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Risk factors for executive function impairment in adolescence: 2004 Pelotas Birth Cohort study

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ABSTRACT

Objective: To investigate risk factors associated with impaired attention-related executive functions (EFs) at age 11 and working memory at age 15.

Methods: Data from the population-based 2004 Pelotas Birth Cohort was analyzed at ages 11 (N=3,582) and 15 (N=1,950). The study measured attentional control, cognitive flexibility, and selective attention using the Daily Attention Test for Children. Spatial working memory was assessed by the Cambridge Automated Neuropsychological Test Battery. Logistic regression was employed to explore the relationship between perinatal and childhood exposures and EF impairment.

Results: Low maternal education had a significant negative impact on EFs. At age 11, it was associated with decreased attentional control (OR=3.04; CI95% 2.09–4.43), and at age 15, it was linked to impaired spatial working memory (OR=2.21; CI95% 1.58–3.09). Additional risk factors included low family income, black or brown maternal skin color, high parity, prematurity, low birth weight, and a high number of siblings. Breastfeeding, regardless of duration, was found to be a protective factor against impaired cognitive flexibility (OR=0.38; CI95% 0.22–0.65).

Conclusion: This study underscores the lasting impact of perinatal exposures on EFs development. Policies that mitigate the negative effects of risk factors and promote EF development, especially among vulnerable populations, are needed.

Keywords: birth cohort, attention, memory, adolescent.

1 Introduction

Cognitive development in childhood and adolescence is influenced by several factors, including socioeconomic and birth conditions, family characteristics, and parenting practices [1]. Executive functions play a critical role in healthy cognitive development as they are responsible for controlling and executing mental, attentional, behavioral, and emotional processes in conflict or distraction situations. According to Diamond [2], executive functions are a set of higher-order cognitive abilities consisting of at least three subcomponents: Inhibition, Working Memory, and Cognitive Flexibility. Other cognitive processes, such as attentional functions, act as underlying factors that support engagement of the main executive functions [3].

Previous research has shown that healthy executive function development is a hugely important predictor for later life outcomes such as subjective and physical well-being [4]. Children who experience adversity during childhood and adolescence are more likely to have impaired executive functions, which affects both their quality of life and development over time [5]. Executive function deficits are associated with risk behaviors such as crime and violence, obesity, overeating, substance abuse, and marital problems in the medium and long term [6]. Attention deficits and internalizing/externalizing problems are also associated with executive function development disorders [7].

The development of executive functions involves several factors and is closely linked to the sensitive periods of brain maturation and the formation of neural circuits, particularly in the prefrontal cortex and limbic regions [8]. Some of these factors are inherent in individual neurobiological development, while others are environmental factors. . It has been argued that adolescence constitute a sensitive period for a range of cognitive functions including affect regulation and executive functions [9]. Studies have described multiple risk factors associated with impaired executive functioning in adolescence, including prematurity, perinatal complications, childhood abuse and neglect, low socioeconomic status, and prolonged exposure to maternal depression [10–13]. These risk factors can disrupt the

normal development of brain regions involved in executive functions, such as the prefrontal cortex, leading to compromised cognitive abilities [14]. Additionally, they may contribute to increased stress levels and altered neurobiological processes, further impairing the functioning of executive processes in adolescence.

Research on risk factors associated with executive function impairment has increased in the literature over the past 20 years [15,16]. However, studies have mainly focused on cohorts from high-income countries, leaving a significant gap in understanding the impact of risk factors on executive function development in low- and middle-income countries (LMICs) [17]. Generalization of results from high-income countries may lead to underestimation of the harmful effects of risk factors on populations in low- and middle-income countries (LMICs), including countries such as Brazil. This discrepancy arises from substantial disparities in the quality of life and socioeconomic conditions experienced by these populations. In LMICs, issues such as child poverty, low birth weight, and inadequate nutrition are more prevalent compared to wealthier nations. As a consequence, the impact of these risk factors is expected to be significantly more pronounced in LMICs [18]. To address this knowledge gap, the present study aims to examine the factors associated with impaired executive functions related to attentional control, selective attention and cognitive flexibility at age 11 and working memory at age 15 among children and adolescents from the 2004 Pelotas Birth Cohort.

2. Methodology

2.1 Ethics

This study was approved by the Ethics Committee for the Analysis of Research Projects of the University of São Paulo and by the Research Ethics Committee of the Federal University of Pelotas. At the sixth follow-up (at age 11), the study was also approved by the Ethics Committee for the Analysis of Research Projects (CAPPESq). Written informed consent was obtained from the adolescents' mothers or guardians. At the sixth and seventh follow-up visits (at ages 11 and 15 years), adolescents signed an informed consent form.

2.2 Participants

The 2004 Pelotas Birth Cohort is a population-based study that included children born in Pelotas, Rio Grande do Sul, Brazil, between January 1 and December 31, 2004. The original cohort comprised 4,231 newborns (99.2% of all births, with 51.2% boys), who were followed throughout childhood and adolescence. The data included 3,491 participants who were followed up at 11 years old and 1,950 who were followed up at 15 years old. The sixth follow-up wave (at 11 years of age) was conducted between May and October 2015, with a follow-up rate of 87%. The seventh follow-up occurred between November 2019 and March 2020 before the beginning of the COVID-19 pandemic. In this follow-up, data collection was interrupted due to the COVID-19 pandemic, and only 46.1% of the original cohort participated in this follow-up before the pandemic. Additional information about the methodology of the 2004 Cohort and the collected data can be found in previous studies [19,20].

2.3 Measures

2.3.1 Executive functions

Attention-related executive functions at age 11 were assessed by performing tasks contained in the Test-of-Everyday-Attention-for-Children (TEA-Ch)[21], a neuropsychological test developed to assess the multidimensional nature of attention and the related executive functions in children and adolescents. The three attention-related executive functions assessed were: attentional control, cognitive flexibility and selective attention. At the age of 15, spatial working memory was examined using a subtest contained in the Cambridge Neuropsychological Testing Automated Battery (CANTAB)[22]. Tasks descriptions are available in Table S1.

In the current study, attention-related executive functions and spatial working memory were dichotomized to define a low-performance group. Attention-related executive functions categorization was done using the cutoff point for <10th percentile, indicating those children who took the most time to complete the task.

Meanwhile, spatial working memory categorization was based on the cutoff point for the 3rd tertile, identifying those with a greater number of errors.

2.3.2 Perinatal exposures

- **Maternal, socioeconomic and pregnancy characteristics**: variables were collected in the perinatal interview and included: family income (measured as a continuous variable and categorized into quintiles), maternal education (categorized into 0, 1-4, 5-8 and ≥9 years of formal education), self-reported maternal skin color (white, black, brown, yellow/indigenous), living arrangement (alone or with partner), maternal age (<20, 20-34, and ≥35 years), and parity (defined as the number of previously born children and categorized as 1, 2, and ≥3). Smoking during pregnancy was retrospectively assessed at birth by maternal reporting (regular smokers were defined as women who smoked at least one cigarette per day in any trimester of pregnancy).
- **Birth characteristics and breastfeeding:** the variables of the child at birth were: low birth weight (birth weight less than 2500g), prematurity (gestational age less than 37 weeks). Breastfeeding was assessed by maternal reporting at 24 months (< 1, 1–3, 3–6, 6–12 or ≥12 months).

2.3.3 Childhood exposures

- **Environmental characteristics**: father absence (social or biological father) was measured in the first 48 months of life (never absent, absent at 24 months, absent at 48 months, always absent). The number of older siblings (none, 1, ≥2) was reported by the mother in the perinatal interview.
- **Maternal depressive symptoms:** The EPDS was originally designed for the identification of postpartum depression disorders in clinical and research settings [23]. The EPDS is a self-administered scale of 10 items; the items were evaluated on a four-point scale (0-3), with a total minimum score of 0 and a maximum score of 30. The scale indicates the intensity of depressive symptoms in the previous seven days. We used the validated version of the questionnaire on the mothers of the 2004 Pelotas Cohort [24]. The EPDS scores

from the 3-month to the 11-year-old follow-up were used to construct the trajectories of maternal depressive symptoms through a semi-parametric group based modeling approach, a specialized form of finite mixture modeling [25,26]. Details of the steps and methods used to identify the trajectories of maternal depressive symptoms have been reported in previous studies [27,28]. Groups 1 ("low" depressive symptomatology trajectory, N=1161) and 2 ("moderately low" trajectory, N=1361) represented 75.7% of mothers, and had EPDS scores lower than 10 points in all follow-ups. Group 3 ("increasing" depressive symptomatology trajectory) included 9% (N=300) of the women monitored, who had a consistent increase in depressive symptoms throughout the study period. Group 4 ("descending" trajectory) included 9.9% (N=329) of women and, unlike the previous group, these mothers had high EPDS scores during the first two years postpartum and a sharp decrease thereafter. Finally, group 5 ("high-chronic" trajectory) represented 5.4% of the population (N=181), and included mothers who had high EPDS scores throughout the study period.

- **Maltreatment:** Adolescent maltreatment was evaluated in the follow-up of 11 years old. Caregivers, most of whom were mothers, were asked about parenting strategies using the parent-child version of the Conflict Tactics Scale (CTSPC) [29]. The Portuguese version of the CTSPC was adapted and validated cross-culturally for use in Brazil [30–32]. The CTSPC comprises a questionnaire composed of 22 items that measure the parental behavior in relation to the child in the last 12 months. The CTSPC evaluates behaviors related to nonviolent discipline (4 items); psychological aggression (5 items); and physical aggression, including corporal punishment (5 items), physical abuse (4 items), and severe physical abuse (4 items; not administered in this study. All items were scored on a 3-point scale (0-2), from never to once and more than once, giving a total score of 0 to 28. Higher scores indicate higher exposure to maltreatment. In this study, the total score on the CTSPC scale was categorized into tertiles.

2.4 Statistical analysis

Comparisons between socioeconomic, maternal and birth characteristics among the participants of the follow-ups of 11 (N=3582) and 15 (N=1950) years old in relation to the total number of participants at baseline (N=4231) were performed using the chi-square test. The descriptive analysis was performed by calculating the absolute and relative frequencies of the variables included in the analysis. The bivariate statistical analysis between each exposure and the study outcomes was performed by means of the chi-square test. To study the potential risk factors for impaired performance in executive functions related to attentional control, cognitive flexibility, selective attention and spatial working memory, logistic regression models were constructed for each executive function analyzed and the adjustment was performed using a hierarchical conceptual model for determining risk factors (Figure 1) with four levels: a) level 1: adjustment for maternal, socioeconomic and pregnancy characteristics; b) level 2: adjustment for level 1 variables and environmental characteristics; c) level 3: adjustment for level 2 variables and characteristics of birth and breastfeeding; d) level 4: adjustment for level 3 variables and maltreatment in childhood. Odds ratios (OR) were used to assess the associations between variables. If the significance level was below 0.20, the variable remained in the model as a potential confounder for the next level [33]. An alpha level of 0.05 was considered to indicate an association, All analyses were conducted using Stata software, version 16.1 (StataCorp LP, College Station, Texas). An additional analysis was conducted, in which potential risk factors were modeled for two distinct groups: participants belonging to the lowest income quintile, representing the economically disadvantaged group; and the other participants belonging to the second to fifth income quintiles.

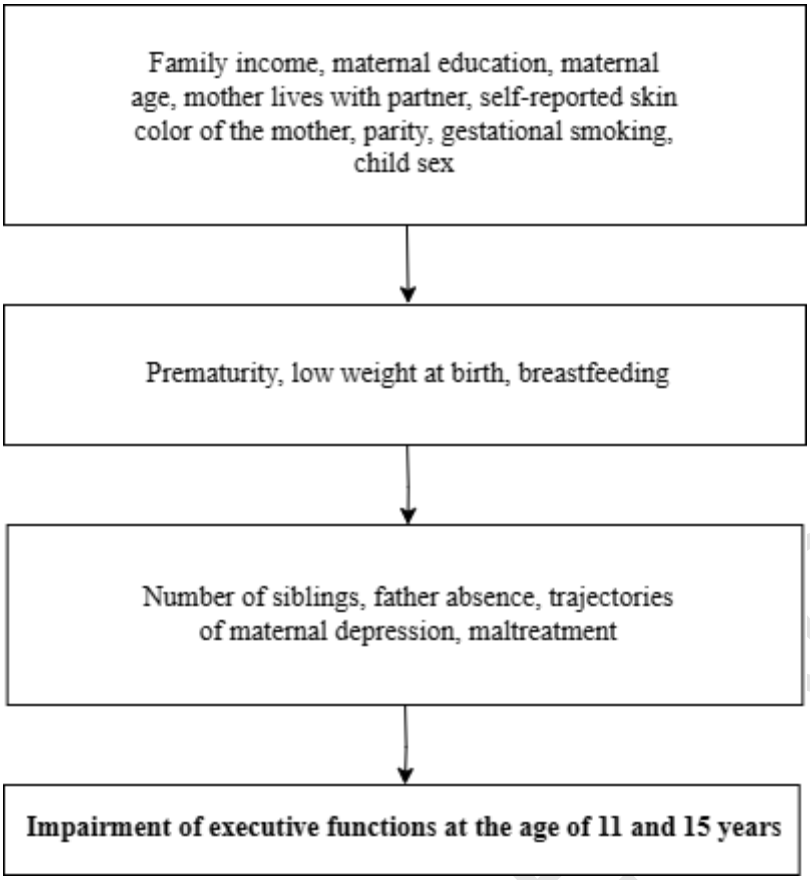

Figure 1: Conceptual model for determining risk factors associated with executive functions at 11 and 15 years of age in adolescents from the 2004 Pelotas Birth Cohort.

3. Results

3.1 Attrition analysis

Participants who were followed up at 11 and 15 years had better socioeconomic indicators than those in the perinatal period, as shown in Table 1. Additionally, there were fewer cases of preterm birth and low birth weight among those followed up at 11 and 15 years compared to the perinatal period. At age 11, a higher proportion of mothers reported living with their partner, while at age 15, more mothers had their children at age 35 or older. There were no differences in maternal skin color and children sex between those followed at 11 and 15 years compared to those at the baseline.

Table 1. Maternal and adolescent characteristics among participants in follow-ups conducted at 11 and 15 years of age in relation to participants in the perinatal period.

		Follow-ups	
Variables	**Perinatal** (N=4231)	**11 years** (N=3582)	**15 years** (N=1950)
	N(%)	N(%)	N(%)
Family income (quintiles)		*p<0.001*	*p=0.001*
5th quintile (wealthiest)	830 (19.6)	693 (19.4)	362 (18.6)
4th quintile	858 (20.3)	754 (21.1)	432 (22.2)
3rd quintile	816 (19.3)	709 (19.9)	407 (20.9)
2nd quintile	854 (20.2)	716 (20.1)	383 (19.7)
1st quintile (poorest)	871 (20.6)	696 (19.5)	365 (18.7)
Maternal education (years)		*p=0.001*	*p=0.021*
≥ 9	1801 (43.0)	1542 (43.7)	868 (44.9)
5-8	1731 (41.4)	1465 (41.5)	790 (40.8)
1-4	611 (14.6)	497 (14.1)	264 (13.6)
0	43 (1.0)	29 (0.8)	13 (0.7)
Self-reported maternal skin color		*p=0.142*	*p=0.057*
White	2581 (61.7)	2197 (62.3)	1220 (63.4)
Black	689 (16.5)	584 (16.6)	316 (16.4)
Brown	868 (20.8)	711 (20.2)	375 (19.5)
Yellow/Indigenous	43 (1.0)	35 (1.00)	14 (0.7)
Maternal age at birth (years)		*p=0.079*	*p<0.001*
20-34	2865 (67.8)	2404 (67.4)	1296 (66.5)
< 20	799 (18.9)	669 (18.8)	350 (18.0)
≥ 35	563 (13.3)	493 (13.8)	303 (15.6)
Mother living with partner		*p=0.001*	*p=0.062*
Yes	3536 (83.6)	3013 (84.5)	1652 (84.8)
No	693 (16.4)	555 (15.6)	297 (15.3)
Child sex		*p=0.348*	*p=0.350*
Male	2.194 (51.8)	1840 (51.6)	996 (51.1)
Female	2.035 (48.1)	1728 (48.4)	953 (48.9)
Low birth weight		*p<0.001*	*p=0.024*
No	3803 (90.0)	3247 (91.0)	175 (91.1)
Yes	423 (10.0)	320 (9.0)	173 (8.9)
Preterm birth		*p=0.007*	*p=0.025*
No	3603 (85.5)	3068 (86.1)	1689 (86.8)
Yes	612 (14.5)	495 (13.9)	257 (13.2)

3.2 Sample description

The majority of mothers followed up at 11 and 15 years of age were white, between 20 and 34 years of age, had at least 9 years of schooling, and did not smoke during pregnancy. The prevalence among boys was slightly higher at both ages 11 and 15 years. For most adolescents, fathers were present during childhood. In addition, the majority of adolescents were breastfed for at least the first month of life. For more details on participant characteristics, see Supplementary Material (Table S2).

3.3 Bivariate analysis

Lower family income, lower levels of maternal education and greater number of siblings were associated with attention-related executive functions at age 11 and spatial working memory impairment ate age 15 (Table 2). Children of single mothers and of mothers who smoked during pregnancy showed lower performance in attentional control. Other factors associated with lower performance in attentional control, selective attention, and spatial working memory were maternal skin color (black or brown), parity of three or more children, and father absence at 24 and 48 months. Additionally, prematurity and low birth weight were associated with lower performance of attention-related executive functions at 11 years of age. Male adolescents presented lower performance in selective attention, while girls showed more frequently lower performance in spatial working memory. Furthermore, adolescents of mothers with chronic and severe depressive symptoms between 3 months and 11 years old had lower performance in attentional control, selective attention and spatial working memory. Higher levels of maltreatment were associated with lower performance in cognitive flexibility. Lower performance in cognitive flexibility was also observed among children who were never breastfed.

Table 2: Frequency of impairment of executive functions related to attention and spatial working memory according to maternal and adolescent characteristics.

Variables	Executive functions impairment			
	Attentional control (p10) at 11 years n=3.452 n (%)	Cognitive flexibility (p10) at 11 years n=3.413 n (%)	Selective attention (p10) at 11 years n=3.392 n (%)	Spatial working memory (p3) at 15 years n=1.910 n (%)
Family income (quintiles)	*p<0.001*	*p=0.001*	*p=0.001*	*p<0.001*
5th quintile (wealthiest)	2 (0.3)	49 (7.4)	30 (4.6)	65 (18.3)
4th quintile	45 (6.1)	54 (7.4)	57 (7.8)	92 (21.7)
3rd quintile	71 (10.3)	77 (11.3)	74 (10.8)	108 (27.1)
2nd quintile	91 (13.0)	9 (1.3)	92 (13.5)	110 (29.5)
1st quintile (poorest)	110 (16.7)	82 (12.6)	86 (13.5)	132 (36.9)
Maternal education (years)	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
≥ 9	72 (4.8)	106 (7.1)	85 (5.7)	162 (18.9)
5-8	159 (11.3)	166 (11.9)	158 (11.5)	235 (30.6)
1-4	105 (22.0)	64 (13.6)	87 (18.7)	100 (38.6)
0	7 (25.9)	4 (16.0)	9 (33.3)	7 (63.6)
Maternal age at birth (years)	*p=0.009*	*p=0.108*	*p=0.006*	*p=0.065*
20-34	221 (9.5)	219 (9.6)	239 (10.5)	332 (26.1)
< 20	84 (12.9)	79 (12.2)	66 (10.3)	106 (31.1)
≥ 35	37 (7.8)	43 (9.1)	33 (7.0)	69 (23.2)
Mother living with partner	*p=0.041*	*p=0.907*	*p=0.689*	*p=0.167*
Yes	277 (9.5)	287 (10.0)	284 (9.9)	421 (26.0)
No	67 (12.4)	54 (10.1)	55 (10.5)	86 (29.9)
Self-reported maternal skin color	*p<0.001*	*p=0.169*	*p<0.001*	*p<0.001*
White	142 (6.7)	19 (0.9)	151 (7.2)	279 (23.3)
Black	96 (16.1)	69 (12.3)	99 (18.1)	113 (36.6)
Brown	93 (13.6)	67 (9.9)	80 (11.9)	106 (29.0)
Yellow/Indigenous	4 (11.8)	2 (5.9)	2 (5.9)	4 (28.4)
Parity	*p<0.001*	*p=0.063*	*p<0.001*	*p=0.009*
1	105 (7.7)	131 (9.7)	109 (8.1)	183 (25.1)
2	71 (7.6)	79 (8.5)	81 (8.8)	127 (23.4)
3 +	168 (14.6)	131 (11.6)	149 (13.3)	197 (30.8)
Smoking during pregnancy	*p=0.004*	*p=0.788*	*p=0.099*	*p=0.470*
No	230 (9.1)	248 (9.9)	236 (9.5)	342 (24.2)
Yes	114 (12.4)	93 (10.2)	103 (11.4)	165 (33.3)
Father absence	*p=0.019*	*p=0.841*	*p=0.005*	*p<0.001*
Never absent	176 (8.6)	196 (9.7)	173 (8.6)	302 (25.3)
Absent at 24 months	22 (10.1)	22 (10.1)	22 (10.4)	27 (26.5)
Absent at 48 months	47 (13.0)	37 (10.3)	51 (14.4)	50 (28.2)
Always absent	52 (12.1)	36 (8.6)	47 (11.4)	66 (30.0)

Low birth weight	*p=0.004*	*p=0.046*	*p<0.001*	*p=0.032*
No	300 (9.5)	309 (9.9)	290 (9.4)	1.292 (74.1)
Yes	44 (14.7)	32 (10.8)	49 (16.8)	111 (66.5)
Preterm birth	*p<0.001*	*p=0.046*	*p<0.001*	*p=0.334*
No	275 (9.2)	282 (9.6)	271 (9.2)	434 (26.2)
Yes	69 (14.7)	58 (12.6)	67 (14.6)	73 (29.1)
Child sex	*p=0.202*	*p=0.710*	*p=0.007*	*p<0.001*
Male	188 (10.6)	178 (10.2)	197 (11.3)	201 (20.7)
Female	156 (9.3)	163 (9.8)	142 (8.6)	306 (32.7)
Maltreatment (CTSPC score)	*p=0.878*	*p=0.022*	*p=0.139*	*p=0.435*
1st tercile (lower)	113 (9.6)	120 (10.3)	107 (9.2)	156 (26.0)
2nd tercile	131 (10.1)	107 (8.4)	117 (9.2)	177 (25.8)
3rd tercile (highest)	95 (10.2)	110 (11.9)	106 (11.5)	152 (28.8)
Number of siblings	*p<0.001*	*p=0.009*	*p<0.001*	*p<0.001*
0	80 (7.2)	94 (8.5)	83 (7.5)	133 (22.5)
1	92 (7.4)	120 (9.7)	118 (9.6)	177 (24.9)
≥ 2	158 (16.3)	119 (12.6)	125 (13.4)	176 (34.2)
Trajectories of maternal depressive symptoms	*p=0.001*	*p=0.218*	*p=0.040*	*p<0.001*
Low	84 (7.7)	95 (8.7)	84 (7.7)	115 (19.6)
Moderate low	137 (9.6)	144 (10.2)	141 (10.0)	223 (27.5)
Decreasing	48 (12.7)	43 (11.5)	46 (12.5)	65 (32.0)
Increasing	47 (15.3)	35 (11.6)	34 (11.4)	52 (31.0)
Chronic high	17 (10.7)	21 (13.4)	19 (12.1)	33 (35.1)
Breastfeeding duration (months)	*p=0.009*	*p=0.000*	*p=0.253*	*p=0.047*
0 months	11 (12.1)	19 (21.6)	15 (16.7)	16 (27.6)
< 1 month	27 (10.3)	21 (8.1)	25 (9.8)	40 (30.8)
1 - 3 months	71 (13.9)	67 (13.4)	53 (10.7)	93 (33.2)
3 - 12 months	105 (8.32)	116 (9.3)	120 (9.6)	175 (25.1)
≥ 12 months	128 (9.7)	11 (9.0)	122 (9.5)	182 (24.7)

p value = x^2 test; p10 = worst decile (adolescents who took longer to complete the task) ; p3 = worst tercile (adolescents who made a higher number of mistakes in the task).

3.4 Adjusted analysis

Several perinatal and childhood predictors were associated with impaired attention-related executive functions and spatial working memory (Table 3). Low maternal education was a strong predictor of deficit on attention-related executive functions and spatial working memory. This observation remained consistent even after stratifying by family income (see Tables S3 and S4). Moreover, lower family

income was associated with higher odds of attentional control impairment. Notably, children of mothers who described their skin color as black performed worse than children of white mothers on attentional control, selective attention, and spatial working memory. This result persisted for selective attention impairment even when family income stratification was taken into account.

Table 3: Logistic regression models for impairment in performance of attentional control, cognitive flexibility and selective attention at age 11 and spatial working memory at age 15.

	Attentional control		Cognitive flexibility		Selective attention		Spatial working memory	
Variables	**Crude**	**Adjusted***	**Crude**	**Adjusted***	**Crude**	**Adjusted***	**Crude**	**Adjusted***
	OR (CI95%)	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**
Family income								
(quintiles)	p<0.001	p=0.029	p=0.001	p=0.247	p<0.001	p=0.241	p<0.001	p=0.064
5th (wealthiest)	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)
4th	1.55 (0.94 – 2.52)	1.14 (0.69 – 1.89)	1.00 (0.67 – 1.49)	-	1.78 (1.13 – 2.80)	-	1.24 (0.87 - 1.77)	1.08 (0.75 - 1.57)
3rd	2.72 (1.72 – 4.30)	1.60 (0.98 – 2.60)	1.59 (1.10 – 2.32)	-	2.54 (1.64 – 3.94)	-	1.66 (1.17 – 2.35)	1.24 (0.85 - 1.80)
2nd	3.55 (2.28 – 5.54)	1.60 (0.98 – 2.60)	1.62 (1.12 – 2.35)	-	3.27 (2.13 – 5.01)	-	1.87 (1.32 – 2.65)	1.20 (0.81 – 1.78)
1st (poorest)	4.76 (3.08 – 7.36)	1.95 (1.20 – 3.17)	1.81 (1.25 – 2.62)	-	3.27 (2.12 – 5.03)	-	2.61 (1.85 – 3.69)	1.66 (1.13 – 2.45)
Maternal								
education (years)	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
≥ 9	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
5-8	2.53 (1.90 – 3.38)	1.55 (1.12 – 2.15)	1.77 (1.37 -2.28)	1.77 (1.37 -2.98)	2.14 (1.63 – 2.82)	1.80 (1.33 – 2.42)	1.89 (1.51 – 2.38)	1.51 (1.17 - 1.95)
1-4	5.60 (4.07 – 7.72)	3.04 (2.09 – 4.43)	2.06 (1.48 - 2.86)	2.06 (1.48 – 2.86)	3.81 (2.77 – 5.24)	3.06 (2.15 – 4.36)	2.70 (2.00 – 3.66)	2.21 (1.58 – 3.09)
0	6.97 (2.85 – 17.01)	4.10 (1.53 – 10.95)	2.49 (0.84 – 7.39)	2.49 (0.84 – 7.39)	8.27 (3.61 – 18.96)	9.15 (3.82 – 21.96)	7.52 (2.17 – 25.99)	4.98 (1.41 – 17.62)
Maternal age at								
birth (years)	p=0.010	p=0.003	p=0.109	p=0.218	p=0.069	p=0.014	p=0.065	p=0.338
20-34	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-
< 20	1.41 (1.07 – 1.84)	1.56 (1.11 – 2.19)	1.31 (1.00 – 1.73)	-	0.98 (0.74 - 1.31)	1.00 (0.70 – 1.41)	1.28 (0.98 – 1.66)	-
≥ 35	0.80 (0.56 – 1.15)	0.67 (0.45 – 0.99)	0.95 (0.6 – 1.33)	-	0.64 (0.44 – 0.94)	0.55 (0.37 – 0.82)	0.85 (0.63 – 1.15)	-
Self-reported								
maternal skin	p<0.001	p<0.001	p=0.173	p=0.430	p<0.001	p<0.001	p<0.001	p=0.036
color								

White	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Black	2.83 (2.15 – 3.74)	2.14 (1.60 – 2.87)	1.36 (1.02 – 1.83)	-	2.86 (2.18 - 3.76)	2.47 (1.86 - 3.27)	1.90 (1.45 - 2.48)	1.52 (1.15 – 2.02)
Brown	2.19 (1.66 – 2.89)	1.66 (1.24 – 2.22)	1.06 (0.79 – 1.42)	-	1.74 (1.31 – 2.32)	1.45 (1.08 – 1.95)	1.34 (1.03 - 1.75)	1.11 (0.85 - 1.47)
Yellow/Indigenous	1.86 (0.65 – 5.36)	1.87 (0.64 – 5.46)	0.61 (0.14 – 2.54)	-	0.81 (0.19 – 3.40)	0.83 (0.20 – 3.53)	1.32 (0.41 – 4.23)	1.07 (0.33 – 3.51)
Parity	p<0.001	p<0.001	p=0.064	p=0.287	p<0.001	p=0.116	p=0.100	p=0.251
1	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-
2	0.99 (0.72 – 1.35)	1.13 (0.80 – 1.61)	0.87 (0.65 – 1.17)	-	1.10 (0.82 – 1.49)	1.03 (0.74 – 1.44)	0.91 (0.70 – 1.18)	-
≥ 3	2.05 (1.59 – 2.66)	1.93 (1.36 – 2.74)	1.23 (0.95 – 1.58)	-	1.74 (1.34 – 2.27)	1.36 (0.98 – 1.90)	1.32 (1.04 – 1.68)	-
Smoking during pregnancy	p=0.004	p=0.738	p=0.788	p=0.264	p=0.099	p=0.471	p<0.001	p=0.063
No	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)
Yes	1.41 (1.11 – 1.80)	-	104 (0.80 – 1.33)	-	1.23 (0.96 – 1.57)	-	1.57 (1.26 - 1.96)	1.26 (0.99 - 1.60)
Mother living with partner	p=0.041	p=0.309	p=0.907	p=0.608	p=0.689	p=0.699	p=0.167	p=0.684
Yes	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
No	1.34 (1.01 – 1.79)	-	1.02 (0.74 – 1.38)	-	1.06 (0.78 – 1.44)	-	1.21 (0.92 – 1.60)	-
Child sex	p=0.203	p=0.085	p=0.710	p=0.689	p=0.007	p=0.005	p<0.001	p<0.001
Female	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Male	1.16 (0.92 – 1.45)	1.23 (0.97 – 1.56)	1.04 (0.83 – 1.31)	-	1.36 (1.08 – 1.71)	1.41 (1.11 – 1.78)	0.54 (0.43 – 0.66)	0.54 (0.44 – 0.67)
Preterm birth	p<0.001	p=0.026	p=0.047	p=0.162	p=0.047	p=0.249	p=0.334	p=0.597
Não	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-
Sim	1.69 (1.27 – 2.25)	1.42 (1.04 – 1.93)	1.36 (1.00 - 1.84)	1.24 (0.92 – 1.69)	1.36 (1.00 – 1.84)	-	1.16 (0.86 – 1.55)	-
Low birth weight	p=0.005	p=0.258	p=0.623	p=0.516	p=0.623	p<0.001	p=0.033	p=0.136
No	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)

Yes	1.63 (1.16 – 2.29)	-	1.10 (0.75 – 1.62)	-	1.10 (0.75 – 1.62)	1.98 (1.40 – 2.79)	1.45 (1.03 - 2.03)	1.31 (0.92 – 1.88)
Breastfeeding duration (months)	p=0.010	p=0.160	p<0.001	p=0.001	p=0.267	p=0.618	p=0.048	p=0.135
0 months	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)
< 1 month	0.84 (0.40 – 1.77)	1.02 (0.46 – 2.27)	0.32 (0.16 – 0.63)	0.32 (0.16 – 0.64)	0.32 (0.16 – 0.63)	-	0.15 (-0.53 – 0.84)	1.41 (0.68 – 2.91)
1 - 3 months	1.18 (0.60 – 2.32)	1.33 (0.65 – 2.75)	0.56 (0.32 – 0.99)	0.56 (0.31 – 0.99)	0.56 (0.32 - 0.99)	-	0.27 (-0.36 – 0.89)	1.42 (0.73 – 2.75)
3 - 12 months	0.66 (0.34 – 1.28)	0.87 (0.43 – 1.75)	0.37 (0.22 – 0.64)	0.40 (0.23 – 0.70)	0.37 (0.22 – 0.64)	-	-0.13 (-0.73 – 0.47)	1.05 (0.56 – 1.99)
≥ 12 months	0.78 (0.40 – 1.51)	0.94 (0.47 – 1.90)	0.36 (0.21 – 0.62)	0.38 (0.22 – 0.65)	0.36 (0.21 – 0.62)	-	-0.15 (-0.75 – 0.45)	0.98 (0.52 – 1.85)
Number of siblings	p<0.001	p=0.015	p=0.009	p=0.358	p<0.001	p=0.294	p<0.001	p=0.042
0	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)
1	1.04 (0.76 – 1.41)	1.05 (0.73 – 1.48)	115 (0.87 – 1.53)	-	1.30 (0.97 – 1.74)	-	1.15 (0.89 - 1.48)	0.96 (0.72 – 1.27)
≥ 2	1.53 (1.90 – 3.36)	1.60 (1.10 – 2.33)	1.53 (1.15 – 2.04)	-	1.89 (1.41 – 2.53)	-	1.79 (1.37 – 2.34)	1.34 (1.00 – 1.81)
Father absence	p=0.020	p=0.394	p=0.842	p=0.717	p=0.005	p=0.074	p=0.471	p=0.986
Never absent	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-
Absent at 24 months	1.19 (0.74 – 1.89)	-	1.05 (0.66 – 1.66)	-	1.04 (0.66 - 1.66)	0.93 (0.57 – 1.53)	1.06 (0.67 – 1.68)	-
Absent at 48 months	1.58 (1.12 – 2.23)	-	1.07 (0.74 – 1.54)	-	1.07 (0.74 – 1.54)	1.58 (1.11 – 2.24)	1.16 (0.82 – 1.65)	-
Always absent	1.46 (1.05 – 2.02)	-	0.87 (0.60 – 1.26)	-	0.87 (0.60 - 1.26)	1.09 (0.76 – 1.56)	1.27 (0.92 – 1.74)	-
Trajectories of maternal depressive symptoms (3	p=0.001	p=0.209	p=0.221	p=0.819	p=0.042	p=0.995	p<0.001	p=0.013

months to 11 years)								
Low	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)
Moderate low	1.28 (0.96 – 1.70)	-	1.19 (0.91 – 1.56)	-	1.19 (0.91 – 1.56)	-	1.65 (1.29 - 2.14)	1.61 (1.23 - 2.12)
Decreasing	1.76 (1.21 – 2.56)	-	1.36 0.93 – 1.99)	-	1.36 (0.93 – 1.99)	-	1.93 (1.35 - 2.77)	1.52 (1.02 - 2.25)
Increasing	2.18 (1.49 – 3.20)	-	1.38 (0.92 – 2.08)	-	1.38 (0.92 – 2.08)	-	1.84 (1.25 - 2.70)	1.44 (0.95 - 2.20)
Chronic high	1.45 (0.83 – 2.50)	-	1.62 (0.98 – 2.69)	-	1.62 (0.98 – 2.69)	-	2.22 (1.39 – 3.55)	1.69 (1.00 – 2.83)
Maltreatment (CTSPC score)	p=0.878	p=0.964	p=0.023	p=0.051	p=0.140	p=0.517	p=0.574	p=0.753
3rd tercile (highest)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-
2nd tercile	1.06 (0.81 – 1.38)	-	0.80 (0.61 – 1.05)	0.82 (0.62 – 1.08)	0.80 (0.61 – 1.05)	-	0.99 (0.77 – 1.27)	-
1st tercile (lower)	1.07 (0.80 – 1.43)	-	1.18 (0.89 – 1.55)	1.16 (0.88 – 1.54)	1.18 (0.89 – 1.55)	-	1.15 (0.89 – 1.50)	-

* For attentional control: smoking during pregnancy (p=0.738), low birth weight (p=0.258), father absence (p=0.394), trajectories of maternal depression (p=0.209) and maltreatment (p=0.964), father absence (p=0.394) were excluded from the final model. For cognitive flexibility: family income (p=0.247), maternal age at birth (p=0.218), self-reported maternal skin color (p=0.430), parity (p=0.287), smoking during pregnancy (p=0.264), childs sex (p=0.689), mother living with partner (p=0.608), low birth weight (p=0.516), number of siblings (p=0.358), trajectories of maternal depression symptoms (p=0.819) and father absence (p=0.717) were excluded from the final model. For selective attention: income (p=0.241), mother living with partner (p=0.699), smoking during pregnancy (p=0.471), preterm birth (p=0.249), number of siblings (p=0.294), trajectories of maternal depression symptoms (p=0.995), breastfeeding duration (p=0.618), maltreatment (p=0.517) were excluded from the final model. For working memory: maternal age at birth (p=0.338), parity (p=0.251), mother living with partner (p=0.684), preterm birth (p=0.597), father absence (p=0.986), maltreatment (p=0.753) were excluded from the final model.

In addition, a greater number of siblings was associated with impaired attentional control and spatial working memory. Additionally, low birth weight was found to be related to poorer selective attention at 11 years of age. Moderate low and decreasing maternal depression symptoms were linked to poorer spatial working memory at age 15. The stratification for family income revealed that within the lowest income quintile group, moderate low and increasing maternal depression symptoms were associated with impaired attentional control.

In terms of sex differences, girls exhibited a reduced risk of selective attention impairment at the age of 11, while presented poorer performance in spatial working memory at age 15.

Interestingly, any kind of breastfeeding reduced the chance of impaired cognitive flexibility regardless of duration. In addition, a protective effect was observed in which children of mothers older than 35 years showed higher cognitive flexibility. Potential risk factors such as maternal age, whether the mother lived with a partner, father absence, smoking during pregnancy, and maltreatment were not found to have any significant association with executive functions.

4 Discussion

Based on data from a population-based cohort study, the present study examined the impacts of socioeconomic, parental and adolescent variables on the performance of attention-related executive functions at the age of 11 and spatial working memory at the age of 15 years old. Among the perinatal exposures investigated, low maternal education was the risk factor that presented the greatest negative impact on attention-related executive functions at 11 years old and spatial working memory at 15 years old. The results also indicated that breastfeeding, regardless of duration and late maternity, had a protective effect on the performance of attention-related executive functions at age 11.

Low maternal education and low family income have been consistently identified as risk factors for executive functions development, as shown in a meta-analysis by Lawson and colleagues with 18 independent populations [15]. Our results

add to this literature by showing that the negative association of low family income is particularly strong in countries such as Brazil, where about 42% of children aged 0-14 years live in poverty [34]. Furthermore, our study revealed that low maternal education had a greater negative impact on executive functions at 11 and 15 years of age than family income. Maternal education plays a critical role in child development, reflecting maternal characteristics that may influence the parent-child relationship, while income has a greater impact on children's exposure to environmental stressors [35]. Compared to countries in the Global North, countries in the South offer less social protection for children in terms of nutrition, health and education. Thus, mothers and caregivers have a more central role in the child's development process. Mothers with higher levels of education have the potential to create healthier and more stimulating home environments for child development. This includes providing greater economic resources, enhanced information processing capacity, and increased access to better educational environments [36]. Higher levels of maternal education are associated with a decreased risk of maternal depressive symptoms, which in turn can have a great impact on the quality of the mother-child relationship [37]. Interestingly, the study also found that older maternal age served as a protective factor for executive functioning impairment, possibly due to greater maternal experience and stability.

Results of this study showed negative consequences of maternal characteristics on the development of executive functioning in late childhood and adolescence. Maternal skin color (black or brown) has been identified as a risk factor that can reflect disparities in access to resources and opportunities, potentially influencing the development of offspring's executive functions [38]. Multiparity, or having multiple children, has been linked to potential challenges in parenting practices that may negatively affect children's executive functions. This association is particularly notable in families of low socioeconomic status, where the presence of multiple siblings can lead to competition for parents' time and attention [39].

Exposures to maternal depressive symptoms and high number of siblings in the first years of age were identified as potential risk factor for impairment of attention-related executive functions and spatial working memory at ages 11 and 15. According to the theory of ecological development, stressors in the environment and the absence of complex stimuli can impair the development and regulation of cognitive processes linked to executive functions [40]. Having a higher number of siblings can impair executive functions due to factors such as reduced limited parental monitoring, limited practice in negotiation and conflict resolution, and increased social complexity [39]. This can result in reduced opportunities for one-on-one interactions and cognitive stimulation, which are important for the development of executive functions. Meanwhile, maternal depressive symptoms have a persistent negative impact on executive functioning throughout child development due to a lack of essential environmental stimuli important for cognitive growth, including cognitive stimulation, communication, and positive emotions [41].

In addition to maternal characteristics, birth characteristics such as prematurity and low birth weight were identified as risk factors for impaired executive functions at age 11. Prematurity was associated with impaired attentional control, while low birth weight was associated with impaired selective attention. These results are in line with previous research that points to prematurity and low birth weight as risk factors for several long-term cognitive outcomes, including executive functions impairment [13,42]. Although positive parenting and good parental mental health can minimize the negative effects of premature birth, and positively influence neurodevelopment [43], adverse effects of prematurity and complications related to the development of brain regions such as the prefrontal cortex may be associated with cognitive deficits throughout childhood, adolescence and adulthood [13].

In our study, we found sex differences in selective attention at age 11 and in spatial working memory at age 15. However, this result should be interpreted with caution. A recent literature review indicates that gender is not the main factor in individual differences in executive function and cognitive performance [44]. The

literature suggests that these differences are often due to minor changes in task design, suggesting that variations in strategic approaches and outcome preferences contribute to the observed effects on executive function rather than being due to inherent ability differences between the sexes.

Furthermore, breastfeeding was identified as a protective factor for cognitive flexibility at age 11 years, regardless of its duration. Our findings not only emphasize the influence of breastfeeding on children's cognitive development but also align with longitudinal observations from the 1982 Pelotas Birth Cohort study [45]. This study highlights the association between breastfeeding and improved performance on intelligence tests even after three decades. Importantly, despite growing recognition of breastfeeding's positive effects on child cognitive development, there's limited evidence associating it to executive function, as emphasized by a recent review [46]. In addition to the scarcity of studies in this field, breastfeeding duration is a complex behavior that is influenced by several factors, including the duration and exclusivity of breastfeeding pattern, maternal health, and other infant feeding practices like age of complementary feeding introduction. These factors may vary across studies, leading to inconsistent results. Lastly, the long-term effects of breastfeeding on executive function and cognitive development are not fully understood, and further research is needed to investigate the underlying physiological and behavioral mechanisms that may explain the observed associations.

Our study highlights the association between several perinatal, maternal, and environmental characteristics and impaired executive functioning in late childhood and adolescence. This multifaceted nature suggests that impaired executive function results from the convergence of multiple environmental influences, rather than single exposures. One plausible mechanism for these impairments is toxic stress, which manifests as chronic, uncontrollable stressors. When experienced without the support of caring adults, these stressors tend to trigger toxic stress responses in children [47]. Children exposed to prolonged adverse poverty and a buildup of unfavorable conditions (such as maternal

depression, overcrowding, substandard housing, and family turbulence) often display elevated stress hormone levels [48]. Children with toxic stress exhibit higher cortisol levels, which could potentially mediate the link between these environmental factors and executive function impairment. Toxic stress impacts brain architecture, particularly in regions rich in glucocorticoid receptors like the amygdala, hippocampus, and prefrontal cortex. This leads to discernible differences in learning, memory, and executive functions [49]. Caregivers, whether parents or providers, play a critical role in modulating stress hormone production during a child's formative years. Their empathetic and attentive support acts as a protective barrier against exposure to stress hormones. These practices hold special significance for vulnerable children, preventing the activation of the stress system. Inappropriate parenting practices could potentially mediate the connection between risk factors and executive function impairments.

When considering future public policies that could improve the development of children's executive functions, particularly in the face of negative events or insecure environments in low- and middle-income countries, it becomes imperative to underscore the role of positive influences in their early life experiences. A recent meta-analysis of 102 randomized controlled trials underscores the impact of parenting interventions in this context, revealing more pronounced effects on child cognitive development in low- and middle-income countries when compared to high-income countries [50]. Notably, this meta-analysis highlights the effectiveness of interventions that prioritize parental sensitivity and responsiveness, and shows that the impact on cognitive development was three times greater in low- and middle-income countries. The interventions which included parenting practices, child cognitive development, parental knowledge, and parent-child interactions, were more effective contrasted with interventions lacking such content. This suggests that fostering a supportive and nurturing caregiving environment through targeted interventions can play an important role in mitigating the impact of negative events or insecure surroundings on children's executive functions in low- and middle-income countries.

The present study broadens the understanding of the risk factors associated with impaired executive functions in adolescence. The information used was obtained from a large unselected Brazilian population, whose data were acquired through the use of standardized instruments applied by trained field workers. However, it is important to consider some limitations. The interruption of the follow-up carried out at the age of 15, due to the COVID-19 pandemic, resulted in the loss of approximately 50% of the original cohort. The results of the analysis of the follow-up losses revealed that participants evaluated at age 15 had more favorable socioeconomic conditions in relation to those followed at birth. Thus, our analyses may be subjected to selection bias. If the sample studied had not suffered losses, it could have been possible that the association found between maternal education and executive functions impairment could have been even stronger than the association found in the present study. Regarding the generalizability of our results, it is important to note that our sample has particular demographic characteristics which should be considered when extending our results to other populations from different low- and middle-income countries.

5 Conclusion

This study examined risk and protective factors related to impaired executive functions in adolescence. The findings highlighted several significant predictors, with low maternal education showing the most detrimental effect on attention-related executive functions at age 11 and spatial working memory at age 15. Perinatal exposures associated with maternal and birth characteristics, such as maternal black or brown skin color, low birth weight, and prematurity, were also identified as relevant risk factors. On the other hand, breastfeeding emerged as a protective factor for cognitive flexibility. These results provide evidence regarding the long-term impact of perinatal exposures on the development of executive functions. Results of this study can contribute for future public policies aiming to mitigate the negative effects of risk factors and enhance executive function development, particularly among vulnerable populations.

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Conflicts of interest

The authors declare no conflicts of interest.

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Supplementary material

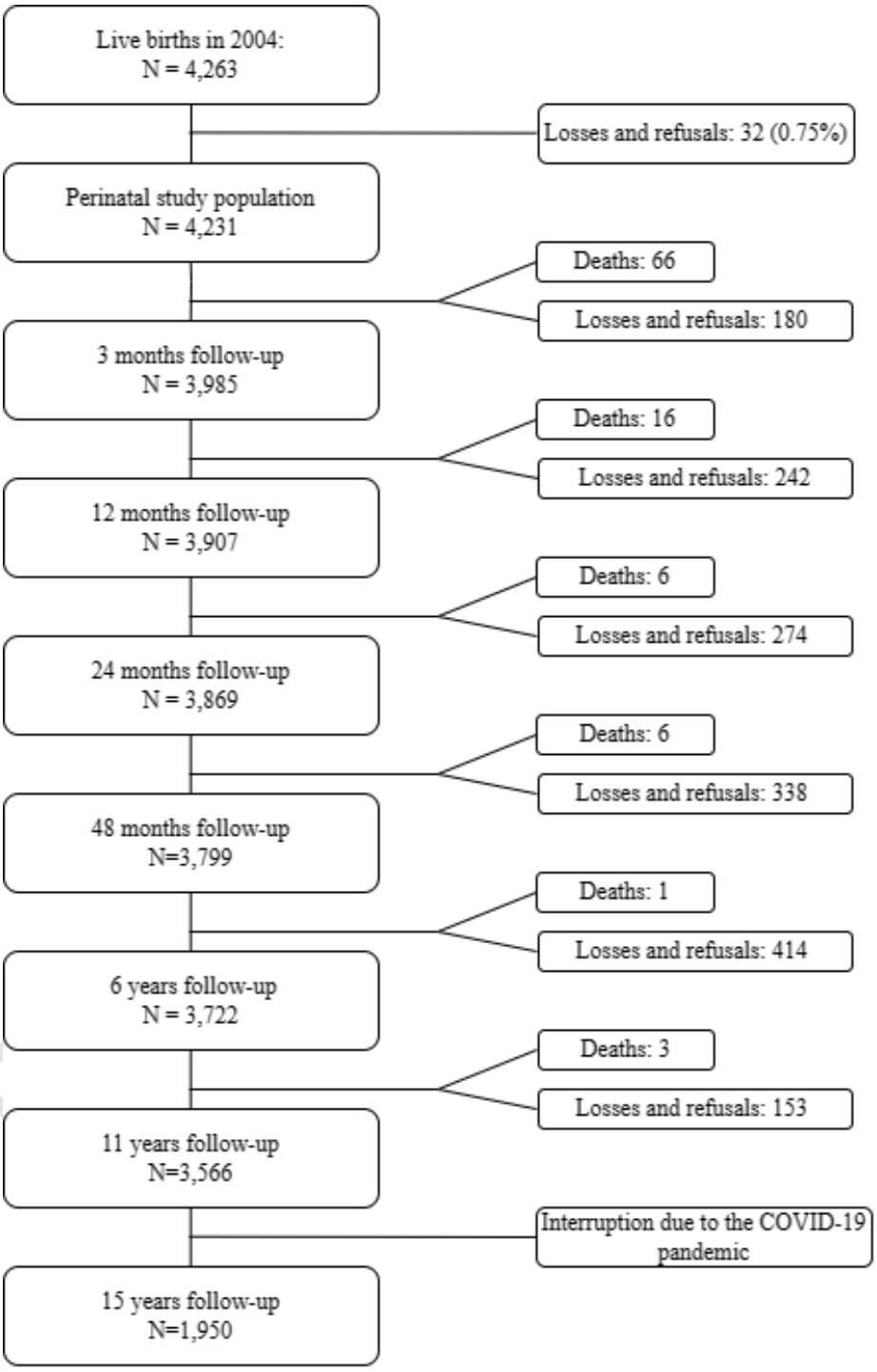

Figure S1: Flowchart illustrating the participation of subjects in the 2004 Pelotas Birth Cohort Study

Table S1: Description of executive functions tasks

Instrument	Executive function assessed	Task description and scoring
Test-of-Everyday-Attention-for-Children (TEA-Ch)	Attentional control	The child was shown to a row of 24 elements, which were composed by the numbers "1" and "2". At first, the child was instructed to read the numbers as quickly as possible while the instructor kept his finger close to each number in the row until the child read it correctly. This task was named "*Same World"*. In a second moment, the child was instructed to read the row of numbers as quickly as possible, but this time saying "one" when the number seen was "2" and saying "two" when the number seen was "1" This task was called *"Opposite World"* The average time required to complete the "*Opposite World*" task was defined as the measure of attentional control outcome. Higher reaction times indicate more impaired ability (considering verbal processing speed).
(TEA-Ch)	Cognitive flexibility	The cognitive flexibility assessment instrument was the latency time on a double attention task of the *Sky-Search subtest*. Initially, the child was instructed to select matching pairs of spacecrafts from matching and non-matching crafts contained in the test sheet. Then the same task was repeated with the addition of another task: the child was also asked to count the number of noises (beats) emitted by a recording while performing the task. The difference in speed and accuracy when completing the task with and without the addition of noises was taken as an indication of switching. A higher score indicates more impaired dual attention.
(TEA-Ch)	Selective attention	This ability was assessed by the latency time on the *"Sky-Search task"*. Initially, the child was instructed to select pairs of spacecrafts from matching and non-matching spacecrafts. On the test sheet, 50% of the spacecraft pairs were matched. The total time in seconds to perform the task (circle all pairs of spacecrafts) and the number of hits (corresponding pairs of crafts) were recorded. At another time, the child was instructed to perform the same procedure on a workout sheet that contained only matching pairs. The total time to perform this task and the number of correct answers were recorded. For each participant, motor-processing reaction time was subtracted from the ability score to provide the final measure of selective attention. The higher the score, the more impaired the child´s selective attention.

Cambridge Neuropsychological Testing Automated Battery (CANTAB)	Spatial working memory	During the test, the child was presented with a series of colored squares displayed on a tablet screen. The goal was to locate a yellow 'token' within each box by systematically selecting and eliminating boxes. With each round, an empty column on the right side of the screen would be filled, increasing the difficulty level. The number of boxes gradually increased, with a maximum of 12 boxes for participants to search through. To discourage the use of repetitive strategies, the color and position of the boxes were changed with each attempt. The total number of errors was used as an indicator of spatial working memory. Higher scores reflected greater impairment in spatial working memory.

Table S2: Frequency of participants characteristics at 11 and 15 years follow-ups

	Follow-ups	
Variables	**11 years (N=3582)**	**15 years (N=1950)**
	N (%)	N (%)
Family income (quintiles)		
5th quintile (wealthiest)	693 (19.4)	362 (18.6)
4th quintile	754 (21.1)	432 (22.2)
3rd quintile	709 (19.9)	407 (20.9)
2nd quintile	716 (20.1)	383 (19.7)
1st quintile (poorest)	696 (19.5)	365 (18.7)
Maternal education (years)		
≥ 9	1542 (43.7)	868 (44.9)
5-8	1465 (41.5)	790 (40.8)
1-4	497 (14.1)	264 (13.6)
0	29 (0.8)	13 (0.7)
Maternal age at birth (years)		
20-34	2404 (67.4)	1296 (66.5)
< 20	669 (18.8)	350 (18.0)
≥ 35	493 (13.8)	303 (15.6)
Self-reported maternal skin color		
White	2197 (62.3)	1220 (63.4)
Black	584 (16.6)	316 (16.4)
Brown	711 (20.2)	375 (19.5)
Yellow/Indigenous	35 (1.00)	14 (0.7)
Parity		
1	1,407 (39.44)	744 (38.17)
2	958 (26.86)	546 (28.01)
≥ 3	1,202 (33.70)	659 (33.81)
Smoking during pregnancy		
No	2,616 (73.32)	1,440 (73.88)
Yes	952 (26.68)	509 (26.12)
Mother living with partner		
Yes	3013 (84.5)	1652 (84.8)
No	555 (15.6)	297 (15.3)
Child sex		
Male	1840 (51.6)	996 (51.1)
Female	1728 (48.4)	953 (48.9)
Preterm birth		

Não	3068 (86.1)	1689 (86.8)
Sim	495 (13.9)	257 (13.2)
Low birth weight		
No	3247 (91.0)	175 (91.1)
Yes	320 (9.0)	173 (8.9)
Breastfeeding duration (months)		
0 months	97 (2.73)	63 (3.25)
< 1 month	273 (7.69)	133 (6.85)
1 - 3 months	539 (15.17)	287 (14.79)
3 - 12 months	1,296 (36.49)	710 (36.58)
≥ 12 months	1,347 (37.92)	748 (38.54)
Number of siblings		
0	1,150 (33.61)	603 (32.52)
1	1,285 (37.55)	726 (39.16)
≥ 2	987 (28.84)	525 (28.32)
Father absence		
Never absent	2,099 (66.76)	1,220 (70.68)
Absent at 24 months	225 (7.16)	102 (5.91)
Absent at 48 months	370 (11.77)	179 (10.37)
Always absent	450 (14.31)	225 (13.04)
Trajectories of maternal depressive symptoms (3 months to 11 years)		
Low	1,136 (32.58)	593 (31.23)
Moderate low	1,475 (42.30)	831 (43.76)
Decreasing	387 (11.10)	206 (10.85)
Increasing	319 (9.15)	171 (9.00)
Chronic high	170 (4.88)	98 (5.16)
Maltreatment (CTSPC score)		
3rd tercile (highest)	1,221 (34.70)	616 (33.30)
2nd tercile	1,350 (38.36)	698 (37.73)
1st tercile (lower)	948 (26.94)	573 (28.97)
Attention control impairment		
No	3,108 (90.03)	1,666 (91.19)
Yes	344 (9.97)	161 (8.81)
Cognitive flexibility impairment		
No	3,072 (90.01)	1,625 (89.98)

Yes	341 (9.99)	181 (10.02)
Selective attention impairment		
No	3,053 (90.01)	1,641 (91.42)
Yes	339 (9.99)	154 (8.58)
Spatial working memory impairment		
No	1,344 (73.36)	1,403 (73.46)
Yes	488 (26.64)	50 (26.54)

Table S3: Logistic regression models for impairment in attentional control, cognitive flexibility and selective attention at age 11 and spatial working memory at age 15 in adolescents in the first income quintile.

	Attentional control		Cognitive flexibility		Selective attention		Spatial working memory	
Variables	**Crude**	**Adjusted***	**Crude**	**Adjusted***	**Crude**	**Adjusted***	**Crude**	**Adjusted***
	OR (CI95%)	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**
Maternal education (years)	p=0.003	p=0.005	p=0.014	p=0.008	p=0.008	p=0.002	p=0.004	p=0.004
≥ 9	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
5-8	1.95 (0.78 – 4.86)	1.66 (0.65 – 4.26)	2.44 (1.28 – 4.62)	2.72 (1.38 – 5.38)	1.65 (0.68 – 4.01)	2.01 (0.78 – 5.18)	2.77 (1.46 – 5.24)	3.00 (1.53 – 5.86)
1-4	10.31 (2.54 – 41.75)	10.79 (2.57 – 45.33)	3.08 (0.64 – 14.66)	3.56 (0.71 – 17.76)	8.54 (2.14 – 34.12)	14.56 (3.25 – 65.21)	3.89 (0.63 – 23.98)	3.27 (0.49 – 21.83)
0	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty
Maternal age at birth (years)	p=0.525	p=0.476	p=0.056	p=0.851	p=0.102	p=0.076	p=0.739	p=0.803
20-34	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-
< 20	1.19 (0.34 – 4.13)	-	2.54 (1.15 – 5.64)	-	0.29 (0.04 – 2.17)	0.15 (0.02 – 1.26)	1.43 (0.54 – 3.75)	-
≥ 35	0.51 (0.15 – 1.76)	-	0.92 (0.41 – 2.04)	-	0.26 (0.06 – 1.11)	0.31 (0.07 – 1.38)	1.15 (0.60 – 2.20)	-
Self-reported maternal skin color	p=0.073	p=0.097	p=0.030	p=0.091	p=0.018	p=0.040	p=0.808	p=0.687
White	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	-

Black	1.83 (0.52 – 6.44)	1.93 (0.54 – 6.98)	2.86 (1.24 – 6.58)	2.51 (1.07 – 5.90)	3.92 (1.48 – 10.36)	3.74 (1.35 – 10.37)	1.20 (0.46 – 3.10)	-
Brown	1.61 (0.53 – 4.91)	1.30 (0.40 – 4.21)	1.79 (0.79 – 4.04)	1.47 (0.64 – 3.41)	1.91 (0.69 – 5.29)	1.34 (0.42 – 4.28)	0.67 (0.25 – 1.79)	-
Yellow/Indigenous	8.19 (1.59 – 42.23)	7.95 (1.48 – 42.64)	Empty	Empty	Empty	Empty	1.47 (0.15 – 14.37)	-
Parity	p=0.291	p=0.469	p=0.349	p=0.400	p=0.726	p=0.807	p=0.502	p=0.297
1	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
2	0.60 (0.21 – 1.70)	-	0.65 (0.65 – 1.17)	-	1.31 (0.56 – 3.10)	-	0.69 (0.36 – 1.31)	-
≥ 3	1.45 (0.61 – 3.48)	-	0.64 (0.30 – 1.40)	-	1.40 (0.56 – 3.50)	-	0.96 (0.49 – 1.88)	-
Smoking during pregnancy	p=0.638	p=0.222	p=0.408	p=0.117	p=0.681	p=0.308	p=0.197	p=0.486
No	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-
Yes	0.75 (0.22 – 2.53)	-	0.67 (0.26 – 1.73)	0.45 (0.16 – 1.22)	1.22 (0.46 – 3.30)	-	1.60 (0.78 – 3.29)	-
Mother living with partner	p=0.492	p=0.774	p=0.193	p=0.805	p=0.910	p=0.977	p=0.974	p=0.495
Yes	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
No	1.47 (0.49 – 4.36)	-	1.70 (0.76 – 3.79)	-	0.93 (0.28 – 3.15)	-	0.88 (0.35 – 2.22)	-
Child sex	p=0.903	p= 0.981	p=0.745	p= 0.602	p=0.121	p=0.103	p=0.004	p=0.011
Female	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Male	0.95 (0.44 – 2.06)	-	1.10 (0.61 – 1.98)	-	1.85 (0.85 – 4.01)	1.97 (0.87 – 4.44)	0.45 (0.26 – 0.78)	0.47 (0.27 – 0.84)

Preterm birth	p=0.258	p=0.419	p=0.286	p=0.285	p=0.625	p=0.463	p=0.329	p=0.583
Não	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
Sim	0.31 (0.04 – 2.34)	-	0.52 (0.16 - 1.72)	-	1.31 (0.44 – 3.87)	-	1.47 (0.68 – 3.16)	-
Low birth weight	p=0.470	empty	p=0.365	p=0.724	p=0.408	p=0.304	p=0.796	p=0.911
No	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
Yes	0.48 (0.06 – 3.58)	-	0.51 (0.12 – 2.18)	-	0.43 (0.06 – 3.20)	-	1.13 (0.44 - 2.89)	-
Breastfeeding duration (months)	p=0.197	p=0.546	p=0.860	p=0.673	p=0.840	p=0.834	p=0.791	p=0.619
0 months	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
< 1 month	2.30 (0.74 – 7.16)	-	0.38 (0.06 – 2.48)	-	0.82 (0.08 – 8.54)	-	1.18 (0.18 – 7.43)	-
1 - 3 months	1.32 (0.43 – 4.06)	-	0.63 (0.12 – 3.28)	-	0.99 (0.11 – 8.84)	-	0.90 (0.16 – 4.98)	-
3 - 12 months	0.66 (0.25 – 1.75)	-	0.50 (0.11 – 2.37)	-	0.57 (0.07 – 4.75)	-	0.73 (0.15 – 3.66)	-
≥ 12 months	Empty	-	0.52 (0.11 – 2.51)	-	0.61 (0.07 – 5.20)	-	1.06 (0.21 – 5.30)	-
Number of siblings	p=0.093	p=0.326	p=0.619	p=0.624	p=0.409	p=0.315	p=0.184	p=0.335
0	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
1	0.63 (0.25 – 1.59)	-	1.28 (0.66 – 2.48)	-	1.79 (0.75 – 4.26)	-	1.31 (0.70 – 2.42)	-
≥ 2	1.91 (0.75 – 4.92)	-	1.49 (0.63 – 3.49)	-	1.65 (0.53 – 5.17)	-	2.08 (0.95 – 4.54)	-

Father absence	p=0.932	p=0.732	p=0.413	p=0.145	p=0.853	p=0.783	p=0.754	p=0.644
Never absent	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-
Absent at 24 months	0.89 (0.11 – 6.93)	-	0.72 (0.17 – 3.11)	0.56 (0.12 – 2.61)	1.54 (0.34 – 6.90)	-	0.93 (0.19 – 4.42)	-
Absent at 48 months	1.31 (0.29 – 5.85)	-	0.51 (0.12 – 2.17)	0.17 (0.02 – 1.34)	1.12 (0.25 – 4.94)	-	0.44 (0.10 – 1.95)	-
Always absent	Empty	-	0.24 (0.03 – 1.76)	0.20 (0.03 – 1.55)	0.52 (0.07 – 3.96)	-	1.04 (0.33 – 3.25)	-
Trajectories of maternal depressive symptoms (3 months to 11 years)	p=0.004	p=0.014	p=0.721	p=0.937	p=0.891	p=0.651	p=0.122	p=0.699
Low	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-	1 (ref)	-
Moderate low	3.71 (1.20 – 11.54)	3.38 (1.06 – 10.76)	1.38 (0.72 – 2.63)	-	1.33 (0.57 – 3.14)	-	1.42 (0.76 - 2.65)	-
Decreasing	5.27 (1.14 – 24.39)	3.71 (0.75 – 18.47)	1.99 (0.70 – 5.67)	-	1.40 (0.29 – 6.60)	-	3.48 (1.31 – 9.21)	-
Increasing	12.86 (3.26 – 50.64)	11.19 (2.62 – 47.90)	1.51 (0.42 – 5.43)	-	1.86 (0.38 – 8.89)	-	1.43 (0.44 – 4.64)	-
Chronic high	Empty	Empty	1.16 (0.14 – 9.39)	-	1.15 (0.26 – 18.05)	-	2.61 (1.63 – 10.82)	-
Maltreatment (CTSPC score)	p=0.294	p=0.658	p=0.349	p=0.113	p=0.559	p=0.725	p=0.063	p=0.301
3rd tercile	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-

(highest)								
2nd tercile	2.08 (0.82 – 5.24)	-	0.65 (0.32 – 1.31)	0.67 (0.31 – 1.45)	1.13 (0.47 – 2.71)	-	1.19 (0.62 – 2.29)	-
1st tercile (lower)	1.76 (0.58 – 5.35)	-	0.64 (0.30 – 1.40)	1.61 (0.73 – 3.53)	1.67 (0.64 – 4.33)	-	2.25 (1.11 – 4.58)	-

* For attentional control: smoking during pregnancy (p=0.222), mother living with partner (p=0.774), child sex (p=0.981), parity (p=0.469) and maternal age at birth (p=0.476), preterm birth (p=0.419), breastfeeding duration (p=0.546), number of siblings (p=0.326), father absence (p=0.732), maltreatment (p=0.658) were excluded from the final model. For cognitive flexibility: mother living with partner (p=0.389), child sex (0.602), maternal age at birth (p=0.851), parity (p=0.400), mother living with partner (p=0.805), preterm birth (p=0.285), low birth weight (p=0.724), breastfeeding duration (p=0.673), number of siblings (p=0.624) and trajectories of maternal depression symptoms (p=0.937) were excluded from the final model. For selective attention: mother living with partner (p=0.977), parity (p=0.807), smoking during pregnancy (p=0.308), preterm birth (p=0.463), low birth weight (p=0.304), breastfeeding duration (p=0.834), number of siblings (p=0.315), father absence (p=0.783), trajectories of maternal depression symptoms (p=0.651), maltreatment (p=0.725) were excluded from the final model. For working memory: maternal age at birth (p=0.803), mother living with partner (p=0.495), smoking during pregnancy (p=0.486), selreported maternal skin color (p=0.687), preterm birth (p=0.583), low birth weight (p=0.911), breastfeeding (p=0.619), number of siblings (p=0.335), father absence (p=0.644), trajectories of maternal depression symptoms (p=0.699), maltreatment (p=0.301) were excluded from the final model.

Table S4: Logistic regression models for impairment in attentional control, cognitive flexibility and selective attention at age 11 and spatial working memory at age 15 in adolescents in the second, third, fourth and fifth income quintiles.

	Attentional control		Cognitive flexibility		Selective attention		Spatial working memory	
Variables	**Crude**	**Adjusted***	**Crude**	**Adjusted***	**Crude**	**Adjusted***	**Crude**	**Adjusted***
	OR (CI95%)	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**	**OR (CI95%)**
Maternal education (years)	p<0.001	p<0.001	p=0.008	p=0.001	p<0.001	p<0.001	p<0.001	p<0.001
≥ 9	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
5-8	2.23 (1.62 – 3.07)	1.66 (1.18 – 2.33)	1.90 (1.27 -2.84)	1.61 (1.21 – 2.16)	1.77 (1.15 – 2.73)	1.63 (1.18 – 2.25)	1.65 (1.28 – 2.14)	1.46 (1.16 – 1.91)
1-4	4.69 (3.31 – 6.65)	3.26 (2.23 – 4.77)	2.10 (1.28 – 3.45)	1.89 (1.33 – 2.70)	2.50 (1.50 – 4.18)	2.64 (1.81 – 3.85)	2.37 (1.72 – 3.28)	2.29 (1.63 – 3.21)
0	6.17 (2.49 – 15.29)	4.48 (1.66 – 12.06)	1.68 (0.20 – 13.79)	2.42 (0.81 – 7.28)	12.58 (3.23 – 49.07)	7.09 (2.84 – 17.67)	6.61 (1.90 – 22.95)	5.02 (1.43 – 17.65)
Maternal age at birth (years)	p=0.111	p=0.001	p=0.199	p=0.350	p=0.883	p=0.058	p=0.180	p=0.194
20-34	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)
< 20	1.30 (0.99 – 1.71)	1.73 (1.21 – 2.47)	1.44 (0.97 – 2.14)	-	0.95 (0.61 - 1.50)	1.06 (0.74 – 1.52)	1.18 (0.90 – 1.55)	1.09 (0.81 – 1.45)
≥ 35	0.89 (0.61 – 1.31)	0.67 (0.45 – 1.01)	1.08 (0.66 – 1.76)	-	0.88 (0.52 – 1.49)	0.60 (0.40 – 0.92)	0.82 (0.59 – 1.15)	0.76 (0.53 – 1.07)
Self-reported maternal skin color	p<0.001	p<0.001	p=0.982	p=0.629	p<0.001	p<0.001	p<0.001	p=0.009

White	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Black	2.58 (1.93 – 3.45)	2.23 (1.65 – 3.02)	1.05 (0.67 – 1.64)	-	2.46 (1.60 - 3.77)	2.33 (1.73 – 3.12)	1.87 (1.41 - 2.48)	1.65 (1.23 – 2.22)
Brown	2.02 (1.51 – 2.70)	1.74 (1.29 – 2.34)	1.09 (0.72 – 1.66)	-	1.50 (0.95 – 2.37)	1.41 (1.04 – 1.92)	1.35 (1.02 - 1.78)	1.23 (0.92 – 1.65)
Yellow/Indigenous	1.03 (0.24 – 4.41)	1.08 (0.25 – 4.69)	0.97 (0.12 – 7.76)	-	1.47 (0.18 – 11.83)	1.05 (0.24 – 4.56)	1.30 (0.33 – 5.07)	1.16 (0.29 – 4.60)
Parity	p<0.001	p<0.001	p=0.327	p=0.219	p=0.039	p=0.114	p=0.032	p=0.259
1	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-
2	0.99 (0.72 – 1.35)	1.24 (0.85 – 1.81)	0.87 (0.56 – 1.35)	-	1.07 (0.67 – 1.73)	1.02 (0.72 – 1.46)	0.96 (0.72 – 1.28)	-
≥ 3	2.05 (1.59 – 2.66)	2.08 (1.43 – 3.02)	1.20 (0.82 – 1.77)	-	1.64 (1.08 – 2.48)	1.38 (0.97 – 1.96)	1.32 (1.03 – 1.72)	-
Smoking during pregnancy	p=0.026	p=0.889	p=0.337	p=0.564	p=0.337	p=0.553	p=0.001	p=0.059
No	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)
Yes	1.32 (1.03 – 1.69)	-	1.19 (0.83 – 1.71)	-	1.19 (0.83 – 1.71)	-	1.47 (1.16 - 1.87)	1.27 (0.99 – 1.64)
Mother living with partner	p=0.127	p=0.193	p=0.801	p=0.616	p=0.801	p=0.832	p=0.205	p=0.912
Yes	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-	1 (ref)	-
No	1.26 (0.94 – 1.69)	1.24 (0.90 – 1.70)	1.06 (0.68 – 1.66)	-	1.06 (0.68 – 1.66)	-	1.21 (0.90 – 1.62)	-
Child sex	p=0.142	p=0.070	p=0.756	p=0.703	p=0.016	p=0.013	p<0.001	p<0.001
Female	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)

Male	1.19 (0.94 – 1.51)	1.26 (0.98 – 1.61)	1.04 (0.82 – 1.32)	-	1.34 (1.06 – 1.70)	1.37 (1.07 – 1.75)	0.56 (0.44 – 0.70)	0.55 (0.44 – 0.69)
Preterm birth	p<0.001	p=0.065	p=0.256	p=0.052	p=0.119	p=0.325	p=0.562	p=0.333
Não	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-
Sim	1.76 (1.32 – 2.36)	1.40 (0.98 – 1.99)	1.30 (0.82 – 2.06)	1.37 (1.00 – 1.89)	1.45 (0.91 – 2.32)	-	1.10 (0.80 – 1.51)	-
Low birth weight	p=0.003	p=0.135	p=0.496	p=0.633	p<0.001	p<0.001	p=0.030	p=0.112
No	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Yes	1.70 (1.20 – 2.42)	1.38 (0.90 – 2.12)	1.21 (0.70 – 2.10)	-	2.67 (1.65 – 4.31)	2.17 (1.52 – 3.09)	1.50 (1.04 - 2.17)	1.37 (0.93 – 2.01)
Breastfeeding duration (months)	p=0.024	p=0.146	p<0.001	p=0.002	p=0.308	p=0.654	p=0.030	p=0.051
0 months	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	1 (ref)
< 1 month	0.71 (0.32 – 1.54)	0.86 (0.37 – 1.97)	0.27 (0.10 – 0.69)	0.34 (0.16 – 0.71)	0.35 (0.12 – 1.03)	-	1.16 (0.55 – 2.44)	1.39 (0.64 – 3.04)
1 - 3 months	1.11 (0.55 – 2.22)	1.31 (0.63 – 2.73)	0.50 (0.24 – 1.07)	0.57 (0.31 – 1.06)	0.55 (0.23 – 1.33)	-	1.39 (0.70 – 2.73)	1.44 (0.71 – 2.95)
3 - 12 months	0.65 (0.33 – 1.28)	0.83 (0.41 – 1.69)	0.28 (0.14 – 0.58)	0.39 (0.22 – 0.71)	0.50 (0.22 – 1.13)	-	0.93 (0.49 – 1.79)	1.03 (0.52 – 2.05)
≥ 12 months	0.72 (0.37 – 1.40)	0.91 (0.45 – 1.85)	0.27 (0.13 – 0.56)	0.37 (0.20 – 0.66)	0.45 (0.20 – 1.01)	-	0.83 (0.43 – 1.58)	0.89 (0.45 – 1.76)
Number of siblings	p<0.001	p=0.022	p=0.100	p=0.370	p=0.141	p=0.233	p<0.001	p=0.257
0	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-	1 (ref)	-
1	1.11 (0.79 – 1.55)	1.12 (0.77 – 1.63)	1.14 (0.74 – 1.75)	-	1.41 (0.89 – 2.23)	-	1.12 (0.84 - 1.49)	-

≥ 2	2.41 (1.78 – 3.26)	1.65 (1.11 – 2.46)	1.55 (1.01 – 2.38)	-	1.59 (1.00 – 2.54)	-	1.67 (1.25 – 2.21)	-
Father absence	p=0.092	p=0.356	p=0.324	p=0.902	p=0.042	p=0.072	p=0.588	p=0.873
Never absent	1 (ref)	-	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-
Absent at 24 months	1.12 (0.69 – 1.81)	-	0.50 (0.20 – 1.26)	-	1.04 (0.46 - 2.34)	0.93 (0.55 - 1.57)	1.02 (0.63 – 1.66)	-
Absent at 48 months	1.46 (1.02 – 2.08)	-	1.04 (0.60 – 1.79)	-	1.96 (1.17 – 3.28)	1.61 (1.12 – 2.31)	1.20 (0.83 – 1.74)	-
Always absent	1.38 (0.99 – 1.93)	-	0.71 (0.40 – 1.25)	-	1.57 (0.95 – 2.62)	1.10 (0.76 - 1.60)	1.21 (0.87 – 1.69)	-
Trajectories of maternal depressive symptoms (3 months to 11 years)	p=0.092	p=0.423	p=0.303	p=0.928	p=0.186	p=0.983	p=0.005	p=0.203
Low	1 (ref)	-	1 (ref)	-	1 (ref)	-	1 (ref)	-
Moderate low	1.08 (0.80 – 1.45)	-	0.93 (0.62 – 1.41)	-	1.25 (0.79 – 2.00)	-	1.59 (1.19 - 2.11)	-
Decreasing	1.41 (0.96 – 2.09)	-	1.11 (0.62 – 1.97)	-	1.94 (1.08 – 3.49)	-	1.66 (1.12 - 2.45)	-
Increasing	1.64 (1.10 – 2.45)	-	1.45 (0.81 – 2.60)	-	1.72 (0.90 – 3.28)	-	1.75 (1.16 - 2.65)	-
Chronic high	1.20 (0.69 – 2.10)	-	1.69 (0.84 – 3.38)	-	1.13 (0.45 – 2.82)	-	2.00 (1.21 – 3.31)	-
Maltreatment (CTSPC score)	p=0.949	p=0.954	p=0.879	p=0.152	p=0.907	p=0.680	p=0.924	p=0.695

3rd tercile (highest)	1 (ref)	-	1 (ref)	1 (ref)	1 (ref)	-	1 (ref)	-
2nd tercile	0.97 (0.73 – 1.28)	-	1.11 (0.74 – 1.67)	0.74 (0.53 – 1.03)	1.10 (0.71 – 1.70)	-	0.95 (0.72 – 1.25)	-
1st tercile (lower)	0.95 (0.71 – 1.29)	-	1.05 (0.69 – 1.62)	0.97 (0.69 – 1.36)	1.08 (0.69 – 1.70)	-	1.00 (0.75 – 1.32)	-

* For attentional control: smoking during pregnancy (p=0.889), father absence (p=0.356), trajectories of maternal depression (p=0.423) and maltreatment (p=0.954) were excluded from the final model. For cognitive flexibility: mother living with partner (p=0.616), smoking during pregnancy (p=0.564), self-reported maternal skin color (p=0.629), parity (p=0.219), child sex (p=0.703), maternal age at birth (p=0.350), low birth weight (p=0.633), number of siblings (p=0.370), father absence (p=0.902), trajectories of maternal depression symptoms (p=0.928) were excluded from the final model. For selective attention: mother living with partner (p=0.832), smoking during pregnancy (p=0.553), preterm birth (p=0.325), breastfeeding duration (p=0.654), number of siblings (p=0.233), trajectories of maternal depression symptoms (p=0.983), maltreatment (p=0.680) were excluded from the final model. For working memory: parity (p=0.259), mother living with partner (p=0.912), preterm birth (p=0.333), number of siblings (p=0.257), father absence (p=0.873), trajectories of maternal depression symptoms (p=0.203), maltreatment (p=0.695) were excluded from the final model.