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Moderating effect of social risk on the relationship between biological risk and child development

Efeito moderador do risco social na relação entre risco biológico e desenvolvimento infantil

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Abstract *Human development is influenced by the interaction between biological and social factors. This study aimed to verify the moderating effect of social risk on the relationship between biological risk and child development. Data were collected on 201 children, aged 6 to 72 months. The independent variable was measured by the biological risk index, and the moderator variable by the social risk index was assessed by the Denver II test. Linear regression, effect size, and analysis of moderation were used to verify the relationship between BRI and the child development (Denver II), and the moderating effect of the SRI. BRI was negatively associated with child development, the interaction between the BRI and SRI increased the explained variance in the Denver II result to 14%. The SRI was also a significant moderator of the Language and Gross Motor domains. This research evidence that social risk moderates the relationship between biological risk and child development, the more social risk factors, the stronger this relationship becomes. On the other hand, it can be said that some social factors favor child development, even in the presence of biological risk factors.*

Key words *Child development, Risk factors, Biological risk, Social risk*

Resumo *O desenvolvimento humano é influenciado pela interação entre fatores biológicos e sociais. Este estudo teve como objetivo verificar o efeito moderador do risco social na relação entre risco biológico e desenvolvimento infantil. Os dados foram coletados em 201 crianças, com idades entre 6 e 72 meses. A variável independente foi medida pelo índice de risco biológico, e a variável moderadora pelo índice de risco social. O desenvolvimento infantil foi avaliado por meio do teste Denver II. Regressão linear, tamanho do efeito e análise de moderação foram utilizados para verificar a relação entre IRB e o desenvolvimento infantil (Denver II) e o efeito moderador do IRS. O IRB associou-se negativamente ao desenvolvimento infantil, a interação entre o IRB e o IRS aumentou a variância explicada no resultado do Denver II para 14%. O IRS também foi um moderador significativo dos domínios Linguagem e Motor Grosso. Esta pesquisa evidenciou que o risco social é um moderador da relação entre risco biológico e desenvolvimento infantil; quanto mais fatores de risco social, mais forte essa relação se torna. Por outro lado, pode-se dizer que alguns fatores sociais favorecem o desenvolvimento infantil, mesmo na presença de fatores de risco biológicos.*

Palavras-chave *Desenvolvimento infantil, Fatores de risco, Risco biológico, Risco social*

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Introduction

Human development is characterized by constant changes, which are influenced by the interaction between biological factors and the environment in which the individual is inserted[1-3]. Throughout life, all areas of human development occur in an integrated and dynamic way. Early childhood development is especially important, as it is a period of great change and vulnerability to the influence of external factors[4] .

Historically, child development has been studied predominantly from the prospective of the influence of biological factors. The biological risks most strongly associated with impairments in child development are complications in the fetal period, prematurity, low birth weight, brain injury, post-maturity, and a low APGAR index[1,5,6]. In addition, in low- and middle-income countries, delay in child development has been also linked to biological factors such as intrauterine growth restriction, and anemia in infancy[4,5] .

The relationship between biological risk and delay in child development cannot be understood as a direct relationship[4,6,7], since child development is also influenced by family, social, and cultural contexts that can influence this relationship positively or negatively. Social risk factors, such as mothers with low education, symptoms of depression, short stature, adolescent, and without support during pregnancy, as well as low socioeconomic status, lack of access to clean water, poverty, parental stress, and the absence of a father are also associated with delayed motor, cognitive, and language development, and poor school performance[4-7].

Although the impacts of biological and social risks are known in the process of child development, these are multifaceted and complex, and interact with each other[8-10]. The chance of child development delay increases when multiple factors are present[11-13]. Social factors can modify child development, negatively or positively, thus playing a moderating role in the relationship between biological risk and child development[11,13,14]. Moderation occurs when the relationship between an independent variable and a dependent variable varies due to the interaction of a third variable, called a moderator. Identification of the moderating effect of social risk on the well-known relationship between biological risk and child development could help in understanding how these complex associations impact the development of children at risk of delay[11,12,14,15].

In Brazil, the literature has shown that biological factors, such as uterine growth restriction, prematurity, childhood malnutrition, low weight and short stature are associated with child development delay[16-19]. Some studies also demonstrate that the child development of Brazilian children is influenced by social factors, such as low socioeconomic status, single-parent families, low maternal education and maternal depression[4,5,19,20]. However, there is a lack of studies in Brazilian literature that verify the influence of these factors in a more complex way. In Brazil, monitoring of development throughout childhood is carried out through the Child Health Book[21], in which the items intended for screening child development are based on the Denver II test. Despite this, most Brazilian studies on child development use other assessment instruments, such as Bayley Scales, instead of the Denver II[22-25].

The present study aimed to verify the moderating effect of social risk on the relationship between biological risk and child development. Two hypotheses were raised: 1) biological risk factors are associated with worst performance in child development evaluated by the Denver II test, and 2) the relationship between biological risk and child development is moderated by social risk factors.

Method

Design

This is a cross-sectional descriptive study approved by the Research Ethics Committee of the Faculty of Health Sciences of the University of Brasília (CAAE: 93584218.9.0000.0030). Participants were invited to participate voluntarily and signed the consent form.

Participants

Children between six months and six years of age (72 months) were included in a convenience sample, with a history of biological and/or social risk for developmental delays, such as prematurity, low birth weight, low maternal education, and low socioeconomic status. Children with a proven diagnosis of genetic, congenital, or neurological health conditions, such as Down Syndrome and Cerebral Palsy were excluded. Data were collected between May 2019 and February 2020.

Procedures

The children were selected in public daycare centers, at follow-up outpatient clinics, and Early Education Programs of the Federal District-Brazil. When the child's parent/guardian agreed to participate in the study, an interview was conducted with one of the parents/guardians, and the child's evaluation was scheduled at the place where they attend follow up. The parents attended an interview to answer a questionnaire prepared by the researchers, including questions about the child (biological factors) and data on the family and the environment (social factors). Information on personal factors was also verified in the child's health book and medical records.

Dependent variable – child development

The study-dependent variable, child development, was evaluated by too examiners, physical therapists (JATS and KMAA), using the Denver II – Development Screening Test. The Denver II assesses the ability of children to perform age-appropriate tasks in order to identify possible suspects of delays[26,27]. The Denver II evaluates child development in four domains: Personal-Social (25 items), Fine-Adaptive-Motor (29 items), Language (39 items), and Gross Motor (32 items). The items were arranged on a score sheet, according to the degree of complexity. The score was assessed as follows: Passed (performed the item successfully); Failed (did not perform the item); No Opportunity or Refused. Subsequently, each item is classified as advanced, normal, caution or delay[28]. The final result is interpreted as: "*Normal*" (no delay or a maximum of one caution in the items); or "*Suspect*" (two or more cautions and/or one or more delays in the items)[26,27].

To calculate the numerical score, the points of each item evaluated as "Passed", plus one point for each less complex item on the score sheet, were added, producing numerical scores for each domain and the total score[26]. The domains of the Denver II were applied directly to the children, by one of the examiners (JATS or KMAA). The version translated and adapted for the Brazilian population was used, which presents good validity and reliability indices[26,27]. For this study, the reliability between the two examiners (JATS and KMAA) was evaluated in six children, who were not part of the study, obtaining an excellent correlation index (ICC = 0.99) in the four domains of the test.

Independent variable – Biological Risk Index

Six variables, recognized by the literature as biological risk factors for delay in child development, were included in this study: gestational age (GA), birth weight (BW), 5-minute Apgar score, duration of breastfeeding (in months), need for hospitalization for health complications, and number of prenatal consultations. These variables were selected by three researchers of this study (JATS, KMAA, ACRC), with more than 20 years of clinical and research experience in child development, based on an extensive literature review and the data available on the Brazilian medical records. The experts combined these six variables to produce a Biological Risk Index (BRI), following the model presented in previous studies[8,12,13,29].

The created BRI ranged from 0 (low risk) to 8 (very high risk) points, and the higher the score, the higher the biological risk for developmental delay. Gestational age (GA) and BW were scored as follows: 1 point for GA between 37-34 weeks, or 2 points if GA < 34 weeks; 1 point for BW between 2499-1500 grams, or 2 points if BW < 1,499 grams. The other variables, when present, added one point each: 5-min Apgar score < 7; breastfeeding < 3 months; < 6 prenatal consultations; more than three hospitalizations associated with complications due to health problems (e.g., respiratory disease, anemia, cardiac problems).

Moderating variable – Social Risk Index

Five variables, recognized by the literature[11,13,18,20,30-32] as social risk factors for delay in child development, were included in this study: economic class, maternal age, maternal education, marital status, and parental stress. As with the biological risk factors, the researchers' experts (JATS, KMAA, ACRC) grouped the social risk factors to form the Social Risk Index (SRI), which was the study's moderating variable. The SRI was based on an extensive literature review, and followed the model presented in the study by Lean and collaborators[8].

The SRI ranged from 0 (low risk) to 8 (very high risk) points, according to the presence of the following factors: middle economic class (1 point), or low economic class (2 points); maternal age < 19 years (1 point); intermediate maternal education (1 point), or low or very low maternal education (2 points); marital status of single/divorced, where the mother or father of the child does not live with the family (1 point); intermediate parental stress (1 point), or high parental

stress (2 points). The higher the SRI score, the higher the social risk for developmental delay.

The economic class was determined by the Brazilian Criteria of Economic Classification (BCEC), into lower class (D and E), middle class (C), and high class (A and B)[33]. Maternal education was categorized as: very low (early childhood education), low (elementary school), intermediate (high school), high (higher education)[33]. Maternal marital status was categorized as: married or in stable union; single or divorced. The parental stress of the mother was evaluated by the Parental Stress Scale (PSS), which measures the level of stress experienced by parents of children under 18 years of age, adapted and validated for Brazil[34]. The (PSS) contains 18 items, and final results are categorized according to three scoring intervals: 18-42 low stress; 43-66 intermediate stress; 67-90 high stress[34].

Statistical analysis

Descriptive statistics (mean, standard deviation, and frequency) were used to characterize the sample. The Denver II gross score was standardized into Z scores, using means and standard deviations (SD) for each age group of the Denver II score sheet, due to the effects of age on the increase in the score, and thus, to facilitate comparisons[35]. To calculate the Z score, children were divided into 8 age groups: 6-9; 10-12; 13-18; 19-14; 25-36; 37-48; 49-59 and 60-72 months.

To analyze the association between the BRI and Denver II scores, simple linear regression analysis was used between the independent variable and the total Denver II score and its domains. The value of the estimated coefficients (β = standardized regression coefficient, and R^2 = adjusted coefficient of determination) of the regression model was provided through the F test for each coefficient in a confidence interval of 95%. The effect size (f^2) was calculated after the linear regression analysis, considering the values of the coefficient of determination (R^2). The effect size was calculated using the G*Power 3.1.9.7 program and the strength of the association was considered: small ($f^2 = 0.02$), medium ($f^2 = 0.15$) or large ($f^2 \geq 0.35$).

Next, it was verified whether the SRI could moderate the effect of the relationship between the BRI and total Denver II score. To estimate moderation, Hayes PROCESS Model 1 software was used[36]. The interaction result is observed through the regression coefficient (B), adjusted coefficient of determination (R^2), and the p value[36]. The effect of the moderating variable was estimated with 5,000 bootstraps, upper and lower confidence intervals, with values divided into -1SD (below mean), mean, and +1SD (above mean). The conditional effect (*B*) corresponds to the interaction between the moderating variable (SRI) and the independent variable (BRI). The data were analyzed using the Statistical Package SPSS, version 23.0, and the level of significance established was $\alpha = 0.5$.

Results

In total, 201 children were evaluated, with a mean age of 24 months (SD 18.5), the majority were premature (64.2%), with a mean birth weight of 2,450 grams (SD 869.7). The assessment by Denver II identified that 68.7% of the children presented a development suspect, that is, out of the expected for the age. The BRI ranged from 1 to 8 points with a mean of 2.88 (SD 1.8) and the SRI ranged from 0 to 8 points with a mean of 3.80 (SD 1.8). Table 1 presents the characteristics of the study participants.

Table 2 presents the results of the univariate linear regression model. A statistically significant negative association was identified between the BRI and total Denver II score, and 12% of the Denver II score were explained by the variance in the BRI, with a small effect size ($f^2 = 0.14$). There was also a statistically significant association between the BRI and each of the four domains of the Denver II (Table 2), with a small effect size in the personal-social ($f^2 = 0.12$), language ($f^2 = 0.10$), and gross motor domains ($f^2 = 0.14$) and medium in the fine motor domain ($f^2 = 0.15$). Thus, the higher the BRI score, the lower the Denver II score.

There was a statistically significant interaction ($p = 0.02$) between the BRI and SRI, indicating the presence of SRI moderation in the relation of the BRI with the total Denver II score (Table 3). The interaction between the BRI and SRI increased the explained variance of the total Denver II score from 12 to 14%. The SRI was also a significant moderator in the language ($p = 0.01$) and gross motor ($p = 0.04$) domains, increasing the explained variance. Additional information is presented in Table 3.

To better understand the conditional effect of SRI moderation on the relationship between the BRI and Denver II scores, the moderating variable (SRI) was divided into three cut-off points[17]: +1SD (+1SD = 1.86); mean = 0; -1SD (-1SD =

Table 1. Biological and social factors of the study participants.

	Mean (SD)	N (%) Total = 201
Biological factors		
Chronological age (months)	24.61 (18.1)	
Premature		129 (64.25)
Birth weight	2,450 (869.77)	
Male		121 (60.2)
5-min Apgar score	7.64 (1.70)	
Breastfeeding (months)	11.08 (9.06)	
Prenatal care	6.93 (3.72)	
Hospitalization		103 (51.2)
Environmental factors		
Mother's education		
Primary		26 (12.9)
Elementary		30 (14.9)
High school		97 (48.3)
University education		48 (23.9)
Maternal Civil Status		
Married		159 (79.1)
Single		42 (20.9)
Maternal age at delivery	28.8 (7.3)	
Parental stress		
Low		107 (53.2)
Intermediate		92 (45.3)
High		2 (1.0)
Economic class		
Lower class		95 (47.3)
Middle class		94 (46.8)
Higher class		12 (6.0)
Denver II interpretation		
Normal		63 (31.3)
Suspect		138 (68.7)
Biological risk index (BRI)	2.88 (1.80)	
Social risk index (SRI)	3.8 (1.45)	

N: number of subjects; %: frequency; SD: standard deviation.

Source: Authors.

-1.86). The conditional effect of the SRI on the relationship between the BRI and total Denver II score was negative and significant in the three cut-off points ($p < 0.05$). For higher SRI levels (+1SD), the negative relationship between the BRI and Denver II total score was higher (B = -7.534) when compared to lower SRI levels (-1SD) (B = -3.280). Figure 1 presents a graphical representation of the moderation model found.

Discussion

The results of this study demonstrate that there is a significant association between biological risk factors and child development and social risk factors have a moderating effect in this relationship. The more social risk factors the child presents, the stronger the relationship between biological risk factors and worst performance in child development. On the other hand, the more favorable the social environment, the greater the chance of better child development performance, even in the presence of biological risk factors.

In the present study, the significant association between the biological risk index and the Denver II scores demonstrated that the presence of biological risk variables may cause a delay in child development, as demonstrated in previous studies[1,16,18,19,37,38]. A recent Brazilian study evaluated the development of 30 children who were premature, malnourished, or who had neonatal complications. The results showed that 43.3% presented inadequate development, and that the presence of neonatal complications or need for hospitalization were the main factors associated with the results in the Denver II[38].

Although the literature demonstrates the relationship between biological risk and delay in child development, this relationship is not always strong or present for all factors recognized as risk factors[39]. It should be noted that, in the present

Table 2. Simple linear regression analysis between the Biological Risk Index score and Denver II scores.

Denver II	B (CI = 95%)	β	R^2	SEE
Personal-social	-1.20 (-1.67/-0.740)	-0.339	0.11*	0.237
Fine-adaptive-motor	-1.14 (-1.55/-0.728)	-0.359	0.13*	0.209
Language	-1.61 (-2.30/-0.911)	-0.305	0.09*	0.354
Gross Motor	-1.29 (-1.78/-0.809)	-0.347	0.12*	0.246
Total score	-5.25 (-7.23/-3.27)	-0.346	0.12*	1.00

B = regression coefficient; CI = confidence interval; β = standardized regression coefficient; R2 = adjusted coefficient of determination; SEE = standard error of estimate. * $p < 0.05$.

Source: Authors.

Table 3. Interaction of the Social Risk Index moderator in the relationship between the Biological Risk Index and Denver II scores.

Variables	B (CI = 95%)	t	R^2	SEE
Personal--social	-0.193 (-0.44/0.58)	-1.51	0.12	0.12
Fine-adaptive-motor	-0.199 (-0.42/0.23)	-1.76	0.14	0.07
Language	-0.44 (-3.49/-1.47)	-4.86	0.12*	0.51
Gross Motor	-0.30 (-056/-0.04)	-2.31	0.14*	0.13
Total score	-1.14 (-2.20/-0.80)	-2.12	0.14*	0.54

B = regression coefficient; CI = confidence interval; R2 = adjusted coefficient of determination; SEE = standard error of estimate, t = t-value, * $p < 0.05$.

Source: Authors.

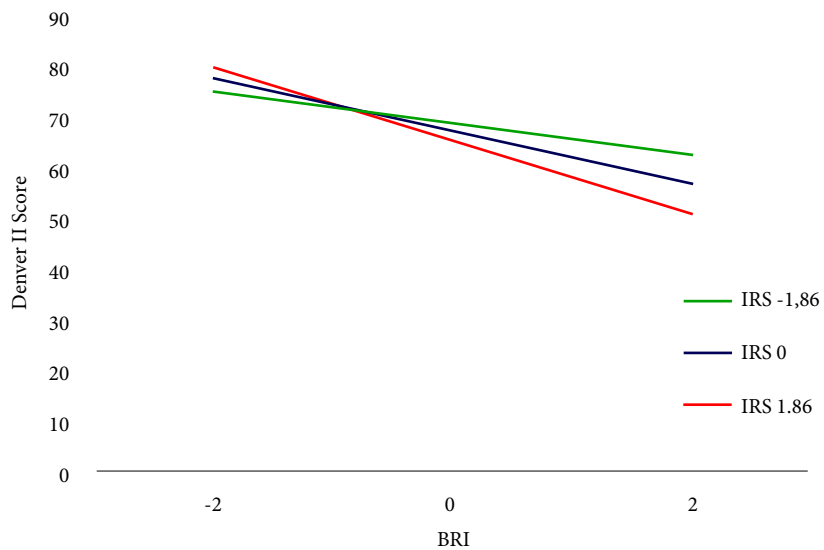

Figura 1. Moderating effect of the Social Risk Index on the relationship between the Biological Risk Index and Denver II total score. Negative moderator effect for Denver II values resulting from the interaction between the independent variable (BRI) and the moderator variable (SRI). Denver II score wih a tendency to decrease as the BRI value increases. Centered averages; SRI-1SD (-1.86); mean SRI (0); SRI+1SD (1.8.6). BRI - biological risk index: SRI - social risk index.

Source: author.

study, the biological risk index presented a small effect size on the total Denver II score and each of the development domains, probably due to the protective influence of improvement in pre-and perinatal care and early intervention programs in recent decades, in addition to the family environment in which the child is inserted[40,41]. A Brazilian longitudinal study followed the development of 49 infants in the first year of life and found no association between the biological risk factors studied and delay in motor and cognitive development of the participants[2]. The authors concluded that variability in motor and cognitive development was better explained by the environment and by the knowledge and practice of parents than by biological risk factors, such as prematurity, low birth weight, APGAR, and hospitalization time[2].

In addition to biological risk factors, the multiplicity of social risk factors such as low economic class, low maternal education, and a high parental stress index, negatively interfere

with child development[11–14,25,29]. Studies show that cumulative social risk factors are associated with a worse state of health and a higher risk of delayed development in children[42], in addition to lower cognitive, language, and motor skills[8]. Level of maternal education and economic class are the social predictors with the greatest impact on child development[2,4,5,20,30,43]. A study conducted with 819 children in a low-income country identified that the situation of extreme poverty was associated with the worst performance in all Denver II developmental domains[44].

The majority of the current literature verified the relationship between biological effects and social effects on motor development linearly or cumulatively, without verifying the moderating effect of one factor on the other, as in the present study[2,5,8,14,30]. Considering the moderating effect of the social risk index, our results demonstrate that in the presence of social risks intensifies the negative effects of biological risk on global development.

A previous study conducted in Brazil verified the moderating effect of social risk on the relationship between biological risk and activities of daily living in children born prematurely, divided into groups according to higher and lower gestational age[14]. The results revealed a significant interaction of social risk factors with mobility skills and social independence of groups of children with a higher biological risk compared to children at lower risk[14]. The authors concluded that social risk played a moderating role in the relationship between prematurity and functional performance of three-year-old children[14]. These results corroborate the present study, confirming that the relationship between biological factors and child development is not linear, principally, it is influenced by the environment in which the child is inserted.

The moderating effect was also evidenced in the DENVER II language and Gross Motor domains, suggesting that these domains are more affected in the presence of higher social risk. Language and motor development are influenced by environmental factors, such as family and school, since typical motor development is context dependent[18,31,32]. Brazilian study with 68 children and their families that evaluated language and writing performance shows that the influence of environmental factors, such as lower parental education and socioeconomic level, increases the probability changes in vocabulary in their children[32]. Also corroborating our results, a cohort study, with 20-month-old premature babies, demonstrated that the level of maternal education is the strongest predictor of motor and language outcomes, in addition to cognitive function[31].

A limitation of this study was the cross-sectional design used, which captures information from a single cut out in time, thus hindering knowledge about the time relationships between the variables. It is suggested that longitudinal studies be conducted on the subject, to better understand the impact of the moderating effect of long-term social risk on child development.

The literature on the investigation of the moderating effect of social risk on the relationship between biological risk and child development is still scarce, which demonstrates that linear relationships remain the most widely studied. Understanding the isolated effect of one factor or another contributes little to the proper planning of possible interventions[45]. According to contemporary theories, it is necessary to understand child development in the context of the life of the child and the relationships that occur between biological factors and the environment. From this new perspective, early intervention programs have used environmental enrichment strategies and highlighted the importance of making changes in the family environment and education to stimulate the children in their own context[40,41,46,47].

Conclusion

The present study identified that social risk factors moderate the relationship between biological risk and child development. Environments and contexts with lower risks may favor child development, even in the presence of biological risk factors. Monitoring child development should include assessments of social risks and interventions which are also directed to the context in which the child is inserted.

Collaborations

JAT Santos: realize the data collect, concept and essay of the manuscript. KMA Ayupe: manuscript concept and essay and final revisor. NL Medeiros: translation and manuscript revisor. ACR Camargos: Writing and manuscript revisor. PJB Gutierres Filho: manuscript revisor.

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References

1. Direk MÇ, Makharoblidze K, Sevimli E, Çelik Y, Taşdelen B, Kömür M, Okuyaz Ç. Long-term cognitive outcomes of prematurely born infants: a longitudinal follow-up of Denver II, Bayley III and WISC-IV Tests. *Pediatr Int* 2021; 63(12):1504-1509.
2. Pereira KR, Valentini NC, Saccani R. Brazilian infant motor and cognitive development: Longitudinal influence of risk factors. *Pediatr Int* 2016; 58(12):1297-1306.
3. Sparrow J. Newborn behavior, parent-infant interaction, and developmental change processes: research roots of developmental, relational, and systems-theory-based practice. *JChild Adolesc.Psychiatr Nurs* 2013; 26(3):180-185.
4. Sania A, Sudfeld CR, Danaei G, Fink G, McCoy DC, Zhu Z, Fawzi MCS, Akman M, Arifeen SE, Barros AJD, Bellinger D, Black MM, Bogale A, Braun JM, van den Broek N, Carrara V, Duazo P, Duggan C, Fernald LCH, Gladstone M, Hamadani J, Handal AJ, Harlow S, Hidrobo M, Kuzawa C, Kvestad I, Locks L, Manji K, Masanja H, Matijasevich A, McDonald C, McGready R, Rizvi A, Santos D, Santos L, Save D, Shapiro R, Stoecker B, Strand TA, Taneja S, Tellez-Rojo MM, Tofail F, Yousafzai AK, Ezzati M, Fawzi W. Early life risk factors of motor, cognitive and language development: a pooled analysis of studies from low/middle-income countries. *BMJ Open* 2019; 9(10):e026449.
5. Munhoz TN, Santos IS, Blumenberg C, Barcelos RS, Bortolotto CC, Matijasevich A, Santos Júnior HG, Santos LMD, Correa LL, Souza MR, Lira PIC, Altafim ERP, Macana EC, Victora CG. Factors associated infant development in Brazilian children: baseline of the impact assessment of the Happy Child Program. *Cad Saude Publica* 2022; 38(2)e00316920.
6. Otto C, Haller A-C, Klasen F,Hölling H, Bullinger, Ravens-Sieberer U; BELLA study group. Risk and protective factors of health-related quality of life in children and adolescents: results of the longitudinal BELLA study. *PLoS One* 2017; 12(12):e0190363
7. Tung I, Christian-Brandt AS, Langley AK, Waterman JM. Developmental outcomes of infants adopted from foster care: predictive associations from perinatal and preplacement risk factors. *Infancy* 2020; 25(1):84-109.
8. Lean RE, Paul RA, Smyser TA, Smyser CD, Rogers CE. Social adversity and cognitive, language, and motor development of very preterm children from 2 to 5 years of age. *J Pediatr* 2018; 203:177-184.
9. Donald KA, Wedderburn CJ, Barnett W, Nhapi RT, Rehman AM, Stadler JAM, Hoffman N, Koen N, Zar HJ, Stein DJ. Risk and protective factors for child development: An observational South African birth cohort. *PLoS Med* 2019; 16(9):e1002920.
10. Van Malderen C, Amouzou A, Barros AJ, Masquelier B, Van Oyen H, Speybroeck N. Socioeconomic factors contributing to under-five mortality in sub-Saharan Africa: a decomposition analysis. *BMC Public Health* 2019; 19(1):760.
11. Horodynski MA, Brophy-Herb HE, Martoccio TL, Contreras D, Peterson K, Shattuck M, Senehi N, Favreau Z, Miller AL, Kaciroti N, Lumeng JC. Familial psychosocial risk classes and preschooler body mass index: the moderating effect of caregiver feeding style. *Appetite* 2018; 123:216-224.

12. Larson K, Russ SA, Crall JJ, Halfon N. Influence of multiple social risks on children's health. *Pediatrics* 2008; 121(2):337-44.
13. Cheng ER, Poehlmann-Tynan J, Mullahy J, Witt WP. Cumulative social risk exposure, infant birth weight, and cognitive delay in infancy. *Acad Pediatr* 2014; 14(6):581-588.
14. Mancini MC, Megale L, Brandão MB, Melo APP, Sampaio RF. The moderating effect of social risk in the relationship between biologic risk and child functional performance. *Braz J Mother Child Health* 2004; 4(1):25-34.
15. Hayes AF. *Introduction to mediation, moderation, and conditional process analysis: a regression-based approach*. New York: Guilford Publications; 2017.
16. Yamaguchi B, Silva AZ, Araujo LB, Guimarães ATB, Israel VL. Psychomotor evaluation of children attending Child Education Centers in the south of Brazil. *Early Child Dev Care* 2021; 191(11):1707-1714.
17. Chaves KYS, Campos MMMS, Nobre RA. Mother-child bonding, environment, and motor development of babies at risk accompanied by a follow-up. *Rev Bras Saude Mater Infant* 2022; 21(4):1015-1023.
18. Bortagarai FM, Moraes AB, Pichini FS, Souza APR. Risk factors for fine and gross motor development in preterm and term infants. *CoDAS* 2021; 33(6):e20200254.
19. Sudfeld CR, McCoy DC, Danaei G, Fink G, Ezzati M, Andrews KG, Fawzi WW. Linear growth and child development in low- and middle-income countries: a meta-analysis. *Pediatrics* 2015; 135(5):e1266-1275.
20. Costa P, Forni E, Amato I, Sassaki RL. Risk and protective factors to early childhood development during the COVID-19 pandemic. *Rev Esc Enferm USP* 2022; 56:e20220196.
21. Brasil. Ministério da Saúde (MS). Ministério da Saúde reforça a importância do uso da Caderneta da Criança [Internet]. 2022. [cited 2023 maio 9]. Available from: https://www.gov.br/saude/pt-br/assuntos/noticias/2022/marco/ministerio-da-saude-reforca-a-importancia-do-uso-da-caderneta-da-crianca
22. Altafim ERP, McCoy DC, Brentani A, Ulhôa Escobar AM, Grisi SJ, Fink G. Measuring early childhood development in Brazil: validation of the Caregiver Reported Early Development Instruments (CREDI). *J Pediatr* 2020; 96(1):66-75.
23. Moreira RS, Magalhães LC, Siqueira CM, Alves CRL. Cross-cultural adaptation of the child development surveillance instrument" Survey of Wellbeing of Young Children (SWYC)" in the Brazilian context. *J Hum Growth Dev* 2019; 29(1):28-38.
24. Guimarães MAP, Magalhães LC, Moreira RS, Bessa FR, Alves CRL. Survey of Well-Being of Young Children (SWYC): preliminary norms for screening for developmental delay in Brazilian children younger than 65 Months. *J Dev Behav Pediatr* 2022; 43(9):e614-e622.
25. Scherrer IRS, Alves CRL. Association of maternal depression, family composition and poverty with maternal care and physical health of children in the first year of life. *J Hum Growth Dev* 2021; 31(1):18-27.
26. Santos JAT, Ayupe, KMA, Lima ALO, Albuquerque KA, Morgado F, Gutierres Filho P. Psychometric properties of the Brazilian version of the Denver II: developmental screening test. *Cien Saude Colet* 2022; 27(3):1097-1106.
27. Boo FL, Mateus MC, Sabatés AL. Initial psychometric properties of the Denver II in a sample from Northeast Brazil. *Infant Behav Dev* 2020; 58:101391.
28. Sabatés AL. *Denver II: teste de triagem do desenvolvimento: manual de treinamento*. São Paulo: Hogrefe; 2017.
29. Evans GW, Li D, Whipple SS. Cumulative risk and child development. *Psychol Bull* 2013; 139(6):1342-1396.
30. Lodi MN, Trubian F, Sangali CC, Moura Rodrigues L, Saccani R. The influence of maternal practices on the motor development of premature children. *R Bras Ci Saude* 2020; 24(3):505-514.
31. Patra K, Greene MM, Patel AL, Meier P. Maternal education level predicts cognitive, language, and motor outcome in preterm infants in the second year of life. *Am J Perinatol* 2016; 33(8):738-744.
32. Dias NM, Bueno JOS, Pontes JM, Mecca TP. Oral and written language in Infant education: relation with environmental variables. *Psicol Esc Educ* 2019; 23:e178467.
33. Associação Brasileira de Empresas de Pesquisa (ABEP). Critério Brasil [Internet]. 2018. [acessado 2021 maio 16]. Disponível em: http://www.abep.org/criterio-brasil
34. Brito A, Faro A. Differences by gender, adaptation and validation of the Parental Stress Scale. *Aval Psicol* 2017; 16(1):38-47.
35. Rubio-Codina M, Araujo MC, Attanasio O, Muñoz P, Grantham-McGregor S. Concurrent validity and feasibility of short tests currently used to measure early childhood development in large scale studies. *PloS One* 2016; 11(8):e0160962.
36. Hayes, Andrew F. Process. The PROCESS macro for SPSS, SAS, and R [Internet]. 2021. [cited 2021 maio 16]. Available from: http://www.processmacro.org/index.html
37. Chaves KYS, Campos MMMS, Nobre RA. Vínculo mãe-filho, ambiente e desenvolvimento motor de bebês acompanhados em seguimento de risco. *Rev Bras Saude Mater Infant* 2022; 21(4):1015-1023.
38. Zago JTC, Pinto PAF, Leite HR, Santos JN, Morais RLS. Association between neuropsychomotor development and biological and environmental risk factors in early childhood children. *Rev CEFAC* 2017; 19(3):320-329.
39. Abessa TG, Bruckers L, Kolsteren P, Granitzer M. Developmental performance of hospitalized severely acutely malnourished under-six children in low- income setting. *BMC Pediatr* 2017; 17(1):197.
40. Novak I, Morgan C, Fahey M, Finch-Edmondson M, Galea C, Hines A, Langdon K, Namara MM, Paton MC, Popat H, Shore B, Khamis A, Stanton E, Finemore OP, Tricks A, Te Velde A, Dark L, Morton N, Badawi N. State of the evidence traffic lights 2019: systematic review of interventions for preventing and treating children with cerebral palsy. *Curr Neurol Neurosci Rep* 2020; 20(2):3.

41. Novak I, Morgan C. High-risk follow-up: early intervention and rehabilitation. *Handb Clin Neurol* 2019; 162:483.
42. Stevens GD. Gradients in the health status and developmental risks of young children: the combined influences of multiple social risk factors. *Matern Child Health J* 2006; 10(2):187-199.
43. Panceri C, Valentini NC, Silveira RC, Smith BA, Procianoy RS. Neonatal adverse outcomes, neonatal birth risks, and socioeconomic status: combined influence on preterm infants' cognitive, language, and motor development in Brazil. *J Child Neurol* 2020; 35(14):989-998.
44. Worku BN, Abessa TG, Wondafrash M, Vanvuchelen M, Bruckers L, Kolsteren P, Granitzer M. The relationship of undernutrition/psychosocial factors and developmental outcomes of children in extreme poverty in Ethiopia. *BMC Pediatr* 2018; 18(1):45.
45. Bronfenbrenner U, Morris PA. *The ecology of developmental processes. In: Handbook of child psychology: theoretical models of human development*, *volume 1*. Hoboken: John Wiley & Sons Inc; 1998. p. 993-1028.
46. Damiano DL, Longo E. Early intervention evidence for infants with or at risk for cerebral palsy: an overview of systematic reviews. *Dev Med Child Neurol.* 2021; 63(7):771-784.
47. Ferreira RC, Alves CRL, Guimarães MAP, Menezes KKP, Magalhães LC. Effects of early interventions focused on the family in the development of children born preterm and/or at social risk: a meta-analysis. *J Pediatr* 2020; 96(1):20-38.

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