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Maternal depression trajectories and offspring positive attributes and social aptitudes at early adolescence: 2004 Pelotas birth cohort

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Abstract

There is growing evidence that adolescent positive attributes and social aptitudes are associated with beneficial outcomes, including higher educational attainment and lower risk of later psychiatric disorder. Although maternal depression is a well-known risk factor for a variety of offspring adverse outcomes, less is known on its repercussion on children's positive behavioral traits. This study aimed to evaluate the impact of maternal depression trajectories on offspring positive attributes and social aptitudes, testing sex-moderated models for the studied association. The 2004 Pelotas Birth Cohort is an ongoing cohort originally comprised by 4231 live births from Brazil. We included 3465 11-year-old adolescents (48.6% female; maternal self-reported skin color: 27.0% non-white). Maternal depressive symptoms were assessed by the Edinburgh Postnatal Depression Scale (EPDS) at all follow-ups. Adolescent positive attributes and social aptitudes were ascertained by specific subscales of Development and Well-Being Assessment (DAWBA). Multivariate linear regression was used to examine the effect of maternal depression trajectories on offspring's outcomes, adjusting for potential confounding variables. Moderation was assessed with interaction terms. Adolescents from mothers who presented high-chronic levels of depressive symptoms during offspring's life have lower scores of positive attributes and social aptitudes. Boys exposed to maternal depression during their lifetime are more affected than girls regarding positive attributes, but this sex difference was not observed for social aptitudes. Interventions targeting the promotion of adaptive behavioral traits may represent an effective way to buffer the adverse impact of maternal depression on offspring development, especially for vulnerable groups such as male adolescents.

Keywords Maternal depression · Positive attributes · Social aptitudes · Adolescent · Cohort study

Introduction

As stated by World Health Organization (WHO), mental health is not merely the absence of illness, but a state of well-being in which individuals are aware of their own competences and able to handle the stress of daily life [1]. In recent years, some studies showed that positive and negative mental health, though correlated, are independent constructs, having different socioeconomic and demographic predictors [2]. In addition, higher levels of positive mental health indicators were associated with lower probabilities of the engagement in unhealthy behaviors, such as smoking and sedentary lifestyle, and act as protective factor against the development of psychopathologies [3, 4]. Childhood and adolescence are decisive periods to prevent mental health problems, as substantial proportion of mental illness and harmful behaviors in adults originate early in life [5, 6]. Therefore, epidemiological and interventional studies targeting children and adolescent mental health have emerged as

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a priority focus area in global initiatives [5, 7]. The positive psychological resources and socioemotional competences are not predetermined at birth, but can be shaped by experiences during the lifespan as well as promoted given the proper stimulation [8]. The investigation of positive mental health determinants might elucidate mechanisms of resilience and provide evidence for interventions targeting especially vulnerable children and adolescents [9].

Children's positive attributes and social aptitudes have been recently associated to beneficial outcomes, including higher educational attainment and lower risk of later psychiatric disorders [10–12]. Positive attributes, such as being affectionate, responsible or generous, encompass positive personality traits that are related to mental well-being and may protect against life stressors [12, 13]. Social aptitudes comprehend the abilities of communication and interaction with others in a socially appropriated manner [14]. Poor social skills reduce the probability of high-quality relationships and may lead to peer rejection and social isolation, which are associated with higher risk of mental health problems [15]. Positive attributes and social aptitudes can be measured by specific sections (Youth Strength Inventory—YSI; Social Aptitudes Scale—SAS) of Development and Well-Being Assessment (DAWBA) [16] showing good psychometric properties in previous studies [10–12]. Also, YSI and SAS presented low to moderate correlation with Strengths and Difficulties Questionnaire—SDQ [10, 11, 17], a common screening for children's psychiatric symptoms. Thus, YSI, SAS, and SQD apparently measure different constructs, expanding the possibilities of socio-emotional measurements available for research and screening purposes [11].

An important risk factor associated with the impaired development of adaptive behavioral traits is maternal depression [19]. Maternal depression affects up to 20% of women globally, and involves several contextual and individual determinants, such as socioeconomic status, social support, and history of mental health problems [20]. It is well known that poor maternal mental health during offspring's life has negative impacts on a variety of child's socio-emotional and behavior outcomes [21, 22]. Those socio-emotional outcomes were measured through several questionnaires, although the majority were focused on negative behaviors or behavioral problems [23]. Few studies have examined the repercussion of maternal depression on children's strengths in social and emotional domains, specially applying instruments with good psychometric properties and ease of administration [23]. The investigation of the impacts of maternal depression on both offspring positive and negative aspects of mental health is relevant as it provides information regarding the wholly developmental trajectories of children in a broader and integrative perspective [1, 24]. Interventions aiming child development can be formulated considering both positive and negative mental health dimensions, which,

in turn, may lead to more effective results and beneficial outcomes [1, 24].

Despite the importance and the growing interest of scientific community on the topic of child positive psychological characteristics [24], the vast majority of studies have still been conducted in high-income countries [25]. Besides, to the best of our knowledge, no previous study has neither evaluated the determinants of adolescent's positive attributes and social aptitudes nor the impact of maternal depression trajectories on both outcomes. The current study, using data from a population-based birth cohort from a middle-income country, aimed to: (1) evaluate the impact of maternal depression trajectories on positive attributes and social aptitudes of offspring; and (2) examine sex-interaction effects of maternal depression trajectories on adolescents' outcomes.

Methods

Participants

The municipality of Pelotas is located in the Southern of Brazil and has a predominantly urban population (93%). In 2004, all the hospitals in the city were visited daily to identify births. The original cohort recruited 4,231 live newborns (99.2% of the births in 2004). Postpartum women were interviewed during pregnancy and childbirth. The newborns were examined by trained field researchers. Follow-up assessments were made at home at mean (standard deviation) ages 3.0 (0.1), 11.9 (0.2), 23.9 (0.4) and 49.5 (1.7) months and at a research clinic at 6.8 (0.3) and 11.0 (0.3) years, with follow-up rates between 87 and 96%. Further methodological details were published elsewhere [26].

Main exposure: maternal depressive symptoms

The Edinburgh Postnatal Depression Scale (EPDS) was used to assess maternal depressive symptoms during the postnatal period [27]. The EPDS consists of a self-report questionnaire with 10 items rated on a 4-point scale based on the intensity of depressive symptoms over the preceding 7 days. The score range varies from 0 to 30 points, with higher scores indicating more severe depressive symptoms. We used a previously translated and validated version of the questionnaire [28]. The EPDS was administered to almost all mothers at each follow-up, except at the 3-month follow-up when it was completed by a subsample of 965 mothers.

EPDS scores from 3 months to 11-year follow-up were used to construct the trajectories of maternal depressive symptoms through a semi-parametric group-based modeling approach [29, 30]. Group-based trajectory modeling is a specialized form of finite mixture modeling. The steps and methods used to identify the trajectories of maternal

depressive symptoms were detailed in previous studies [31, 32]. Overall, 3841 mothers with data from at least three follow-ups were included in the analyses. As group-based trajectory modeling handles missing data using maximum likelihood estimation, individuals with missing information were not excluded from the model. The number and shape of trajectories were based on the best fit of the model (maximum Bayesian information criteria, BIC) and on the interpretability of the trajectories obtained [29]. Analyses were conducted specifying three-, four-, five-, and six-group models to identify trajectories of maternal depressive symptoms with EPDS scores, and BIC improved as more groups were added. The improvement observed when moving from the five-group to the six-group model was low and the five-group model emerged as the best fitting and most parsimonious model. Selection of the appropriate model was also guided by the individual's probability of belonging to each of the trajectory groups (posterior probability scores). For all five groups, the average posterior probability was above the lower recommended threshold for assignment of 0.7 (average posterior probability of 0.87, 0.81, 0.78, 0.79 and 0.87 for Group 1 to Group 5, respectively) [29]. Inspection of parameter estimates for the five-group model revealed that the constant term differed from zero for all five groups.

Main outcomes: adolescents' positive attributes and social aptitudes

Positive attributes and social aptitudes were ascertained by parent report using subscales of Development and Well-Being Assessment (DAWBA) [16].

Positive attributes were assessed by Youth Strengths Inventory (YSI), Section N from DAWBA [12, 16]. YSI is a 24-item questionnaire divided into two blocks regarding adolescent's characteristics (e.g., if the adolescent is generous, easy going or responsible) and adolescent's actions to please others (e.g., if the adolescent helps around the home or if he/she likes to get involved in family activities). Each item scores on a three-point Likert scale, i.e. "No" (0 point), "A little" (1 point) and "A lot" (2 points). A total score was derived by summing scores for all the items, with higher scores indicating more positive attributes. YSI showed adequate goodness-of-fit for a 1-factor solution using CFA in a Brazilian community-based sample of children aged between 6 and 12 years old (root mean square error of approximation (RMSEA) = 0.057, 90% CI 0.055–0.059; comparative fit index (CFI) = 0.957; Tucker Lewis Index (TLI) = 0.950; Chi-square test of model fit = 2201.316; $p < 0.001$) [10].

Social aptitudes were measured by Social Aptitudes Scale (SAS), Section ASD from DAWBA [11, 16]. SAS is a 10-item scale that assesses social skills and identifies children with increased risk of psychiatric disorders and Autistic Spectrum Disorder (ASD). Examples of items are:

"Considering other adolescents in the same age group, do you think that your child is a good loser? Is aware of what is and is not socially appropriate?". For each item, parents rated their child as "a lot worse than average" (– 2 points), "a bit worse than average" (– 1 point), "about average" (0 point), "a bit better than average" (+ 1 point) or "a lot better than average" (+ 2 points). A total score was derived by summing scores for all the items, with higher scores indicating more social aptitudes. Liddle et al. (2009) found good fit to the unidimensional model, good reliability (Cronbach's alpha = 0.88), and high factor loadings for all SAS items (> 0.60) [11]. Also, in the same Brazilian community-based sample previously mentioned, SAS showed adequate goodness-of-fit for a 1-factor solution using CFA: RMSEA = 0.05 (CI 90% 0.04–0.05); CFI = 0.99; TLI = 0.99], with all items loading high on the social aptitudes latent trait (ranging from 0.55 to 0.68; median = 0.61) [18].

Covariates

Information about maternal, pregnancy, and child characteristics was collected at the perinatal interview. Socioeconomic and maternal characteristics were: monthly family income in the month prior to delivery (quintiles); maternal schooling (number of completed years of formal education, categorized as 0–4, 5–8, and ≥ 9 years); maternal self-reported skin color (white or non-white); maternal age at childbirth (< 20 , 20–34, ≥ 35 years old); living with a partner (yes or no); parity (the number of previous viable pregnancies resulting in a live birth or a late fetal death, categorized as 0, 1 or ≥ 2).

Smoking during pregnancy was evaluated retrospectively at birth by mother's self-report. Women were categorized as having smoked during pregnancy if they reported smoking at least one cigarette per day during any trimester. Maternal mood symptoms during pregnancy was defined as "present" if the mother answered positively to the following question: "During pregnancy, did you feel depressed or have any nervous condition?".

Child variables were: sex; low birthweight (< 2.500 g); gestational age (≤ 36 , 37–41 or ≥ 42 weeks); Intelligence Quotient (IQ) assessed by the Wechsler Intelligence Scale for Children-III (WISC-III) at age six and categorized as high average (> 0.75 SD), average ($- 0.75$ to 0.75 SD) and low average ($< - 0.75$ SD).

Statistical analysis

Descriptive statistics of adolescents and mother's characteristics were conducted among those with and without missing data on both exposure and outcomes. The mean score and standard deviation (SD) of the outcomes according to

maternal and adolescents' characteristics were analyzed using ANOVA.

Theoretical (based on previous literature evidences) [10, 12, 33] and empirical (bivariate analysis) criteria were used to identify potential confounding variables. We conducted multivariate linear regression analysis to evaluate the association between trajectories of maternal depression and YSI and SAS scores adjusting for selected confounding variables in three distinct models for each outcome: unadjusted results (model 1), model 1 + socioeconomic variables (model 2), model 2 + maternal and adolescent's variables (model 3). The distinct models were based on a conceptual framework that describes a hierarchical relationship between covariates [34]. If the significance level was below 0.20, the variable remained in the model as a potential confounder for the next level.

Next, moderation by adolescent's sex was assessed with an interaction term in the fully adjusted linear regression models for each outcome separately. The likelihood-ratio test was used to compare the models with and without the interaction term (trajectories of maternal depression*adolescent's sex). As the output of regression models is difficult to interpret, especially with an interaction term, we converted the beta coefficients to an estimated mean according to the trajectories of maternal depression using Stata's margins command [35]. The marginal effects means can be interpreted as the outcomes' mean change associated with a change in the category of maternal depressive symptoms trajectories according to sex, when an interaction is observed. All analyses and figures were performed with Stata software version 14.2 (StataCorp LP, College Station, Tex).

Results

Attrition analysis

Of the 4231 participants constituting the original cohort, 98 died in the first 11 years of life and 3566 were interviewed at 11 years. Data about the outcomes (positive attributes and social aptitudes) and main exposure were available for 3465 individuals (81.9% of the original cohort). Adolescents without missing data belonged to families with higher income, more educated and older mothers. Also, adolescents included in the analysis had mothers less likely to be single, multiparous, smokers or to present mood symptoms during pregnancy. In addition, those adolescents without missing data were less likely to have low birth weight and preterm birth than those with missing data (Table 1).

Maternal depressive symptoms trajectories

Sample distribution regarding maternal depression trajectories showed that groups "low" and "moderate-low" including mothers with EPDS scores below 10 across all time points, comprised 75.0% of the mothers. Group "increasing" included 11.1% of the women that had a consistent increase in depressive symptoms during the study period. The fourth group, "decreasing", containing 9.1% of the sample and was composed by women that showed high EPDS scores in the first 2 years postpartum and a marked decrease afterwards. Finally, the group including mothers with high EPDS scores across the 11 years of the study ("high-chronic" group) comprised 4.8% of the sample (data not shown in the tables).

Table 1 Comparison of maternal and child characteristics between those included and not included in the present study, 2004 Pelotas Birth Cohort

Variables	Included (<i>n</i> = 3465; 81.9%)	Not included (<i>n</i> = 766; 18.1%)	<i>p</i> value*
Family income, lowest quintile (%)	19.13	27.28	<0.001
Maternal schooling (years), mean (SD)	8.16 (3.40)	7.76 (3.75)	0.004**
Maternal skin colour, white (%)	72.98	73.24	0.888
Maternal age (years), mean (SD)	26.23 (6.87)	25.35 (6.50)	0.001**
Single mother (%)	15.41	21.02	0.001
Parity ≥ 2 (%)	33.46	38.30	0.028
Smoking during pregnancy (%)	26.75	30.68	0.028
Planned pregnancy (%)	43.71	41.77	0.329
Mood symptoms during pregnancy (%)	23.88	30.41	<0.001
Child sex, male (%)	51.40	54.17	0.164
Low birth weight (%)	8.39	17.43	<0.001
Preterm birth (< 37 w) (%)	13.37	20.57	<0.001

*Chi-squared test

**ANOVA test

Adolescent's positive attributes and social aptitudes scores according to socioeconomic and family characteristics

Sample positive attributes mean score (SD) at age 11 was 38.67 (0.11) (positive attributes score range: 0–48 points) and sample social aptitudes mean score (SD) age 11 was 20.91 (0.06) (social aptitudes score range: 0–48). Both positive attributes scale (Cronbach's $\alpha=0.87$) and social aptitudes scale (Cronbach's $\alpha=0.79$) showed good reliability on our sample.

Lower positive attributes scores were found in adolescents from mothers with the following characteristics: with lower family income; less educated; single at childbirth; with younger age; multiparous; who reported smoking during pregnancy; and who reported mood symptoms during pregnancy. In addition, male adolescents and those with lower IQ scores presented lower positive attributes scores (Table 2).

Adolescents from the poorer families, from mothers with less education, younger, non-white, single at childbirth, smokers and unplanned pregnancies presented lower social aptitudes scores. Being male and having lower IQ scores were also associated with lower social aptitudes scores (Table 2).

Adolescents from mothers in the high-chronic depression trajectory had the lowest positive attributes and social aptitudes scores than any other group (test for linear trend $p < 0.001$ for both outcomes) (Table 2).

Adolescents' positive attributes and social aptitudes scores at age 11 as a function of maternal depression trajectory

The results from the linear regression models showed a slightly change in the beta coefficients from the crude model (model 1) to the fully adjusted model (model 3). It indicates that although the socioeconomic, maternal and child variables attenuated the studied association, crude and fully adjusted analysis did not substantially differ in relation to the magnitude of the impact of maternal depressive symptoms trajectories on both outcome scores (See online resource Table S1). The association between the maternal depression trajectories and the positive attributes scores was moderated by adolescent's sex (p value = 0.023 for the likelihood-ratio test from the fully adjusted linear regression models with and without interaction term). Male adolescents showed an estimated lower mean score of positive attributes in all categories of maternal depression trajectories when compared to female adolescents (Table 3 and Fig. 1a). The difference in the mean score between males and females increases as we move from the "low" to the "chronic high" trajectory, depicting an ordinal interaction between the adolescent's sex and maternal depression trajectories on positive attributes

scores. This is visually expressed in the spacing between the two lines in the Fig. 1a, which slightly grows apart with increasing levels of maternal depression and becomes more evident in the "chronic high" trajectory.

Table 3 also shows that both male and female adolescents from mothers belonging to "low" depressive symptomatology present higher positive attributes scores when compared to their peers from mothers belonging to the "moderate low", "increasing", "decreasing" and "chronic high" trajectories. For male adolescents, there is a significant difference for those from mothers in the "moderate low" vs. "increasing" [mean score (moderate low–increasing) = 1.13, 95% CI 0.13–2.12, p value = 0.03] and "decreasing" vs. "chronic-high" [Δ mean score (decreasing–chronic high) = 2.69, 95% CI 0.13–2.12, 0.94–4.44, p value < 0.001] trajectories, indicated by no overlapping confidence intervals.

Regarding social aptitudes scores, no interaction effect was observed between adolescent's sex and maternal depression trajectories on the estimated outcome mean scores (p value = 0.453 for the likelihood-ratio test from the fully adjusted linear regression models with and without interaction term). Therefore, the interaction term was removed from the analysis and the results are presented without sex stratification. Adolescents from mothers in the "low" depressive symptoms trajectory group presented a higher social aptitudes mean scores compared to those from mothers in the "moderate low", "increasing", "decreasing" and "chronic high" trajectory groups (Table 3 and Fig. 1b). There is also a significant difference in the social aptitudes mean scores between adolescents from mothers in the "moderate low" vs "chronic high" trajectories (Table 3).

Discussion

The present study examined the extent to which the trajectories of maternal depression affected offspring's positive attributes and social aptitudes at age 11. Our findings indicate that adolescents from mothers who presented high levels of depressive symptoms during offspring's life have lower scores of positive attributes and social aptitudes, even after socioeconomic, maternal and child factors had been controlled for. Our results further indicate that boys, when exposed to maternal depression during their lifetime, are more affected than girls regarding positive attributes. This sex difference, however, was not observed for social aptitudes.

The negative impact of chronic maternal depression on offspring socioemotional development is well-established in the literature [21, 22, 36]. However, most of those evidences measured children emotional and behavioral problems or psychiatric symptoms [20, 23]. Our results add to this literature by showing that maternal depression has also an adverse

Table 2 Positive attributes and social aptitudes scores according to maternal and child characteristics, 2004 Pelotas birth cohort

Variables	N (%)	Positive attributes score (range 0–48)		Social aptitudes score (range: 0–40)	
		Mean (SD)	<i>p</i>	Mean (SD)	<i>p</i>
Family income (quintiles)			<0.001		<0.001
1 (lowest)	663 (19.13)	37.71 (7.10)		20.47 (3.30)	
2	699 (20.17)	38.40 (6.86)		20.55 (3.49)	
3	694 (20.03)	38.54 (6.93)		20.87 (3.68)	
4	742 (21.41)	38.94 (6.09)		21.12 (3.50)	
5 (highest)	667 (19.25)	39.71 (5.41)		21.53 (3.79)	
Years of maternal schooling			0.001		<0.001
0–4	507 (14.77)	38.05 (7.72)		20.40 (3.60)	
5–8	1425 (41.52)	38.42 (6.71)		20.64 (3.38)	
≥9	1500 (43.71)	39.11 (5.88)		21.31 (3.68)	
Skin color			0.097		0.018
White	2529 (72.99)	38.78 (6.40)		21.00 (3.62)	
Non-white	936 (27.01)	38.36 (6.88)		20.67 (3.41)	
Living with a partner			<0.001		0.029
Yes	2931 (84.59)	38.89 (6.45)		20.97 (3.56)	
No	534 (15.41)	37.42 (6.87)		20.60 (3.61)	
Age at childbirth (years)			0.006		<0.001
<20	654 (18.89)	37.98 (6.76)		20.64 (3.47)	
20–34	2326 (67.17)	38.75 (6.53)		20.88 (3.56)	
≥35	483 (13.95)	39.15 (6.18)		21.43 (3.73)	
Parity			0.015		0.208
0	1375 (39.69)	38.35 (6.45)		20.96 (3.61)	
1	930 (26.85)	39.15 (6.19)		21.02 (3.48)	
≥2	1159 (33.46)	38.67 (6.86)		20.76 (3.58)	
Planned pregnancy			0.081		0.002
Yes	1514 (43.71)	38.89 (6.39)		21.12 (3.75)	
No	1950 (56.29)	38.50 (6.64)		20.75 (3.41)	
Smoking during pregnancy			<0.001		<0.001
Yes	927 (26.75)	37.51 (7.03)		20.48 (3.56)	
No	2538 (73.25)	39.09 (6.29)		21.06 (3.56)	
Mood symptoms during pregnancy			<0.001		0.867
Yes	827 (23.88)	38.99 (6.34)		20.89 (3.83)	
No	2636 (76.12)	37.61 (7.02)		20.91 (3.49)	
Child's sex			<0.001		<0.001
Male	1781 (51.40)	37.67 (6.69)		20.678 (3.49)	
Female	1684 (48.60)	39.72 (6.20)		21.15 (3.64)	
Low birth weight			0.488		0.128
Yes	291 (8.40)	38.41 (7.03)		20.60 (3.71)	
No	3174 (91.60)	38.69 (6.49)		20.94 (3.55)	
Gestational age			0.065		0.094
≤36 weeks	463 (13.37)	38.11 (7.00)		20.58 (3.73)	
37–41 weeks	2781 (80.33)	38.80 (6.38)		20.95 (3.52)	
≥42 weeks	218 (6.30)	38.22 (7.35)		21.05 (3.79)	
Intelligence quotient (IQ)			<0.001		<0.001
High average (>0,75 SD)	706 (21.64)	39.98 (5.23)		21.86 (3.75)	
Average (-0,75 to 0,75 SD)	1781 (54.60)	38.86 (6.33)		20.94 (3.42)	
Low average (<-0,75 SD)	775 (23.76)	37.15 (7.65)		20.14 (3.58)	
Maternal depressive trajectories			<0.001		<0.001

Table 2 (continued)

Variables	N (%)	Positive attributes score (range 0–48)		Social aptitudes score (range: 0–40)	
		Mean (SD)	<i>p</i>	Mean (SD)	<i>p</i>
Low	1133 (32.70)	40.53 (5.32)		21.36 (3.55)	
Moderate low	1466 (42.31)	38.27 (6.52)		20.82 (3.47)	
Increasing	385 (11.11)	37.23 (7.00)		20.60 (3.74)	
Decreasing	316 (9.12)	37.13 (7.02)		20.65 (3.44)	
High chronic	165 (4.76)	35.73 (8.59)		19.84 (4.00)	

Table 3 Estimated mean scores of outcomes (positive attributes and social aptitudes) according to maternal depressive symptoms trajectory categories, 2004 Pelotas Birth Cohort

	Trajectories of maternal depressive symptoms				
	Low	Moderate low	Increasing	Decreasing	Chronic high
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Positive attributes score					
Positive attributes score Male	39.54 (39.01–40.07)	37.51 (37.05–37.96)	36.37 (35.48–37.25)	36.18 (35.18–37.19)	33.50 (32.06–34.95)
Positive attributes score Female	41.24 (40.71–41.77)	39.20 (38.73–39.68)	38.79 (37.86–39.72)	38.51 (37.51–39.52)	37.85 (36.51–39.19)
Difference in means* female—male	1.69 (0.95–2.44)	1.70 (1.04–2.36)	2.42 (1.14–3.70)	2.35 (0.93–3.77)	4.37 (2.41–6.32)
Social aptitudes score					
Social aptitudes score	21.26 (21.04–21.48)	20.87 (20.68–21.06)	20.77 (20.41–21.14)	20.85 (20.44–21.26)	20.02 (19.45–20.59)

* $p < 0.001$; 95% CI 95% confidence interval

repercussion on adolescent positive mental health domains. Previous studies showed that high levels of positive attributes and social aptitudes are not merely the absence of psychopathology [10–13]. Indeed, children presenting high levels of positive attributes had lower risk of psychiatric symptoms in the future [12]. In addition, positive attributes predicted educational outcomes independently of IQ and buffered the negative effects of low levels of intelligence on learning problems in a Brazilian sample of children [10]. Therefore, our study shows that maternal depression also adversely impacts adaptive behavioral traits that may have a protective role for future psychopathology.

Our results also indicate that maternal depression trajectories have a greater adverse impact on positive attributes for male offspring than for female ones. This finding is in accordance with previous studies suggesting that boys are more vulnerable than girls when faced with maternal depression [21]. Some evidence indicates that mother–offspring relationship differs according to child sex and this difference may exert an impact on psychological development [37]. Mothers tend to display a greater involvement in daughters' life, with more hours spent in shared activities than mothers of sons [38]. Also, mothers show more emotionally closer relationship with daughters than with sons and this natural difference may be exacerbated in a context of depression

[39]. Such interactions disparities may explain why girls of depressed mothers showed less impact on positive attributes, such as being affectionate, caring and involved in family activities. Indeed, Murray et al. (2006) reported that girls exposed to maternal depression showed enhanced sensitivity and maturity while boys showed diminished responses [39]. The sex difference for adolescent mental disorders development is well established in the literature [40], although less is known regarding positive mental health indicators. More studies exploring the moderating role of adolescent sex exposed to lifetime maternal depressive symptoms are needed to establish at-risk groups for socioemotional maladjustments.

There are relevant implications and strengths of our findings. First, as mentioned before, there is some evidence that positive mental health domains are associated with better school learning [10] and this, in turn, can affect adult outcomes, such as employment and criminality [41]. The study of predictors of individual strengths is important to the identification of potential resilience mechanisms against the burden of mental illness observed in the last decades [7]. Second, interventions targeting the promotion of socioemotional competences and adaptive behavioral traits, such as positive attributes and social aptitudes, may represent an effective way to buffer the adverse impact of maternal depression on

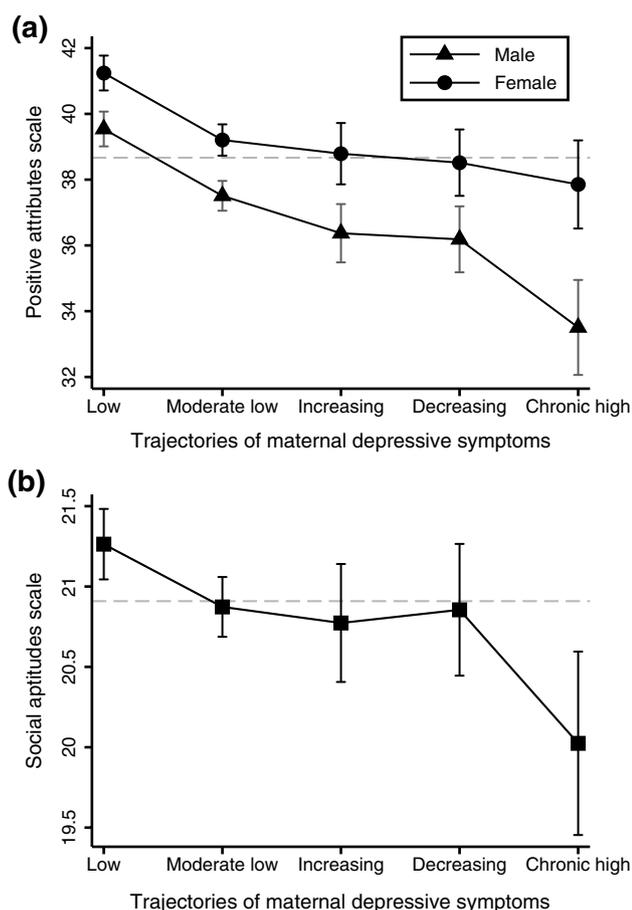


Fig. 1 Predictive mean scores of outcomes according to the categories of maternal depressive symptoms trajectory. **a** Positive attributes scores for male (triangles) and female (circles) adolescents. Ordinal interaction effect of adolescent's sex on the association between trajectories of maternal depressive symptoms and positive attributes score. Dashed line represents the sample mean score of 38.67 points in the scale unit. **b** Social aptitudes scores for the whole sample (squares), as no interaction effect of adolescent's sex was observed. Dashed line represents the sample mean score of 20.91 points in the scale unit

offspring development [42]. Third, we identified that male offspring of chronic depressed mothers may be at higher risk of behavioral maladjustment, configuring a vulnerable population for public policies and programs. Fourth, the present study contributes to addressing the lack of population-based studies on psychiatric disorders in adolescents from low- and middle-income countries. Finally, the longitudinal design, high response rates at all follow-ups, use of validated instruments for exposure and outcomes assessments and inclusion of potential confounders in multivariate analysis strengthen the unbiased causal inference of our results.

Some limitations must be addressed for proper interpretation of our findings. First, as with many large longitudinal cohort studies, there were losses at follow-ups and nearly 20% of the original sample were not included in the analysis

due to missing data. This type of selection bias, however, is more likely to influence prevalence estimates rather than the magnitude of association between maternal depressive symptoms and offspring's outcomes [43]. As sample attrition is strongly associated with socioeconomic and family disadvantages, this limitation should be considered in policy-making decisions regarding mental health service provisions. Second, as adolescent's positive attributes and social aptitudes were ascertained by maternal report only, maternal reporting bias due to mental distress is a relevant concern [44]. However, there are evidences suggesting that maternal depression symptoms do not distort significantly offspring behavior reports and provide useful information on current child functioning [45]. Nevertheless, it is certainly important the use of multiple sources of information for the assessment of children socio-emotional competences in future studies. Third, early adolescence represents a period of rapid biological and social changes in life and an intermediate phase between childhood and adolescence. As the outcomes were measured at age 11, it is not possible to affirm that the impact of maternal depression trajectories will have long-lasting effects on positive attributes and social aptitudes through individual's life. Thus, further research encompassing adolescence and adulthood periods would be helpful to address this issue. Finally, we cannot rule out the possibility of confounding effects by unmeasured variables.

We extended the evidences of negative impact of maternal depression on offspring outcomes by including positive mental health indicators in early adolescence. Moreover, although adolescents of mothers in the high-chronic trajectories presented the lowest positive attributes and social aptitudes scores, those from all other trajectories had lower outcomes scores compared to the reference group. This result underscore the importance of proper assistance of women with a varying level of depressive symptoms as well as during all offspring's life and not focused only on the pregnancy period.

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Author contributions JMM undertook the analysis, interpreted the results, and drafted the first version of the article. AM and ISS participated in the design and analysis of the study and collaborated with the interpretation of the findings and writing of the article. TNM collaborated with the interpretation of the findings and writing of the article. All authors approved the final version of the manuscript submitted.

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Data availability The data that support the findings of this study are available from the corresponding author, JMM, upon reasonable request.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards All 2004 Pelotas Birth Cohort follow-up waves were approved by the Federal University of Pelotas Medical School Research Ethics Committee. All guardians of the participating children signed an informed consent form before data collection. At the 11-year follow-up, adolescents also signed an informed consent form. Cases of severe mental health problems, as identified by the psychologists, were evaluated and, when necessary, were referred to the psychiatric or psychological care facilities.

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