

Caregiver-Child Interaction Duration and Early Childhood Development: Videotaped Evidence of Home Play in Rural China

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Abstract

Background: Recent studies have begun to explore the relationship between caregiver-child interaction and early childhood development in rural China. However, there exist challenges in obtaining an accurate measurement of caregiver-child interaction, especially on caregiver-child interaction duration.

Objective: This paper uses the method of videotaping and coding to quantify caregiver-child interaction duration and examines its relationship to early childhood development.

Methods: Ten-minute home plays for each of the 488 caregiver-child dyads from rural areas in China were videotaped. A coding system was used to quantify the caregiver-child interaction duration. Children were assessed for cognition, language, motor, and social-emotional abilities using the Caregiver Reported Early Development Instrument (CREDI). Demographic information was collected by field survey.

Results: We found that rural caregiver-child dyads had relatively short interaction durations in the observed home play, especially when the primary caregiver was the child's grandmother. Mediation analysis revealed that caregiver-child interaction duration significantly mediated the relationships between different caregivers and children's cognition, language, motor, and social emotions. Moderated-mediation analysis showed that grandmothers and mothers who did not complete middle school education had significantly greater differences in interaction duration with their children compared to those who did.

Conclusion: Interventions aimed at promoting early childhood development in rural China should attach greater importance to the caregiver-child interaction duration in daily home play, especially for grandmothers with low education levels.

Keywords: Videotaped home play, Caregiver-child interaction duration, Early childhood development, Rural China

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1. Introduction

It is well established in previous literature that development during the first 3 years of life is crucial for human capital investment and has a lasting impact on adulthood. According to research lead by James Heckman, winner of the Nobel Economics Prize, the period with the highest return on human capital investment is 0-3 years of age (Carneiro & Heckman, 2003; Heckman et al., 2013). Early childhood development can also predict many aspects of adulthood, such as physical health (Campbell et al., 2014; Heckman, 2007), income level (Gertler et al., 2014; Huggett et al., 2011), social mobility (Heckman & Mosso, 2014), and other welfare indicators (Cunha & Heckman, 2007; Heckman, 2006).

Caregiver-child interaction plays a vital role in early childhood development. Previous researches have demonstrated that enriching caregiver-child interaction can stimulate early developmental outcomes (Black et al., 2017; Francesconi & Heckman, 2016). By observing and coding caregiver-child interactions, psychology studies have found that positive involvement in such interactions can be beneficial for children's subsequent cognition development (Dodici et al., 2003; Feldman et al., 1996; Tamis-LeMonda et al., 2004), literacy and language skills (Tomasello & Farrar, 1986; Yoder & Warren, 1999), motor abilities (Beckwith et al., 1976; Cohen & Beckwith, 1979) and social behaviors (Chazan-Cohen et al., 2009).

Previous psychology studies have discussed the amount of time spent on interactions and its association with early childhood abilities. By asking mothers to keep diary records and videotaping home plays by the mothers and their one-year-olds at monthly intervals, Tomasello & Todd (1983) found that infants who spent more time in joint interaction with their mothers had significantly larger vocabularies. Carpenter et al. (1998) found that the amount of time infants aged between 9 and 15 months spent in joint interaction with their mothers predicted infants' earliest skills of gestural and linguistic communication. However, little is known about the caregiver-child interaction duration in the context of rural China.

Despite China's rapid urbanization in the past decade, many pressing problems have emerged, such as the issue of left-behind children in rural areas. To raise income levels, many rural parents migrated to urban areas searching for better jobs, leaving young children in the care of their grandparents. Reports released by the All-China Women's Federation showed that there were more than 61 million left-behind children in rural China in 2013, which was three times higher than the estimated number in 2000 (ACWF, 2013). Recent domestic studies have demonstrated developmental delays in language, cognition, social emotions of children under 3 years old in rural China (Luo et al., 2019; Wei et al., 2015; Yue et al., 2017). Concerns that grandmothers are not as suitable as mothers when taking care of young children since they have relatively low education levels are growing, which possibly explains the differences in parenting behaviors (Yue et al., 2018).

Recent studies have begun to explore the relationship between caregiver-child interaction and early childhood development in rural China via questionnaires. Some researchers described caregiver-child interaction in rural families by asking caregivers questions such as "Did you tell your child stories yesterday?" "Did you sing songs to your child yesterday?" and "Did you play with your child yesterday?" (Luo et al., 2019; Yue et al., 2019). While the method of questionnaires can collect information on whether there were any caregiver-child interactions, such method is difficult to obtain accurate measurement of the caregiver-child interaction duration. Since the data collection of caregiver-child interaction duration is facing challenges, there is a lack of research on the relationship between caregiver-child interaction duration and early childhood development in rural China.

The goal of this paper is to address this gap in literature by using the videotaping and coding method to quantify caregiver-child interaction duration and examine its role in the relationship between different caregivers and early childhood development in rural China. To achieve the above goal, three research questions are proposed as follows: 1) What is the current situation of the caregiver-child interaction duration in rural families, especially the difference

between mother-child and grandmother-child dyads? 2) Does the caregiver-child interaction duration mediate the relationship between different caregivers and early childhood development? 3) Does the caregiver's education level moderate the mediated effects of caregiver-child interaction durations?

2. Method

2.1 Sample Selection

The field survey was conducted in a poverty-stricken county in Jiangxi Province, which had a middle economic level in relation to all poverty-stricken counties across China in 2018. Three out of sixteen towns in this county were randomly selected as sample towns, and a comprehensive list of all the villages from each sample town was obtained with the assistance of local officials. There were ten, nine, and eight villages in the three sample towns, respectively. All the children that were between 6 and 30 months of age and lived in the villages were included in the field survey. To identify the difference between mothers and grandmothers in their interaction with their children, this study only includes families where either the mother or the grandmother is the primary caregiver. The primary caregiver is defined as the person living in the same household who was primarily responsible for the child's care. Thus, 488 caregiver-child dyads are included in this study. The distribution of caregiver-child dyads in three sample towns are shown in Table 1.

Ethical approval for this study was obtained from Peking University Institutional Review Board (PU IRB). The grant number is IRB00001052-17056.

2.2 Data Collection

Fifty enumerators were recruited and trained before conducting the field survey. A comprehensive 5-day training was provided to the enumerators, which included the introduction of the field survey, communication skills, explanations of questionnaires and instrument content, and precautions for videotaping. Simulation tests were also conducted, during which enumerators were trained to deal with different kinds of problems, to ensure that the field survey went smoothly.

For the field study, enumerators visited each family in pairs and collected three types of information for their field survey: the caregiver-child interaction duration, early childhood development, and demographic information.

2.2.1 Caregiver-Child Interaction Duration

Fifty enumerators worked in pairs and were led into the rural households by the local officials. The local officials helped us in explaining the goal and process of this survey to the caregivers in local dialect to make sure they fully understand. Before the survey started, our enumerators would play some warm-up activities such as chatting with the caregiver or playing hide and seek with the child, in order to get acquaintance with the household and create a comfortable environment for the survey.

Each caregiver-child dyad was videotaped in a 10-minute home play. We provided a standardized set of kitchen toys for each dyad, solving the potential problem of having no toys at home. We then asked the primary caregiver to play with the child as they normally did at home. The 10-minute video only captured the caregiver-child dyad. Irrelevant people like siblings, neighbors and our enumerators could not enter the video-shooting scope. Also, our enumerators would not talk to or give advices to either the caregiver or the child. These videos of home play were later coded by trained coders for further analysis.

When coding the videos, two types of segments were defined and distinguished as interaction and non-interaction. Interactive segments contain verbal (i.e., in words) or non-

verbal signals (i.e., gestures, movements or emotions) that are sent by one party to another. Non-interaction segments contain no such signals of interaction between the dyad. An interaction segment starts from the point where one party exhibits a signal of interaction and ends when the caregiver-child dyad begins playing alone, or when both stop playing for more than 10 seconds. The ending point of the preceding interaction segment was also the starting point of the succeeding non-interactive segment, and vice versa. The caregiver-child interaction duration was defined as the sum durations of all interaction segments within the 10-minute home play.

Several measures were taken to ensure consistency among all coders. First, following the coding system for the parent-child interaction by Robinson & Eyberg (1981) and Landry et al. (2006), we developed our own coding system suitable to our research purpose. A coding manual was then carefully developed, including a list of codes, definitions of each code, and instructions on the coding scheme. Second, all coders were gathered to study the coding manual and train from case videos before the formal coding procedure. Third, 5% of the videos were randomly selected and coded by all the coders simultaneously, to test whether their consistency could meet internationally recognized standards. The Cronbach's coefficient alpha for caregiver-child interaction durations was 0.85, indicating sound consistency across all the coders (Nunnally, 1978).

2.2.2 Early Childhood Development

The Caregiver Reported Early Development Instrument (CREDI), designed by the Harvard Graduate School of Education, is used to assess for cognitive, language, motor, and social-emotional abilities of children in this study. CREDI is designed as a cross-culturally comparable and population-level measure of early childhood development for children under 3 years of age (McCoy et al., 2019; McCoy et al., 2017). CREDI comprises 108 multiple-choice questions, each corresponding to at least one domain among children's early cognition, language, motor, and social emotion abilities. Each question has three options: yes, no, and unsure. Different ages (in months) have different starting point of the instrument. The caregiver need to choose from the three options for each question according to the actual situation of the child. If the caregiver chooses to answer "no" to five questions in a row, the process then stops. If not, the caregiver continues to answer the remaining questions. We use norm-referenced standardized scores (i.e., z scores) in assessing the cognitive, language, motor, and social-emotional development of the children. The calculation rule is shown as Equation (1).

$$Z - scores = \frac{Raw_{sample} - Raw_{CREDI}}{\sigma_{age}} \quad (1.)$$

Z-scores are short for the norm-referenced standardized scores. Raw_{sample} means the average raw score of sample children. Raw_{CREDI} means the average raw score of the CREDI reference children of the same age (in month), i.e., the international norm. σ_{age} is the age specific standard deviation. A norm-referenced standardized score between -2 to 2 roughly translates to a region where 95% of the scores from the same-age reference group are located (McCoy et al., 2018).

2.2.3 Demographic Information

Demographic information was collected via survey questionnaires, including whether the primary caregiver was the mother or the grandmother, characteristics of caregivers (age and education level), characteristics of children (age in months, gender, whether the child's birthweight was lower than 2500 g, whether the child had siblings), characteristics of migrant parents (age and education level), and household characteristic (whether the household had received the minimum livelihood guarantee from the government).

2.3 Statistical Model

The models of mediation effect and moderated-mediation effect were developed according to our research goal. First, we examined a simple mediation model using ordinary least squares regression and the bootstrap method. Following Baron & Kenny (1986) and Judd & Kenny (1981), we propose a simple mediation model consisting of Equations (2) and (3), as follows:

$$Duration_i = a_0 + a_1 * Caregiver_i + \gamma_1 * Z_i + \varepsilon_{1i} \quad (2.)$$

$$ECD_i = b_0 + b_1 * Duration_i + c * Caregiver_i + \gamma_2 * Z_i + \varepsilon_{2i} \quad (3.)$$

$Duration_i$ is the mediator, which stands for caregiver-child interaction duration. $Caregiver_i$ is the key independent variable, which stands for the primary caregiver (mother or grandmother) of child i . ECD_i is the dependent variable, which stands for the early childhood development of child i , including CREDI scores of cognition, language, motor, and social emotion. Z_i accounts for the covariates, which include characteristics of the children, caregivers, and households, as well as the fixed effects of coders and villages. ε_{1i} and ε_{2i} are error terms. The product $a_1 b_1$ is the mediation effect.

We then followed Preacher et al. (2007) and developed the moderated mediation model, comprising Equations (4):

$$\begin{aligned} Duration_i &= a_0 + a_1 * Caregiver_i + a_2 * Edu_care_i + a_3 * Caregiver_i * Edu_care_i + \gamma_3 * Z'_i + \varepsilon_{3i} \\ &= (a_0 + a_2 * Edu_care_i) + (a_1 + a_3 * Edu_care_i) * Caregiver_i + \gamma_3 * Z'_i + \varepsilon_{3i} \end{aligned} \quad (4.)$$

and Equation (5):

$$\begin{aligned} ECD_i &= b_0 + b_1 * Duration_i + c'_1 * Caregiver_i + c'_2 * Edu_care_i + c'_3 * Caregiver_i * Edu_care_i \\ &\quad + \gamma_4 * Z'_i + \varepsilon_{4i} \\ &= (b_0 + c'_2 * Edu_care_i) + (c'_1 + c'_3 * Edu_care_i) * Caregiver_i + b_1 * Duration_i + \gamma_4 * Z'_i + \varepsilon_{4i} \end{aligned} \quad (5.)$$

The moderator, Edu_care_i , stands for the caregiver's education level. The product term $Caregiver_i * Edu_care_i$ denotes the product of the key independent variable and the moderator. Z'_i accounts for the covariates. ε_{3i} and ε_{4i} are error terms. The product term $(a_1 + a_3 * Edu_care_i)b_1$ indicates the moderated mediation effect of the caregiver's education level. The moderated-mediation model is depicted in Figure 1.

Three types of 95% confidence intervals are calculated to test the statistical significance of the mediation effects $a_1 b_1$ and the moderated mediation effects $(a_1 + a_3 * Edu_care_i)b_1$. The BC confidence interval corrects for bias, while BCa corrects for both bias and skewness in the distribution of bootstrap estimates of standard errors, on the basis of the percentile method (Efron, 1987), which optimizes confidence intervals and inference (MacKinnon et al., 2004). The mediation and moderated-mediation effects are statistically significant if the confidence intervals do not contain zero. Stata 15.0 is used for the statistical analysis.

3. Results

3.1 Descriptive Statistics

The definition of variables and summary statistics by different caregivers are shown in Table 2. Note that the caregiver-child interaction duration was 4.443 minutes on average, which is less than half of the 10 minutes. The average duration of the mother-child interaction was 4.858 minutes, which was 0.926 minutes longer than the average duration for the grandmother-child interaction. Therefore, grandmothers tended to interact less than mothers with their children in our rural sample.

Negative scores indicated poorer early childhood development compared to the international norms for the same age group (measured in months). As shown in Table 2, the

children of our study had poorer early developmental abilities comparing to the international norm. More specifically, children raised by their grandmothers had lower CREDI scores in cognition (-0.554<-0.155), language (-0.497<-0.066), motor (-0.270<-0.020), and social emotion (-0.330<0.080) than those raised by their mothers (see Figure 2).

Figure 3 shows the correlation between caregiver-child interaction duration and CREDI scores of children. The longer the caregiver-child interaction duration, the higher the CREDI scores for cognition, language, motor, and social emotion, indicating better early development of the corresponding domains. If the caregiver and child interacted for roughly less than 7 minutes, children had poorer early developmental abilities compared to international norms.

3.2 Tests of Mediation Effects

To better assess the mediation effects, we applied the bootstrap resampling method, following MacKinnon et al. (2004) and Shrout & Bolger (2002). Bootstrap results of the mediation analysis are based on 1000 resampling and are shown in Table 3. Point estimates for the mediation effects a_1b_1 are 0.049 (SE=0.026) when the dependent variables are cognition, 0.059 (SE=0.036) when language, 0.046 (SE=0.030) when motor, and 0.062 (SE=0.031) when social emotion. Furthermore, neither of the corresponding percentile, BC, and BCa 95% confidence intervals include zero, which proves that caregiver-child interaction durations significantly mediate the relationship between different caregivers and the cognitive, language, motor, and social-emotional development of children. In other words, the mother-child interaction duration was significantly longer than the grandmother-child interaction duration, which is related to significantly higher scores for cognition, language, motor, and social emotion in children.

3.3 Tests of Moderated-Mediation Effects

The moderated mediation model was developed by setting the caregiver's education level as the moderator and then adding the interaction term of the moderator and key independent variable. As displayed in Section 2.3, the product term $(a_1 + a_3 * Edu_care_i)b_1$ indicated the moderated mediation effect of the caregiver's education level. When this level was under middle school (i.e., $Edu_care_i = 0$), the point estimate of the moderated mediation effect $(a_1 + a_3 * Edu_care_i)b_1 = (a_1 + a_3 * 0)b_1 = a_1b_1$. When the caregiver's education level was middle school and above (i.e., $Edu_care_i = 1$), the point estimate $(a_1 + a_3 * Edu_care_i)b_1 = (a_1 + a_3 * 1)b_1 = (a_1 + a_3)b_1$.

Table 4 presents the bootstrap results of the moderated mediation effects. As shown in the table, the moderated-mediation effects $(a_1 + a_3 * Edu_care_i)b_1$ were stronger and significant when the caregiver's education level fell under middle school. Point estimates of moderated-mediation effects were 0.056 (SE=0.033) when the dependent variable was cognition, 0.068 (SE=0.041) when language, 0.052 (SE=0.033) when motor, and 0.071 (SE=0.037) when social emotion. Furthermore, the corresponding percentile, BC, BCa 95% confidence intervals did not include zero when the caregiver's education level was under middle school. However, the moderated-mediation effects $(a_1 + a_3 * Edu_care_i)b_1$ were weaker and insignificant when the caregiver's education level was middle school and above, and the corresponding percentile, BC, BCa 95% confidence intervals did include zero. Therefore, the caregiver's education level significantly moderated the strength of the mediation effects of caregiver-child interaction durations in the relationship between different caregivers and the early cognitive, language, motor, and social-emotional development of children.

To understand the results of moderated mediation effects more intuitively, Figure 4 presents the difference between mother-child and grandmother-child interaction durations, moderated by caregivers' education level. Caregivers who did not complete middle school showed a greater difference between mother-child and grandmother-child interaction durations compared to those who did. The mediated effects were stronger for caregivers with

low education levels. In other words, if the education level of caregivers is increased, the improvement in children's early development (via increased caregiver-child interaction durations) would be larger when the caregiver is a grandmother, rather than when the caregiver is the mother.

4. Discussion

Previous studies on rural caregiver-child interaction mainly used questionnaires to gain information on the existence or types of caregiver-child interaction (whether the caregiver had read to / sing songs to / play with the child yesterday) (Luo et al., 2019; Wei et al., 2015; Yue et al., 2017). As a result, detailed measurement such as interaction duration is hard to obtain. However, the method of videotaping and coding can gain accurate measurement on interaction duration and solve the problem of measurement error, as what we did in this study, which enrich our understanding on caregiver-child interaction in rural China.

In addition, we found that rural caregiver-child dyads had relatively short interaction durations in the observed home play. Existing literature points out that there may be several reasons for the above phenomenon. Yue et al. (2017) suggested that busy farming and housework may be the reason of such limited interaction time between rural caregivers and children. Wei et al. (2015) found that 75.0% of the children had no books and 10.4% had no toys, which indicates the severely inadequate learning opportunities for young children in rural China. Besides that, caregiver's personal characteristics such as lack of proper parenting knowledge (Luo et al., 2019) and inaccurate parental belief (Wei et al., 2015) may also be the reasons of inadequate interactions. In this paper, we found that even provided with play equipment and appointed time, rural caregivers still interact for only a short period with their children. Our findings imply that in addition to play materials and time constraints (Yue et al., 2017), inaccurate parental belief (Wei et al., 2015), and lack of proper parenting knowledge (Luo et al., 2019), poor parenting skills may also lead to limited interaction durations.

Findings in this paper also showed that caregiver-child interaction duration is positively correlated with early childhood development. This is in line with some previous psychology studies that infants who spent more time in joint interaction with their mothers had significantly larger vocabularies (Tomasello & Todd, 1983) and better earliest skills of gestural and linguistic communication (Carpenter et al., 1998). However, the above literature only examined the link between interaction duration and one specific domain of early childhood development like language. Findings in this paper enrich the link between caregiver-child interaction duration and different domains of early childhood development, and provide empirical evidence in the context of rural China.

Furthermore, the findings also indicate the mediation effects of caregiver-child interaction duration in the relationship between different caregivers and early childhood development. Mothers tended to have longer interaction duration with their child, which in turn, correlated to better development on early cognitive, language, motor, and social-emotional abilities. This mediation model is theoretically informed, and is consistent with previous studies that caregivers' impact on early childhood development may function through home environment (Petrill et al., 2004), socioeconomic status (Barrett & Turner, 2005), parental investment (Zhong et al., 2020), parenting practices (Zhong et al., 2021), caregiver's mental health (He et al., 2020; Petterson & Albers, 2001) and so on. Findings of the mediation effects of caregiver-child interaction duration in this study add to the emerging literature about the influence mechanism of early childhood development.

Finally, findings on the moderating role of caregiver's education level further refine the influence mechanism. Previous studies have mainly considered the caregiver's education level as a control variable in study designs and analyzed the relationships between feeding practices (Yue et al., 2018), parenting behaviors (Luo et al., 2019), caregiver's mental health (Zhong et al., 2021) and early childhood development. One step further than the existing

literature, we examined the moderating role of caregiver's education level in the relationships between different caregivers, caregiver-child interaction duration, and early childhood development, which helps to get a deeper understanding on caregiver-child dyads in rural China.

This study has two policy implications. First, rural caregivers need to spend more time interacting with their children in daily home play, rather than just watching them play alone, or interacting with them only for a short period. Second, interventions aimed at promoting early developmental outcomes of children in rural China should attach greater importance to the caregiver-child interaction duration and provide rural caregivers with scientific parenting knowledge, proper parenting belief and parenting skills. In addition, more guidance on parenting should be given to rural grandmothers, especially those with low education levels.

We acknowledge that there are some limitations in this study. First, with cross-sectional data, we could only analyze the correlation between caregiver-child interaction duration and early childhood development, rather than inferring causal relationships. Second, caregiver-child interaction duration is only one of the many measurements for caregiver-child interaction qualities. Further research is needed to enrich the knowledge of daily caregiver-child interaction in other aspects of families living in rural China, and to provide evidence for more comprehensive and targeted early childhood services.

5. Conclusion

In conclusion, this paper quantified caregiver-child interaction duration by using the method of videotaping and coding and examined its role in the relationship between different caregivers and early childhood development. Our study finds that rural caregivers had relatively short interaction durations with their children. Compared to mothers, grandmothers tended to interact less with their children, which in turn related to lower scores for cognition, language, motor, and social emotions in children. For caregivers with low education level, the difference of interaction durations between mother-child dyads and grandmother-child dyads was larger. Interventions aimed at promoting early childhood development in rural China should attach greater importance to caregiver-child interaction durations in daily home play, especially for grandmothers with lower education level.

CRedit authorship contribution statement:

Yuting Chen: Methodology, Validation, Formal analysis, Writing - original draft, Writing - review & editing. **Jingjing Gao:** Project administration, Writing - review & editing. **Yang He:** Software, Writing - review & editing. **Tianyi Wang:** Supervision, Visualization, Writing - review & editing. **Chengfang Liu:** Writing - review & editing. **Renfu Luo:** Conceptualization, Resources, Writing - review & editing, Investigation, Funding acquisition.

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Reference

- ACWF. (2013). Research report into the situation of rural left behind children and rural to urban migrant children in China. Retrieved from <http://acwf.people.com.cn/n/2013/0510/c99013-21437965.html>
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of personality and social psychology*, 51(6), 1173.
- Barrett, A. E., & Turner, R. J. (2005). Family structure and mental health: The mediating effects of socioeconomic status, family process, and social stress. *Journal of health and social behavior*, 46(2), 156-169.
- Beckwith, L., Cohen, S. E., Kopp, C. B., et al. (1976). Caregiver-infant interaction and early cognitive development in preterm infants. *Child Development*, 579-587.
- Black, M. M., Walker, S. P., Fernald, L. C., et al. (2017). Early childhood development coming of age: science through the life course. *The Lancet*, 389(10064), 77-90.
- Campbell, F., Conti, G., Heckman, J. J., et al. (2014). Early childhood investments substantially boost adult health. *Science*, 343(6178), 1478-1485.
- Carneiro, P. M., & Heckman, J. J. (2003). Human capital policy.
- Carpenter, M., Nagell, K., Tomasello, M., et al. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the society for research in child development*, i-174.
- Chazan-Cohen, R., Raikes, H., Brooks-Gunn, J., et al. (2009). Low-Income Children's School Readiness: Parent Contributions Over the First Five Years. *Early Education & Development*, 20(6), 958-977. doi:10.1080/10409280903362402
- Cohen, S. E., & Beckwith, L. (1979). Preterm infant interaction with the caregiver in the first year of life and competence at age two. *Child Development*, 767-776.
- Cunha, F., & Heckman, J. (2007). The technology of skill formation. *American Economic Review*, 97(2), 31-47.
- Dodici, B. J., Draper, D. C., & Peterson, C. A. (2003). Early parent—child interactions and early literacy development. *Topics in Early Childhood Special Education*, 23(3), 124-136.
- Efron, B. (1987). Better bootstrap confidence intervals. *Journal of the American statistical Association*, 82(397), 171-185.
- Feldman, R., Greenbaum, C. W., Yirmiya, N., et al. (1996). Relations between cyclicity and regulation in mother-infant interaction at 3 and 9 months and cognition at 2 years. *Journal of Applied Developmental Psychology*, 17(3), 347-365.
- Francesconi, M., & Heckman, J. J. (2016). Child development and parental investment: Introduction. *The Economic Journal*, 126(596), F1-F27.
- Gertler, P., Heckman, J., Pinto, R., et al. (2014). Labor market returns to an early childhood stimulation intervention in Jamaica. *Science*, 344(6187), 998-1001.
- He, Y., Liu, C., Chen, Y., et al. (2020). Intergenerational transmission of parenting style in rural China and the mediation effect of Caregiver's mental health. *Children and Youth Services Review*, 117, 105319.
- Heckman, J., Pinto, R., & Savelyev, P. (2013). Understanding the mechanisms through which an influential early childhood program boosted adult outcomes. *American Economic Review*, 103(6), 2052-2086.
- Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science*, 312(5782), 1900-1902.
- Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the national Academy of Sciences*, 104(33), 13250-13255.
- Heckman, J. J., & Mosso, S. (2014). The Economics of Human Development and Social Mobility. *Annual Review of Economics*, 6(1), 689-733. doi:10.1146/annurev-economics-080213-040753
- Huggett, M., Ventura, G., & Yaron, A. (2011). Sources of lifetime inequality. *American Economic Review*, 101(7), 2923-2954.
- Judd, C. M., & Kenny, D. A. (1981). Process analysis: Estimating mediation in treatment evaluations. *Evaluation review*, 5(5), 602-619.
- Landry, S. H., Smith, K. E., & Swank, P. R. (2006). Responsive parenting: establishing early foundations for social, communication, and independent problem-solving skills.

- Developmental psychology*, 42(4), 627.
- Luo, R., Jia, F., Yue, A., et al. (2019). Passive parenting and its Association with Early Child Development. *Early Child Development and Care*, 189(10), 1709-1723. doi:10.1080/03004430.2017.1407318
- MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, 39(1), 99-128.
- McCoy, D. C., Cuartas, J., Waldman, M., et al. (2019). Contextual variation in young children's acquisition of social-emotional skills. *PloS one*, 14(11), e0223056.
- McCoy, D. C., Sudfeld, C. R., Bellinger, D. C., et al. (2017). Development and validation of an early childhood development scale for use in low-resourced settings. *Population health metrics*, 15(1), 3.
- McCoy, D. C., Waldman, M., Team, C. F., et al. (2018). Measuring early childhood development at a global scale: evidence from the Caregiver-Reported early development instruments. *Early childhood research quarterly*, 45, 58-68.
- Nunnally, J. C. (1978). *Psychometric Theory: 2d Ed*: McGraw-Hill.
- Petrill, S. A., Pike, A., Price, T., et al. (2004). Chaos in the home and socioeconomic status are associated with cognitive development in early childhood: Environmental mediators identified in a genetic design. *Intelligence*, 32(5), 445-460.
- Petterson, S. M., & Albers, A. B. (2001). Effects of poverty and maternal depression on early child development. *Child Development*, 72(6), 1794-1813.
- Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioral Research*, 42(1), 185-227.
- Robinson, E. A., & Eyberg, S. M. (1981). The dyadic parent-child interaction coding system: Standardization and validation. *Journal of consulting and clinical psychology*, 49(2), 245.
- Shrout, P. E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: new procedures and recommendations. *Psychological methods*, 7(4), 422.
- Tamis - LeMonda, C. S., Shannon, J. D., Cabrera, N. J., et al. (2004). Fathers and mothers at play with their 2 - and 3 - year - olds: Contributions to language and cognitive development. *Child Development*, 75(6), 1806-1820.
- Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development*, 1454-1463.
- Tomasello, M., & Todd, J. (1983). Joint attention and lexical acquisition style. *First language*, 4(12), 197-211.
- Wei, Q. W., Zhang, J. X., Scherpbier, R. W., et al. (2015). High prevalence of developmental delay among children under three years of age in poverty-stricken areas of China. *Public Health*, 129(12), 1610-1617. doi:10.1016/j.puhe.2015.07.036
- Yoder, P. J., & Warren, S. F. (1999). Maternal responsivity mediates the relationship between prelinguistic intentional communication and later language. *Journal of Early Intervention*, 22(2), 126-136.
- Yue, A., Shi, Y., Luo, R., et al. (2017). China's invisible crisis: Cognitive delays among rural toddlers and the absence of modern parenting. *The China Journal*, 78(1), 50-80.
- Yue, A., Shi, Y., Luo, R., et al. (2019). Stimulation and Early Child Development in China: Caregiving at Arm's Length. *Journal of Developmental & Behavioral Pediatrics*, 40(6), 458-467.
- Yue, A., Zhang, N., Liu, X., et al. (2018). Do Infant Feeding Practices Differ Between Grandmothers and Mothers in Rural China? Evidence From Rural Shaanxi Province. *Family & community health*, 41(4), 233-243.
- Zhong, J., Gao, J., Wang, T., et al. (2020). Interrelationships of parental belief, parental investments, and child development: A cross-sectional study in rural China. *Children and Youth Services Review*, 118, 105423.
- Zhong, J., Wang, T., He, Y., et al. (2021). Interrelationships of caregiver mental health, parenting practices, and child development in rural China. *Children and Youth Services Review*, 121, 105855.

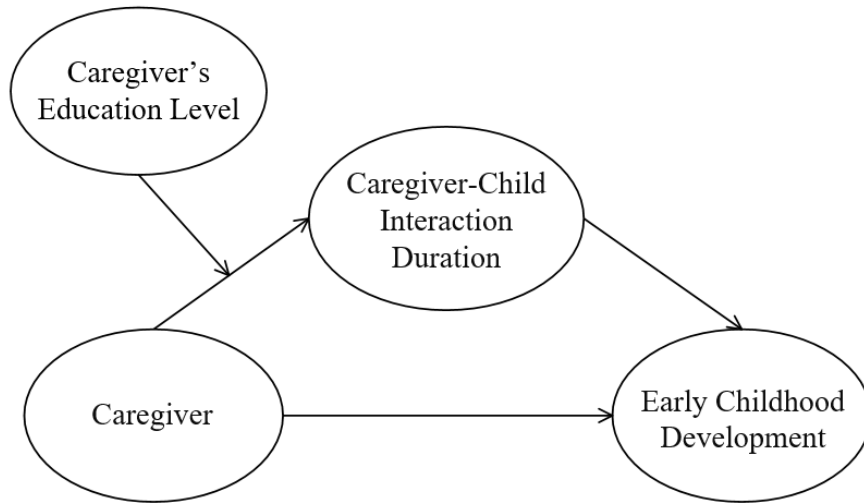


Figure 1: Moderated-Mediation Model

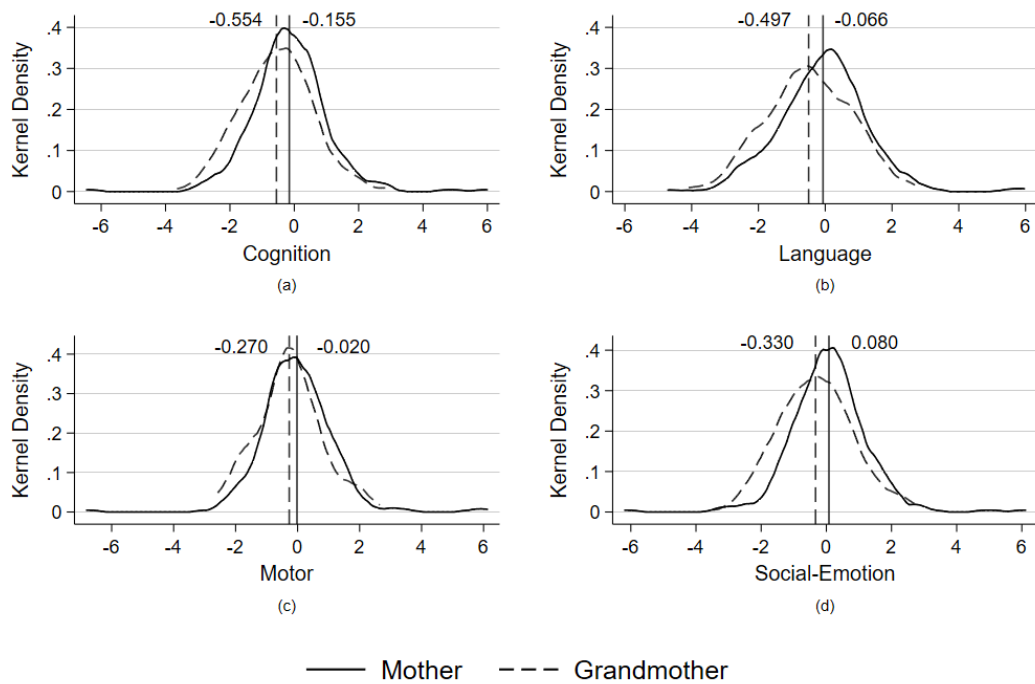


Figure 2: Density Distributions of CREDI Scores of Children Raised by Mothers and Grandmothers

Data Source: Authors' Survey

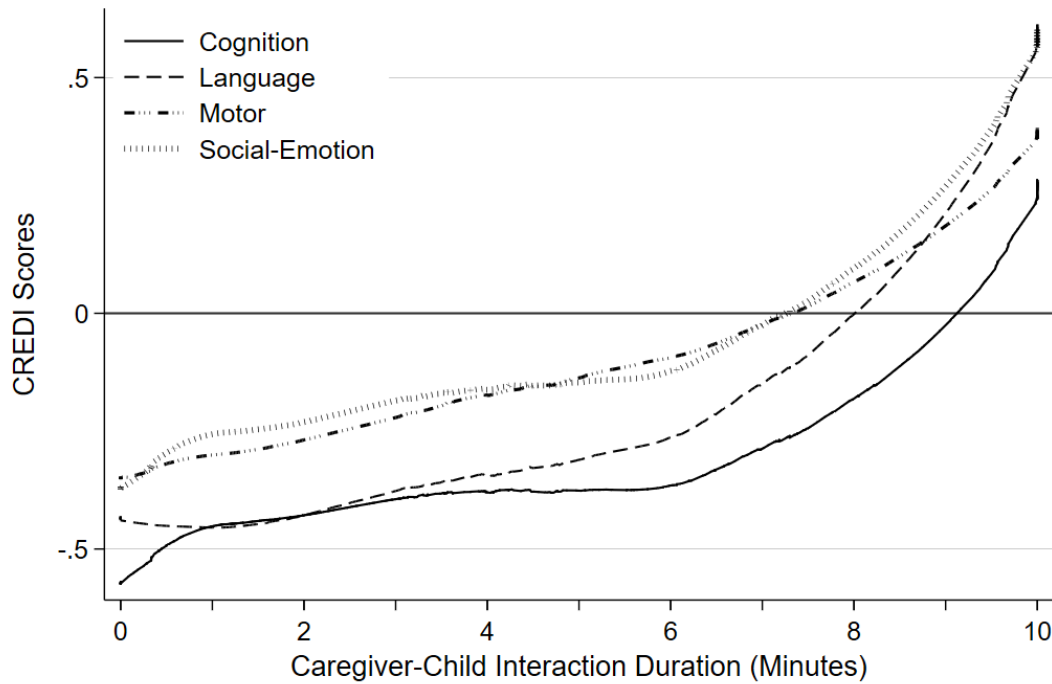


Figure 3: The Correlations Between Caregiver-Child Interaction Duration and CREDI Scores of Children

Data Source: Authors' Survey

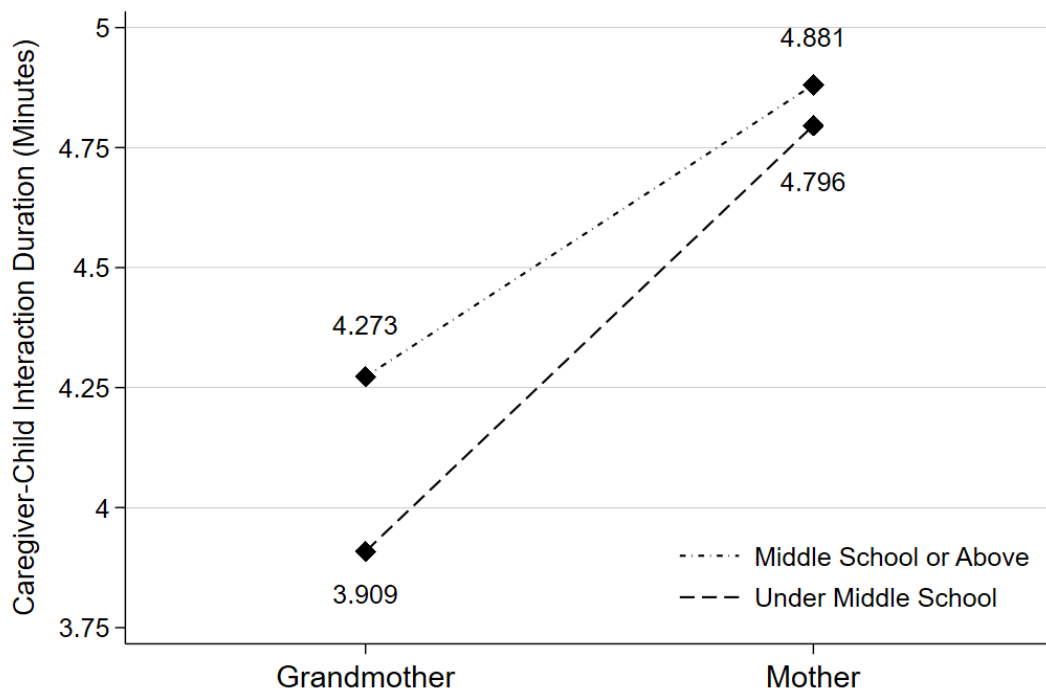


Figure 4: Caregiver-child Interaction Duration Predicted by Different Caregivers Moderated by Caregiver's Education Levels

Data Source: Authors' Survey

Table 1 Distribution of Primary Caregivers in Sample Towns

Primary Caregiver	Town A	Town B	Town C	Total
Mother	87 (60.4%)	89 (56.7%)	93 (50.3%)	269 (55.1%)
Grandmother	57 (39.6%)	68 (43.3%)	92 (49.7%)	219 (44.9%)

Data Source: Authors' Survey

Table 2 Summary Statistics by Caregivers

Variable	All Sample (1)	Mother (2)	Grandmother (3)	P-value Ho: (2)=(3)
Cognition	-0.33 (1.17)	-0.16 (0.07)	-0.55 (0.07)	0.00***
Language	-0.26 (1.32)	-0.07 (0.08)	-0.50 (0.09)	0.00***
Motor	-0.13 (1.14)	-0.02 (0.07)	-0.27 (0.07)	0.02**
Social-emotion	-0.10 (1.18)	0.08 (0.07)	-0.33 (0.08)	0.00***
Interaction duration	4.44 (3.12)	4.86 (0.20)	3.93 (0.19)	0.00***
Caregiver's education level	0.43 (0.50)	0.73 (0.03)	0.06 (0.02)	0.00***
<i>(1=middle school and above, 0=below middle school)</i>				
Caregiver's age	40.90 (14.15)	29.01 (0.28)	55.51 (0.39)	0.00***
Child's gender (1=male, 0=female)	0.52 (0.50)	0.52 (0.03)	0.51 (0.03)	0.70
Child's age in months	17.38 (6.50)	16.23 (0.41)	18.79 (0.40)	0.00***
Child's birth weight	0.04 (0.19)	0.05 (0.01)	0.02 (0.01)	0.10*
<i>(1=low birth weight, 0=normal birth weight)</i>				
Child has siblings (1=yes, 0=no)	0.61 (0.49)	0.68 (0.03)	0.53 (0.03)	0.00***
Migrant parents' ages	30.33 (4.56)	31.32 (0.31)	29.10 (0.23)	0.00***
Migrant parents' education levels	0.80 (0.40)	0.87 (0.02)	0.72 (0.03)	0.00***
<i>(1=middle school and above, 0=below middle school)</i>				
Poverty (1=yes, 0=no)	0.13 (0.34)	0.12 (0.02)	0.15 (0.02)	0.38

Data Source: Authors' Survey

*** p < 0.01, ** p < 0.05, * p < 0.1.

Table 3 Multivariate Regression of the Mediation Effects

Variables	Duration	Cognition	Language	Motor	Social emotion
Interaction duration		0.050*** (0.015)	0.061*** (0.017)	0.047*** (0.014)	0.063*** (0.014)
Caregiver (1=mother, 0=grandmother)	0.975** (0.463)	0.067 (0.158)	0.283 (0.181)	0.058 (0.118)	0.138 (0.171)
Caregiver's education level (1=middle school and above, 0=below middle school)	-0.014 (0.346)	0.247* (0.138)	0.174 (0.176)	0.107 (0.108)	0.201 (0.155)
Caregiver's age (1=65 years old and above, 0=less than 65 years old)	-0.484 (0.790)	-0.167 (0.374)	-0.170 (0.502)	-0.168 (0.245)	-0.061 (0.365)
Child's age in months	0.092*** (0.019)	-0.033*** (0.010)	0.016* (0.009)	-0.010 (0.009)	-0.022** (0.010)
Child's gender (1=male, 0=female)	0.042 (0.327)	-0.318** (0.134)	-0.451*** (0.123)	-0.277* (0.138)	-0.364** (0.142)
Child's birth weight (1=low birth weight, 0=normal)	0.546 (0.744)	-0.838*** (0.193)	-0.655* (0.360)	-0.812*** (0.211)	-0.709*** (0.189)
Child had siblings (1=yes, 0=no)	-0.611 (0.373)	-0.058 (0.110)	-0.048 (0.117)	-0.023 (0.124)	-0.054 (0.121)
Migrant parents' ages	-0.008 (0.036)	0.003 (0.015)	-0.006 (0.017)	0.000 (0.015)	-0.003 (0.013)
Migrant parents' education level (1=middle school and above, 0=below middle school)	0.452 (0.461)	0.415*** (0.132)	0.422** (0.163)	0.436*** (0.120)	0.446*** (0.136)
Poverty (1=yes, 0=no)	-0.004 (0.419)	-0.091 (0.108)	0.071 (0.155)	-0.060 (0.142)	-0.105 (0.120)
Coder FE	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes
Observations	488	488	488	488	488
R ²	0.225	0.190	0.181	0.153	0.185

Notes: Table 2 reports the regression results indicated by Eq. (1) – (2). Standard errors present in parentheses are clustered at the village level.

*** p < 0.01, ** p < 0.05, * p < 0.1.

Table 4 Bootstrap Results of Mediation Analysis

Dependent Variable	Point Estimate	S.E.	95% Confidence Interval		
			Percentile	BC	BCa
Cognition	0.049**	0.026	(0.006,0.108)	(0.011,0.120)	(0.011,0.120)
Language	0.059**	0.036	(0.008,0.146)	(0.010,0.162)	(0.010,0.162)
Motor	0.046**	0.030	(0.005,0.122)	(0.005,0.124)	(0.005,0.124)
Social emotion	0.062**	0.031	(0.009,0.129)	(0.013,0.139)	(0.013,0.139)

Note: (i) Table 2 reports the bootstrap estimates of mediation effects of caregiver-child interaction duration. The dependent variables are CREDI scores of children's cognition, language, motor, and social emotion. The mediator is caregiver-child interaction duration. The key independent variable is the caregiver (mother or grandmother). The point estimate a_1b_1 measures the mediation effects in Eq. (2) – (3).

(ii) Bootstrap standard errors are based on resampling with 1000 replications.

(iii) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5 Bootstrap Results of Moderated-Mediation Analysis

Dependent Variable	Value of Moderator	Point Estimate	S.E.	95% Confidence Interval		
				Percentile	BC	BCa
Cognition	0	0.056**	0.033	(0.007,0.137)	(0.011,0.144)	(0.011,0.141)
	1	0.021	0.042	(-0.057,0.111)	(-0.046,0.130)	(-0.049,0.130)
Language	0	0.068**	0.041	(0.004,0.159)	(0.007,0.170)	(0.007,0.169)
	1	0.025	0.049	(-0.073,0.120)	(-0.065,0.128)	(-0.068,0.127)
Motor	0	0.052**	0.033	(0.002,0.132)	(0.006,0.147)	(0.006,0.147)
	1	0.019	0.040	(-0.060,0.113)	(-0.049,0.132)	(-0.050,0.126)
Social emotion	0	0.071**	0.037	(0.009,0.155)	(0.016,0.164)	(0.016,0.164)
	1	0.026	0.049	(-0.078,0.123)	(-0.075,0.126)	(-0.078,0.123)

Note: (i) Table 5 reports the bootstrap estimates of moderated mediation effects of caregiver's education level. The dependent variables are CREDI scores of children's cognition, language, motor, and social emotion. The mediator is caregiver-child interaction duration. The key independent variable is the caregiver (mother or grandmother). The moderator is caregiver's education level. The point estimate $(a_1 + a_3 * Edu_care_i)b_1$ measures the moderated mediation effect in Eq. (4) – (5).

(ii) Bootstrap standard errors are based on resampling with 1000 replications.

(iii) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.