

RESEARCH ARTICLE

Parental Migration and the Suspected Developmental Delay of Left-Behind Children in Rural China

Yating Cheng¹ | Yuxuan Zhu¹ | Ying Wang^{2,3} | Xianhong Huang^{1,4} | Tao Sun^{1,4} | Feng Wang^{1,4}

¹Department of Health Management and Policy, School of Public Health, Hangzhou Normal University, Hangzhou, Zhejiang Province, China | ²Department of Surgical Nursing, The First People's Hospital of Yuhang District, Hangzhou, Zhejiang Province, China | ³Department of Surgical Nursing, The First Affiliated Hospital Zhejiang University School of Medicine Liangzhu Branch, Hangzhou, Zhejiang Province, China | ⁴Hangzhou International Urbanology Research Center & Center for Urban Governance Studies, Hangzhou, Zhejiang Province, China

Correspondence: Tao Sun (hydsuntao@126.com) | Feng Wang (wangfeng2022@hznu.edu.cn)

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ABSTRACT

Background: There are estimated 41.77 million left-behind children (LBC) in rural China, among whom 14.26 million are under the age of 5 years. However, limited research exists on how different parental migration status affects the early development of rural LBC. The purpose of this study is to examine early child development of previous-left-behind children (PLBC), children with single parent migrating (SLBC), children with both parents migrating (BLBC) as compared to never-left-behind children (NLBC). This study also attempts to explore the factors affecting the early development levels of four types of rural children.

Methods: A questionnaire survey was conducted among 1614 child caregivers in Nanling County, Anhui Province. Ages & Stages Questionnaires–Chinese version (ASQ-C) was conducted to measure suspected developmental delay (SDD) of rural children. The parenting knowledge, depressive symptoms and parenting behaviours of caregivers were measured using the Knowledge of Infant Development Inventory-P (KIDI-P), Beck Depression Inventory-II (BDI-II) and Family Care Indicators (FCI). After controlling for the sociodemographic characteristics of children and primary caregivers, binary logistic regression was employed to assess the association between various categories of rural children and early developmental delays.

Results: The results showed significant differences in total SDD among the four types of rural children ($p < 0.01$), and the risk of total SDD in BLBC was 1.78 times that of NLBC [OR = 1.78, 95% CI (1.23–2.60), $p < 0.01$]. The study showed that caregivers' parenting knowledge [0.54, (0.31–0.93), $p < 0.05$], parenting behaviour [0.86, (0.80–0.92), $p < 0.001$] and caregiver depressive symptoms [1.51, (1.14–1.99), $p < 0.01$] were strongly associated with total SDD.

Conclusion: In this study, BLBC exhibit the most pronounced early developmental delay. Additionally, PLBC who have experienced being left behind also face disadvantages. The findings provide valuable insights into LBC across various parental migration contexts and contribute to a better understanding of the risk factors of early childhood development. Correspondingly, the study emphasizes that family, society and government should formulate corresponding intervention measures to reduce the risk of early development for rural children.

Summary

- LBC have a higher risk of early developmental delay, BLBC have 1.78 times higher risk of developmental delays than NLBC.
- This study evaluated the risk of early developmental delayed among children in rural China who experience different types of parental absence.
- This study explored the specific impact of parenting knowledge, parenting behaviour, and caregivers' depression symptoms on the early development of rural children.
- Rural areas must prioritize the early development of LBC, necessitating the concerted attention of families, communities, and governments.

1 | Introduction

Early child development (ECD) refers to the comprehensive development of children's cognitive, language, motor, social-emotional competencies and social adaptive behaviour (UNICEF 2017a). ECD is the foundation for adult health and well-being, and is also an essential component of the sustainable development goals (SDGs) (Lu et al. 2016). Future intellectual and financial success is more likely for children who experience higher levels of early development (Almond and Currie 2011; Campbell et al. 2001; Horton 2008). Conversely, children with lower levels of early development may potentially pose significant costs and societal burdens in the future (Garner et al. 2012). Economic studies also demonstrate that investment in ECD can promote socioeconomic development (Rolnick and Grunewald 2003). However, according to the Lancet report, approximately 249 million children under the age of five are at risk of developmental delays worldwide, with 17.43 million in China, making it the second highest in the world (Lu et al. 2016). Additionally, Chinese studies reveal that rural children, particularly left-behind children (LBC), are at a higher risk of early developmental delays (Yu et al. 2019).

Many rural residents have relocated to the city in pursuit of work since China's economy started to expand quickly in the late 1970s; their children are now in the care of a single parent or their grandparents at the household registration places (Qu et al. 2020). Because of this, the phrase "left-behind children (LBC)" was coined to describe children under the age of 18 who are left behind in their small rural community while one or both of their parents migrate for employment (UNICEF 2017b). According to China population census in 2020, there are 41.77 million LBC in rural areas, of which 14.26 million (34.1%) are children under 5 years old (National Bureau of Statistics 2021b).

LBC often have worse physical health and are more likely to get sick than children who are not left behind (NLBC) (Li et al. 2015; Zhang et al. 2015). They also exhibit higher rates of malnutrition (Tao et al. 2016) and hypoferric anaemia (Li et al. 2011). When it comes to mental health, LBC are more likely to have poorer self-esteem (Luo et al. 2012), increased

depression (Sun et al. 2015) and thoughts of suicide (Fellmeth et al. 2018). Recent studies have shown that compared to NLBC, LBC has a higher risk of developmental delay in cognitive, language, motor and socio-emotional domains (Bai et al. 2023; Gao et al. 2018). However, the impact of different types of LBC on child health is diverse. BLBC and PLBC often report higher levels of emotional symptoms, behavioural issues and hyperactivity than NLBC (Wang et al. 2019). Another study found that migration of one parent has no significant effect on child health (Li et al. 2015). Therefore, we speculate that the impact of different parental migration on ECD may vary. But many studies have only compared the difference in ECD between LBC and NLBC without further categorization. Moreover, the majority of research on rural children's health primarily focuses on school-aged children, while research on ECD primarily target children aged 0–3 or 3–6, with fewer studies covering the 0–6 age range. However, a report from The Lancet emphasized the importance of early development intervention programs for children aged 0–6 (Engle et al. 2007). Consequently, our research will focus on the early development of children aged 0–6.

Caregivers are the individuals who have the most contact and the closest connection during children's growth. Previous studies have indicated caregivers' parenting knowledge, parenting behaviours and depressive symptoms are closely related to ECD (Ma et al. 2023; Zhong et al. 2020). The definition of parenting knowledge was "knowledge of child development process, familiarity with caregiving skills, and understanding of development norms and milestones" (Benasich and Brooks-Gunn 1996). Numerous studies have shown that parenting knowledge is crucial for ECD, and is positively correlated with children's cognitive, language, motor and social-emotional development (Li et al. 2019; Yue et al. 2017; Zhong et al. 2020). A high level of parenting knowledge can help caregivers create an interactive and developmental home environment that is conducive to ECD (Parks and Smeriglio 1986; Yue et al. 2017). However, caregivers of LBC generally have lower level of knowledge compared to NLBC (Tao et al. 2014).

Positive parenting behaviours lay the groundwork for early, developmentally appropriate stimulation, which improves brain structure by creating, preserving and reducing synaptic connections—a process that eventually helps children with ECD (Black et al. 2017; Ma et al. 2023). The positive parenting behaviours include playing games, drawing, outdoor play, telling stories, singing and reading with children and other parent-child interactions. Absence of positive parenting behaviours by caregivers can negatively impact development of children's language and cognitive skills (Jeong et al. 2016). The migration of parents, which is the primary distinction between LBC and NLBC, may result in a low quality and low-stimulation parenting behaviours. Previous studies have reported that LBC receive less interaction and early stimulation (Bai et al. 2022). For example, the probability of reading, telling stories, singing, playing together and recognizing things with children was merely approximately one-third of what it is for NLBC (Gao et al. 2018).

As several studies have shown, caregivers' depression has serious consequences with children's behavioural problems

or emotional function (Goodman et al. 2011), language, cognition and motor function development (Liu et al. 2021). Developmental delays in children were more likely to occur when their caregivers have moderate or severe depressive symptoms (Ma et al. 2023). In five Chinese provinces, a survey done in rural areas found that 40.02% of LBC caregivers had depressive symptoms (Tan et al. 2020). Nevertheless, few studies compared the differences in depressive symptoms among caregivers of different types of LBC. In addition, there are limited studies exploring the impact of various forms of parental migration on parenting knowledge and behaviour in rural areas.

This survey aimed to investigate the effects of diverse forms of parental migration on ECD in rural China, including children left behind by both parents (BLBC), children left behind by one parent (SLBC), previous-left-behind children (PLBC) and children with neither parent had migrated (NLBC). We were also interested in the possibility that caregivers' characteristics (e.g., parenting knowledge, parenting behaviours and depressive symptoms) influence ECD.

2 | Methods

2.1 | Participants and Procedures

We conducted this cross-sectional survey in Nanling County, Anhui Province from June to October 2023. Anhui is a relatively underdeveloped province with large-scale population migration. In 2020, the number of rural LBC in Anhui Province has surpassed 2 million (Lyu et al. 2024). We randomly selected one city (Wuhu City) from 16 cities in Anhui Province, and then randomly selected one county (Nanling County) from seven counties in Wuhu City. The questionnaire survey was conducted in eight towns in Nanling County. First, the vaccination rate of children included in the national immunization program was close to or exceeding 99% in 2020 (National Bureau of Statistics 2021a). In China, vaccination sites are mainly located in community health service centres or township health centres. Therefore, 10 health centres (one community health service centre and nine township health centres) were randomly selected from eight towns for investigation. Professionally trained volunteers conduct questionnaire surveys on vaccinated children and their caregivers. The main participants in the questionnaire survey at the health centre are children aged 0–3 years. Then, we conducted a questionnaire survey on children aged 3–6 years in kindergartens. The registered kindergartens roster was provided by the Education Bureaus in Nanling after obtaining informed permission. Fourteen kindergartens in urban areas and rural areas were randomly selected from eight towns in total. Due to the age limit of the questionnaire, children under 66 months from the selected kindergartens were invited to participate. Questionnaires were distributed by head teachers and then were taken home by the children. Caregivers completed the questionnaires at home and give feedback in the form of signed receipts. Informed consent was acquired from the legal guardians of the children, and the survey was conducted in compliance with the Declaration of Helsinki. This study has been approved by the Ethics Committee of Hangzhou Normal University (number: 2023-1047).

2.2 | Measures

2.2.1 | Sociodemographic Variables and Parental Migration Status

Sociodemographic characteristics involved the following: age, gender of child, preterm, low birth weight, only child, maternal childbearing age, maternal education level, paternal education level, parental marital status and monthly family income. In addition, we identified primary caregiver by asking “who usually spends the most time with child” with three alternatives, mother, grandmother and other (Liang et al. 2021).

Parental migration status was defined by asking participants the following questions: since the birth of the child, has the father/mother left the county to work or do business elsewhere (more than 6 months) (Akezhuali et al. 2022)? The answer options are ‘currently migrates’, ‘previously migrated, currently at home’, ‘never migrate’ and other. These two questions divided children into four categories: NLBC—neither parent had migrated; PLBC—previous-left-behind children; SLBC—left-behind children with one parent migrating; BLBC—left-behind children with both parents migrating. Considering that children whose parents have passed away or divorced could exert differing effects, we excluded samples that both parents selected ‘other’. A total of 1614 samples were included in the final study: 789 NLBC, 239 PLBC, 456 SLBC and 130 BLBC.

2.2.2 | Knowledge of Infant Development Inventory-P (KIDI-P)

The parenting knowledge of caregivers was measured by the Knowledge of Infant Development Inventory-P (KIDI-P). Knowledge of Infant Development Inventory (KIDI) was designed by MacPhee in 1981 and revised in 2002 (MacPhee 1981). KIDI had a total of 75 questions. KIDI-P was a subsection of KIDI with 58 questions that consisted of two parts: a knowledge test, which assesses caregivers' knowledge of child development, and a belief test, which assesses caregivers' beliefs about the achievement of children of a specific age (Al-Maadadi and Ikhlef 2015; Yue et al. 2017). Then, Larsen and Juhasz (1986) developed a scale containing 56 questions. Finally, Chinese scholars removed 16 questions due to individual variations in child development and cultural disparities between Asia and Europe (Qian 2021). Therefore, KIDI-P in our study consisted of 40 questionnaires. The answer options were ‘correct’, ‘incorrect’ or ‘not sure’. Every correct answer received one point, but any wrong or unsure response received no points. This study investigated the total index as caregivers' KIDI-P scores. The higher the score, the better the caregiver's parenting knowledge. The Cronbach's alpha test result for our study participants was 0.89.

2.2.3 | Beck Depression Inventory-II (BDI-II)

We used Beck Depression Inventory-II (BDI-II) to evaluate caregivers' depressive symptoms. The BDI-II had been used

extensively in research and practice, and was one of the most frequently used psychological tests to date (David 2010). This measure can be used to evaluate the degree of depression symptoms in the last 2 weeks in both healthy individuals and patients with mental illness (McPherson and Martin 2010). The BDI-II consisted of 21 items: each item was scored from 0 to 3. Higher total scores indicated more severe depressive symptoms. Depressive symptoms were categorized into four levels: no depression (score of 0–13), mild (score of 14–19), moderate (score of 20–28) and severe (score of 29 or above) (Beck 1996). In the current study, caregivers' depressive symptoms were analysed as BDI-II scores < 13 (no depression) and BDI-II scores $\geq$ 14 (mild, moderate or severe). Cronbach's alpha coefficient was 0.90 in this study.

2.2.4 | Family Care Indicators (FCI)

This study utilized the Family Care Indicator (FCI) survey to assess caregivers' parenting behaviours. The FCI survey was developed by the United Nations International Children's Emergency Fund (UNICEF) (Frongillo et al. 2003). This study assessed FCI scores based on whether caregivers and children participated in the following six activities together in the past 3 days: read books or picture books with your children; tell stories to your children; sing nursery rhymes to your children; take your children to play games outdoors; play games with your children with toys; name, count or draw things with your children. Each activity was scored: yes = 1 and no = 0, the total score may reach 6 (Zhang et al. 2018). The total FCI score of caregivers was directly proportional to the quality of parenting behaviour. The Cronbach's alpha coefficient of the inventory was 0.72.

2.2.5 | Ages & Stages Questionnaires–Chinese Version (ASQ-C)

Ages & Stages Questionnaires–Chinese version (ASQ-C) was completed by parents to evaluate early development of children. This questionnaire was available in 21 variants that were appropriate for kids between the ages of 1 and 66 months. ASQ-C was a trustworthy and useful screening tool for assessing the developmental stages of Chinese children (Chang et al. 2023). It contained five developmental domains: communication (CM), gross motor (GM), fine motor (FM), problem-solving (CG) and personal-social (PS). Each domain consisted of six items. Responses to each item were scored as follows: 'most of the time' (10 points), 'sometimes' (5 points) and 'never or rarely' (0 points). The scores for each of the six items were summed to create a domain score, and the scores for each domain were summed to create a total ASQ-C score, with higher scores indicating better development. Any domain with a score more than one standard deviation below the Chinese normal mean indicated suspected developmental delay (SDD) in that domain (Yao et al. 2010). Children with SDD in one or more domains were considered to have total SDD (Yao et al. 2010). Preliminary studies have shown that the internal reliability of ASQ-C was 0.77, the sensitivity of ASQ-C was 85.00% and the specificity of ASQ-C was 84.26% (Bian et al. 2010).

2.3 | Statistical Analysis

The Kruskal–Wallis and Chi-squared tests were employed to examine the variations in early child developmental outcomes and sociodemographic characteristics between the four groups. Additionally, between these groups, post hoc comparisons using the Bonferroni test were carried out. Finally, we used binary logistic regression to assess the impact of various parental migration status on the development of five domains. The initial model (Model 1) was unadjusted, while Model 2 was further adjusted for covariates (age, gender of child, preterm birth, low birth weight, only child, maternal childbearing age, maternal level of education, paternal level of education, parental marital status and monthly household income). Data entry was performed using Epidata, and data analysis was performed using SPSS 26.0 version. The two-sided *p*-value of 0.05 was considered statistically significant.

3 | Results

3.1 | Comparison of Basic Characteristics of Participants by Parental Migration Status

Table 1 presents the descriptive statistics of socio-demographic characteristics categorized by parental migration status. BLBC accounted for the largest proportion in the age group of 37–66 months (86.2%). There was significant difference in only-child status among four groups ($p < 0.05$), with BLBC families having a significantly higher proportion of only children (53.1%) compared to the other three groups' families. Also, the groups varied significantly in both maternal childbearing age ($p < 0.05$) and parental education level ($p < 0.001$). Relatively, BLBC families (21.5%) reported a higher proportion of mothers with childbearing age less than 25. Regarding parental education levels, BLBC families had both lower maternal education level and paternal education level. Monthly family income was also statistically different ($p < 0.001$), with BLBC families having significantly higher monthly income than the other three groups' families. The proportions of grandmothers as the primary caregivers were highest for the BLBC families (87.7%). However, NLBC families (19.6%) and PLBC families (25.5%) also existed relatively high proportions of grandmothers as the primary caregivers even if their parents were at home. Table 1 also shows significant differences in FCI scores. The BLBC's caregivers had the lowest scores (3.22) on the FCI scores as compared to the other three groups' caregivers. However, there was no statistically significant difference in gender of child, preterm, low birthweight, parental marital status, caregivers' KIDI-P scores or caregivers' depressive symptoms.

3.2 | Differences in Early Developmental Outcomes Among Different Parental Migration Status

Table 2 illustrates the differences in ECD outcomes among the four groups of children. Significant differences were observed in total SDD ($p < 0.05$). The proportion of BLBC (50%) in total SDD was significantly higher than that in NLBC

TABLE 1 | Socio-demographic characteristics stratified by parental migration status, *n*(%).

	NLBC (<i>n</i> = 789) (1)	PLBC (<i>n</i> = 239) (2)	SLBC (<i>n</i> = 456) (3)	BLBC (<i>n</i> = 130) (4)	K-W or χ^2	<i>p</i> value
Age (month) ^a						
1–36	209(26.5)	46(19.2)	93(20.4)	18(13.8)	15.28	0.002
37–66	580(73.5)	193(80.8)	363(79.6)	112(86.2)		
Gender of child					5.35	0.148
Male	429(54.4)	132(55.2)	221(48.5)	64(49.2)		
Female	360(45.6)	107(44.8)	235(51.5)	66(50.8)		
Preterm (gestational weeks < 37)					4.94	0.177
Yes	68(8.6)	30(12.6)	49(10.7)	17(13.1)		
No	721(91.4)	209(87.4)	407(89.3)	113(86.9)		
Low birthweight(< 2.5 kg)					2.53	0.470
Yes	21(2.7)	10(4.2)	13(2.9)	6(4.6)		
No	768(97.3)	229(95.8)	443(97.1)	124(95.4)		
Only child ^b					13.55	0.004
Yes	292(37.0)	84(35.1)	176(38.6)	69(53.1)		
No	497(63.0)	155(64.9)	280(61.4)	61(46.9)		
Maternal childbearing age ^c					8.81	0.032
< 25	103(13.1)	42(17.6)	61(13.4)	28(21.5)		
≥ 25	686(86.9)	197(82.4)	395(86.6)	102(78.5)		
Maternal education level ^d					34.46	< 0.001
Middle school and lower	251(31.8)	105(43.9)	184(40.4)	56(43.1)		
High school	344(43.6)	97(40.6)	201(44.1)	61(46.9)		
College and above	194(24.6)	37(15.5)	71(15.6)	13(10.0)		
Paternal education level ^e					42.79	< 0.001
Middle school and lower	246(31.2)	107(44.8)	196(43.0)	62(48.1)		
High school	359(45.5)	103(43.1)	194(42.5)	52(40.3)		
College and above	184(23.3)	29(12.1)	66(14.5)	15(11.6)		
Parental marital status					3.92	0.270
Married	743(94.2)	223(93.3)	431(94.5)	117(90.0)		
Other	46(5.8)	16(6.7)	25(5.5)	13(10.0)		
Monthly family income (RMB*) ^f					50.66	< 0.001
5999 and lower	193(24.5)	64(27.0)	94(20.6)	13(10.0)		

(Continues)

TABLE 1 | (Continued)

	NLBC (<i>n</i> = 789) (1)	PLBC (<i>n</i> = 239) (2)	SLBC (<i>n</i> = 456) (3)	BLBC (<i>n</i> = 130) (4)	K-W or χ^2	<i>p</i> value
6000–8999	208(26.4)	57(24.1)	137(30.0)	21(16.2)		
9000–11 999	176(22.3)	56(23.6)	101(22.1)	27(20.8)		
12000 and above	211(26.8)	60(25.3)	124(27.2)	69(53.1)		
Primary caregiver ^g					278.65	< 0.001
Mother	603(76.4)	168(70.3)	332(72.8)	9(6.9)		
Grandmother	155(19.6)	61(25.5)	103(22.6)	114(87.7)		
Other	31(3.9)	10(4.2)	21(4.6)	7(5.4)		
Caregivers' KIDI-P scores ^h , Mean (SD)	0.56(0.20)	0.57(0.20)	0.58(0.19)	0.59(0.20)	1.20	0.754
Caregivers' depressive symptoms					4.01	0.260
Yes (scores ≥ 14)	129(16.3)	46(19.2)	88(19.3)	17(13.1)		
No (scores < 13)	660(83.7)	193(80.8)	368(80.7)	113(86.9)		
Caregivers' FCI scores ⁱ , Mean (SD) ^h	4.57(1.54)	4.57(1.54)	4.50(1.59)	3.22(2.38)	37.17	< 0.001

Abbreviations: BLBC: LBC with both parents migrating, LBC left-behind children, NLBC: neither parents had migrated, PLBC: previous-left-behind children, SLBC: LBC with one parent migrating.

^aPost hoc, (1,2)(1,3)(1,4).

^bPost hoc, (1,4)(2,4)(3,4).

^cPost hoc, (1,4)(3,4).

^dPost hoc, (1,2)(1,3)(1,4).

^ePost hoc, (1,2)(1,3)(1,4).

^fPost hoc, (1,4)(2,4)(3,4).

^gPost hoc, (1,4)(2,4)(3,4).

^hPost hoc, (1,4)(2,4)(3,4).

ⁱ\$1 = 7.17RMB (2024).

Knowledge of Infant Development Inventory-P, the full score of this scale is 1; %:Six questions from Family Care Indicators, the full score of this scale is 6.

TABLE 2 | Early child developmental outcomes by parental migration status^a, *n*(%).

	NLBC (<i>n</i> = 789) (1)	PLBC (<i>n</i> = 239) (2)	SLBC (<i>n</i> = 456) (3)	BLBC (<i>n</i> = 130) (4)	χ^2	<i>p</i> value
Total suspected developmental delay (total SDD) ^a	283(35.9)	99(41.4)	163(35.7)	65(50.0)	11.635	0.009
Communication (CM)	82(10.4)	32(13.4)	42(9.2)	19(14.6)	4.939	0.176
Gross motor (GM)	167(21.2)	58(24.3)	102(22.4)	35(26.9)	2.698	0.441
Fine motor (FM) ^b	111(14.1)	47(19.7)	64(14.0)	28(21.5)	8.771	0.032
Problem solving (CG)	47(6.0)	12(5.0)	29(6.4)	10(7.7)	1.146	0.766
Personal social (PS) ^c	77(9.8)	39(16.3)	37(8.1)	18(13.8)	13.260	0.004

Abbreviations: BLBC: LBC with both parents migrating, LBC: left-behind children, NLBC: neither parents had migrated, PLBC: previous-left-behind children, SLBC: LBC with one parent migrating.

^aPost hoc, (1,4)(3,4).

^bPost hoc, (1,2)(1,4)(3,4).

^cPost hoc, (1,2)(2,3)(3,4).

*Any domain that scored below the Chinese norm mean by more than one standard deviation indicates the suspected developmental delay in the domain. Children with the suspected developmental delay in one or more domains were considered with total suspected developmental delay (total SDD).

(35.9%), PLBC (41.4%) and SLBC (35.7%). Regarding the developmental domain of FM ($p < 0.05$), the proportion of SDD in BLBC (21.5%) and PLBC (19.7%) was significantly higher than that in NLBC (14.1%) and SLBC (14.0%). In the domain of PS

($p < 0.05$), compared to NLBC (9.8%) and SLBC (8.1%), it was found that there existed higher proportion of SDD in PLBC (16.3%) and BLBC (13.8%). The prevalence in the domain of CM, GM and CG showed little difference overall. However,

in the domain of GM, the proportion of NLBC (21.2%), PLBC (24.3%) with SDD was also high, close to SLBC (22.4%) and BLBC (26.9%).

3.3 | Risk Factors Associated With SDD in LBC

Table 3 displays the results of binary logistic regression. Model 1 shows the association between different parental migration status and various outcomes in ECD. BLBC had a higher risk of total SDD than NLBC [OR = 1.78, 95% CI (1.23–2.60), $p < 0.01$]. In the developmental domain of FM, PLBC and BLBC were at higher risk of SDD than NLBC [1.50, (1.03–2.18), $p < 0.05$; 1.68, (1.05–2.67), $p < 0.05$]. And in the domain of PS, Model 1 indicated that PLBC existed higher risk of SDD than NLBC [1.80, (1.19–2.73), $p < 0.05$]. After adjusting for socio-demographic variables (Model 2), the risk of total SDD and SDD in domain of FM were no longer significant in BLBC and PLBC when compared to NLBC. But PLBC still had higher risk of SDD than NLBC [1.70, (1.10–2.64), $p < 0.05$] in the domain of PS. However, in the domain of CM, GM and CG, there was no significant difference between the four groups of children before and after adjustment.

According to the results of Model 2, KIDI-P scores were negatively associated with total SDD [0.54, (0.31–0.93), $p < 0.05$] and all domains [0.42, (0.19–0.94), $p < 0.05$; 0.42, (0.22–0.78), $p < 0.01$; 0.23, (0.08–0.65), $p < 0.01$; 0.40, (0.18–0.89), $p < 0.05$] except the domain of FM. Also, FCI scores had a negative impact on total SDD [0.86, (0.80–0.92), $p < 0.001$] and the domains of CM, GM, FM, PS [0.90, (0.82–0.99), $p < 0.05$; 0.92, (0.85–0.99), $p < 0.05$; 0.84, (0.78–0.91), $p < 0.001$; 0.87, (0.79–0.95), $p < 0.01$]. Yet, caregivers' depressive symptoms increased the risk of total SDD [1.51, (1.14–1.99), $p < 0.01$] and SDD in the domains of CM, GM, CG, PS [1.57, (1.07–2.30), $p < 0.05$; 1.40, (1.02–1.91), $p < 0.05$; 1.63, (1.00–2.65), $p < 0.05$; 1.71, (1.16–2.52), $p < 0.01$]. Model 2 also reported that in the domains of CM and FM, grandmothers as primary caregivers were risk factors for SDD [1.52, (1.02–2.26), $p < 0.05$; 1.47, (1.04–2.08), $p < 0.05$].

4 | Discussion

Overall, our study investigated the association between parental migration status and ECD in rural China for children under 66 months. We observed that BLBC had higher risk of delay in early development, especially in domain of FM, while PLBC existed higher risk in domain of PS. Additionally, significant associations were found between caregivers' factors (parenting knowledge, parenting behaviours and depressive symptoms) and the domains of CM, GM, FM, CG, PS.

Research showed that parents of BLBC have lower levels of education than NLBC, and this finding is consistent with previous research (Wang et al. 2021). Individuals with lower levels of education often encounter more challenges in securing employment and achieve lower earnings (Yang et al. 2022). However, our results showed that BLBC households have higher monthly income. This is due to the fact that BLBC's parents moved to other places in pursuit of better employment prospects and greater pay, which also accounted for the reasons behind rural

population migration (Lyu et al. 2024). Furthermore, the challenge of rural employment difficulties should be prioritized, with a focus on fostering economic growth in rural regions. It should be noted that one fourth of NLBC and one fifth of PLBC still have grandmothers as their primary caregivers, even with parents currently at home. This result reveals that it is common in China for grandparents to be the primary caregivers for children. In fact, in China, parents tend to let grandparents to take care of their children, driven by both necessity and the traditional right and expectation of grandparents to care for young children (Nyland et al. 2009).

Our research indicated that scores of parenting knowledge in rural areas of China were relatively low. The average KIDI-P scores among caregivers in our sample were 0.56 (NLBC), 0.57 (PLBC), 0.58 (SLBC) and 0.59 (BLBC), which is close to the result (0.54) of previous research conducted in rural China (Yue et al. 2017). Studies conducted by experts from China have demonstrated that the average KIDI-P score of mothers from three low-income counties in the United States (0.81) is consistently higher than the score of Chinese mothers, supporting the notion that parenting knowledge in developing countries may be lower than that in developed countries (Al-Maadadi and Ikhlef 2015; Garrett-Peters et al. 2008). Additionally, according to the hypothesis of the transmission mechanism of parenting knowledge on parenting behaviours, parenting knowledge will affect parenting behaviours (Huang et al. 2005; Miller 1986). However, our study found no difference in parenting knowledge among the four caregiver groups, but differences in parenting behaviours were observed. This conclusion is consistent with a previous study in China (Li et al. 2019). In fact, parenting behaviour encompasses both quantity (the frequency of parenting behaviours) and quality (the level of positivity in parenting behaviours) (Fagan et al. 2014). According to previous research (Li et al. 2019), the quantity of parenting behaviours may affect the quality of parenting behaviours, ultimately influencing ECD. Future research can focus on the relationship between the quantity and quality of parenting behaviours.

The study showed that BLBC exhibit higher risk of total SDD, which is consistent with previous research that has suggested that the migration of both parents can harm children's early development (Li et al. 2021). Our research revealed that the motor development of children living in rural areas was severely compromised. In the domain of FM, BLBC presented the higher risk of SDD. Previous research has established a strong link between activities such as painting and playing with small toys and FM development (Suggate et al. 2017). However, the findings of this study indicated that BLBC's caregivers have the lowest FCI scores, suggesting that these caregivers engage less with their children in these activities. In the domain of GM, although no significant difference is observed among the four groups of children, the proportion of delays in GM was highest among five domains of this study, which was also significantly higher than the proportion of delays observed in previous studies (Dou et al. 2023; Gao et al. 2018). The probable cause of this outcome is the lack of outdoor activities and participation in organized sports (Barnett et al. 2016). Future research could consider exploring the influencing factors of early children's motor development.

TABLE 3 | Regression analysis for early child development by parental migration status with adjustment for socio-demographic characteristics, OR(95% CI).

	Total suspected developmental delay (total SDD)		Communication (CM)		Gross motor (GM)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Parental migration status (ref: NLBC)						
PLBC	1.26(0.94,1.70)	1.10(0.80,1.50)	1.33(0.86,2.06)	1.29(0.82,2.03)	1.19(0.85,1.68)	0.96(0.67,1.38)
SLBC	1.00(0.78,1.27)	0.91(0.71,1.17)	0.88(0.59,1.29)	0.88(0.59,1.33)	1.07(0.81,1.42)	0.92(0.68,1.23)
BLBC	1.78(1.23,2.60)**	1.28(0.82,2.00)	1.48(0.86,2.53)	1.30(0.68,2.46)	1.37(0.90,2.10)	1.05(0.63,1.75)
Primary caregiver (ref: Mother)						
Grandmother		1.22(0.94,1.60)		1.52(1.02,2.26)*		1.12(0.82,1.54)
Other		1.02(0.60,1.72)		0.90(0.39,2.10)		0.77(0.41,1.45)
Caregivers' KIDI-P scores		0.54(0.31,0.93)*		0.42(0.19,0.94)*		0.42(0.22,0.78)**
Caregivers' depressive symptoms		1.51(1.14,1.99)**		1.57(1.07,2.30)*		1.40(1.02,1.91)*
Caregivers' FCI scores		0.86(0.80,0.92)***		0.90(0.82,0.99)*		0.92(0.85,0.99)*
Fine motor (FM)						
Personal social (PS)		Problem solving (CG)		Model 1		Model 2
Parental migration status (ref: NLBC)	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
PLBC	1.50(1.03,2.18)*	1.26(0.85,1.88)	0.84(0.44,1.60)	0.79(0.41,1.55)	1.80(1.19,2.73)*	1.70(1.10,2.64)*
SLBC	1.00(0.72,1.39)	0.93(0.64,1.28)	1.07(0.67,1.73)	1.07(0.65,1.76)	0.82(0.54,1.23)	0.80(0.52,1.22)
BLBC	1.68(1.05,2.67)*	0.90(0.51,1.57)	1.32(0.65,2.68)	1.14(0.49,2.62)	1.49(0.86,2.58)	1.07(0.55,2.08)
Primary caregiver (ref: Mother)						
Grandmother		1.47(1.04,2.08)*		1.57(0.93,2.63)		1.25(0.83,1.89)
Other		1.38(0.72,2.62)		1.98(0.86,4.58)		2.32(1.21,4.45)*
Caregivers' KIDI-P scores		0.58(0.29,1.18)		0.23(0.08,0.65)**		0.40(0.18,0.89)*
Caregivers' depressive symptoms		1.24(0.87,1.77)		1.63(1.00,2.65)*		1.71(1.16,2.52)**
Caregivers' FCI scores		0.84(0.78,0.91)***		0.92(0.82,1.05)		0.87(0.79,0.95)**

Abbreviations: BLBC: LBC with both parents migrating, LBC: left-behind children, NLBC: neither parents had migrated, PLBC: previous-left-behind children, SLBC: LBC with one parent migrating.
Model 1: No adjustment was made for age, gender of child, preterm birth, low birth weight, only child, maternal childbearing age, maternal level of education, paternal level of education, parental marital status and monthly household income.
Model 2: Adjusted for age, gender of child, preterm birth, low birth weight, only child, maternal childbearing age, maternal level of education, paternal level of education, parental marital status and monthly household income.
SDD: Model 1: $n = 1614$, Nagelkerke $R^2 = 0.010$, $p = 0.010$; Model 2: $n = 1610$, Nagelkerke $R^2 = 0.105$, $p < 0.001$.
CM: Model 1: $n = 1614$, Nagelkerke $R^2 = 0.006$, $p = 0.192$; Model 2: $n = 1610$, Nagelkerke $R^2 = 0.075$, $p < 0.001$.
GM: Model 1: $n = 1614$, Nagelkerke $R^2 = 0.002$, $p = 0.451$; Model 2: $n = 1610$, Nagelkerke $R^2 = 0.126$, $p < 0.001$.
FM: Model 1: $n = 1614$, Nagelkerke $R^2 = 0.009$, $p = 0.040$; Model 2: $n = 1610$, Nagelkerke $R^2 = 0.101$, $p < 0.001$.
CG: Model 1: $n = 1614$, Nagelkerke $R^2 = 0.002$, $p = 0.770$; Model 2: $n = 1610$, Nagelkerke $R^2 = 0.085$, $p < 0.001$.
PS: Model 1: $n = 1614$, Nagelkerke $R^2 = 0.016$, $p = 0.006$; Model 2: $n = 1610$, Nagelkerke $R^2 = 0.095$, $p < 0.001$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Our findings also highlighted a lower ability to complete something alone or interact with others among PLBC. Following the adjustment for relevant sociodemographic variables, PLBC still reported higher SDD risks in domain of PS compared to NLBC. However, the earlier study reported that BLBC had poorer social skills (Hu et al. 2020). There are several reasons why this disparity could exist. After the migration of parents, children need to adapt to the care relationship with new primary caregivers. When the parents return a few years later, the children must face the same challenge again, as they will once again face with losing the sense of security they have established with their adoptive parents (Pottinger 2005). This means that PLBC will experience one more challenge than BLBC. Therefore, future research should pay special attention to the risks of PLBC in early development.

Additionally, we also found that caregiver factors (KIDI-P scores, depressive symptoms and FCI scores) have a great impact on children's early development. As our study demonstrated, KIDI-P scores were negatively associated with total SDD and SDD in domains of CM, GM, CG and PS. Consistent with previous research findings in western China, which have shown a positive correlation between KIDI-P scores and children's language, cognitive and motor development (Zhong et al. 2020). However, another study in central China has shown that there is no significant correlation between KIDI-P scores and children's motor development (Yue et al. 2017). This discrepancy could be attributed to the disparity in wealth between different regions in China, suggesting that unequal regional economic development may also impact the outcome. Meanwhile, mediating factors such as the quality of the home environment might exist between parenting knowledge and final outcomes (Breiner et al. 2016). In order to resolve these apparent disparities, more research on this subject is required.

In term of depressive symptoms of caregiver, the present results reported that caregivers with depressive symptoms are at an increased risk of total SDD and SDD in domains of CM, GM, CG and PS. Consistent with previous studies, caregivers with depressive symptoms are important predictors of developmental delay in children (Wei et al. 2015). There are numerous mechanisms that can negatively impact a caregivers' depression on a children's developmental outcome. For example, children may learn from their parents by observing and interacting with their depressive behaviours (Downey and Coyne 1990), such as withdrawal rather than interaction in the domain of PS. Further studies have revealed that depressive parents are more likely to be aloof, agitated and antagonistic with their kids (Pelaez et al. 2008). These behaviours are detrimental to the early development of children.

There was also a negative association between FCI scores and SDD (CM, GM, FM, PS), which is consistent with previous research results indicating that the most important predictive factors for SDD in children are stimulation factors (Zhang et al. 2018). However, the FCI score of BLBC was the lowest in our study. This result could be connected to the primary caregivers' parenting concept (Zhou et al. 2020). Primary caregivers of BLBC are mostly grandparents. Compared to their children's parents, grandparents have a lower level of education, and a considerable portion of them does not attend

school. Although grandparents have rich practical experience in raising children, there is still a significant big gap between these experience and scientific parenting behaviours (Li et al. 2013). They typically focus on the daily life and basic needs of LBC, aiming primarily to provide sufficient food and clothing. In addition to the responsibility of taking care of children, grandparents also have other labour burdens such as farm work, which leaves them with insufficient time to spend with children, let alone adopting scientifically effective parenting behaviours (Ye and Wang 2006).

The United Nations' 2030 Agenda for Sustainable Development clarifies goals related to ECD and calls for greater global investment in early childhood development (Lu et al. 2016). There is a large number and a large proportion of LBC in China. The 'Strengthening Early Childhood Development Services' plan was mentioned in the 'Healthy China Action 2019–2030' (National Health Commission of the People's Republic of China 2019). Our research findings offer valuable insights that can inform and enhance the aforementioned plan. Firstly, rural areas should pay more attention to the early development of LBC, calling for joint attention from families, communities and government. For example, rural communities can establish production and living mutual aid groups to help caregivers of LBC reduce the pressure of labour burden (Li et al. 2013; Ye and Wang 2006), allowing caregivers to have more time to focus on the development of LBC. Secondly, efforts should be made to enhance the parenting support for caregivers. The government can invite experts to hold regular lectures on scientific parenting in each village and adopt rewarding knowledge competitions to attract caregivers. Concurrently, safeguarding the mental well-being of caregivers stands as a critical requisite. Establish a monitoring mechanism (Rahman et al. 2008), regularly evaluate the mental health of rural children's caregivers, and promptly identify and solve problems. These measures are urgently needed for rural children in China.

Still, it is important to acknowledge some limits. First, this study's cross-sectional methodology hampered its ability to account for any causal relationships. Second, the study did not subdivide 'one parent migrating' into 'mother migrating' or 'father migrating' because the proportion of 'mother migrating' in our sample was very limited and cannot provide sufficient data support for detailed analysis. Therefore, when considering the comprehensiveness and reliability of the research, we chose to consider 'one parent migrating' as a whole to ensure the objectivity and accuracy of the research results. Third, this study only conducted a sample survey in one region. Therefore, it is important to proceed with caution when extending and applying these findings to Chinese children. Future research can consider expanding the sample range to improve the reliability of the research results.

5 | Conclusions

Despite the aforementioned limitations, our study emphasized the risk of early developmental delay in children with different parental migration status in rural China, and examined the specific impact of parenting knowledge, parenting behaviour and caregivers' depression symptoms on the early

development of rural children. In the survey area of this study, LBC were confronted with numerous early development challenges, with BLBC encountering the most severe situation. Additionally, PLBC with left-behind experience were also at a disadvantage. Therefore, it is important to proceed with caution when extending and applying these findings to Chinese children. The results of this study can provide valuable information and knowledge for the development of intervention measures and prevention plans to promote the well-being of LBC. For future interventions in LBC, it is necessary to prioritize BLBC and ensure the inclusion of PLBC. Future research should extend these findings to more comprehensive migration status of parents.

Author Contributions

Yating Cheng: writing – original draft, investigation, data curation, formal analysis. **Yuxuan Zhu:** writing – original draft, investigation, data curation. **Ying Wang:** investigation, data curation. **Xianhong Huang:** data curation, methodology. **Tao Sun:** writing – review and editing, supervision. **Feng Wang:** conceptualization, investigation, writing – review and editing, resources, supervision, funding acquisition.

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Ethics Statement

The survey has been performed in accordance with the Declaration of Helsinki, and informed consent was obtained from children's legal guardians. This study has been approved by the Ethics Committee of Hangzhou Normal University (Number: 2023-1047).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

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

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