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Nonlinear associations between parental depressive symptoms and specific parenting disciplines in Chinese preschoolers

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Abstract

Background

Parental depression is associated with adverse parenting outcomes, yet the precise nature of these associations remains unclear. This study examined linear and non-linear relationships between parental depressive symptoms and three dimensions of dysfunctional discipline (laxness, overreactivity, and verbosity) and identified symptom thresholds.

Methods

A cross-sectional study of 21,366 parents of preschoolers in western China assessed depressive symptoms (The Center for Epidemiologic Studies Depression Scale) and parenting discipline (Arnold-O'Leary Parenting Scale). Multivariable linear regression and restricted cubic spline analysis were employed.

Results

Parental depression score was positively associated with overreactivity (β = 0.043) and laxness (β = 0.012), but negatively associated with verbosity (β = −0.009). Non-linear relationships were identified for all outcomes (P < 0.0001). Overreactivity showed a threshold at 16.90, approximating the clinical cutoff of 16, while laxness and verbosity showed thresholds at 11.46, indicating sensitivity to milder symptoms. Household income significantly moderated the depression-overreactivity association (interaction P = 0.0035).

Conclusions

Parental depressive symptoms exhibit non-linear dose-response relationships with specific parenting dimensions. Parenting behaviors change at parental depressive scores below traditional clinical cutoffs, may supporting early identification and intervention to prevent parenting dysfunction and disrupt intergenerational risk transmission.

1 Introduction

Parental depression is a prevalent and impactful mental health condition that undermines parents' well-being and, by disrupting parenting behaviors, contributes to adverse child outcomes. This process increases offspring vulnerability to mental health problems, perpetuating an intergenerational cycle of risk [1, 2]. Such transmission imposes significant burdens on families and presents long-term health and economic challenges for society. For preschool-aged children, parents are the cornerstone of the early environment, and nurturing parenting is critical for healthy social development [3]. Parenting practices, defined as the attitudes and behaviors parents exhibit toward their offspring during daily interactions, play a pivotal role in children's neuropsychological development [4]. Currently, identification and intervention for parental depression often occur only after symptoms become severe, while the prevention of adverse parenting outcomes remains overlooked. Thus, from a public health perspective, identifying early patterns linking parental depressive symptoms to specific maladaptive parenting behaviors is essential to inform targeted prevention and intervention strategies that disrupt intergenerational risk transmission.

Raising young children demands substantial emotional, cognitive, and physiological effort from parents as they navigate daily stressors and support their children's developmental progression [5]. Ineffective parental discipline is consistently associated with heightened risks of externalizing, internalizing, and social difficulties in children [6, 7, 8]. Arnold et al. conceptualized dysfunctional discipline along three dimensions: laxness, characterized by excessive permissiveness and often inconsistent follow-through; overreactivity, expressed through irritability and harshness; and verbosity, or an overreliance on talking that fails to correct behavior [9]. These dimensions form the basis of the Arnold-O'Leary Parenting Scale, a tool widely used to assess maladaptive parenting across cultures.

Extensive research has established associations between parental depression and various maladaptive parenting behaviors [10, 11]. As core features of depression, emotion dysregulation, irritability, and negative cognitive biases toward child behavior may undermine parents' capacity to regulate emotions during daily exchanges with their children, consequently elevating the risk of harsh or overreactive disciplinary responses [12]. Depressed parents exhibit notably negative parenting characteristics, and these associations are particularly pronounced during current depressive episodes [13]. Although the link between parental depressive symptoms and dysfunctional parenting is well-documented, most studies have treated parenting as a global construct or focused on limited dimensions, failing to capture its internal heterogeneity [11, 14]. Moreover, the majority of research has relied on linear assumptions, potentially overlooking more complex dose–response relationships [15, 16]. Emerging evidence suggests that depressive symptom profiles may differentially relate to parenting behaviors [17], yet whether specific symptom thresholds trigger marked changes in parenting remains unexplored. Neglecting such nonlinear dynamics may bias risk identification and result in missed opportunities for early intervention. Therefore, precisely quantifying the associations between parental depressive symptoms and specific discipline dimensions (particularly laxness, overreactivity and verbosity) and exploring potential threshold effects represents a critical gap in the literature. Examining potential nonlinear associations within a cross-sectional framework may offer an alternative perspective to characterize the dose–response relationship between parental depressive symptoms and parenting styles.

The present study aimed to address this gap by employing a cross-sectional design with stratified cluster sampling to recruit a large, representative community sample of 21,366 children aged 3–6 years and their parents from a city in western China. In addition to conventional multivariable linear

regression to quantify linear associations, we applied restricted cubic spline (RCS) analysis to explore potential nonlinear dose–response relationships between parental depressive symptoms and each parenting outcome, and to identify symptom thresholds beyond which parenting behaviors change markedly. By achieving these objectives, this study seeks to provide valuable evidence for threshold-based early identification and stratified intervention strategies, ultimately promoting healthier psychosocial development in children.

2 Methods

2.1 Study design and population

This cross-sectional study was conducted in collaboration with the Education Bureau and local schools in a city of western China. A stratified cluster sampling method was employed to obtain a representative sample of kindergarten children. Initially, the city was divided into 13 districts and counties for stratification. Public kindergartens were randomly selected from each district using an official list of kindergartens. To account for differences in the total number of children across districts, proportional allocation was applied to determine the required number of participants from each district based on the proportion of children relative to the overall population. In total, 189 kindergartens were selected as recruitment sites, and all children aged 3 to 6 years, along with their parents, were invited to participate. The recruitment period spanned from February 28 to March 5, 2025. Informed consent was obtained from parents or guardians prior to participation. One parent per child completed the survey. A total of 25,017 parent-child dyads participated. After excluding responses with outlying values for the form filler's age (n = 517), non-parental respondents (n = 2,408), and invalid child age (n = 726), the final analysis included 21,366 participants. The intraclass correlation coefficients (ICCs) for all parenting outcomes were negligible (all < 0.002; see Supplementary Table S1), indicating minimal kindergarten-level clustering. To assess the robustness of our findings to missing data, we performed multiple imputation using the MICE algorithm with five imputations. The results were virtually identical to those obtained from the complete-case analysis (Supplementary Table S2), indicating that missing data did not bias our conclusions.

2.2 Exposure

Parental depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale (CES-D) [18, 19, 20]. This 20-item instrument measures the frequency of depressive symptoms experienced during the preceding seven days on a 4-point scale ranging from 0 (rarely/never) to 3 (frequently/always). Total scores range from 0 to 60, with higher scores indicating greater depressive symptom severity. Based on the validated clinical cut-off of 16, participants were categorized as depressed (score ≥ 16) or non-depressed (score < 16) [21, 22]. The scale demonstrated good internal consistency in this sample (Cronbach's α = 0.849). Throughout the manuscript, the continuous score is referred to as parental depression score (CES-D score), and the binary variable as depression status.

2.3 Outcome

Parenting discipline was measured using the Arnold-O'Leary Parenting Scale [9], a 30-item questionnaire assessing dysfunctional parental discipline for children aged 2 to 16 years. Each item is rated on a 7-point Likert scale, where a score of 7 reflects a higher likelihood of discipline errors and a score of 1 indicates effective discipline strategies. For each participant, we calculated the mean score across all items to obtain an overall Parenting score, and the mean scores for the three subscales: Laxness, Overreactivity, and Verbosity. Higher mean scores indicate more dysfunctional parenting in the respective dimension. The scale has been validated for use with parents of preschool-aged children and shows good internal consistency [23, 24]. In the present sample, the Parenting Scale demonstrated satisfactory internal consistency (Cronbach's α = 0.962).

2.4 Covariates

In order to address possible confounding variables, the following covariates were gathered: parental gender (male/female), parental age (continuous or categorical: < 40, ≥ 40 years), child age (continuous or categorical: < 4, ≥ 4 to < 5, ≥ 5 years), child gender (boys/girls), education level (≤ junior high school, high school diploma/junior college, ≥ undergraduate degree), occupation (working/not working), marital status (married/living with partner vs. others), and annual family income (< 30,000 ¥, 30,000–100,000 ¥, ≥ 100,000 ¥). All categorical variables were treated as factors in the analyses.

2.5 Statistical analysis

All statistical analyses were performed using R software (version 4.4.2). Continuous variables were summarized as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Group comparisons between depressed and non-depressed participants were conducted using t-tests for continuous variables and chi-square tests for categorical variables.

Multivariable linear regression was employed to examine the associations of CES-D score (continuous) and depression status (binary) with each parenting discipline (Parenting score, Laxness, Overreactivity, Verbosity). For each exposure, both unadjusted and adjusted models were fitted; adjusted models included all covariates listed above. Results are presented as unstandardized coefficients (β) with 95% confidence interval (CI), representing the change in the mean score of the parenting dimension per one-unit increase in CES-D score (for continuous exposure) or the mean difference of parenting dimension between depressed and non-depressed parents (for binary exposure). For depression status, a global Wald test was performed to assess its overall significance. Multicollinearity was assessed using generalized variance inflation factors (GVIF); values of GVIF^(1/(2×Df)) < 2 were considered indicative of no serious collinearity, with detailed results provided in Supplementary Table S3.

To explore potential non-linear dose–response relationships between CES-D score and each parenting outcome, RCS analysis was employed. Models were fitted with 3, 4, and 5 knots placed at the recommended percentiles based on Harrell's default settings in the rms package: for 3 knots, at the 10th, 50th, and 90th percentiles; for 4 knots, at the 5th, 35th, 65th, and 95th percentiles; for 5 knots, at the 5th, 27.5th, 50th, 72.5th, and 95th percentiles. The optimal number of knots for each outcome was selected by minimizing the Akaike information criterion (AIC) and Bayesian information criterion (BIC), as detailed in

Supplementary Table S4. Non-linearity was tested using a likelihood ratio test comparing the linear model with the RCS model. Threshold identification was based on derivative analysis: from the fitted RCS function, the first derivative (slope) and second derivative (curvature) were computed via numerical differentiation using the numDeriv package. The threshold was defined as the CES-D score where the slope declined to 50% of its initial value, and the point of maximum curvature was defined as the score at which the absolute value of the second derivative peaked. To quantify uncertainty, bootstrap resampling with 1000 replications was performed, and the 2.5th and 97.5th percentiles of the bootstrap distribution were taken as the 95% CI (percentile method). Results are summarized in Table 4 and illustrated in Fig. 1, which combines the RCS curve with its first and second derivatives. Sensitivity analyses were conducted by re-fitting RCS models with different knot numbers and overlaying the resulting curves to visually assess robustness (Supplementary Fig. S1–S4).

Table 4
Non-linearity tests and thresholds (with 95% bootstrap CI) from selected RCS models.

Outcome	Knots	p-nonlinear	Threshold[1]	95% CI[2]	Max curvature point[3]	95% CI[2]
Parenting score	4	< 0.0001	16.04	14.61–17.19	12.03	12.03–12.03
Overreactivity	4	< 0.0001	16.90	15.75–18.04	12.03	12.03–12.03
Laxness	3	< 0.0001	11.46	11.13–12.32	10.88	10.88–12.03
Verbosity	3	< 0.0001	11.46	10.88–12.60	10.88	10.88–12.03
[1] Threshold defined as the depression score value where the slope declined to 50% of its initial value.						
[2] 95% confidence interval based on 1000 bootstrap replications (percentile method).						
[3] Point of maximum curvature defined as the depression score with the largest absolute second derivative.						

Stratified analyses were performed to examine whether the association between depression status and parenting outcomes varied across population subgroups. Within each stratum, linear regression models were fitted adjusting for all covariates except the stratification variable itself. Effect modification was formally tested by including a product term (depression status × stratification variable) in the full model and performing a likelihood ratio test. Interaction P-values are reported in Table 5. To account for multiple testing across the eight stratification variables, a Bonferroni correction was applied. The family-wise error rate was controlled at $\alpha = 0.05$, resulting in a corrected significance threshold of $P < 0.00625$ (0.05/8) for interaction tests.

Table 5
Stratified analyses of the association between parental depression status and parenting discipline

Characteristics	Parenting score		P interaction	Laxness		P interaction	Overreactivity		P interaction	Verbosit
	Non-depressed	Depressed		Non-depressed	Depressed		Non-depressed	Depressed		Non-depress
		β (95% CI)			β (95% CI)			β (95% CI)		
Child age			0.8437			0.4488			0.5096	
<4	Ref.	0.172 (0.134, 0.210)*		Ref.	0.087 (0.016, 0.158)*		Ref.	0.511 (0.420, 0.602)*		Ref.
≥4 to 5	Ref.	0.186 (0.157, 0.216)*		Ref.	0.100 (0.047, 0.153)*		Ref.	0.545 (0.473, 0.617)*		Ref.
≥5	Ref.	0.190 (0.167, 0.212)*		Ref.	0.137 (0.095, 0.179)*		Ref.	0.493 (0.438, 0.548)*		Ref.
Child gender			0.9134			0.4219			0.5367	
Boys	Ref.	0.186 (0.164, 0.208)*		Ref.	0.127 (0.085, 0.168)*		Ref.	0.504 (0.449, 0.558)*		Ref.
Girls	Ref.	0.183 (0.160, 0.207)*		Ref.	0.102 (0.059, 0.145)*		Ref.	0.523 (0.466, 0.579)*		Ref.
Parental age			0.6020			0.5853			0.5222	
<40	Ref.	0.187 (0.170, 0.204)*		Ref.	0.118 (0.086, 0.150)*		Ref.	0.519 (0.477, 0.561)*		Ref.
≥40	Ref.	0.171 (0.127, 0.216)*		Ref.	0.087 (0.006, 0.167)*		Ref.	0.481 (0.371, 0.591)*		Ref.
Parent gender			0.2703			0.9247			0.6582	
Male	Ref.	0.167 (0.135, 0.199)*		Ref.	0.122 (0.063, 0.181)*		Ref.	0.485 (0.402, 0.568)*		Ref.
Female	Ref.	0.189 (0.171, 0.208)*		Ref.	0.112 (0.078, 0.147)*		Ref.	0.520 (0.475, 0.564)*		Ref.
Education level			0.3184			0.7573			0.0432	
≤Junior high	Ref.	0.167 (0.140, 0.195)*		Ref.	0.115 (0.061, 0.168)*		Ref.	0.462 (0.393, 0.531)*		Ref.
High school/Junior college	Ref.	0.191 (0.166, 0.216)*		Ref.	0.126 (0.080, 0.172)*		Ref.	0.501 (0.440, 0.563)*		Ref.
≥Undergraduate	Ref.	0.196 (0.162, 0.229)*		Ref.	0.091 (0.034, 0.149)*		Ref.	0.602 (0.525, 0.679)*		Ref.
Occupation			0.5188			0.6432			0.5724	
Not working	Ref.	0.193 (0.165, 0.222)*		Ref.	0.128 (0.075, 0.182)*		Ref.	0.495 (0.427, 0.562)*		Ref.
Working	Ref.	0.180 (0.160, 0.200)*		Ref.	0.109 (0.073, 0.144)*		Ref.	0.519 (0.471, 0.567)*		Ref.
Marital status			0.3894			0.9996			0.5760	

Data are presented as β(95% CI) for the association between depression status and each parenting outcome, derived from linear regression models adjuste stratification variable itself. P interaction values are from likelihood ratio tests comparing models with and without the product term between depression sta variable.

* denotes significant correlations (P < 0.05).

Characteristics	Parenting score		P interaction	Laxness		P interaction	Overreactivity		P interaction	Verbosit
	Non-depressed	Depressed		Non-depressed	Depressed		Non-depressed	Depressed		Non-depress
		β (95% CI)			β (95% CI)			β (95% CI)		
Married/Partner	Ref.	0.186 (0.169, 0.202)*		Ref.	0.114 (0.084, 0.144)*		Ref.	0.515 (0.475, 0.555)*		Ref.
Others	Ref.	0.155 (0.075, 0.236)*		Ref.	0.136 (-0.013, 0.285)		Ref.	0.439 (0.231, 0.647)*		Ref.
Household income (¥)			0.0122			0.7712			0.0035	
<30,000	Ref.	0.174 (0.151, 0.197)*		Ref.	0.115 (0.072, 0.159)*		Ref.	0.456 (0.399, 0.513)*		Ref.
30,000–100,000	Ref.	0.180 (0.154, 0.206)*		Ref.	0.107 (0.060, 0.154)*		Ref.	0.539 (0.477, 0.602)*		Ref.
≥100,000	Ref.	0.242 (0.195, 0.288)*		Ref.	0.136 (0.053, 0.218)*		Ref.	0.651 (0.542, 0.761)*		Ref.

Data are presented as β(95% CI) for the association between depression status and each parenting outcome, derived from linear regression models adjuste stratification variable itself. P interaction values are from likelihood ratio tests comparing models with and without the product term between depression sta variable.

* denotes significant correlations (P < 0.05).

All statistical tests were two-sided, and P < 0.05 was considered statistically significant.

3 Results

3.1 Participant characteristics

Of the 21,366 participants, 3,372 (15.8%) were classified as depressed (CES-D score ≥ 16). Compared with non-depressed parents, depressed parents had significantly higher mean scores on Parenting score, Laxness, and Overreactivity, and lower mean scores on Verbosity (all P < 0.001). They were also older, had lower education levels, were more likely to be unemployed, had lower household income, and were less likely to be married. No significant differences were observed in parental or child gender. Detailed baseline characteristics are presented in Table 1.

Table 1
Baseline characteristics by parental depression status

Characteristics	All(n = 21366)	Non-depressed (n = 17994)	Depressed (n = 3372)	P-value
Child age (years)	4.82 ± 0.89	4.80 ± 0.89	4.90 ± 0.87	< 0.001
Child gender				0.483
Boys	11062 (51.8)	9297 (51.7)	1765 (52.3)	
Girls	10304 (48.2)	8697 (48.3)	1607 (47.7)	
Parent age (years)	34.75 ± 4.56	34.71 ± 4.54	34.95 ± 4.70	0.008
Parent gender				0.437
Male	5108 (23.9)	4320 (24.0)	788 (23.4)	
Female	16258 (76.1)	13674 (76.0)	2584 (76.6)	
Education level				< 0.001
≤ Junior high school	5741 (26.9)	4555 (25.3)	1186 (35.2)	
High school diploma and junior college	9476 (44.4)	8092 (45.0)	1384 (41.0)	
≥Undergraduate degree	6149 (28.8)	5347 (29.7)	802 (23.8)	
Occupation				< 0.001
Not working	5724 (26.8)	4531 (25.2)	1193 (35.4)	
Working	15642 (73.2)	13463 (74.8)	2179 (64.6)	
Marital status				< 0.001
Married/Living with partner	20761 (97.2)	17546 (97.5)	3215 (95.3)	
Others	605 (2.8)	448 (2.5)	157 (4.7)	
Annual family income, in thousands, ¥				< 0.001
< 30	8619 (40.3)	6925 (38.5)	1694 (50.2)	
30–100	8619 (40.3)	7349 (40.8)	1270 (37.7)	
≥ 100	4128 (19.3)	3720 (20.7)	408 (12.1)	
Parenting score	3.75 ± 0.44	3.72 ± 0.45	3.92 ± 0.36	< 0.001
Laxness	3.94 ± 0.80	3.92 ± 0.82	4.04 ± 0.71	< 0.001
Overreactivity	2.90 ± 1.08	2.82 ± 1.09	3.36 ± 0.91	< 0.001
Verbosity	4.56 ± 0.86	4.56 ± 0.87	4.51 ± 0.79	< 0.001

Continuous variables are expressed as means ± standard deviations and categorical data using number (percentage). Continuous variables were compared by t-test, categorical variables by χ^2 test.

3.2 Linear associations

Multivariable linear regression revealed that CES-D score was positively associated with the mean scores of Parenting score (β = 0.016, 95% CI: 0.015–0.017), Laxness (β = 0.012, 95% CI: 0.010–0.013), and Overreactivity (β = 0.043, 95% CI: 0.041–0.045), and negatively associated with the mean score of Verbosity (β = − 0.009, 95% CI: − 0.010 to − 0.007) after full adjustment (all P < 0.001; Table 2). Similarly, depression status was independently associated with all four outcomes: depressed parents exhibited higher mean Parenting score (β = 0.185, 95% CI: 0.168–0.201), Laxness (β = 0.115, 95% CI: 0.085–0.144), and Overreactivity (β = 0.512, 95% CI: 0.473–0.552), and lower mean Verbosity (β = − 0.068, 95% CI: − 0.100 to − 0.037) compared with non-depressed parents (all global P < 0.001; Table 3). Multicollinearity diagnostics confirmed the absence of problematic collinearity, with all GVIF^(1/(2×Df)) values below 2 (range: 1.00–1.51; Supplementary Table S3).

Table 2
Association of parental depression score with parenting discipline

Outcome	Non-adjusted model	Adjust model
Parenting score	0.016 (0.015, 0.017) < 0.0001	0.016 (0.015, 0.017) < 0.0001
Laxness	0.012 (0.011, 0.014) < 0.0001	0.012 (0.010, 0.013) < 0.0001
Overreactivity	0.043 (0.041, 0.046) < 0.0001	0.043 (0.041, 0.045) < 0.0001
Verbosity	-0.007 (-0.009, -0.005) < 0.0001	-0.009 (-0.010, -0.007) < 0.0001
Data are represented as β(95% CI) P value.		
Non-adjusted model adjust for: None		
Adjust model adjust for: parental gender; parental age; child gender; child age; education level; marital status; employment status and annual family income;		

Table 3
Associations of parental depression status with parenting discipline

Outcome	Depression status	Non-adjusted model	Global P (non-adjusted, Wald)	Adjust model	Global P (adjusted, Wald)
Parenting score	Non-depressed	Ref.	< 0.001	Ref.	< 0.001
	Depressed	0.194 (0.178, 0.21) < 0.001		0.185 (0.168, 0.201) < 0.001	
Laxness	Non-depressed	Ref.	< 0.001	Ref.	< 0.001
	Depressed	0.117(0.088,0.147) < 0.001		0.115 (0.085, 0.144) < 0.001	
Overreactivity	Non-depressed	Ref.	< 0.001	Ref.	< 0.001
	Depressed	0.536(0.497,0.576) < 0.001		0.512 (0.473, 0.552) < 0.001	
Verbosity	Non-depressed	Ref.	< 0.001	Ref.	< 0.001
	Depressed	-0.058(-0.09, -0.027) < 0.001		-0.068 (-0.1, -0.037) < 0.001	
Data are represented as β(95% CI) P value.					
Non-adjusted model adjust for: None					
Adjust model adjust for: parental gender; parental age; child gender; child age; education level; marital status; employment status and annual family income;					
Global P from Wald test for the binary depression variable.					

3.3 Non-linear dose–response relationships

AIC and BIC comparisons indicated that a 4-knot RCS model was optimal for Parenting score and Overreactivity, while a 3-knot model was preferred for Laxness and Verbosity (Supplementary Table S4). Likelihood ratio tests confirmed significant non-linearity for all outcomes (all P < 0.0001). Figure 1 displays the adjusted RCS curves along with their first and second derivatives. As shown in Fig. 1A, Parenting score increased progressively with CES-D score, with a threshold of 16.04 (95% CI: 14.61–17.19) and a point of maximum curvature at 12.03 (95% CI: 12.03–12.03). Overreactivity also exhibited a non-linear increase (Fig. 1B), with a threshold at 16.90 (95% CI: 15.75–18.04) and maximum curvature at 12.03 (95% CI: 12.03–12.03). Laxness increased steeply at lower depression scores and then plateaued (Fig. 1C); the threshold was 11.46 (95% CI: 11.13–12.32) and the point of maximum curvature was 10.88 (95% CI: 10.88–12.03). In contrast, Verbosity decreased monotonically with increasing depression score (Fig. 1D); the absolute slope declined after a threshold of 11.46 (95% CI: 10.88–12.60), indicating a deceleration of the decline, with maximum curvature at 10.88 (95% CI: 10.88–12.03). These thresholds and curvature points are summarized in Table 4. Sensitivity analyses overlaying 3-knot and 4-knot curves demonstrated substantial overlap for all outcomes (Supplementary Fig. S1–S4), confirming the robustness of the non-linear patterns to knot specification.

3.4 Stratified analyses

Table 5 presents the stratified analyses examining the association between depression status and each parenting outcome across various demographic and socioeconomic subgroups. The association remained consistent in direction across most strata, with depressed parents generally showing higher mean scores on Parenting score, Laxness, and Overreactivity, and lower mean scores on Verbosity. After applying Bonferroni correction for multiple testing (adjusted significance threshold P < 0.00625), only household income remained a significant effect modifier: the positive association between depression and Overreactivity was strongest in the highest income group (≥ 100,000 ¥; β = 0.651, 95% CI: 0.542–0.761; interaction P = 0.0035). No other significant interactions were observed after correction. All stratum-specific estimates and interaction P-values are detailed in Table 5.

4 Discussion

This large cross-sectional study of 21,366 parent-child dyads from western China examined associations between parental depressive symptoms and three dimensions of dysfunctional discipline: laxness, overreactivity, and verbosity. Parental depressive symptom was positively associated with overreactivity and laxness, but negatively associated with verbosity. RCS analyses identified non-linear dose-response relationships with specific threshold effects, providing novel insights into the levels at which parenting behaviors begin to change markedly.

Consistent with previous research, positive associations were observed between depressive symptoms and both overreactivity and laxness. Parental overreactive parenting mediates the association between depressive symptoms and child externalizing problems [25], and accounts for over one-third of the relationship between parental depression and child prosocial behavior in the same western China population[12]. Emotion dysregulation demonstrates significant associations with both overreactivity and laxness among trauma-exposed parents [26]. Both over-reactive and permissive parenting styles modify relationships between parental depressive symptoms and toddler outcomes [27]. Longitudinal evidence indicates bidirectional relations, with greater parental overreactive parenting predicting more child ADHD symptoms [28]. Heterogeneous profiles of parental depressive symptoms reveal that those characterized by high depressed affect and physical symptoms demonstrate the greatest risk for harsh parenting [17]. Collectively, these findings underscore the robust and multifaceted nature of the association between parental depressive symptoms and maladaptive parenting behaviors across diverse populations.

The negative association between depressive symptoms and verbosity represents a novel contribution. Significant differences in verbosity have been documented between depressed and non-depressed parents [29], and improvements in verbosity following online parenting programs have been reported [30]. This negative association may reflect psychomotor retardation characteristic of depression, or alternatively, depressed parents may disengage from ineffective verbal reasoning strategies [30]. This finding highlights that not all parenting dimensions are uniformly affected by depressive symptoms, suggesting differential mechanisms underlying various parenting behaviors.

A major contribution of this study is the identification of non-linear relationships with specific thresholds derived from derivative analysis. For overreactivity, the slope of the curve declined to 50% of its initial value at a CES-D score of 16.90, closely approximating the clinical cutoff of 16, indicating that parenting becomes markedly more overreactive once symptoms reach this level. The point of maximum curvature at 12.03 represents the most rapid acceleration in overreactive parenting, suggesting this could be a sensitive period for early intervention. For laxness, the threshold was notably lower at 11.46, indicating that permissive parenting is particularly sensitive to even mild depressive symptoms, with the steepest increase occurring at 10.88. For verbosity, the decline decelerated after 11.46 (the same threshold as laxness), suggesting diminishing additional impact on verbal parenting beyond this point, which indicated that both laxness and verbosity were sensitive to mild depressive symptoms. The overall parenting score showed a threshold at 16.04 with maximum curvature at 12.03, consistent with the pattern observed for overreactivity. These threshold effects highlight the potential value of moving beyond linear assumptions [14, 31] and may explain inconsistencies in previous research that treated parenting as a global construct [32]. Importantly, these distinct threshold patterns suggest that different parenting dimensions may require tailored intervention strategies based on the severity of parental depressive symptoms.

Moderation analyses revealed that household income significantly influenced the depression-overreactivity association, with strongest effects in the highest income group. Depression in higher-income parents may be particularly impactful on parenting due to expectations of competence and reduced social support [33]. Fathers' cognitive empathy can buffer effects of maternal parenting stress [34], while parental physiological reactivity moderates associations between parent and youth psychopathology [35]. Three parenting profiles have been identified, with negative parenting associated with adolescent depression and anxiety [36]. These moderation findings highlight the importance of considering socioeconomic and family contextual factors when developing targeted interventions.

These findings contribute to understanding intergenerational transmission of psychopathology risk, as parental depressive symptoms and parenting behaviors are key mechanisms linking parent and child mental health. Parenting behavior is central to the transmission of intergenerational trauma-related risk [37], and early exposure to family adversity affects children's mental health through parental psychological functioning [38]. Systematic reviews have further highlighted that parenting practices in childhood are associated with risk of depression and anxiety in adolescence, underscoring the importance of examining specific parenting dimensions [14]. By identifying precise symptom thresholds, this study suggests potential thresholds for further investigation to disrupt these intergenerational pathways.

These findings may have potential clinical implications. Parenting behaviors change at CES-D scores below traditional clinical cutoffs, supporting early identification and intervention for parents with even mild depressive symptoms. Parenting interventions that include emotion regulation components may be particularly beneficial [26]. Online parenting programs demonstrate sustained improvements in over-reactivity, verbosity, and depression [30], with similar effects found for parents of adolescents with autism [39]. Online mindful parenting training improves over-reactive parenting, depression, and anxiety [40]. Harsh parenting and parental depression have been linked to poorer executive function in early childhood [41]. Collectively, these findings suggest that interventions targeting both depressive symptoms and specific parenting behaviors, particularly at or above the identified thresholds, hold promise for preventing adverse developmental outcomes.

4.1 Limitations

Several caveats warrant consideration when interpreting our findings. First, the observational nature of the cross-sectional design means that causal directions cannot be determined. Prospective longitudinal follow-ups are needed to establish temporal precedence between parental depressive symptoms and changes in specific parenting dimensions. Second, all data were gathered via parent-completed questionnaires, raising the possibility of common method variance and self-report biases, including tendencies toward socially desirable responding that may differ across cultural groups. Such biases could either inflate or attenuate the observed associations. Third, recruitment was confined to one metropolitan area in western China, so the extent to which our threshold estimates generalize to other regions or sociocultural settings remains unknown. Fourth, while we controlled for several demographic and family-level confounders, we could not account for all potentially relevant factors, such as the quality of neighborhood environments, the availability of social

support, or children's temperamental characteristics. Furthermore, the lack of observational coding of parent-child interactions or collateral reports (e.g., from teachers or clinicians) may limit the completeness of our parenting assessment. Future investigations should test whether the same threshold values emerge in different populations and whether family-based interventions targeting parents with CES-D scores exceeding 11 (for laxness) or 16 (for overreactivity) can effectively reduce parenting dysfunction and interrupt the intergenerational transmission of risk. Overcoming these methodological constraints is essential before our threshold findings can be translated into routine clinical and public health practice.

5 Conclusions

This large community-based study of 21,366 parent-child dyads from western China identified non-linear dose-response relationships between parental depressive symptoms and three distinct dimensions of dysfunctional discipline. Parental depressive symptoms were positively associated with overreactivity and laxness but negatively associated with verbosity. Critically, RCS analyses revealed specific thresholds: overreactive parenting became markedly more dysfunctional as symptoms approached the clinical CES-D cutoff of 16 (threshold: 16.90), while laxness and verbosity showed sensitivity to even milder symptoms (threshold: 11.46). Household income significantly moderated the association between depression and overreactivity, with strongest effects in the highest income group. These findings move beyond global parenting constructs and linear assumptions, offering potential thresholds that may guide early identification and intervention. Parenting behaviors change at CES-D scores below traditional clinical cutoffs, supporting targeted screening and prevention efforts to disrupt intergenerational transmission of psychopathology risk.

Declarations

Ethics statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the Affiliated Children's Hospital of Xi'an Jiaotong University (Approval NO.20250225-21). Informed consent in the study was obtained from parent or legal guardian.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Consent for publication

Not applicable.

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Author Contribution

Hongli Sun: Original draft, Visualization, Conceptualization. Jiahua Liu: Writing –Methodology, Formal analysis, Conceptualization. Xiangdi Yang: Methodology, Conceptualization, Data curation. Yuan Li: Methodology, Conceptualization, Data curation. Jie Mi: Supervision, Methodology, Data curation, Conceptualization and Review.

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Data Availability

This data set is still being used for analysis. Please contact the corresponding author regarding access to the full dataset.

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Figures

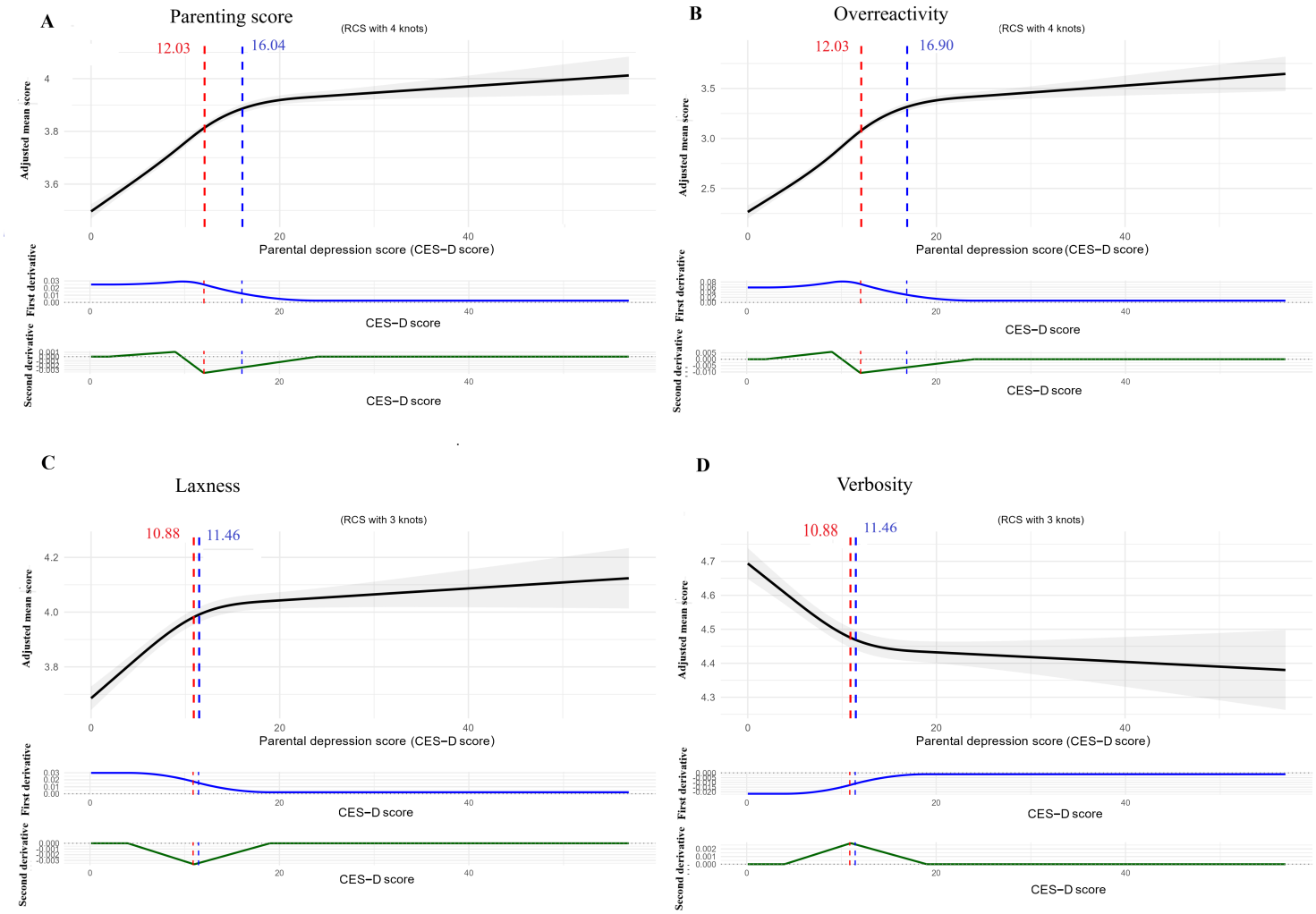


Figure 1

Non-linear dose-response relationships between parental depressive score and parenting discipline. Restricted cubic spline (RCS) curves with 95% confidence intervals (shaded areas) showing the adjusted associations between parental depressive score(CES-D score) and parenting discipline, along with first derivative (slope) and second derivative (curvature) plots. Thresholds (vertical blue dashed lines) were defined as the depression score where the slope declined to 50% of its initial value. Points of maximum curvature (vertical red dashed lines) represent scores with the largest absolute second derivative. (A) Overall Parenting score (4-knot RCS model). (B) Overreactivity (4-knot RCS model). (C) Laxness (3-knot RCS model). (D) Verbosity (3-knot RCS model). Models were adjusted for parental gender, parental age, child gender, child age, education level, marital status, employment status, and annual family income.

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