective factors, associated with greater likelihood of typical NPMD, while worse scores (less than adequate and moderately adequate) were associated with at-risk NPMD.

In PS, babies with an adequate score were considered protective factors, with a 2.57 greater likelihood of typical NPMD than babies classified as less than adequate. Babies classified as excellent were 4.69 times more likely to have typical NPMD than babies classified as less than adequate. In VS, babies with an adequate score were 15.79 times more likely, and those with an excellent score were 11.31 times more likely to have a typical NPMD than babies with a less than adequate score. AHEMD-IS adequate total score meant they were 4.67 times more likely, and an excellent score, 5.4 times more likely to have typical NPMD.

DISCUSSION

SDGs are integrated, indivisible, and must be addressed in both local and global contexts. Hence, while they have a universally appliable global nature, each country's different realities, capacities, levels of national development, policies, and priorities must be considered[18].

The global recommendations, according to the measures highlighted in the SDGs, indicate access to educational opportunities and care for small children worldwide – especially in low- and medium-income countries, whose proportion of children who do not reach their NPMD potential is high[19]. This was confirmed in the present study, as the NPMD in 45.3% of the children were classified as at-risk and/or delay.

SDG 3, which addresses health and well-being, encompasses 13 objectives, three of them related to reproductive health and child health. The study by[20] proposes that future studies approach the relationship between primary health care indicators and SDG 3, leading to measures based on the findings. Thus, NPMD screening in children who attend public daycare centers may be a functioning indicator useful to follow up health measures and opportunities to small children throughout life with the ICF BPS model[3,4,15,21].

SDG 4, which deals with quality education, aims to ensure access to inclusive and equitable quality education and promote learning opportunities to everyone throughout life[22]. Hence, the opportunities given to children who attend daycare centers must be analyzed, especially in early childhood, which is a crucial phase of development, with lifelong consequences. Encouragement and investment in this phase promote the development of the country[2,23].

Likewise, identifying risk and protective factors may help local decision making, with implementation of public policies and actions to optimize early childhood protective measures[24] and decrease the risk factors. According to[9], this is particularly important because these factors are understudied in low- and medium-income countries. Risk and protective factors accumulated over time are known to be powerful adverse influences (risk) or facilitators (protective) of development[9,25].

Concerning the fathers', mothers', or guardians' perception of their children's NPMD, less than 8% indicated risk, although a large portion of the sample (45.3%) had some risk or delay verified with screening. This discrepancy may be discussed based on parental beliefs regarding NPMD, as proposed by[26] and[27]. They point out how parents idealize their children and cope with adversities at home based on their own experiences and culture. Hence, qualified health professionals can investigate these beliefs and favor a more effective work in family-centered programs[3,17].

This research verified the relevance of having the family pay close attention to the children's NPMD. Nevertheless, typical babies' parents were 7.5 times more likely to correctly identify their children's NPMD than at-risk/delayed babies' parents – only 11 (13.6%) out of the 81 cases of risk/delay were identified by the parents. This finding agrees with the underused personal child health record identified by[28], especially in following up child development milestones. It also corroborates the study by[24], who found a significant correlation between delayed child vaccination schedule and NPMD delay. Therefore, the families must pay attention to NPMD, supported by health professionals and family training and involvement actions, from detection to intervention[3,29], and coordinated with other sectors, including education.

The study by[30] restates the need for child development screening tests in their follow-up routine. Also, reflect on how professionals who screen babies at developmental risk interpret scores in standardized assessments. They highlight the magnitude of adding other likewise relevant information to these tests, such as the perceptions of both parents and professionals involved with the children. Therefore, being in direct contact with the children and families in the daycare setting and exchanging experiences with educators provide a differential for advancements in this scientific field.

The parents'/guardians' lack of perception of the risks posed to children's NPMD, associated with underused follow-up measures, may also reflect the disconnection between education and health. Families are either not properly instructed or do not follow the instructions they receive. Moreover, education professionals are not in direct contact with health professionals, which, regarding public policies, creates a gap in multidisciplinary measures and inclusion of health professionals in educational settings. Thus, development surveillance at school, as conducted in this research, must be emphasized as an integral part of child health care[23]. Furthermore, health professionals should be included in primary care, with cooperation between sectors to surveil child development and approach families[21,31,32].

The study by[33] verified that maternal knowledge of child development is closely related to the mothers' educational attainment and the babies' development indicators. Hence, investing in basic education may benefit child development, agreeing with discussions about the SDGs, especially 3 and 4.

In this regard, the present study identified a significant association between NPMD and maternal educational attainment. Mothers whose educational attainment was below high school level were up to 3.8 times more likely to have babies whose NPMD was at risk. These findings corroborate the studies by[25] and[34], who identified low educational attainment as a risk factor for baby health. The study by[35] verified that higher maternal educational attainment was associated with higher scores, especially in cognitive and language development.

The study by[36] identified that higher paternal and maternal educational attainment resulted in more favorable motor development opportunities. Likewise, the study by[37] stated that the higher the parents' educational attainment, the higher their children's level of development. This suggests that the home context must be approached and investigated[38].

In the present study, adequate and excellent home stimulation were protective factors associated with greater likelihood of typical NPMD, whereas less than adequate and moderately adequate classifications were associated with at-risk NPMD. Adequate total scores in the scale meant they were 4 times more likely, and excellent scores meant they were 5.4 times more likely to have typical NPMD. These findings corroborate the results of research by[39], who highlight that the quality of the family setting is extremely relevant to child development.

In the present study, babies who had the opportunity to develop in an excellent PS were up to 4 times more likely to have a typical NPMD. The inside and outside PS of the home and the stimulation opportunities they provide are closely related to the families' socioeconomic condition. This was discussed in the study by[5], who verified that the lower the families' socioeconomic level, the poorer the stimulations provided by the PS at home.

Various studies[40] have highlighted that stimulus-rich environments with wholesome development opportunities, particularly for young brains, have positive effects on child NPMD. Besides the PS, babies with an adequate VS were up to 15 times more likely to have an adequate development.

These findings corroborate current NPMD theories, in that the context of the task and the stimuli provided to the children are essential to the wholesome development[21].

The variety and diversity of stimuli is necessary to achieve neuroplastic changes and motor learning[4].

Given a variety of factors, daycare centers are a favorable alternative to VS at home – which ratifies the need for the country's investment in SDG 4 targets.

The single assessment stands out among the limitations of the study. It is suggested that children assessed in future studies have long-term follow-up.

CONCLUSION

The research objective was reached, as it identified that maternal educational attainment, parental perception, and home stimulation are risk and/or protective factors for the NPMD of babies up to 18 months old. The main results showed that the SDG 3 targets (health and well-being) are threatened by the lack of home stimulation and low maternal educational attainment. Parental perception of their children's NPMD and SDG 4 (quality education) must be given importance, having in mind that local daycare centers are appropriate to promote NPMD.

These findings help optimize NPMD protective measures proposed in the SGDs, especially 3 and 4, providing services and actions to improve early childhood development both at home and school.

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