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ORIGINAL CONTRIBUTION

Positive maternal mental health attenuates the associations between prenatal stress and children's internalizing and externalizing symptoms

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Abstract

Positive maternal mental health can improve perceptions of stressful situations and promote the use of adaptive coping strategies. However, few studies have examined how positive maternal mental health affects children's development. The aims of this study were to examine the associations between positive maternal mental health and children's internalizing and externalizing symptoms, and to ascertain whether positive maternal mental health moderated the associations between prenatal stress and children's internalizing and externalizing symptoms. This study is based on the Norwegian Mother, Father, and Child Cohort Study (MoBa), and comprised 36,584 mother–child dyads. Prenatal stress was assessed using 41 self-reported items measured during pregnancy. Positive maternal mental health (self-efficacy, self-esteem, and enjoyment) was assessed by maternal report during pregnancy and postpartum. Child internalizing and externalizing symptoms were assessed by maternal report at age 5. Structural equation modeling was used for analysis. Maternal self-efficacy, self-esteem, and enjoyment were negatively associated with internalizing and externalizing symptoms in males and females. The association between prenatal stress and internalizing symptoms in males was stronger at low than at high levels of maternal self-esteem and enjoyment, whereas for females, the association was stronger at low than at high levels of maternal self-esteem and self-efficacy. This study provides evidence of associations between positive maternal mental health and children's mental health, and suggests that higher positive maternal mental health may buffer against the impacts of prenatal stress. Positive maternal mental health may represent an important intervention target to improve maternal–child well-being and foster intergenerational resilience.

Keywords Stress · Depression · Mental health · Behavior problems · Epidemiology

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Introduction

Distress and psychopathology are common among expecting and new mothers—for example, up to 20% of women report symptoms of depression in the prenatal and postnatal periods [1, 2], and up to 60% report experiencing at least one stressful life event during pregnancy [3, 4]. In turn, it is well established that maternal distress and mental health problems adversely impact children's development [5–7]. However, many women report high levels of positive mental health during the prenatal and postnatal periods, including high self-rated mental health and high life satisfaction [8, 9]. Though inversely associated, it is possible to experience concurrently high levels of both positive mental health and distress or psychopathology [10], but few studies have examined associations between indicators of positive maternal mental health and children's development.

Positive mental health is typically viewed from hedonic and eudaimonic perspectives, which are related but have distinct psychosocial and biological correlates [11, 12]. For example, the hedonic perspective highlights the importance of pleasure, comfort, and positive mood in promoting happiness and well-being. By comparison, the eudaimonic perspective prioritizes meaning and self-actualization through promoting traits such as autonomy, self-esteem, engagement, and self-efficacy [13, 14]; these eudaimonic traits are strongly correlated with resilience [15]. During the perinatal period, both hedonic and eudaimonic indicators of positive mental health can influence how women are affected by and cope with adversity. For example, women who report high levels of optimism during pregnancy report lower levels of depression and distress [16–18], and higher levels of mastery and self-esteem [18]. Positive affect and optimism are positively associated with improved stress management and adaptive coping strategies and are inversely associated with the use of avoidant coping strategies during pregnancy [19, 20]. In turn, positive stress appraisals and coping strategies can reduce levels of maternal distress and improve maternal well-being [21].

Given that higher positive maternal mental health can improve perceptions of stressful situations and promote the use of adaptive coping strategies, this implies that even in the context of prenatal distress and psychopathology it may be beneficial to target attributes of positive mental health to improve maternal and child health outcomes. Research suggests that positive mental health may buffer against the negative effects of prenatal distress [18, 22]. The potential buffering role of positive mental health is further supported by research which suggests that eudaimonic factors, such as self-esteem and self-efficacy, are associated with improved parenting behaviors, which can positively impact children's development [23]. Hedonic factors including enjoyment and positive affect have also been linked to improvements in children's socio-emotional development among children [24]. However, we are aware of only one small study that has examined the potential moderating role of positive maternal mental health on the relation between prenatal maternal distress and children's development. Findings from this study reported that infants of prenatally stressed mothers who reported higher self-efficacy during pregnancy cried less than the infants of prenatally stressed mothers who reported low levels of self-efficacy [25].

There is a need for research that examines whether indicators of positive maternal mental health are associated with children's mental health and development, and whether they can attenuate the associations between prenatal stress and adverse children's outcomes beyond infancy. Using a large longitudinal sample of mothers and their children, we first examined the independent associations between prenatal maternal stress, three indicators of positive maternal mental health (self-efficacy, self-esteem, and enjoyment) measured during pregnancy and postnatally, and children's internalizing and externalizing symptoms at five years of age. We hypothesized that prenatal maternal stress and positive maternal mental health would be positively and negatively associated with children's internalizing and externalizing symptoms at 5 years of age, respectively. We then examined whether positive maternal mental health moderated the associations between prenatal maternal stress and children's internalizing and externalizing symptoms; we hypothesized that the associations would be attenuated at high levels of positive maternal mental health, and strengthened at lower levels of positive maternal mental health.

Methods

Data and participants

This study used data from the Norwegian Mother, Father and Child Cohort Study (MoBa), a population-based pregnancy cohort study conducted by the Norwegian Institute of Public Health. Participants were recruited from across Norway between 1999 and 2008, and women consented to participation in 41% of pregnancies. The cohort includes over 114,500 children, 95,200 mothers and 75,200 fathers [26]. Maternal questionnaire response rates at 17 weeks' gestation, 30 weeks' gestation, 18 months, and 5 years after birth were 95.1%, 91.4%, 87.0% and 54.0%, respectively [26, 27]. The current study was based on version 12 of the quality-assured data files released for research in 2020. The establishment of MoBa and initial data collection was based

on a license from the Norwegian Data Protection Agency and approval from The Regional Committees for Medical and Health Research Ethics. The MoBa cohort is now based on regulations governed by Norwegian Health Registry Act. The study sample included 36,584 mother–child dyads with complete data on key study variables (Fig. 1). This study was approved by The Regional Committees for Medical and Health Research Ethics (#2013/2061).

Measures

Prenatal maternal stress

A broad measure of prenatal maternal stress was constructed based on methods developed by Cecil and colleagues [28], which have also been adapted for use in other prospective birth cohort studies [29, 30]. The prenatal

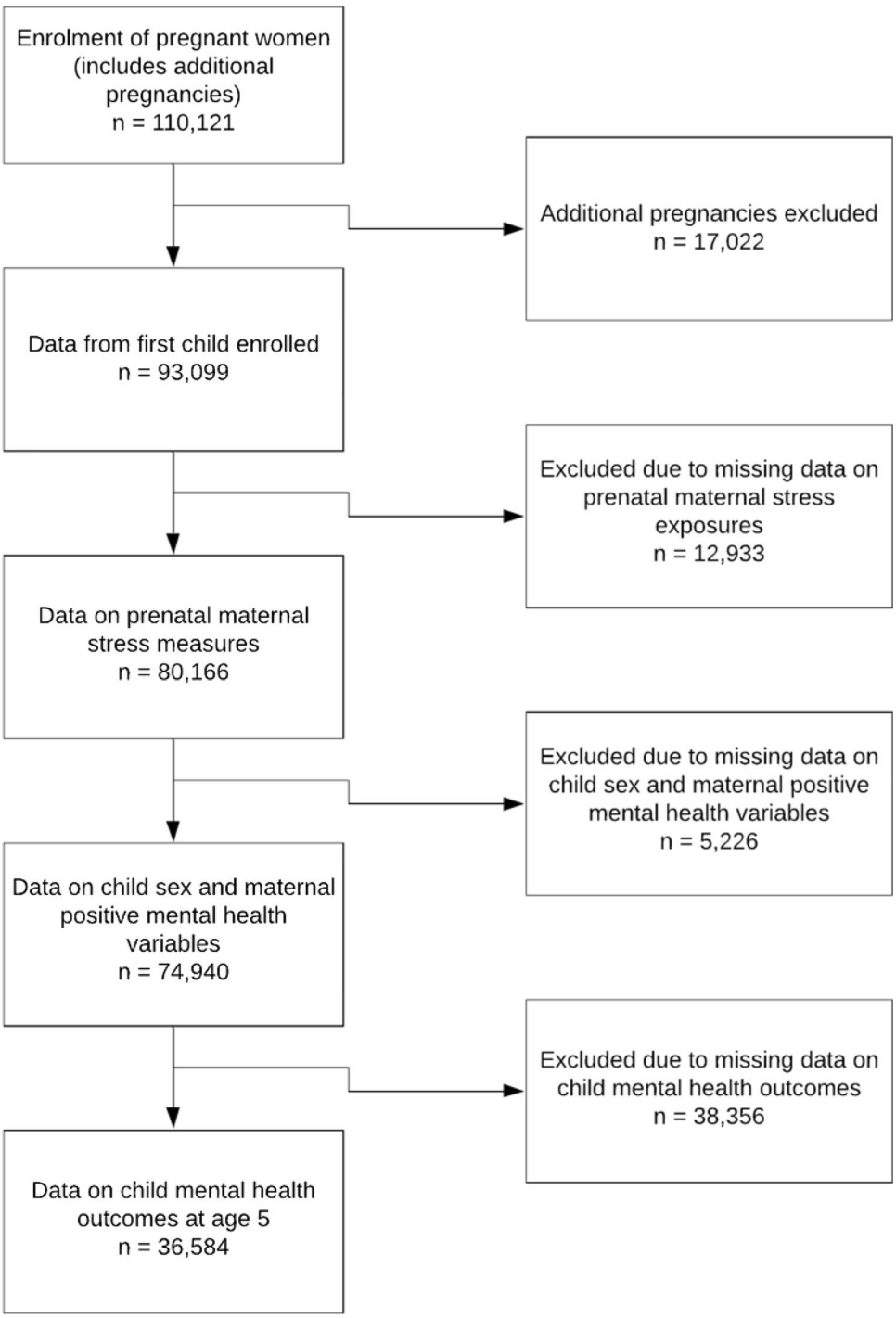

Fig. 1 Participant selection flow-chart

stress measure comprised 41 items collected by maternal questionnaire at 17 and 30 weeks' gestation that spanned four stress domains: life stress, contextual stress, personal stress, and interpersonal stress (see Online Appendix). Items from each domain were summed and divided by the total number of items to generate domain-specific mean scores. Next, scores from the four stress domains were used as indicators in a confirmatory factor analysis to extract a latent prenatal maternal stress factor that demonstrated excellent model fit according to fit indices (see Fig. S1); development of the prenatal maternal stress measure included respondents who had complete data on at least two out of four stress domains. Relative to the original measure [28], we excluded maternal education from the personal stress domain given that prior research suggests maternal education may impact developmental outcomes through mechanisms independent of prenatal stress [30]. We also added items from an occupational stress measure to the contextual stress domain, and removed maternal hospitalizations during pregnancy from the life stress domain to improve measurement model fit.

Positive maternal mental health

Three positive mental health measures encompassing both hedonic and eudaimonic perspectives were examined during pregnancy: self-efficacy (eudaimonic perspective), self-esteem (eudaimonic perspective), and enjoyment (hedonic perspective). Self-efficacy was measured at 30 weeks' gestation using a short-form, 5-item version of the General Self-Efficacy Scale (GSES) [31, 32], which was designed to examine the belief in one's ability to cope with challenging life demands. Items were summed to generate total self-efficacy scores, with higher scores representing greater self-efficacy. The General Self-Efficacy Scale demonstrated good internal consistency in the study sample (Cronbach's alpha = 0.84). Self-esteem and enjoyment were examined at 30 weeks' gestation and at 6 months, 18 months, and 36 months postpartum using a short-form version of the Rosenberg Self-Esteem scale [33] and the enjoyment subscale of the Differential Enjoyment Scale [34]. In line with scoring recommendations [33], total scores were generated for maternal self-esteem at each assessment point by summing across items, and mean scores for maternal enjoyment were generated by calculating total scores and dividing by the number of items [34]. Given that the same self-esteem and enjoyment items were administered at all four assessment points of interest and were highly correlated, latent maternal self-esteem and enjoyment factors were generated by combining scores for each measure across all assessment points using confirmatory factor analysis. Generation of factor scores required complete data on maternal self-esteem and enjoyment at 30 weeks' gestation, as well as complete data on these measures during at least one postnatal assessment point. All scales used to measure positive maternal mental health in the current study have demonstrated high internal consistency [34–36], and the short-form versions of the General Self-Efficacy Scale and Rosenberg Self-Esteem Scale used in the current study correlate strongly with scores from the full versions [32].

Child internalizing and externalizing symptoms

Children's internalizing and externalizing symptoms at 5 years of age were examined using short-form versions of the Child Behavior Checklist (CBCL), a standardized, adult-reported scale commonly used to assess a broad range of neuropsychiatric outcomes in children [37]. The short-form versions for the MoBa cohort were constructed by a team clinical and developmental psychologists. We used five items to assess internalizing symptoms and eight items to assess externalizing symptoms. Items were rated on a 3-point scale and summed to create total scores for internalizing and externalizing symptoms. The CBCL has demonstrated good predictive validity in distinguishing between children with and without psychiatric disorders in a Norwegian sample [38], and prior research demonstrates that the short-form version of the externalizing scale used in the MoBa cohort is highly correlated with the full externalizing scale of the CBCL ($r = 0.92$), using data from the NICHD Study of Early Child Care and Youth Development [39]. Factor analysis of the MoBa CBCL items load clearly onto two distinct internalizing and externalizing latent constructs [40].

Covariates

Child sex (male or female) was examined as a potential moderating variable given recommendations to examine sex-stratified associations where possible in the existing fetal programming literature [41]. In addition, a number of potential confounding variables were selected a priori based on theoretical grounds and were adjusted for in analyses. These included maternal and paternal educational attainment (post-secondary and above; and high school and below); smoking during the first trimester of pregnancy (yes; no); alcohol consumption during the first trimester of pregnancy (never; 1–3 times per month; 1 time per week or more); and parity (no prior births; at least one prior birth). Cumulative stressful life events from birth to 5 years of age were adjusted for in sensitivity analyses.

Statistical analyses

Examination of respondent characteristics was performed using Stata version 15 (StataCorp, College Station, TX); all

remaining analyses were performed using MPlus version 8 (Muthén & Muthén, Los Angeles, CA). All models estimated in MPlus used full information maximum likelihood estimation with robust standard errors (MLR) to account for potential non-normality of data and missing values on covariates, a method which is valid under the assumption that missing data were missing at random [42].

We used structural equation modeling to examine the associations between prenatal maternal stress, positive maternal mental health measures, and child internalizing and externalizing symptoms; separate models were run for each positive mental health measure. Prenatal maternal stress, maternal self-esteem, and maternal enjoyment were standardized by scaling their variances to 1; thus, standardized parameter estimates (β) reported represent changes in child internalizing and externalizing symptoms per one standard deviation increase in these latent factors, and were used to ascertain effect size. Unstandardized parameter estimates are also reported (b), and represent changes in child internalizing or externalizing symptoms per one unit increase in predictor variables. To ascertain potential sex differences, multiple group analyses were conducted to test the equality of coefficients between males and females on associations of interest (i.e., associations between prenatal maternal stress, positive maternal mental health, and child internalizing and externalizing symptoms). Likelihood ratio tests, with statistical significance set at a threshold of $p < 0.05$, were used to indicate whether or not parameter estimates significantly differed by sex; subsequent analyses were stratified by sex when likelihood-ratio tests were significant. The comparative fit index (CFI) and the root mean square error of approximation (RMSEA), with threshold values of ≥ 0.90 or ≤ 0.06 were used to indicate good model fit [43, 44].

To test whether maternal self-efficacy, self-esteem, and enjoyment moderated the associations between prenatal maternal stress and child internalizing and externalizing symptoms, interaction terms were created between prenatal maternal stress and each positive mental health measure in separate models using the *XWITH* procedure in MPlus [45]. Moderation was deemed to be present if interaction terms were significantly associated with child internalizing or externalizing symptoms, using a threshold of $p < 0.05$. The Johnson–Neyman technique was then used to visually examine statistically significant interactions [46, 47]. This involved plotting the standardized effect (slope) of latent prenatal maternal stress on child internalizing or externalizing symptoms, as well as their 95% confidence intervals (CI) on the y-axis, against the range of values of the positive mental health moderating variables on the x-axis, with maternal enjoyment and self-esteem plotted using the mean (zero) ± three standard deviations, and maternal self-efficacy plotted using the complete range of values. Johnson–Neyman plots indicate at which levels of the moderating variable the effect of interest is statistically significant (i.e., where the 95% CI of the effect does not cross zero [47], and provide a visual representation of the strength of the effect across values of the moderating variable. Fit of moderation models was assessed using a log-likelihood difference test, as traditional fit indices (e.g., CFI, RMSEA) are not generated for moderation models using the *XWITH* procedure in MPlus. This test involved calculating the difference in − 2*log-likelihood values between nested (i.e., main effects) models and models containing interaction terms to generate a difference value that is approximately distributed as $\chi 2$, with degrees of freedom calculated as the difference in free parameters estimated between models. Significant log-likelihood difference tests ($p < 0.05$) indicated that models with interactions had better fit than the models without. Additional analyses included testing the moderating role of a comprehensive positive mental health measure (i.e., using a second-order latent variable including maternal self-efficacy, latent self-esteem, and latent enjoyment), and adjusting primary analyses for all maternal stressful events occurring from birth to 5 years of age.

Results

Descriptive characteristics of the study sample are provided in Table 1. Almost all mothers included in the sample were married or cohabiting, and the majority had some level of post-secondary education. Mean age of mothers in the sample was 30.2 years ($SD = 4.36$). Approximately 4.8% of women reported smoking (sometimes or daily), and 9.8% of women reported alcohol use (1 drink per month or greater) at 17 weeks' gestation. 50.8% of the children in the study sample were males. Correlations between prenatal maternal stress, maternal self-esteem, maternal self-efficacy, maternal enjoyment, and child internalizing and externalizing symptoms (ranging between − 0.43 and 0.58) are provided in Table S1. Correlations between all items included in positive mental health measures (ranging between 0.27 and 0.65) are provided in Table S2. Given significant findings from multiple group analyses (p's < 0.05), all structural equation model analyses were stratified by sex (results not shown).

Across all models, higher prenatal maternal stress was associated with higher internalizing symptoms and higher externalizing symptoms in males and females prior to and after adjustment for covariates (unadjusted models not shown; see Tables 2, 3, 4). Higher maternal self-efficacy was associated with lower internalizing symptoms and lower externalizing symptoms in females, but not males. Both higher maternal self-esteem and higher maternal enjoyment, as well as a comprehensive measure of positive mental health involving all indicators (see Table S3), were associated with lower internalizing symptoms in females, and

Table 1 Descriptive characteristics of sample at 17 weeks' gestation ($N = 36{,}584$)

Characteristic	Mean ± SD or *n* (%)
Maternal age	30.23 (4.36)
Parity	
0	17,845 (48.78)
1+	18,447 (50.42)
Missing	292 (0.80)
Marital status	
Married	18,059 (49.36)
Cohabiting	17,519 (47.89)
Single	861 (2.35)
Missing	145 (0.40)
Maternal education	
> High school	25,864 (70.70)
High school and below	9,066 (24.78)
Missing	1,654 (4.52)
Paternal education	
> High school	19.274 (52.68)
High school and below	14,384 (39.32)
Missing	2,926 (8.00)
Smoking	
None	34,005 (92.95)
Sometimes	659 (1.80)
Daily	1,087 (2.97)
Missing	833 (2.28)
Alcohol use	
None	28.753 (78.59)
1–3 drinks per month	3,437 (9.39)
1 + drinks per week	151 (0.41)
Missing	4,243 (11.60)
Child gender	
Male	18,596 (50.83)
Female	17,988 (49.17)

SD standard deviation

lower externalizing symptoms in both males and females. Model fit across all models was good.

The interaction between prenatal maternal stress and prenatal maternal self-efficacy was small but statistically significant for female internalizing symptoms ($\beta = -0.038$, 95% CI = − 0.060, − 0.016); remaining interaction terms were not statistically significant. The log-likelihood test for this model was statistically significant ($\chi^2(8) = 960.880$, $p < 0.001$), indicating that the model with the interaction between prenatal maternal stress and prenatal self-efficacy had better fit than the main effects model. Figure 2A demonstrates that the association between prenatal maternal stress and internalizing symptoms in females was strongest at lower levels of maternal self-efficacy, and attenuated at higher levels of self-efficacy. Interactions between prenatal maternal stress and maternal self-esteem were small but statistically significant for internalizing symptoms in males ($\beta = -0.026$, 95% CI = − 0.045, − 0.007) and females ($\beta = -0.017$, 95% CI = − 0.034, 0.000); remaining interactions were not statistically significant. The log-likelihood tests for male ($\chi^2(5) = 330.793$, $p < 0.001$) and female ($\chi^2(5) = 1294.042$, $p < 0.001$) models were significant, indicating that models with interactions between prenatal maternal stress and self-esteem had better fit than the models without. Figure 2B, C demonstrates that the associations between prenatal maternal stress and internalizing symptoms in males and females were stronger at lower levels of maternal self-esteem, and attenuated at higher levels of self-esteem. The interaction between prenatal maternal stress and maternal enjoyment was small but statistically significant for internalizing symptoms in males ($\beta = -0.023$, 95% CI = − 0.046, − 0.001); the log-likelihood test for this model was also significant ($\chi^2(5) = 1635.908$, $p < 0.001$), indicating that the model with the interaction between prenatal maternal stress and maternal enjoyment had better fit than the model without. Remaining interaction terms that were tested were not statistically significant. Figure 2D demonstrates that the association between prenatal maternal stress and internalizing symptoms in males was strongest at lower levels of maternal enjoyment, and attenuated at higher levels of enjoyment.

Additional analyses including interactions between prenatal maternal stress and a comprehensive positive mental health measure were statistically significant for internalizing symptoms in males ($\beta = -0.029$, 95% CI = − 0.049, − 0.009) and females ($\beta = -0.021$, 95% CI = − 0.038, − 0.004), but not for externalizing symptoms. Findings across models remained statistically significant after additional adjustment for cumulative postnatal stressful events (Tables S4–S6).

Discussion

Findings from this study of over 36,000 mothers and their children suggest that prenatal maternal stress and indicators of positive maternal mental health are associated with children's internalizing and externalizing symptoms at 5 years of age. Our findings further suggest that higher levels of positive maternal mental health during pregnancy may buffer the associations between prenatal maternal stress and child internalizing and externalizing symptoms Specifically, our findings suggest that the association between prenatal maternal stress and internalizing symptoms in males is stronger at low than at high levels of maternal self-esteem and maternal enjoyment. Findings also suggest that the association between prenatal maternal stress and internalizing symptoms in females may be stronger at low than at high levels of

Table 2 Main effect and moderation models of associations between prenatal maternal stress, maternal self-efficacy, and internalizing and externalizing symptoms in males and females

		Males ($n = 18,596$)		Females ($n = 17,988$)	
		b (SE)	*β* (95% CI)	*b* (SE)	*β* (95% CI)
Internalizing symptoms	Main effects model (unadjusted)				
	Prenatal maternal stress	1.895 (0.114)***	0.251 (0.229, 0.273)	1.675 (0.107)***	0.234 (0.212, 0.256)
	Maternal self-efficacy	− .002 (0.001)***	− .008 (− .012, − .003)	− 0.005 (0.001)***	− 0.020 (− 0 0.025, − 0.015)
	Main effects model (adjusted)				
	Prenatal maternal stress	1.985 (0.122)***	0.270 (0.245, 0.295)	1.765 (0.115)***	0.254 (0.229, 0.279)
	Maternal self-efficacy	0.001 (0.001)	0.016 (− 0.001, 0.032)	− 0.002 (0.001)*	− 0.023 (− 0.040, − 0.007)
	Moderation model				
	Prenatal maternal stress	2.556 (0.377)***	0.347 (0.250, 0.445)	2.994 (0.420)***	0.431 (0.321, 0.540)
	Maternal self-efficacy	0.001 (0.001)*	0.017 (0.001, 0.033)	− 0.002 (0.001)*	− 0.020 (− 0.036, − 0.004)
	Prenatal maternal stress x self-efficacy	− 0.041 (0.025)	− 0.017 (− 0.037, 0.003)	− 0.087 (0.027)**	− 0.038 (− 0.060, − 0.016)
Externalizing symptoms	Main effects model (unadjusted)				
	Prenatal maternal stress	1.916 (0.116)***	0.223 (0.202, 0.245)	1.607 (0.105)***	0.215 (0.193, 0.237)
	Maternal self-efficacy	− 0.004 (0.001)**	− 0.015 (− 0.019, − 0.010)	− 0.005 (0.001)***	− 0.020 (− 0.025, − 0.015)
	Main effects model (adjusted)				
	Prenatal maternal stress	1.812 (0.121)***	0.216 (0.192, 0.240)	1.543 (0.111)***	0.213 (0.188, 0.238)
	Maternal self-efficacy	− 0.001 (0.001)	− 0.009 (− 0.026, 0.007)	− 0.002 (0.001)**	− 0.027 (− 0.044, − 0.011)
	Moderation model				
	Prenatal maternal stress	1.678 (0.387)***	0.200 (0.110, 0.291)	2.057 (0.418)***	0.283 (0.174, 0.392)
	Maternal self-efficacy	− 0.001 (0.001)	− 0.010 (− 0.026, 0.006)	− 0.002 (0.001)**	− 0.026 (− 0.042, − 0.010)
	Prenatal maternal stress x self− efficacy	0.012 (0.026)	0.003 (− 0.015, 0.022)	− 0.037 (0.027)	− 0.015 (− 0.037, 0.006)
Model fit statistics		CFI	RMSEA (95% CI)	CFI	RMSEA (95% CI)
	Main effects model (adjusted)	0.885	0.046 (0.044, 0.048)	0.885	0.045 (0.042, 0.047)

Models adjusted for the following covariates: maternal education, paternal education, maternal alcohol use, maternal smoking, and parity

b unstandardized regression coefficient, *SE* standard error, *β* standardized regression coefficient, *CI* confidence interval, *CFI* comparative fit index, *RMSEA* root mean square error of approximation

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

maternal self-esteem and maternal self-efficacy. These findings held after adjustment for postnatal maternal adversity.

The examined positive mental health indicators have been directly and indirectly associated with children's development. For example, similar to enjoyment, positive maternal affect has been associated with positive socio-emotional and cognitive outcomes in children, as well as the development of children's positive affect [48, 49]. Broadly, research suggests that higher positive mental health lowers risk of onset and reduces symptom severity of mental health disorders [50, 51]. Positive maternal affect and self-efficacy have been associated with positive parenting behaviors [52, 53], which, in turn, can protect against the development of mental health problems in children and promote their positive mental health [54–56]. Maternal self-esteem has also been associated with improved mother–child relationships [57], and with improved self-esteem in children [58]. Our findings contribute to this growing evidence base by suggesting that independent of prenatal maternal stress, higher maternal self-efficacy, self-esteem, and enjoyment are associated with lower internalizing and externalizing symptoms in children at 5 years of age. Given that a limited number of studies have directly examined the associations between

Table 3 Main effect and moderation models of associations between prenatal maternal stress, maternal self-esteem, and internalizing and externalizing symptoms in males and females

		Males ($n = 18,596$)		Females ($n = 17,988$)	
		b (SE)	*β* (95% CI)	*b* (SE)	*β* (95% CI)
Internalizing symptoms	Main effects model (unadjusted)				
	Prenatal maternal stress	1.859 (0.138)***	0.243 (0.212, 0.273)	1.509 (0.132)***	0.205 (0.174, 0.236)
	Maternal self-esteem	− 0.003 (0.002)	− 0.020 (− 0.046, 0.006)	− 0.012 (0.002)***	− 0.068 (− 0.094, − 0.042)
	Main effects model (adjusted)				
	Prenatal maternal stress	1.902 (0.146)***	0.257 (0.223, 0.290)	1.549 (0.138)***	0.218 (0.184, 0.253)
	Maternal self-esteem	− 0.002 (0.002)	− 0.009 (− 0.035, 0.018)	− .010 (0.002)***	− 0.058 (− 0.085, − 0.031)
	Moderation model				
	Prenatal maternal stress	1.825 (0.143)***	0.247 (0.214, 0.280)	1.519 (0.136)***	0.214 (0.181, 0.248)
	Maternal self-esteem	− 0.001 (0.002)	− 0.006 (− 0.032, 0.020)	− 0.010 (0.002)***	− 0.055 (− 0.082, − 0.028)
	Prenatal maternal stress x self-esteem	− 0.129 (0.048)**	− 0.026 (− 0.045, − 0.007)	− 0.085 (0.043)*	− 0.017 (− 0.034, 0.000)
Externalizing symptoms	Main effects model (unadjusted)				
	Prenatal maternal stress	1.570 (0.142)***	0.180 (0.150, 0.210)	1.259 (0.127)***	0.164 (0.133, 0.194)
	Maternal self-esteem	− 0.017 (0.003)***	− 0.086 (− 0.111, − 0.060)	− 0.019 (0.002)***	− 0.104 (− 0.129, − 0.078)
	Main effects model (adjusted)				
	Prenatal maternal stress	1.420 (0.147)***	0.168 (0.136, 0.200)	1.131 (0.138)***	0.153 (0.120, 0.186)
	Maternal self-esteem	− 0.015 (0.003)***	− 0.077 (− 0.103, − 0.051)	− 0.018 (0.002)***	− 0.098 (− 0.125, − 0.072)
	Moderation model				
	Prenatal maternal stress	1.426 (0.146)***	0.169 (0.137, 0.201)	1.115 (0.131)***	0.151 (0.118, 0.183)
	Maternal self-esteem	− 0.015 (0.003)***	− 0.077 (− 0.103, − 0.051)	− 0.018 (0.002)***	− 0.097 (− 0.123, − 0.070)
	Prenatal maternal stress x self-esteem	− 0.004 (0.047)	− 0.001 (− 0.017, 0.016)	− 0.052 (0.049)	− 0.010 (− 0.029, 0.009)
Model fit statistics		CFI	RMSEA (95% CI)	CFI	RMSEA (95% CI)
	Main effects model (adjusted)	0.968	0.034 (0.032, 0.035)	0.967	0.034 (0.032, 0.035)

Models adjusted for the following covariates: maternal education, paternal education, maternal alcohol use, maternal smoking, and parity

b unstandardized regression coefficient, *SE* standard error, *β* standardized regression coefficient, *CI* confidenceinterval, *CFI* comparative fit index, *RMSEA* root mean square error of approximation

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

maternal self-efficacy, self-esteem, and enjoyment on children's outcomes, findings from this study contribute to this literature. Based on existing research, our findings may suggest that positive maternal mental health can play a protective role on the development of children's internalizing and externalizing symptoms through potential mechanisms including the promotion of positive parenting behaviors and by directly improving children's positive mental health and developmental outcomes.

Our findings highlight the potential for both hedonic and eudaimonic dimensions of positive maternal mental health to reduce the adverse effects of prenatal distress on children's development. In line with our findings regarding the potential protective role of positive maternal mental health following stress exposure, a longitudinal study by McDonald and colleagues found that the association between cumulative prenatal maternal stress and preterm birth was only significant for mothers who reported low levels of dispositional optimism [59]. Longitudinal research also suggests that maternal self-efficacy reduces the impacts of prenatal maternal stress on infant crying behavior [25]; persistent infant crying has been associated with negative

Table 4 Main effect and moderation models of associations between prenatal maternal stress, maternal enjoyment, and internalizing and externalizing symptoms in males and females

		Males ($n = 18,596$)		Females ($n = 17,988$)	
		b (SE)	*β* (95% CI)	*b* (SE)	*β* (95% CI)
Internalizing symptoms	Main effects model (unadjusted)				
	Prenatal maternal stress	1.749 (0.119)***	0.259 (0.230, 0.289)	1.465 (0.112)***	0.230 (0.200, 0.259)
	Maternal enjoyment	0.001 (0.007)	0.002 (− .022, 0.026)	− 0.021 (− .007)**	− .039 (− 0.063, − 0.014)
	Main effects model (adjusted)				
	Prenatal maternal stress	1.753 (0.127)***	0.266 (0.233, 0.298)	1.464 (0.121)***	0.235 (0.202, 0.269)
	Maternal enjoyment	− 0.001 (0.007)	− 0.001 (− 0.026, 0.024)	− 0.023 (0.007)**	− 0.041 (− 0.067, − 0.015)
	Moderation model				
	Prenatal maternal stress	1.692 (0.124)***	0.256 (0.224, 0.288)	1.430 (0.119)***	0.230 (0.197, 0.263)
	Maternal enjoyment	0.000 (0.007)	− 0.001 (− 0.025, 0.024)	− 0.022 (0.007)**	− 0.040 (− 0.065, − 0.014)
	Prenatal maternal stress x enjoyment	− 0.339 (0.166)*	− 0.023 (− 0.046, − 0.001)	− 0.222 (0.125)	− 0.016 (− 0.034, 0.001)
Externalizing symptoms	Main effects model (unadjusted)				
	Prenatal maternal stress	1.565 (0.119)***	0.204 (0.176, 0.232)	1.290 (0.109)***	0.194 (0.165, 0.223)
	Maternal enjoyment	− 0.040 (0.008)***	− 0.061 (− 0.085, − 0.038)	− 0.042 (0.007)***	− 0.073 (− 0.097, − 0.049)
	Main effects model (adjusted)				
	Prenatal maternal stress	1.348 (0.128)***	0.180 (0.148, 0.211)	1.109 (0.116)***	0.171 (0.138, 0.203)
	Maternal enjoyment	− 0.046 (0.008)***	− 0.070 (− 0.095, − 0.046)	− 0.049 (0.007)***	− 0.084 (− 0.109, − 0.059)
	Moderation model				
	Prenatal maternal stress	1.358 (0.127)***	0.180 (0.149, 0.211)	1.102 (0.114)***	0.170 (0.138, 0.202)
	Maternal enjoyment	− 0.046 (0.008)***	− 0.071 (− 0.095, − 0.046)	− 0.048 (0.007)***	− 0.084 (− 0.108, − 0.059)
	Prenatal maternal stress x enjoyment	0.009 (0.150)	0.001 (− 0.017, 0.018)	− 0.064 (0.130)	− 0.004 (− 0.022, 0.013)
Model fit statistics		CFI	RMSEA (95% CI)	CFI	RMSEA (95% CI)
	Main effects model (adjusted)	0.957	0.037 (0.036, 0.039)	0.957	0.037 (0.035, 0.039)

Models adjusted for the following covariates: maternal education, paternal education, maternal alcohol use, maternal smoking, and parity

b unstandardized regression coefficient, *SE* standard error, *β* standardized regression coefficient, *CI* confidence interval, *CFI* comparative fit index, *RMSEA* root mean square error of approximation

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

mother–child interactions [60], and greater risk of children's behavioral and psychological difficulties later in childhood [61]. To our knowledge, no other studies have examined the moderating role of positive maternal mental health on the associations between prenatal maternal stress and children's internalizing and externalizing symptoms. It is important to note that in the current study, moderation analyses were significant for internalizing, but not externalizing symptoms; this contrasts with other studies that have demonstrated associations between children's self-esteem and self-efficacy with both internalizing and externalizing symptoms during adolescence [62, 63]. Given that children in the current study were 5 years of age at outcome ascertainment, these associations may benefit from further inquiry as children continue to develop through late childhood and adolescence. In addition, some sex differences were observed in moderation analyses; for example, maternal enjoyment buffered the association between prenatal maternal stress and boys' internalizing symptoms, whereas maternal self-efficacy buffered the association between prenatal maternal stress and girls' internalizing symptoms. In line with these findings, one study reported that male gender was negatively associated with mothers' parental self-efficacy, suggesting that mothers may be less likely to use positive parenting practices with

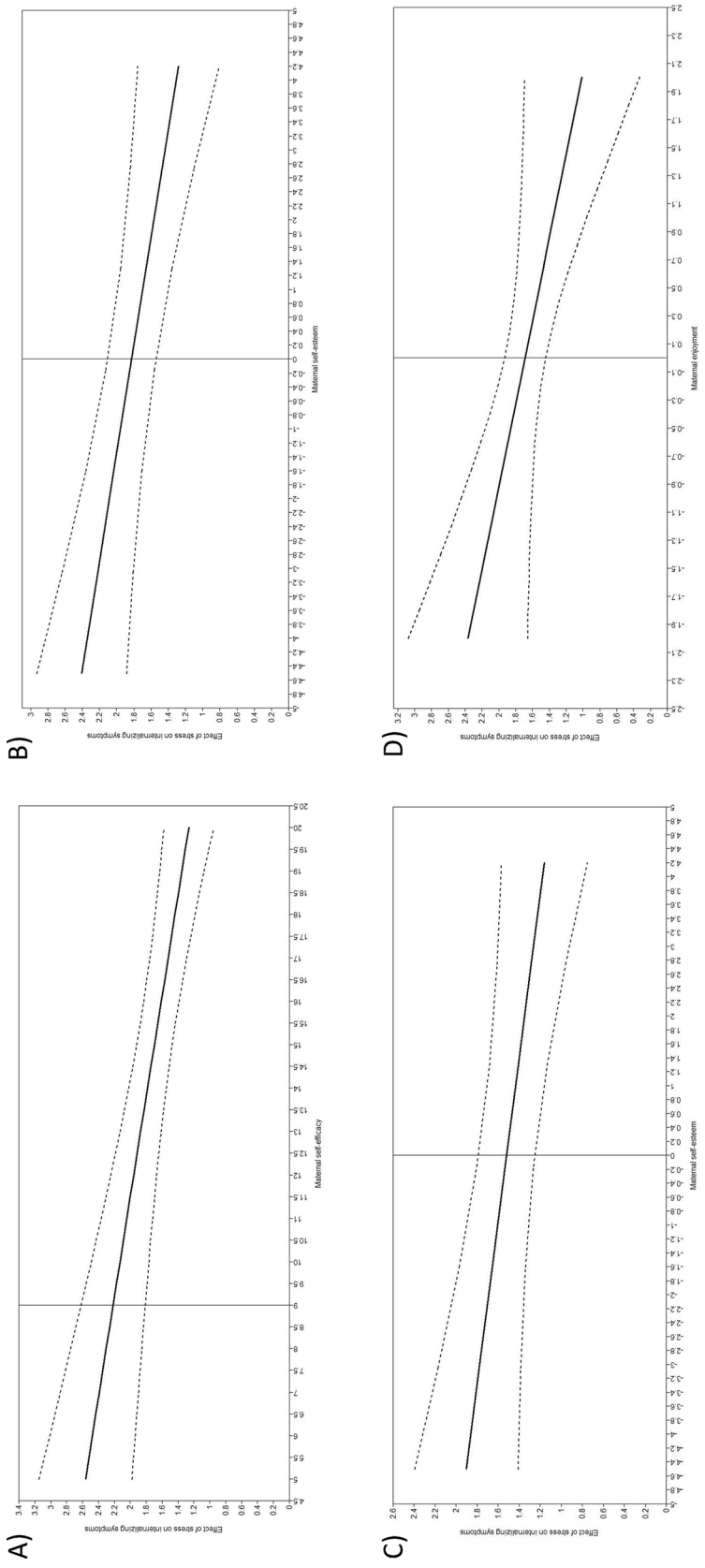

Fig. 2 Johnson-Neyman plots of (**A**) moderating role of maternal self-efficacy at 30 weeks gestation on the relationship between prenatal maternal stress and female internalizing symptoms, (**B**) moderating role of maternal self-esteem on the relationship between prenatal maternal stress and male internalizing symptoms, (**C**) moderating role of maternal self-esteem on the relationship between prenatal maternal stress and female internalizing symptoms, (**D**) moderating role of maternal enjoyment on the relationship between prenatal maternal stress and male internalizing symptoms. Plot lines represent effect (solid center line) and 95% confidence interval (dotted outer lines)

boys than with girls [64]; this may partially explain why interactions between prenatal maternal stress and maternal self-efficacy were significant for girls but not boys. In another study, mothers were more likely to encourage the expression of positive emotions in boys compared to girls [65], which may potentially address why maternal enjoyment moderated the association between prenatal maternal stress and boys', but not girls', internalizing symptoms. In all, coupling the current study's findings with the existing literature highlights the potential importance of higher positive maternal mental health in reducing the adverse effects of early stress exposure, but also emphasizes the need for additional inquiry into these associations throughout children's development.

Importantly, positive mental health may be modifiable [66, 67], and research suggests that it is possible to develop personal strengths and resources (e.g., self-efficacy, mastery), cultivate a sense of meaning, and enhance positive feelings through positive psychological interventions [67]. Meta-analyses of randomized controlled trials support the efficacy of psychological interventions in increasing subjective and psychological well-being and reducing symptoms of depression [67]. Emerging research also supports the efficacy of positive psychological interventions targeted at improving maternal mental health in the prenatal and postnatal periods. For example, interventions during pregnancy and after birth that integrate positive psychological components, including gratitude journaling and mindfulness, may reduce mothers' perceived stress and symptoms of depression and increase positive affect [68, 69]. Research further suggests that parenting interventions can increase levels of parental self-efficacy and positive affect [70]. Higher parental self-efficacy has been associated with positive parenting behaviors including increased sensitivity, warmth, and responsiveness [71], which can protect against the development of children's mental health problems [54–56, 71]. Although research supporting the effects of these interventions on children's long-term mental health is scarce, this evidence highlights the importance of targeting the improvement of positive maternal mental health in promoting improved maternal well-being and positive parenting behaviors, and by extension, nurturing children's well-being.

These findings should be interpreted in consideration of several limitations. First, significant attrition occurred during the study follow-up period, which may have biased the reported associations. However, attrition analyses completed in the MoBa cohort suggest that participant attrition largely impacts prevalence estimates, and may not substantially bias exposure-outcome associations [72]. Second, we did not examine other potentially important indicators of positive mental health. Although the measures included in our study encompass both hedonic and eudaimonic perspectives, other factors that span both perspectives (e.g., mastery, life satisfaction, and social well-being) would benefit from further inquiry given their limited exploration in the developmental literature. Third, over 99% of MoBa participants are White and most participants are of higher socioeconomic status; as a result, our findings may not generalize to regions with greater socioeconomic or ethnic diversity, and further study of these associations in diverse samples is necessary. Fourth, our study measures were collected by maternal report, and reporting bias cannot be ruled out. However, to address this limitation, we adjusted for maternal adversity after birth, and findings remained largely unchanged. Fifth, since we did not correct for multiple comparisons, it is possible that some of the observed associations may be due to chance. Finally, we did not have data on paternal positive mental health or on genetic information, and thus could not examine how indicators of positive paternal mental health influence children's internalizing and externalizing symptoms, nor could we address potential genetic confounding (e.g., genetic factors may alter the impacts of prenatal maternal stress on the child (55), and subsequent risk towards poor mental health).

The current study has numerous strengths. The use of data from a large, prospective pregnancy cohort allowed for the adjustment of several confounding variables, and afforded sufficient statistical power to examine latent variable interactions and conduct sex-stratified analyses. The majority of measures included in the current study have been well validated and extensively used in both psychiatric and epidemiological studies. Furthermore, in line with research suggesting that positive mental health demonstrates stability over time [73], repeated measurement of maternal enjoyment and self-esteem allowed for the construction of latent variables that examined these aspects of positive mental health from pregnancy up to three years postpartum. Finally, the prenatal maternal stress measure we used allowed for examination of a broad measure of stress that considers the shared variance across stress dimensions and further addresses concerns about variability of prenatal stress measurements highlighted in the extant literature [74].

Conclusions

This study suggests that higher maternal enjoyment, self-efficacy, and self-esteem are associated with lower internalizing and externalizing symptoms in children. Given the small interactions observed between prenatal maternal stress and positive mental health measures, findings also suggest that these aspects of positive maternal mental health may act as buffers in reducing some of the adverse effects of prenatal maternal stress on children's mental health outcomes. If replicated, these findings may have implications for future research and practice. Few studies have examined

the impacts of positive maternal mental health on children's development, and few have directly examined the modifiability of positive maternal mental health through positive psychological and parenting interventions. Further integration of positive maternal mental health measures into the study of maternal mental health can contribute to a deeper understanding of children's development, and aid in the construction of effective interventions to improve maternal–child well-being and foster intergenerational resilience.

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Declarations

Conflict of interest None.

Ethical approval This study was approved by The Regional Committees for Medical and Health Research Ethics (#2013/2061). The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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