RESEARCH

Maternal depression and early childhood development among children aged 24–59 months: the mediating effect of responsive caregiving

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Abstract

This study examined whether maternal depression is related to Early Childhood Developmental (ECD) delay among children by quantifying the mediating contribution of responsive caregiving. We used data from 1235 children (Children's mean age = 50.4 months; 582 girls, 653 boys, 93.9% were Han), selected through convenience sampling, in 2021. 4.7% of children had ECD delay, 34.3% of mothers had depression. Children with depressed mothers were less likely to receive responsive caregiving (OR 4.35, 95% CI 2.60–7.27), and those who did not receive responsive caregiving were more likely to experience ECD delay (OR 3.89, 95% CI 1.89–8.02). Responsive caregiving partly mediated the relationship between maternal depression and ECD. Early intervention for children with depressed mothers is worthy of further investigation.

Keywords Early childhood development, Maternal depression, Responsive caregiving, Positive discipline

Introduction

Early Childhood Development (ECD) is fundamental to the success and happiness of an individual throughout their lifetime. Ensuring every child has the right to

achieve their full developmental potential is central to the United Nations' Sustainable Development Goals (SDGs) for 2030 [30]. Poor ECD can have both short- and long-term negative consequences, including lower cognitive functioning, increased likelihood of dropping out of school, lower economic productivity, and poor health outcomes [42]. In low- and middle-income countries (LMICs), an estimated 249 million children under five are at risk of not attaining their full potential [5]. In China, the world's largest middle-income country, 17% of children under five did not reach their potential development [45].

Under the ECD conceptual framework by the United Nations International Children's Emergency Fund (UNICEF), mothers and other caregivers play a critical role in their offspring's early development, as they are the architects of the environment in which children acquire skills and abilities [42]. Unfortunately, mothers are commonly affected by depression [11, 22]; the 2019 Global

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Burden of Disease Study listed depression as one of the top three causes of disability among females [1]. A meta-analysis of 94 studies found a high prevalence of maternal depression in LMICs, ranging from 19 to 25% [13]. In China, a cross-sectional survey conducted among 2837 children aged 1–35 months reported that 39.8% of the mothers suffered from depression [52]. Maternal depression not only affects the mother's quality of life [25], causing substantial lifetime costs [3], but also increases the risk of passing developmental problems to the next generation [17].

Studies from high-income countries (HICs) have found an association between maternal depression and an increased likelihood of ECD delay, the effects of which may persist into adolescence [15, 36]. The Avon Longitudinal Study of Parents and Children, a community-based study, found that maternal depression may predict childhood emotional and behavioural problems [23]. While studies on the relationship between maternal depression and child development in developing countries are limited, some have also reported consistent associations between maternal depression and ECD. A longitudinal birth cohort study in South Africa found that maternal depression was associated with offspring behavioural problems in mid to late childhood [2]. Similarly, in China, several studies have examined rural children aged 3 years or younger and found that children of depressed mothers were more likely to have developmental delays in domains such as communication, motor skills, problem solving, and socioemotional development [51, 52].

Although empirical research has investigated the association between maternal depression and the health and cognitive outcomes of next-generation offspring, the mechanisms underlying this association remain poorly understood, thus limiting the development of targeted interventions. A systematic review in this area from both HICs (2009–2013) and LMICs (2000–2013) suggests that while the links between maternal depression and ECD are complex, responsive parenting is a key modifiable pathway between the two [36]. Responsive caregiving is defined as the ability of a parent or caregiver to notice, understand, and respond in a timely and appropriate manner when their child sends signals [10, 53] and is operationalized as an indicator related to family skills and child care in the home environment. A cohort study of pregnant Chinese women reported that responsive caregiving positively affected infant development, with responsive caregiving evaluated on 6 items: a warm environment, keeping the baby's skin clean and dry, observing the baby's eyes and navel, feeding on demand and smiling when feeding, touching and hugging the baby, and communicating and playing with the baby [48]. A cluster-randomised trial conducted in Pakistan found

that a responsive stimulation intervention positively affects developmental outcomes [54]. Moreover, two birth cohort studies from Brazil and South Africa found that responsive caregiving was associated with increased adolescent human capital in cognition, psychosocial adjustment, and height [39]. Yet, the 2020 ECD country profiles developed by UNICEF and Countdown to 2030, which cover 99.8% of the world's children under age five, reveal that fewer than half of young children in a third of the world's countries receive responsive caregiving [33]. Although previous evidence has demonstrated that promoting responsive care can improve child development, research on its mediating effect on the relationship between maternal depression and ECD is scant.

The few existing studies on responsive caregiving are limited by inconsistent design, small sample size, or a narrow focus on specific populations in different settings. Evaluation of the mediating effect of responsive caregiving on maternal depression and ECD is critical for policymakers, development organisations, and other stakeholders seeking to develop and implement effective programmes and policies. Therefore, this study explores the association between maternal depression and ECD and quantifies the link between responsive caregiving and maternal depression in the Chinese population.

Methods
Study design and participants
This cross-sectional survey was conducted in kindergartens in the Yanqing District, Beijing. In cooperation with the Yanqing District Mother and Child Health Care Hospital, a self-administered anonymous questionnaire survey was conducted among the caregivers of young children who provided their informed consent. The inclusion criteria were: (1) the caregiver was the child's father or mother, and (2) the child was younger than 6 years old. Before the survey was conducted, the study researchers provided professional training for the staff involved in the project and introduced the purpose and significance of the study and the importance of data confidentiality. The questionnaire was filled in after obtaining the informed consent of the respondents.

A total of 2542 caregivers were recruited in February 2021, of whom 2005 (82.0%) were mothers, 425 (17.0%) were fathers, 12 (0.5%) were grandparents, and 7 (0.3%) were listed as 'other'. Detailed information on children's ECD, caregivers' depression status, responsive care, demographics, socioeconomic status, and other household characteristics were also collected. The applicability of the questionnaire was evaluated according to the reliability and validity tests. Construct validity was larger than 0.4, and criterion-related validity was 0.475. Internal consistency reliability (Cronbach's α was 0.670), split-half

reliability (Spearman-Brown coefficient was 0.711, Guttman Split-Half coefficient was 0.674), and retest reliability (0.716) were also tested.

Based on the exclusion criteria, participants were excluded if they: (1) refused to participate in the study (n = 93), (2) were caregivers who were not mothers (n = 444), (3) had children aged outside the range of 24–59 months (n = 741), or (4) had missing basic information (n = 29). Consequently, 1,307 participants were excluded, leaving 1,235 participants included in the analysis (Supplementary Fig. 1).

Measures
Early childhood development
The ECDI2030 is a population-level data collection instrument designed to evaluate the proportion of children aged 24–59 months who are developmentally 'on track' in health, learning, and psychosocial well-being [6]. To measure the child's overall development status, mothers were asked 20 questions about their child's behaviour, skills, and acquired knowledge [12]. Each response received a numerical score, with the total possible score ranging from 0 to 20. The ECDI2030 has been tested using both quantitative and qualitative approaches, including validity and reliability testing and cognitive testing for instrument validation [6, 31]. The value of Cronbach's alpha for all 20 items in this research sample was 0.726. As defined by UNICEF, the ECDI2030 is classified as a dichotomous variable (0 = ECD normal, 1 = ECD delay) based on age group and total score. For children to be considered to have a 'normal' ECD, those aged 24–29 months must reach a score of seven, those aged 30–35 months must reach a score of nine, those aged 36–41 months must reach a score of 11, those aged 42–47 months must reach a score of 13, and those aged 48–59 months must reach a score of 15.

Maternal depression
Maternal depression was evaluated using the Self-Rating Depression Scale (SDS), a reliable and valid measure for depressive symptoms. Developed by Chinese professor William Zung in 1965, SDS has been widely used in several global contexts [60]. The SDS is a 20-item Likert scale that assesses both affective and somatic symptoms [9]. Mothers reported how they felt about 20 symptom items over the past week, with each item scoring between 1 to 4 points. 10 of these items were positive statements (almost never = 4, sometimes = 3, often = 2, always = 1), while the other 10 were reverse statements (almost never = 1, sometimes = 2, often = 3, always = 4). Total scores ranged from 20 to 80. A SDS score of 50 is recommend as the cut-off point for clinical significance. A score of 50 and above was considered an indication of

maternal depression [8]. The Chinese version of the SDS in this study reported good internal consistency (Cronbach's alpha = 0.852), and use of the SDS for the evaluation of depression has been validated in previous studies. In 2013, a study conducted in China assessed the reliability and validity of the SDS among 501 women aged 20–74, finding that the scale could effectively evaluate maternal depression in the Chinese culture (Cronbach's alpha = 0.784) [32]. Another study of the general Chinese population showed that the Chinese version of the SDS is a valid tool for screening depression (Cronbach's alpha = 0.796) [49].

Responsive caregiving
Mothers' responsive caregiving is a dichotomous variable (yes/no) assessed using a seven-item questionnaire [26, 53]. Based on the UNICEF's Multiple Indicator Cluster Surveys (MICS) Child Development module, mothers in this study were asked, 'In the past 3 days, have you or any household members aged 15 or over engaged in any of the following activities?' The activities included reading books/looking at picture books, telling stories, singing songs, playing outside, playing games, naming/counting/drawing things, and speaking often. According to the MICS Questionnaire for Children Under Five, engaging in four or more of these activities qualifies as responsive caregiving, whereas fewer than four does not [44]. The value of the Cronbach's alpha for all seven items in this research sample was 0.824.

Covariates
This study was adjusted for a variety of maternal and childhood characteristics. Childhood characteristics included age (in months), sex (male/female), ethnicity (Han/minority), and premature birth (yes/no). Maternal characteristics included maternal age (in years), maternal educational achievement (middle school or below/high school/college or university/master's or above), and annual household income in Chinese Yuan (CNY), < 50,000/50,000–200,000/200,000–50,000/ > 500,000). Time spent with children was evaluated by asking mothers how many hours on average per day they spent caring for their children (i.e. reading stories, reading books, drawing pictures). Additionally, positive household discipline was assessed using three items. Mothers were asked, 'In the past month, have you or your family members used any of the following methods to educate your child?' The methods were (1) took away the child's privileges, forbade something the child liked, or did not allow the child to leave the house, (2) explained why the child's behaviour was wrong, and (3) gave the child something else to do. Measurement of positive discipline was based on the Child Discipline module of

the UNICEF MICS questionnaire [40, 41], which was adapted from the Conflict Tactics Scale (CTS) [7]. The value of the Cronbach's alpha for non-violent discipline was 0.70 [37]. Positive discipline is a dichotomous variable; therefore, if the respondent answered 'yes' to at least one of the above three items, discipline was defined as positive.

Statistical analysis

Descriptive statistics were conducted to describe the participants' demographic and socioeconomic characteristics, maternal depression, ECD, and responsive caregiving. Logistic regression analysis was further conducted to explore the association between maternal depression and ECD (normal/delay). Four models were considered in this study: Model 1—univariate logistic regression; Model 2—logistic regression adjusted for child sex and age, premature birth, maternal age and educational attainment, annual household income, and ethnicity;

Model 3—Model 2 adjusted for accompanying time with child and positive discipline; and Model 4—Model 3 adjusted for responsive caregiving. Odds Ratios (ORs) and 95% Confidence Intervals (CIs) were calculated. Logistic regression analysis was also used to explore the association between maternal depression and responsive caregiving (yes/no), adjusted for all the covariates stated above.

The hypothesised mediating role of responsive caregiving (Path ab in Fig. 1) was constructed using the Nurturing Care Framework and tested using the general approach to mediation analysis developed by Imai et al. [20]. This statistical approach overcomes the limitations of linear structural equation modelling (LSEM) and can be applied to nonlinear models. Point estimates for the average causal mediation effect (ACME), average direct effect (ADE), total effect (TE), proportion of mediation (PM), and their 95% CIs were estimated using 1,000 bootstrap resamples. The estimated coefficients are linked to
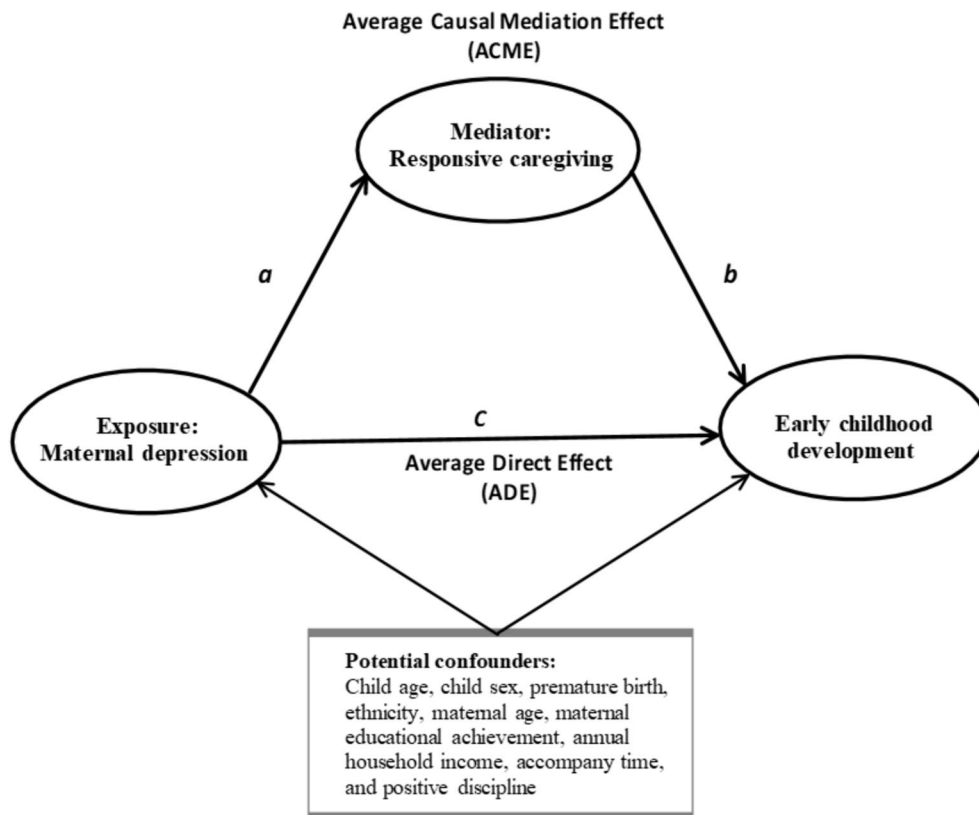

Fig. 1 Conceptual diagram of the mediating effect of responsive caregiving. a Regression coefficient *a* indicates the association between the independent variable (maternal depression) and mediator (responsive caregiving). b Regression coefficient *b* indicates the association between mediator (responsive caregiving) and the dependent variable (early childhood development) after controlling for the independent variable (maternal depression). c Regression coefficient *c* indicates the association between the independent variable (maternal depression) and the dependent variable (early childhood development) without considering the influence of mediator (responsive caregiving). *c'*: Regression coefficient *c'* indicates the association between the independent variable (maternal depression) and the dependent variable (early childhood development) when considering the influence of the mediator (responsive caregiving)

the outcome's probability scale, meaning that they can be directly reported without any transformation, such as an exponential change. All statistical analyses were performed using R 4.1.0 with the mediation package [38]. P-values < 0.05 were considered statistically significant.

Ethical approval

Ethical approval for this study was obtained, and all participants (caregivers) provided written informed consent.

Results

Overall, 1,235 children aged 24–59 months (52.9% boys and 47.1% girls; see Table 1) were analysed in this study. The average age of the children and mothers was 50 months (Interquartile range, IQR 46–54 months) and 34 years (IQR 32–38 years old), respectively. The majority of the children were of Han ethnicity (93.9%). Four out of five mothers had a college or university education (80.0%), followed by high school (12.4%), and master's or

Table 1 Prevalence of early childhood developmental delay by demographic and socioeconomic characteristics (n = 1235)

Characteristic	Total n (%)	Early childhood development		χ^2/F	P-value[2]
		Normal n (%)	Delay n (%)		
ECDI2030					
Normal	1177 (95.3)				
Delay	58 (4.7)				
Maternal depression				28.809	< 0.001
No	812 (65.7)	789 (97.2)	23 (2.8)		
Yes	423 (34.3)	388 (91.7)	35 (8.3)		
Child sex				5.041	0.025
Female	582 (47.1)	563 (96.7)	19 (3.3)		
Male	653 (52.9)	614 (94.0)	39 (6.0)		
Child age (month)[1]	50.4 (46.3, 54.2)	50.3 (46.2, 54.2)	51.4 (49.9, 53.4)	3.160	0.076
Maternal age (year)[1]	34.2 (31.8, 37.8)	34.2 (31.8, 37.7)	34.0 (31.3, 38.0)	0.570	0.450
Ethnicity				0.735	0.575
Han	1,160 (93.9)	1,104 (95.2)	56 (4.8)		
Minority	75 (6.1)	73 (97.3)	2 (2.7)		
Premature birth				0.028	1.000
No	1,165 (94.3)	67 (95.7)	3 (4.3)		
Yes	70 (5.7)	1110 (95.3)	55 (4.7)		
Maternal educational achievement				5.25	0.098
Middle school or below	43 (3.5)	39 (90.7)	4 (9.3)		
High school	153 (12.4)	142 (92.9)	11 (7.1)		
College or university	988 (80.0)	948 (96.0)	40 (4.0)		
Master or above	51 (4.1)	48 (94.1)	3 (5.9)		
Annual household income (CNY)				0.721	0.915
< 50,000	126 (10.2)	119 (94.4)	7 (5.6)		
50,000–200,000	733 (59.4)	698 (95.2)	35 (4.8)		
200,000–500,000	335 (27.1)	320 (95.5)	15 (4.5)		
> 500 000	41 (3.3)	40 (97.6)	1 (2.4)		
Positive discipline				8.766	0.003
No	32 (2.6)	27 (84.4)	5 (15.6)		
Yes	1203 (97.4)	1150 (95.6)	53 (4.4)		
Accompany time (Hours)	3.00 (2.00, 5.00)	13 (11, 16)	12 (10, 14)	1.530	0.216
Responsive caregiving				34.819	< 0.001
No	76 (6.1)	61 (81.3)	14 (18.7)		
Yes	1160 (93.9)	1116 (96.2)	44 (3.8)		

IQR: Interquartile range; CNY: Chinese Yuan

[1] Median (IQR)

[2] One-way ANOVA; Pearson's Chi-squared test or Fisher's exact test

above (4.1%), with only 3.5% having middle school education or below. Annual household income was above CNY 50,000 for around 90% of mothers (Table 1). The baseline characteristics of the participants included in this analysis were similar to those of the 1,307 individuals who were excluded based on the predefined exclusion criteria (Supplementary Table 1).

Of the 1,235 children surveyed, 4.7% had delayed ECD, and 34.3% of mothers suffered from depression. Furthermore, the proportion of ECD delay was 2.8% among

children with non-depressed mothers and 8.3% among children with depressed mothers, with statistically significant differences between groups ($\chi^2 = 28.809$, P < 0.001), as shown in Table 1. Among the children, 1,160 (93.9%) received responsive caregiving and 1,203 (97.4%) received positive discipline. The average time spent accompanying children was three hours (IQR 2–5 h).

Multivariate logistic regression analysis revealed that maternal depression was associated with ECD delays (Table 2). In the unadjusted Model 1, children with

Table 2 Association between maternal depression and early childhood development

Characteristic	Model 1		Model 2 [a]		Model 3 [b]		Model 4 [c]	
	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Maternal depression								
No	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Yes	3.09 (1.80–5.31)	< 0.001	3.33 (1.92–5.78)	< 0.001	3.09 (1.77–5.40)	< 0.001	2.57 (1.44–4.58)	0.001
Child sex								
Female			1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Male			2.10 (1.18–3.73)	0.011	2.05 (1.15–3.64)	0.014	1.94 (1.08–3.47)	0.026
Child age (month)			1.06 (1.00–1.12)	0.056	1.06 (1.00–1.12)	0.045	1.06 (1.00–1.12)	0.049
Premature birth								
No			1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Yes			0.92 (0.27–3.13)	0.893	1.00 (0.29–3.41)	0.998	0.81 (0.23–2.91)	0.751
Maternal age (year)			0.96 (0.90–1.03)	0.275	0.96 (0.90–1.03)	0.247	0.97 (0.91–1.04)	0.441
Maternal educational achievement								
Middle school or below			1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
High school			0.80 (0.23–2.84)	0.729	1.00 (0.27–3.70)	0.996	1.20 (0.30–4.78)	0.795
College or university			0.42 (0.13–1.38)	0.152	0.49 (0.14–1.67)	0.255	0.64 (0.17–2.38)	0.509
Master or above			0.80 (0.15–4.29)	0.792	0.86 (0.15–4.80)	0.865	1.18 (0.20–6.96)	0.852
Annual household income (CNY)								
< 50 000			1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
50 000–200 000			1.13 (0.45–2.83)	0.788	1.04 (0.41–2.63)	0.936	1.15 (0.44–3.05)	0.773
200 000–500 000			1.18 (0.42–3.32)	0.752	1.16 (0.41–3.29)	0.786	1.35 (0.46–4.00)	0.589
> 500 000			0.54 (0.06–4.90)	0.585	0.51 (0.06–4.67)	0.550	0.59 (0.06–5.58)	0.647
Ethnicity								
Han			1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Minority			0.50 (0.12–2.13)	0.350	0.50 (0.12–2.15)	0.355	0.55 (0.13–2.36)	0.422
Positive discipline								
No					1.00 (Ref)		1.00 (Ref)	
Yes					2.88 (0.98–8.43)	0.053	2.92 (0.97–8.76)	0.056
Accompany time (Hours)					0.94 (0.85–1.04)	0.220	0.95 (0.86–1.04)	0.258
Responsive caregiving								
No							1.00 (Ref)	
Yes							3.89 (1.89–8.02)	< 0.001

Model 1: unadjusted

[a] Model 2: adjusted for child age, child sex, premature birth, ethnicity, maternal age, maternal educational achievement, and annual household income

[b] Model 3: Model 1 plus adjustment for positive discipline and accompanying time with child

[c] Model 4: Model 2 plus adjustment for responsive caregiving

CI, confidence interval; OR, odds ratio; Ref, reference

Dependent variable: ECD (0 = normal; 1 = delay)

depressed mothers were 3.09 times more likely to have developmental delay than children with non-depressed mothers (OR 3.09, 95%CI 1.80–5.31). In Models 2 and 3, the association between maternal depression and ECD changed slightly after adjusting for positive discipline and accompanying time. However, the likelihood of ECD delay among children with depressed mothers remained 3.09 times higher than that among children with non-depressed mothers (OR 3.09, 95%CI 1.77–5.40). In Model 4, after the addition of adjusted responsive care, the likelihood of ECD delay among children with depressed mothers was 2.57 times higher than that of children with non-depressed mothers (OR 2.57, 95%CI 1.44–4.58). After adjusting for all covariates, multivariate logistic regression analysis found that children with depressed mothers were 4.35 times more likely to not receive responsive caregiving than children with non-depressed mothers (OR 4.35, 95%CI 2.60–7.27) (Supplementary Fig. 2).

Figure 2 and Table 3 show how responsive caregiving acts as a mediator (dichotomy: no = 1, yes = 0) between maternal depression and ECD. The estimated coefficients (TE, ADE, ACME, and PM) may be interpreted as showing how children with depressed mothers have increased or decreased rates of ECD delay compared with their counterparts. Overall, after adjusting for demographic and socioeconomic characteristics, accompanying time, and positive discipline, responsive caregiving was found to partially mediate maternal depression and ECD in children, accounting for 18.07% of its total effect (95%CI 5.84–48.00, P < 0.001).

As shown in Fig. 3, children with depressed mothers were 4.35 times more likely to not receive responsive caregiving than children with non-depressed mothers. Moreover, children who did not receive responsive caregiving were 3.89 times more likely to have ECD delay than those who received responsive caregiving (OR = 3.89, 95%CI 1.89–8.02). Maternal depression is, therefore, associated with an increased likelihood of non-responsive caregiving for children and, consequently, an increased likelihood of ECD delay.

Discussion
This study investigated 1235 children aged 24–59 months and their mothers in Yanqing District, Beijing. It was found that 4.7% of these children had delayed ECD, and 34.3% of their mothers had depression. A correlation between maternal depression and ECD delay was found.
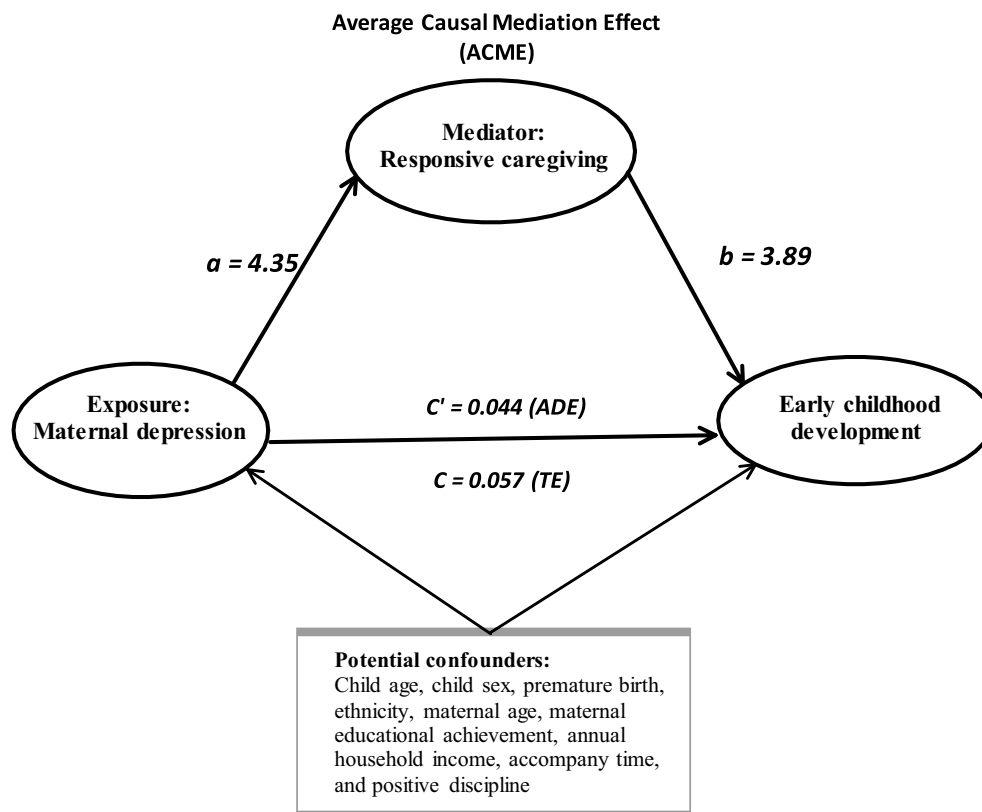

Fig. 2 Mediating effect of responsive care on maternal depression and early childhood development

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Table 3 The Mediating effect of responsive caregiving on the relationship between maternal depression and ECD

	Unadjusted model		Adjusted model [δ]	
	Coef./proportion (95%CI)	P-value	Coef./proportion (95%CI)	P-value
Total				
a*	4.50 (2.73–7.43)	< 0.001	4.35 (2.60–7.27)	< 0.001
b*	4.33 (2.20–8.52)	< 0.001	3.89 (1.89–8.02)	< 0.001
ACME	0.011 (0.004–0.020)	< 0.001	0.010 (0.004–0.020)	< 0.001
ADE	0.044 (0.018–0.070)	< 0.001	0.044 (0.017–0.080)	0.012
TE	0.056 (0.028–0.090)	< 0.001	0.057 (0.018–0.080)	< 0.001
PM(%)	19.73 (7.81–45.00)	< 0.001	18.07 (5.84–48.00)	< 0.001
Female				
a*	6.51 (2.73–15.53)	< 0.001	5.96 (2.43–14.62)	< 0.001
b*	5.18 (1.64–16.34)	0.005	8.02 (2.25–28.53)	0.001
ACME	0.011 (0.002–0.030)	0.010	0.011 (0.002–0.030)	0.008
ADE	0.041 (0.003–0.090)	0.030	0.047 (0.007–0.100)	0.022
TE	0.052 (0.015–0.100)	0.004	0.058 (0.017–0.110)	0.008
PM(%)	19.27 (2.87–75.00)	0.014	17.89 (3.06–60.00)	0.016
Male				
a*	3.69 (1.98–6.87)	< 0.001	3.56 (1.87–6.79)	< 0.001
b*	3.70 (1.59–8.57)	0.002	3.06 (1.22–7.70)	0.017
ACME	0.012 (0.003–0.030)	0.002	0.010 (0.001–0.020)	0.018
ADE	0.050 (0.009–0.100)	0.022	0.052 (0.007–0.110)	0.026
TE	0.062 (0.021–0.110)	0.004	0.061 (0.016–0.110)	0.008
PM(%)	18.47 (4.26–62.00)	0.006	14.53 (1.06–61.00)	0.026

ACME, average causal mediation effect; ADE, average direct effect; TE, total effect; PM, proportion of mediation; Coef., coefficient; CI, confidence interval

* OR, odds ratio

[δ] Model adjusted for child age, child sex, premature birth, ethnicity, maternal age, maternal educational achievement, annual household income, positive discipline, and accompanying time with child
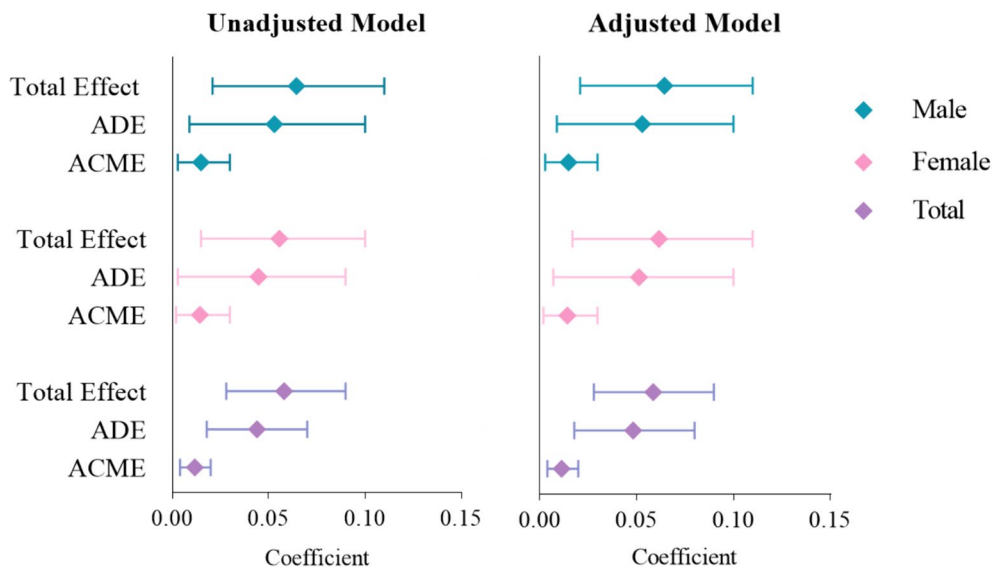

Fig. 3 The mediating effect of responsive caregiving stratified by the child's sex. ACME, average causal mediation effect; ADE, average direct effect. Adjusted model: adjusted for child age, child sex, premature birth, ethnicity, maternal age, maternal educational achievement, annual household income, positive discipline, and accompany time with child

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Maternal depression was associated with a decrease in responsive caregiving, mediating the relationship between maternal depression and ECD.

The proportion of ECD delay among the children investigated in this study was 4.7%, which, although low compared with the findings of previous studies in China, is consistent with those conducted in urban areas. While the proportion of ECD delay in China tends to range from 0.7 to 40% [52, 59], research has suggested that ECD delay is more prevalent in rural areas with lower socioeconomic status, with the proportion of children with ECD delay in urban areas often lower than that in rural areas [56]. For example, a 2012 birth cohort study investigating 491 children in Shanghai found that about 7% of children experienced emotional and behavioural problems [24], while a 2011 study investigating 3,182 children aged 6 to 18 months in Beijing found that the prevalence of developmental delay was 0.7% [59]. Additionally, this variation may also be a reflection of the challenges in global ECD monitoring, including limited cross-cultural validity, response bias, measurement errors, and ease or practicality of survey administration [6]. For example, a 2016 Colombian study of 1311 children aged 6 to 42 months examined the validity of several screening instruments and found that their effectiveness depended on child age and developmental domains [34]. The present study employed the ECDI2030, which is the latest tool developed by UNICEF and is designed to reflect the increased difficulty of skills children aged 24–59 months acquire as they age.

The ECDI2030 is also the recommended measure for SDG indicator 4.2.1 [43] and is currently being integrated into national surveys as part of the MICS programme [29]. To date, only Vietnam has collected relevant data, reporting that 22.8% of children aged 24–59 months had ECD delays [46]. Similar to the findings of the present study, children living in Vietnam's poorest households had a higher ECD delay (35.1%) than those living in the country's richest households (11.4%).

Nearly a third of the children evaluated in this study had mothers with depression, indicating that maternal depression is a problem in China that cannot be ignored. The prevalence of maternal depression was relatively higher than that reported in other studies conducted in China. A meta-analysis of 26 Chinese studies from 2019 revealed that the prevalence of depression among Chinese mothers was 21% [28], however, this number differed by region and population. A meta-analysis of 80 studies on maternal depression conducted worldwide reported a global prevalence of 17.2%, with a prevalence of 14.9% in developed countries and 20% in developing countries [50]. Finally, a study pooling 38,142 mothers from 23 LMICs found the prevalence of depression to be 19.6% [13]. Overall, current research suggests that around one in five women suffer from depression.

The present study was conducted in Beijing, the capital of China. The present study was conducted in Beijing, the capital of China. A 2020 study found that people in Beijing had relatively high work and life stress [55], and previous research has indicated that work stress, combined with caregiver roles, was associated with depression [19]. This may partially explain, the relatively higher rates of depression found in this study. Additionally, the prevalence of depression can vary widely depending on the depression assessment tools, which may also contribute to the discrepancy in findings between the present study and past research. In China, commonly used tools include the SDS, Depression Anxiety Stress Scale 21 (DASS-21), and Edinburgh Postnatal Depression Scale (EPDS). A survey using SDS among 2837 children aged 1–35 months in China found that the prevalence of maternal depression was 39.8% [52]. Another study conducted in China using the DASS-21 found that 32% of mothers were depressed [57, 58, 58]. In contrast, a 2020 survey of 769 pregnant Chinese women using the EPDS found that only 8% had postnatal depression [57, 58, 58].

This study showed a correlation between maternal depression and ECD, consistent with the results of previous studies. Wachs et al. found that children with depressed mothers are at risk of cognitive developmental delay in both HICs and LMICs [47]. In addition, an Australian birth cohort study of 816 children found that as the severity of maternal depression increased, the likelihood of the offspring developing depression increased [18]. In China, a study on rural areas found that caregiver depression was predictive of ECD delay in five developmental domains: communication, gross motor skills, fine motor skills, personal-social skills, and problem solving [52]. Other factors that influence the impact of maternal depression on offspring ECD status have also been identified [15], including genetics and social environment. The *Integrated Model of Intergenerational Transmission of Maternal Depression Risk*, published by Goodman in 2006, suggests that maternal nurturing care is a crucial nongenetic pathway for maternal depression and ECD delay [16].

This study found that maternal depression is correlated with reduced responsive caregiving, which is associated with ECD. Responsive caregiving is necessary for ECD, as responsive parenting by mothers provides children with a sense of security and positive self-perception. Several studies have tested whether maternal-responsive parenting mediates the association between maternal depression, offspring depression, and other outcomes [14]. A cohort study conducted in 2016 among 868 mother–child pairs in Pakistan found that a mother's responsive

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care, frequent interactions with children, and provision of appropriate stimulation were key conditions for the child's healthy social-emotional development [35]. Moreover, there is evidence that the effects of early adversity on ECD can be reversed by responsive care; in a study on 136 abandoned children aged 6–30 months who were either randomly assigned to foster homes or still living in institutions, those living with foster families were more likely to show normal responses to stressors as they matured, while others were more likely to display abnormal responses [27]. These findings highlight the importance of responsive care in ECD.

Other explanations of the effects of maternal depression on ECD status have also been found. First, depressed mothers are less sensitive to the needs of their young children, spend less time playing or talking with them, and are more likely to neglect their needs [4] and provide less support. Moreover, the negative effects of depression on mothers' energy and cognitive functioning may hinder their ability to provide appropriate care and early learning opportunities to their children [21]. Third, maternal depression is negatively associated with social support networks, with depressed mothers more likely to be socially withdrawn and self-isolate, resulting in reduced childcare assistance [14, 21]. Therefore, inadequate maternal support, sensitivity, and responsiveness may result in ECD delay in children.

Strengths and limitations

To the best of our knowledge, this study is among the few to examine the mediating effects of responsive caregiving on the association between maternal depression and ECD in China. This study is the latest to provide evidence that responsive caregiving plays a partial mediating role in the relationship between maternal depression and ECD. This study uses mediation analysis, with the counterfactual and potential outcome approaches using the Nurturing Care Framework. The redefinition of the direct and indirect effects also provides a stronger theoretical basis for causal inference. The study is the first to our knowledge to use the ECDI2030, an internationally comparable tool designed to measure SDG indicator 4.2.1, to assess the developmental status of Chinese children aged 24–59 months, which provides important data for research on early childhood development. More than 15 countries are in various stages of implementing the ECDI2030, but to date, only Vietnam has reported its findings. Therefore, future research should explore the validity of ECDI2030 across different cultural and socioeconomic contexts and its relevance for policymaking.

This study has several limitations. First, the data were obtained from a cross-sectional study, making it impossible to draw causal conclusions between maternal depression and ECD delays. Additionally, the risk of reverse causality is inevitable due to its cross-sectional design. For example, maternal mental health might be a consequence of the offspring's behaviour and developmental issues, rather than (or as well as) a cause. There is need for further investigation of this relationship using a longitudinal cohort design or the development of more appropriate instruments to overcome the endogeneity of the results and obtain unbiased evidence linking maternal depressive symptoms with behavioural and developmental problems in the offspring. Second, the models utilized in this study did not account for prolonged experiences of maternal depression or mother–child feedback loops that might undermine a mother's provision of responsive care. In the future, longitudinal studies in China should be conducted to confirm our findings. Third, a self-reported SDS scale was used to screen for maternal depression, while the mother-reported ECDI2030 instrument was used to screen for ECD delay, both of which are at risk of recall and reporting bias. Fourth, the measurements of responsive caregiving and ECD were both based on the UNICEF MICS Child Development module; the existing indicators are neither prescriptive nor exhaustive and cannot provide a complete picture of responsive caregiving and ECD. However, despite these limitations, these indicators may provide valuable insights to fill the research gap and can serve as a good starting point or foundation for future research. To improve nurturing care for early childhood development, further efforts are needed to standardize monitoring at the population level. In addition, no research in China has previously used ECDI2030, thus evaluation of the reliability and validity of ECDI2030 in the Chinese population is still needed. Fifth, participants recruited in this study generally had a high socioeconomic status, and non-probability sampling was used. Thus, the study sample is not nationally representative, and its findings cannot be extended to Chinese populations with lower socioeconomic status. Further studies could expand the survey area and population and collect more representative sample data to draw more universal conclusions about the association between maternal depression and early childhood development.

Conclusion

This study found a high prevalence of maternal depression among children aged 24–59 months in an urban area of China. Maternal depression was associated with early childhood developmental delay in the domains of health, learning, and psychosocial well-being. Responsive caregiving partially mediated the association between maternal depression and ECD delay, with responsive caregiving acting as a key condition for healthy child development. While further research

is needed to explore how responsive care interventions may benefit children with depressed mothers, our findings suggest that responsive caregiving can help advance the SDG agenda, ensuring every child is able to develop to their full potential and that no child is left behind.

Abbreviations

ECD	Early Childhood Developmental
SDGs	Sustainable Development Goals
LMICs	Low- and middle-income countries
HICs	High-income countries
MICS	Multiple Indicator Cluster Surveys
ECDI2030	Early Childhood Development Index 2030
SDS	Self-Rating Depression Scale
ORs	Odds Ratios
CIs	Confidence Intervals
ACME	Average causal mediation effect
LSEM	Linear structural equation modelling
DASS-21	Depression Anxiety Stress Scale 21
EPDS	Edinburgh Postnatal Depression Scale

Supplementary Information

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> Additional file 1

Author contributions
Siyu Zou: Conceptualization, Methodology, Formal analysis, Writing original draft. Hong Zhou: Conceptualization, Methodology, Supervision, Writing original draft. Xinye Zou: Project administration, Data analysis & interpretation Writing original draft and editing. Ruolin Zhang: Data analysis, Investigation, Data curation, Writing—review and editing. Kefan Xue: Data interpretation, Writing—review and editing. Angela Y. Xiao: Data interpretation, Writing—review and editing. Mo Zhou: Investigation, Data curation, Writing—review and editing. Ziyuan Fu: Data curation, Writing—review and editing.

Availability of data and materials
The data that support the findings of this study are available on reasonable request from the corresponding author. No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of the Beijing Yanqing District Mother and Child Health Care Institution (Ref. 202006). All the participants (caregivers) provided written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no conflicts of interest regarding the aims of this study. The funders had no role in the study design, collection, analysis or interpretation of the data, writing of the report, or decision to submit the paper for publication.

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