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Are infant/toddler developmental delays a problem across rural China?

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ABSTRACT

Using the Bayley Scales of Infant and Toddler Development-III (BSID-III), we examine the rates of developmental delays among children aged 0–3 years in four major subpopulations of rural China, which, altogether, account for 69% of China's rural children and 49% of children nationwide. The results indicate that 85% of the 3,353 rural children in our sample suffer from at least one kind of developmental delay. Specifically, 49% of the children have cognitive delays, 52% have language delays, 53% have social-emotional delays, and 30% have motor delays. The results suggest that these high rates are due to two main factors in the parenting environment. The first is micronutrient deficiencies, which are reflected in a high prevalence of anemia (42%). The second is an absence of interactive parenting inputs, such as storytelling, reading, singing, and playing. Although we find these inputs to be significantly and positively associated with better developmental outcomes, only a small share of caregivers engage in them. With this large and broad sample, we show that, if China hopes to build up enough human capital to transition to a high-income economy, early childhood development in rural areas urgently requires more attention.

1. Introduction

Investments in early childhood development (ECD) have lifelong effects on an individual, are essential for human capital accumulation, and, ultimately, contribute to economic growth. The first few years of life are critical, as the brain is vulnerable to biological, environmental, and psychosocial factors (Grantham-McGregor et al., 2007). The healthy cognitive development of children not only is an inherently important goal but also affects later life outcomes, such as educational attainment, employment, and earnings (Attanasio et al., 2015; Heckman et al., 2010). Research also has shown that investment in ECD can support economic growth, as nations need high levels of human capital to develop into higher wage, higher value-added economies (Rolnick and Grunewald, 2003).

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Despite the potential for significant returns on investment, negative ECD outcomes persist in diverse populations around the world. A recent *Lancet* review paper indicates that poor cognitive development is a common problem among developing countries (Black et al., 2013). Per the authors' estimate, approximately 250 million children (43%) below five years of age across all low and middle-income countries are at risk of long-term reduced cognition. A significant share of at-risk children may live in one of these countries – China, which is home to approximately 45 million 0–3 year olds and suffers from a severe urban-rural gap in terms of economics resources and educational attainment (Xie and Zhou, 2014; Wang et al., 2018).

The potential pervasiveness of ECD delays in rural China may have serious consequences for China's future. Overall, rural children account for nearly 70% of the nation's children aged 0–3 (approximately 15 million are born each year; National Bureau of Statistics, 2010). Cognitive delays among such a large share of the nation's future labor force may have critical implications for future growth and stability (Khor et al., 2016). Moreover, delays of non-cognitive skills have also been shown to be deleterious for both individual prospects as well as the wages and productivity of the labor force (Heckman et al., 2006). Research has shown that continued economic advancement for middle-income countries, such as China, hinges on human capital accumulation (Barro, 1991; Kharas and Kohli, 2011), which may be impeded if large shares of the future labor force are unable to achieve high levels of education due to childhood developmental delays. Because a key ingredient of a strong human capital base is healthy ECD, addressing delayed development among China's rural children is critical to the overall economic development efforts of China's government.

Overall, findings in both developed and developing countries demonstrate that malnutrition, poor health, and the absence of a stimulating home environment are factors that are systematically associated with developmental delays (Attanasio et al., 2015; Grantham-McGregor et al., 2007). Based on these studies, high-quality nutritional inputs and interactive parental inputs have been causally associated with better developmental outcomes. The extent to which these issues are prevalent in rural China and the degree to which they are linked to low ECD, however, are still unclear.

Despite the importance of ECD outcomes in rural China, to date, there have been no large-scale studies that examine either the extent of developmental delays or the relationship between ECD and parenting environments in these rural regions. Most of the research undertaken in China has focused on urban populations. By examining the proportion of the population of infants and toddlers (ages 2–36 months) who scored less than 80 (or 1.3 standard deviations (SDs) below the normalized mean) using the Bayley Scales of Infant Development (BSID), the cognitive outcomes of China's urban populations have been found to be consistent with or lower than those found in healthy populations worldwide. The proportion of infants and toddlers who achieved age-appropriate cognitive development scores of <80, or ≤ 1.3 SDs, as measured by the BSID Mental Development Index (MDI), was 9.1% in Guangzhou ($N = 297$), 7.9% in Xi'an ($N = 206$), and 4.9% in Wuhan ($N = 122$) (Shi et al., 2001; Sun et al., 1996; Xie et al., 2006). In comparison, in healthy populations worldwide, rates of developmental delay have been found to be approximately 15% (Boyle et al., 1994; Rozelle, 2016).

Only three studies measured ECD delays among children in rural China (Luo et al., 2017a; Xu et al., 2009; Yue et al., 2017). Although these studies indicate that developmental delays may be especially prevalent in rural areas, all three were limited in the breadth of the samples that they used, as they included caregiver-toddler dyads from only one rural sub-population: Western China. In addition, none of these studies simultaneously investigated both the potential role of nutrition and the parenting environment as underlying contributors to poor ECD outcomes. The relatively limited scale and extent of these studies indicates a pressing need for more detailed investigations of wider scope.

In this study, we aim to address this gap in the literature by analyzing a large sample of children in rural communities across different subpopulations in China through measuring a range of ECD outcomes as well as nutritional and parental inputs that previous studies have shown to be associated with ECD outcomes. This paper is the first to present evidence on the prevalence of these issues across such a large sample, one that is more representative than any other study regarding ECD in rural China. In particular, this study assesses developmental outcomes and parenting environments for samples of randomly drawn child-caregiver dyads from across four major rural subpopulations in China, which, together, represent nearly half of all children in China. Further, this paper is the first to both produce estimates of multiple measures of developmental outcomes in rural China and explore the relationship between these outcomes and various environmental factors, such as nutrition and interactive parental investments, across a sample of this breadth.

The paper is structured as follows. In Section 2, we describe our sampling and modeling methodology, and in Section 3, we present our results. The paper ends with a discussion and conclusions in Section 4.

2. Sampling, data, and methodology

2.1. Data

In this paper, we analyze results from the broadest, most comprehensive study conducted in rural China thus far, which was administered across multiple provinces in the following rural subpopulations (Table 1): Western China rural communities, resettlement communities, Central China rural communities, and migrant communities.[1] This division of China's rural population is found in the Communiqué on Major Data of the Second National Agricultural Census of China (National Bureau of Statistics, 2008). When

[1] In this paper, we do not examine one of China's other large rural subpopulations—rural communities in the East Coast region of China, which, according to the 2015 Micro-Census, accounts for 36% of all rural individuals in China. Given that it is China's richest, most highly educated rural subpopulation, we assume that rural infants and toddlers are closer in developmental stages to their urban counterparts, based on prior research in the region (Yang & Liu, 2016).

Table 1
Summary of Project 1–Project 5.

Study	Location of study	Date	Community type	Ages of children	Number of observations
Project 1	Southern Shaanxi	2015–16	Western China Rural Communities	6–24 months	1804
Project 2	Hebei; Yunnan	2015–16	Western China Rural Communities	6–30 months	638
Project 3	Guizhou	2017	Western China Rural Communities	6–30 months	444
Project 4	Southern Shaanxi; Henan	2017	Resettlement Migration Communities	6–30 months	135
Project 5a	Henan; Central Shaanxi	2017	Central China Rural Communities	6–30 months	128
Project 5b	Beijing; Zhengzhou, Henan; Xi'an, Shaanxi	2017	Migrant Communities	6–30 months	204

extrapolating the data from our studies in the different sub-regions to national trends, we were careful to use government distinctions and relied on statistical yearbook data to weight our sample populations according to population counts (see online appendix for further details).

2.2. Sample selection

Our overall sampling strategy for the western rural subpopulation is as follows. First, we randomly chose nationally designated poor counties from four provinces (Shaanxi, Hebei, Yunnan, and Guizhou). Second, we created a list of all townships in each county, excluding the relatively richer townships that were co-located in the county seat. From this list, we randomly selected one township to participate in the study. Third, we chose villages in each township to include in the study. Fourth, to choose sample households in selected villages, we obtained a list of all registered births from local village family planning officials. For all of these subpopulations, children between 6 and 30 months of age and their caregivers were enrolled in the study.

To sample central rural communities, we used a similar procedure. After choosing sample counties, sample towns and villages were randomly selected from comprehensive lists of all towns and villages. In addition, in each central China sample community, we randomly chose households with children between 6 and 30 months of age.

For the resettlement community subpopulation, we first obtained a list of all of the resettlement communities in Southern Shaanxi and Henan that had over 50 babies aged 6–30 months. We then randomly chose sample resettlement communities. Once the sample communities were chosen, we obtained a list of all registered births from the community family planning official in each community and then randomly selected the sampled children and their caregivers.

Finally, we chose a set of sample children and their families in migrant communities in three urban areas: Beijing, Zhengzhou, and Xi'an. To choose the samples in the migrant communities, our team visited urban government offices (metropolitan Family Planning offices) and obtained lists of neighborhoods that were known to house migrant communities. From these lists, we randomly chose neighborhoods that were known to have large numbers of migrant households with children 6–30 months of age. From the local Family Planning Commission agent who was in charge of family planning policy implementation in the sampled community, we obtained a list of all migrant households with children 6–30 months of age and randomly selected households from the list.

In all, the sample included a total of 3353 child-caregiver pairs with children between 6 and 30 months of age, to whom five surveys were administered. Specifically, the sample included 2886 child-caregiver pairs from western rural communities, 135 pairs from resettlement communities, 128 pairs from central rural communities, and 204 pairs from migrant communities.[2] As yet, the aggregate sample is by far the largest of any ECD study in rural China.[3]

2.3. Data collection

We collected four types of information from each child-caregiver pair: ECD outcomes, nutrition and health status, parenting investment, and general participant demographic characteristics. All participating caregivers gave their oral consent for their own and their child's involvement in the program.[4]

[2] Throughout this paper, we use sampling weights in order to more accurately represent the share of these communities in China's rural population overall. The proportions for each subpopulation in rural China are 37.7% for Western China rural communities, 1.4% for resettlement migration villages, 42.0% for Central China rural communities, and 18.8% for migrant communities. We calculate the sampling weights, using the following formula: sampling weight = proportion of subpopulation in total population/proportion of subpopulation in sample. The subpopulation proportions in the sample are as follows: 86.0% for Western China rural communities, 4.0% for resettlement migration villages, 3.8% for Central China rural communities, and 6.1% for migrant communities. Therefore, the sampling weight for Western China rural communities is 0.44 (which is equivalent to 37.3%/86%), for resettlement migration villages is 0.35 (1.4%/4%), for Central China rural communities is 11.1 (42%/3.8%), and for migrant communities is 3.08 (18.8%/6.1%).

[3] To demonstrate the national representativeness of our data, we compared the gender distribution of infants, mother's education level, and mother's age distribution in our data with those of three nationally representative data sets: the China Family Panel Survey, China Household Income Project, and China Labor-force Dynamic Survey. We find that our data are nearly identical to these three data sets. Please see the appendix for a complete description of how we determine this.

[4] The response rates of the survey were quite high, with a 99.2% rate for household surveys, a 99.8% rate for the BSID, a 98% rate for child physical examinations that were used to measure height and weight, and a 94% rate for the finger-prick blood test of children's hemoglobin levels.

2.3.1. Measuring child development outcomes

All children were administered the Bayley Scales of Infant and Toddler Development (BSID), an internationally recognized test of ECD (Weiss et al., 2010). This test has been used repeatedly to assess early childhood development in populations around the world, including in urban China. Specifically, we utilized the third and most recent edition of the test (BSID-III), which assesses more domains of ECD than do previous editions. The studies on urban Chinese populations mention in the introduction (Shi et al., 2001; Sun et al., 1996; Xie et al., 2006) used the first edition, which only assesses the domains of cognition and motor. The BSID-III results are categorized into five standardized scales, four of which we use in this study: the cognitive scale, which assesses processing, counting, and number skills; the language scale, which assesses receptive and expressive communication skills; the social-emotional scale, which assesses functional emotional skills, such as self-regulation and ability to use emotions in a purposeful manner (Weiss et al., 2010); and the motor scale, which assesses fine and gross motor skills. The cognitive, language, and motor scales evaluate the child's performance on a series of interactive tasks, whereas the social-emotional scale relies on the caregiver's responses to a series of questions about his or her child. Each of these four indices accounts for the child's gestational and chronological ages. Studies that examine BSID validity found that the four scales exhibit high inter- and intra-rater reliability agreement, high internal consistency, and high test-retest stability even when tested in other cultural contexts (Azari et al., 2017; Weiss et al., 2010).

We then transformed the raw scores into composite scores based on BSID-III guidelines (Bayley, 2005). We first used the composite scores to assess the status of ECD in our sample. Next, we used the scores to compare developmental levels among sample children who were exposed to different degrees of interactive parental inputs. Finally, we examined the rate of developmental delays for each rural subpopulation and for the entire sample.

We define delays according to documented distributions of BSID scores in reference populations. In a healthy population, the mean score (standard deviation) is expected to be 105 (9.6) for the cognitive scale (Lowe et al., 2012; Serenius et al., 2013), 109 (12.3) for the language scale (Serenius et al., 2013), 100 (15) for the social-emotional scale (Bayley, 2005), and 107 (14) for the motor scale (Bos, 2013; Lowe et al., 2012).

2.3.2. Measuring nutrition

To obtain nutritional investment information, we assessed each child's anemia status and recorded height and weight. Nurses from the Xi'an Jiaotong Medical School collected data on hemoglobin concentrations from all children, using a HemoCue Hb 201+ finger-prick system (Hemocue, Inc., Ängelholm, Sweden). We utilized the World Health Organization (WHO) threshold of 110 g/L to determine each child's anemia status (WHO, 2001).

Nurses also collected anthropometric data from each child. Using these measurements, we constructed three standardized indicators, using WHO growth charts (WHO, 2009): height-for-age *z*-scores (HAZ), weight-for-age *z*-scores (WAZ), and weight-for-height *z*-scores (WHZ). Whereas HAZ measures cumulative nutritional investments and illnesses over the long term, WAZ and WHZ are considered to be more indicative of recent or short-term changes in diet (Shariff et al., 2016). According to the WHO, children with HAZ scores of less than −2 standard deviations are identified as stunted; children with WAZ scores of less than −2 standard deviation are identified as underweight; and children with WAZ scores of less than −2 standard deviations are identified as wasted (WHO, 2009).

2.3.3. Assessing interactive parenting inputs

To assess interactive parenting inputs, we asked primary caregivers whether they had engaged in any of the four interactive practices the previous day: telling stories, reading, singing, and playing with their child. We also asked whether a household owned two or more children's books. Psychological and biological literature indicates that these inputs are linked with adequate child development. Telling stories, reading, and talking to one's child have been shown to improve both cognitive and early language development (Raikes et al., 2006). Singing to children has been shown to increase responsiveness (Shenfield et al., 2003), capture attention (Nakata and Trehub, 2004), and elicit positive cognitive behavior (de l'Etoile, 2006).

2.4. Data analysis

To measure the correlation between developmental delays and the interactive parenting inputs, we constructed a model as follows.

$$\text{Developmental Delays}_i = \beta_0 + \beta_1 \text{storytelling}_i + \beta_2 \text{reading}_i + \beta_3 \text{singing}_i + \beta_4 \text{play}_i + \beta_5 \text{childbook}_i + X_i\theta + u_i$$

where the dependent variable, $\text{Developmental Delays}_i$, indicates whether child i has developmental delays. The variables "storytelling_i, reading_i, singing_i, play_i, and childbook_i" represent interactive parenting inputs of the caregiver of infant i. The term X_i is a vector of covariates that are included to capture characteristics of children and their households, such as child gender, age, premature birth, whether the mother is the primary caregiver, maternal age, maternal educational level, whether the household receives social security support, and the household asset index (constructed using polychoric principal components on the following variables: tap water, toilet, water heater, washing machine, computer, Internet, refrigerator, air conditioner, motorized or electronic bicycle, and car.) We account for clustering at the village level and control for BSID administrator fixed effects. We also control for county-level fixed effects.

Table 2
Summary statistics.

	Full sample	Western rural communities	Resettlement migration communities	Central rural communities	Migrant communities
	(1)	(2)	(3)	(4)	(5)
Child characteristics					
Age (in months)	16.48	15.40	16.41	17.62	16.09
	(6.72)	(5.68)	(6.80)	(7.39)	(6.74)
Male (1 = yes)	0.53	0.52	0.54	0.56	0.49
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Premature (1 = yes)	0.06	0.05	0.04	0.06	0.09
	(0.24)	(0.22)	(0.19)	(0.24)	(0.29)
Household characteristics					
Maternal age	0.68	0.62	0.71	0.70	0.75
(1 = above 25 years)	(0.47)	(0.49)	(0.45)	(0.46)	(0.43)
Maternal education level	0.33	0.21	0.36	0.32	0.61
(1 = 12 years or higher)	(0.47)	(0.40)	(0.48)	(0.47)	(0.49)
Primary caregiver	0.65	0.69	0.58	0.59	0.73
(1 = mother)	(0.48)	(0.46)	(0.50)	(0.49)	(0.44)
Household receives social	0.12	0.14	0.11	0.13	0.09
security support (1 = yes)	(0.33)	(0.34)	(0.31)	(0.33)	(0.28)
Household asset index	0.37	−0.17	0.37	0.48	1.23
	(1.20)	(1.19)	(1.22)	(1.08)	(0.86)
Observations	3353	2886	135	128	204

Data source: Authors' survey.
Notes: We calculate overall summary statistics, using sampling weights for each observation. The proportions for each subpopulation in rural China are 37.7% for Western China rural communities, 1.4% for resettlement migration villages, 42.0% for Central China rural communities, and 18.8% for migrant communities. We calculate the sampling weights, using the following formula: sampling weight = proportion of subpopulation in total population/proportion of subpopulation in sample. The subpopulation proportions in the sample are as follows: 86.0% for Western China rural communities, 4.0% for resettlement migration villages, 3.8% for Central China rural communities, and 6.1% for migrant communities. Therefore, the sampling weight for Western China rural communities is 0.44 (which is equivalent to 37.3%/86%), for resettlement migration villages is 0.35 (1.4%/4%), for Central China rural communities is 11.1 (42%/3.8%), and for migrant communities is 3.08 (18.8%/6.1%).

3. Results

3.1. Early childhood development in rural china

Table 2 shows the summary statistics of our samples from four major rural subpopulations. On average, 67% of mothers have attained less than 12 years of education. In migrant communities, 39% of mothers have attained less than 12 years of education, which is significantly lower than in other subpopulations. The data also show that 35% of primary caregivers are not mothers.

Table 3 shows the levels of early childhood development in our sample. Across all four indices (cognitive, language, social-emotional, and motor skills) in all four subpopulations, rates of delays far surpass the rates of delays in healthy populations (15%; Boyle et al., 1994). Based on the regional weighted average across the four rural subpopulations, the rate of cognitive delays is 49%. In other words, the share of children aged 0–3 years with cognitive delays in the sampled areas is more than three times higher than the healthy international average. The data also reveal high levels of language delays. On average, 52% of children in the sample suffer from language delays. Even in the least delayed subpopulation, migrant communities, the share of children delayed is 39%, a rate of delay more than twice that of a healthy population. Rates of social-emotional delays are even higher. Across the entire sample, the average rate of delay in social-emotional development is 53%. Motor delays are the least prevalent, albeit still more pervasive than would be expected in a healthy population. On average, the rate of delay in motor development is 30%.

Accounting for all the children in our sample, 85% exhibit at least one kind of developmental delay, over five times the normal rate in a healthy population. Although there is some variation across the four subpopulations, all exhibit rates of developmental delays that are significantly higher than the norm. Three-quarters or more of the children in western rural communities (90%), resettlement villages (90%), central rural communities (84%), and migrant communities (75%) have some type of delay.

The high prevalence of these delays is particularly worrisome when considering that many of these children might suffer from more than one kind of delay at the same time. Indeed, the data demonstrate that children with at least two kinds of developmental delays account for 57% of the overall sample. Nearly one-third of the overall sample (32%) exhibit at least three kinds of delays, and one-tenth (10%) suffer from all four kinds of developmental delays.

We also explored whether the developmental levels of these children differ across age groups by dividing the sample into two subgroups according to age in months: 6–18 months and 18–30 months (Table 4). We find that, as children get older, the share of children with cognitive delays increases from 46% to 55%, while the shares of children with language, social-emotional, and motor delays decrease from 57% to 45%, from 56% to 49%, and from 40% to 14%, respectively. According to our data, all of the percentages of developmental delays are high no matter how old the children are (except in the case of motor delays, which are at a normal level for children between 18 and 30 months old). In fact, across the cognitive, language, and social-emotional indices, the

Table 3
Child developmental outcomes.

	Full sample (1)	Western rural communities (2)	Resettlement migration communities (3)	Central rural communities (4)	Migrant communities (5)
Cognitive delay	0.49	0.54	0.51	0.48	0.42
(1 = yes)	(0.50)	(0.50)	(0.50)	(0.50)	(0.49)
Language delay	0.52	0.61	0.54	0.49	0.39
(1 = yes)	(0.50)	(0.49)	(0.50)	(0.50)	(0.49)
Social-emotional delay	0.53	0.59	0.67	0.54	0.39
(1 = yes)	(0.50)	(0.49)	(0.47)	(0.50)	(0.49)
Motor delay	0.30	0.35	0.35	0.30	0.19
(1 = yes)	(0.46)	(0.48)	(0.48)	(0.46)	(0.39)
Any of four types of delay	0.85	0.90	0.90	0.84	0.75
(1 = yes)	(0.36)	(0.30)	(0.30)	(0.36)	(0.43)
Any of two types of delay	0.57	0.66	0.63	0.55	0.45
(1 = yes)	(0.49)	(0.47)	(0.48)	(0.50)	(0.50)
Any of three types of delay	0.32	0.39	0.38	0.33	0.15
(1 = yes)	(0.47)	(0.49)	(0.49)	(0.47)	(0.36)
Four types of delay	0.10	0.14	0.16	0.09	0.04
(1 = yes)	(0.30)	(0.35)	(0.36)	(0.29)	(0.19)
Observations	3353	2886	135	128	204

Data source: Authors' survey.
Notes: We calculate overall summary statistics, using sampling weights for each observation. The proportions for each subpopulation in rural China are 37.7% for Western China rural communities, 1.4% for resettlement migration villages, 42.0% for Central China rural communities, and 18.8% for migrant communities. We calculate the sampling weights, using the following formula: sampling weight = proportion of subpopulation in total population/proportion of subpopulation in sample. The subpopulation proportions in the sample are as follows: 86.0% for Western China rural communities, 4.0% for resettlement migration villages, 3.8% for Central China rural communities, and 6.1% for migrant communities. Therefore, the sampling weight for Western China rural communities is 0.44 (which is equivalent to 37.3%/86%), for resettlement migration villages is 0.35 (1.4%/4%), for Central China rural communities is 11.1 (42%/3.8%), and for migrant communities is 3.08 (18.8%/6.1%).

Table 4
Child developmental outcomes at different age in months.

	Age (6–18 months)	Age (18–30 months)
Cognitive delay	0.46	0.55
(1 = yes)	(0.50)	(0.50)
Language delay	0.57	0.45
(1 = yes)	(0.50)	(0.50)
Social-emotional delay	0.56	0.49
(1 = yes)	(0.50)	(0.50)
Motor delay	0.40	0.14
(1 = yes)	(0.49)	(0.35)
Any of four types of delay	0.88	0.79
(1 = yes)	(0.32)	(0.40)
Any of two types of delay	0.60	0.54
(1 = yes)	(0.49)	(0.50)
Any of three types of delay	0.37	0.24
(1 = yes)	(0.48)	(0.43)
Four types of delay	0.13	0.05
(1 = yes)	(0.34)	(0.23)
Observations	2203	1150

Data source: Authors' survey.
Notes: We calculate overall summary statistics using sampling weights for each observation. The proportions for each subpopulation in rural China are 37.7% for Western China rural communities, 1.4% for resettlement migration villages, 42.0% for Central China rural communities and 18.8% for migrant communities. We calculate the sampling weights using the following formula: sampling weight = proportion of subpopulation in total population / proportion of subpopulation in sample. In our data, the subpopulation proportions in the sample are the following: 86.0% for Western China rural communities, 4.0% for resettlement migration villages, 3.8% for Central China rural communities, and 6.1% for migrant communities. Therefore, the sampling weight for Western China rural communities is 0.44 (which is equivalent to 37.3%/86%), the sampling weight for resettlement migration villages is 0.35 (which is equivalent to 1.4%/4%), the sampling weight for Central China rural communities is 11.1 (which is equivalent to 42%/3.8%), and the sampling weight for migrant communities is 3.08 (which is equivalent to 18.8%/6.1%).

Table 5
Child health outcomes.

	Full sample (1)	Western rural communities (2)	Resettlement migration communities (3)	Centralrural communities (4)	Migrant communities (5)
Anemia prevalence	0.42	0.38	0.52	0.46	0.43
(1 = yes)	(0.49)	(0.49)	(0.50)	(0.50)	(0.50)
Stunting	0.04	0.07	0.04	0.02	0.02
(Height for age *z*-score < −2)	(0.20)	(0.25)	(0.19)	(0.14)	(0.15)
Underweight	0.02	0.03	0.02	0.01	0.00
(Weight for age *z*-score < −2)	(0.14)	(0.18)	(0.13)	(0.10)	(0.00)
Wasting	0.04	0.04	0.03	0.04	0.04
(Weight for height *z*-score < −2)	(0.19)	(0.20)	(0.16)	(0.19)	(0.20)
Observations	3272	2836	127	125	184

Data source: Authors' survey.
Notes: We calculate overall summary statistics, using sampling weights for each observation. The proportions for each subpopulation in rural China are 37.7% for Western China rural communities, 1.4% for resettlement migration villages, 42.0% for Central China rural communities, and 18.8% for migrant communities. We calculate the sampling weights, using the following formula: sampling weight = proportion of subpopulation in total population/proportion of subpopulation in sample. The subpopulation proportions in the sample are as follows: 86.0% for Western China rural communities, 4.0% for resettlement migration villages, 3.8% for Central China rural communities, and 6.1% for migrant communities. Therefore, the sampling weight for Western China rural communities is 0.44 (which is equivalent to 37.3%/86%), for resettlement migration villages is 0.35 (1.4%/4%), for Central China rural communities is 11.1 (42%/3.8%), and for migrant communities is 3.08 (18.8%/6.1%).

portion of children who are delayed is over 40%, regardless of age. Even though the share of delays falls for certain metrics, it is still nearly half of the subsample. Similarly, when comparing the share of children that have at least one developmental delay across age groups, we find that delays are slightly less common (but still much more frequent than normal) in children between 18 and 30 months old (79%) than children between 6 and 18 months old (88%).

3.2. Poor nutrition

The results of the nutritional assessment administered to the sample of rural children show that, although rates of stunting, being underweight, and wasting appear to be relatively normal, micronutrient deficiencies are high across all four rural sub-populations (Table 5). The share of sample children who are stunting, underweight, or wasting is low, with rates of less than 5% for all three of these measures. These results indicate that these problems are not highly prevalent among rural children in China. In contrast, however, the data show that 42% of the sample children are anemic. These results reflect the findings of studies of smaller scope/narrower geography on the rates of anemia in rural China, which report similarly high or even higher rates of 32% (Guldan et al., 2000), 35% (Yang et al., 2012), 48% (Luo et al., 2015), and 54% (Luo et al., 2014). As iron deficiency is the major cause of anemia in rural China (Luo et al., 2017b), these high rates indicate that approximately one-third to one-half of the rural children across China do not have adequate micronutrient intake. Previous research has shown anemia to be a contributing factor to developmental delays in children (Li et al., 2015); therefore, it appears that poor feeding practices may be one reason behind the poor developmental outcomes across rural China.

3.3. Lack of parental investment

We next examine interactive parenting inputs. We find that only a minority of rural caregivers engage in any of our five focal practices (Table 6). Only 9% had read a book to their child on the day prior to survey administration, and only 18% had told a story to their child. These low rates are perhaps not surprising, considering that only 38% of caregivers reported having over two children's books in the household. Likewise, only 36% of caregivers indicated that they had sung to their infant yesterday, and only 59% of caregivers reported that they had played with their infant.[5]

International comparisons also show that rural communities in China lag behind in their exercise of interactive parenting practices. A study on parenting inputs and toddler developmental outcomes of the poorest of Colombian families, for example, found that 67% of caregivers in the control group had told a story to their infant (versus 29% in China's migrant communities) and 73% had read a book to their infant (versus 21% in China; Attanasio et al., 2015).[6] Thus, it appears that many caregivers in rural China may still have to significantly modify their parenting techniques to cultivate healthier development in their children.

[5] Yue et al. (2017) found that some caregivers who report "playing" with their child do so in a random manner without any knowledge of structured games to play. Therefore, it should be noted that the quality of play may vary significantly from caregiver to caregiver and may not be indicative of real stimulation.

[6] In contrast to the present study, in the Attanasio et al. (2015) study, researchers asked caregivers whether they had performed certain parental inputs within the last *three* days (instead of just one). It should be noted that this might be one reason behind the differences between the rates.

Table 6
Interactive parenting inputs.

	Full sample (1)	Western rural communities (2)	Resettlement migration communities (3)	Central rural communities (4)	Migrant communities (5)
Told story to child yesterday	0.18	0.13	0.15	0.19	0.29
(1 = yes)	(0.39)	(0.33)	(0.36)	(0.39)	(0.45)
Read book to child yesterday	0.09	0.04	0.05	0.08	0.21
(1 = yes)	(0.29)	(0.21)	(0.22)	(0.27)	(0.41)
Sang song to child yesterday	0.36	0.27	0.29	0.36	0.52
(1 = yes)	(0.48)	(0.45)	(0.46)	(0.48)	(0.50)
Played with child yesterday	0.59	0.48	0.54	0.65	0.68
(1 = yes)	(0.49)	(0.50)	(0.50)	(0.48)	(0.47)
Over 2 child books in household	0.38	0.25	0.33	0.41	0.55
(1 = yes)	(0.48)	(0.43)	(0.47)	(0.49)	(0.50)
Observations	3341	2878	133	127	203

Data source: Authors' survey.
Notes: We calculate overall summary statistics, using sampling weights for each observation. The proportions for each subpopulation in rural China are 37.7% for Western China rural communities, 1.4% for resettlement migration villages, 42.0% for Central China rural communities, and 18.8% for migrant communities. We calculate the sampling weights, using the following formula: sampling weight = proportion of subpopulation in total population/proportion of subpopulation in sample. The subpopulation proportions in the sample are as follows: 86.0% for Western China rural communities, 4.0% for resettlement migration villages, 3.8% for Central China rural communities, and 6.1% for migrant communities. Therefore, the sampling weight for Western China rural communities is 0.44 (which is equivalent to 37.3%/86%), for resettlement migration villages is 0.35 (1.4%/4%), for Central China rural communities is 11.1 (42%/3.8%), and for migrant communities is 3.08 (18.8%/6.1%).

3.4. Relationship between developmental outcomes and parenting environment

We find that four of the five parental inputs are significantly correlated with at least one developmental delay (Table 7). Of these, "played with child yesterday" had the broadest association, as it was significantly and negatively correlated with delays across three measures of toddler development—cognitive, language, and social-emotional. "Sang song to child yesterday" was significantly associated with language and social-emotional delays. "Over two child books in household" was significantly associated with social-emotional delay. "Told story to child yesterday" was significantly and negatively correlated with social-emotional delay. "Read book to child yesterday" was the one parenting practice not significantly correlated with a developmental delay, but this was likely because the share of caregivers who engaged in this behavior was very small (9%) (and therefore the power was not large enough to identify how impactful this behavior really is). It is also worth noting that all five inputs are negatively correlated with each kind of the developmental delays (except for the link between reading books to the child and three developmental delays, for which correlations were positive but insignificant). Overall, the data suggest that parental inputs and developmental delays are related.

We also construct the sampling weight for each observation in different subpopulations to analyze the association between the subpar interactive parenting practices with the developmental delays of children. The results, as presented in Table 8, show that, when these sampling weights are used, three of five parental inputs are significantly correlated with at least one developmental delay. Importantly, these results do not vary substantially from the results of previous analyses without considering sampling weights. Although the results in this paper are not causal, our findings are consistent with literature that suggests that better nutrition and engagement of children with more stimulating activities lead to better developmental outcomes (Luo et al., 2017a).

4. Discussion and conclusion

This study is the first to examine developmental delays of children across four major subpopulations in rural China. We produce evidence that there are high rates of developmental delays in all four of these rural communities, which, together, represent 49% of China's total population of children aged 0–3 years and 69% of all rural families. In these communities, 85% of the children have at least one delay in cognitive, language, social-emotional, or motor development, which is over five times the normal rate in a healthy population. Since the four rural sub-populations represent 49% of China's total population, the results suggest that at least 42% of children (85% times 49%) are delayed by at least one measure. Even assuming that the rate of developmental delays is "normal" (i.e., approximately 15% are delayed) in the remaining 51% of the population not represented by this study, this means that as many as 50% (51% times 15%, plus 42%) of China's children potentially suffer from developmental delays.

If we examine only the rates of cognitive delay, the numbers are still high. Of the sample children, 49% exhibit delays in cognitive development, which is over three times the normal rate in a healthy population (15%). By using the same calculation strategy as above (multiplying the approximate share in the sample that is delayed by the share of the total population represented by the sample), we can estimate that, across China, over 24% (potentially 32%) of children are cognitively delayed.

For the other three measures of ECD according to the BSID III—language, social-emotional, and motor—the rates of delay are no less alarming. Using the same calculation strategies, this means that, of all children in China, 25% (potentially 33%) suffer from language delays, 26% (potentially 34%) suffer from social-emotional delays, and 15% (potentially 23%) suffer from motor delays.

Table 7
OLS regression of interactive parenting inputs on child's developmental delays without assigning sampling weights for each observation.

	Cognitive delay	Language delay	Social-emotional delay	Motor delay
Told story to child yesterday	−0.05	−0.01	−0.05*	−0.02
(1 = yes)	(0.03)	(0.04)	(0.03)	(0.02)
Read book to child yesterday	0.01	−0.01	0.04	0.02
(1 = yes)	(0.05)	(0.05)	(0.05)	(0.04)
Sang song to child yesterday	−0.01	−0.08***	−0.04*	−0.03
(1 = yes)	(0.02)	(0.02)	(0.02)	(0.02)
Played with child yesterday	−0.04**	−0.03*	−0.05***	−0.02
(1 = yes)	(0.02)	(0.02)	(0.02)	(0.02)
Over 2 child books in household	−0.03	−0.01	−0.04**	−0.01
(1 = yes)	(0.02)	(0.02)	(0.02)	(0.02)
Child age (months)	0.01***	−0.01***	−0.00	−0.03***
	(0.00)	(0.00)	(0.00)	(0.00)
Male	0.01	0.06***	−0.00	−0.01
(1 = yes)	(0.02)	(0.02)	(0.02)	(0.01)
Premature	0.04	0.04	0.05	0.01
(1 = yes)	(0.04)	(0.04)	(0.04)	(0.03)
Maternal age	−0.00	−0.02	0.02	−0.01
(1 = above 25 years old)	(0.02)	(0.02)	(0.02)	(0.02)
Maternal education level	−0.06***	−0.06***	−0.06**	−0.04**
(1 = 12 years or higher)	(0.02)	(0.02)	(0.02)	(0.02)
Primary caregiver	0.05**	0.01	0.05***	0.02
(1 = mother)	(0.02)	(0.02)	(0.02)	(0.02)
Household receives social security support	0.03	0.02	0.02	−0.00
(1 = yes)	(0.03)	(0.03)	(0.02)	(0.02)
Household asset index	−0.03***	−0.05***	−0.01	−0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
County Fixed Effect	YES	YES	YES	YES
Tester Fixed Effect	YES	YES	YES	YES
Observations	3231	3231	3229	3229
Adj. R^2	0.117	0.146	0.107	0.223

Data source: Authors' survey.
Notes: Controls include child's age, gender, premature birth, maternal age and education, whether the mother is the primary caregiver, whether the household receives a welfare benefit, and household asset index. The household asset index is constructed using polychoric principal components on the following variables: tap water, toilet, water heater, washing machine, computer, Internet, refrigerator, air conditioner, motorized or electronic bicycle, and car. We also control for Bayley tester fixed effects and county fixed effects. All standard errors account for clustering at the village level.
* $p < 0.10$;
** $p < 0.05$;
*** $p < 0.01$.

Our data demonstrate that subpar parenting in rural areas is one of the major proximate causes of developmental delay. This subpar parenting is manifested in two areas. First, anemia rates of 42% across these populations reflect poor feeding practices in rural households, as the chief cause of anemia is deficiency of iron-rich foods, such as meat and leafy vegetables. Anemia, which has been linked to poor developmental outcomes in children, is much less prevalent in developed countries, such as the United States, where rates among similarly aged children have been found to be as low as 3% (Le, 2016). Hence, the data show that rural China still lags significantly behind in this regard. Fortunately, however, our data indicate that the vast majority of rural children do not suffer from stunting, being underweight, or wasting.

Second, it is clear that interactive parenting investment in children is low. Caregivers in rural communities engage with their children much less frequently than do their counterparts in urban areas. According to the literature, in urban areas of Sichuan Province, 50% of parents read books to their child every day and 64% at least once every two days (Guo, 2016). In the capital city of Shandong Province, 37% of families read to their child every day and 46% once every three days (Liu and Lv, 2015). By contrast, only a small minority of rural caregivers practice parental investment—reading, telling stories, and singing songs to their children—that stimulate child development. When controlling for other variables, the correlation analysis demonstrates that the lack of such stimulation in the household is positively and, in many cases, significantly associated with developmental delays in children. Although not causal, these data from across China are consistent with the literature that has established causal relationships between better parenting practices and developmental outcomes of children (Attanasio et al., 2015).

Our results raise a fundamental question: Are developmental delays in China a new problem? If not, why is it that it is just being discovered now? Papers by He et al. (2018) and Zhao et al. (2018) show that approximately 40–50% of students in rural junior high schools (around 13–14 years old) and rural elementary schools (around 9–10 years old) are cognitively delayed (based on Raven's Progressive Matrices and the Wechsler Intelligence Scale for Children). Presuming that these cognitive delays have existed since the children were toddlers means that the problem has existed for at least a decade or more.

If there has been a problem truly for a long time, then one explanation for why we are just beginning to recognize it is that China's needs have changed. In the past, if a large share of the individuals in the labor force of a poor or middle-income country had low

Table 8
OLS regression of interactive parenting inputs on child's developmental delays assigning sampling weights for each observation.

	Cognitive delay	Language delay	Social-emotional Delay	Motor delay
Told story to child yesterday	−0.06	−0.08	−0.07	−0.04
(1 = yes)	(0.05)	(0.05)	(0.06)	(0.06)
Read book to child yesterday	0.04	0.10**	−0.04	0.01
(1 = yes)	(0.07)	(0.05)	(0.07)	(0.07)
Sang song to child yesterday	0.03	−0.03	−0.02	0.03
(1 = yes)	(0.02)	(0.05)	(0.05)	(0.03)
Played with child yesterday	−0.06	−0.09**	−0.05**	−0.10**
(1 = yes)	(0.04)	(0.03)	(0.03)	(0.05)
Over 2 child books in household	−0.04	−0.00	−0.09**	−0.03
(1 = yes)	(0.02)	(0.03)	(0.05)	(0.04)
Child age (months)	0.00**	−0.01*	−0.00	−0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Male	0.05	0.07**	−0.01	0.02
(1 = yes)	(0.04)	(0.03)	(0.03)	(0.03)
Premature	0.01	−0.07	0.12*	0.05
(1 = yes)	(0.08)	(0.07)	(0.06)	(0.06)
Maternal age	0.05**	0.04	0.01	−0.02
(1 = above 25 years old)	(0.02)	(0.06)	(0.03)	(0.02)
Maternal education level	−0.16***	−0.09***	−0.04	−0.03
(1 = 12 years or higher)	(0.05)	(0.03)	(0.04)	(0.04)
Primary caregiver	0.09*	0.03	0.06**	0.08
(1 = mother)	(0.05)	(0.04)	(0.03)	(0.06)
Household receives social security support	0.06	0.09	0.08*	0.07
(1 = yes)	(0.06)	(0.06)	(0.04)	(0.05)
Household asset index	−0.02	−0.02	−0.02	−0.01
	(0.01)	(0.03)	(0.01)	(0.02)
County Fixed Effect	YES	YES	YES	YES
Tester Fixed Effect	YES	YES	YES	YES
Observations	3231	3231	3229	3229
Adj. R^2	0.264	0.262	0.245	0.197

Data source: Authors' survey.
Notes: Controls include child's age, gender, premature birth, maternal age and education, whether the mother is the primary caregiver, whether the household receives a welfare benefit, and household asset index. The household asset index is constructed using polychoric principal components on the following variables: tap water, toilet, water heater, washing machine, computer, Internet, refrigerator, air conditioner, motorized or electronic bicycle, and car. We calculate the sampling weights, using the following formula: sampling weight = proportion of subpopulation in total population/proportion of subpopulation in sample. The subpopulation proportions in the sample are as follows: 86.0% for Western China rural communities, 4.0% for resettlement migration villages, 3.8% for Central China rural communities, and 6.1% for migrant communities. Therefore, the sampling weight for Western China rural communities is 0.44 (which is equivalent to 37.3%/86%), for resettlement migration villages is 0.35 (1.4%/4%), for Central China rural communities is 11.1 (42%/3.8%), and for migrant communities is 3.08 (18.8%/6.1%. We also control for Bayley tester fixed effects and county fixed effects. All standard errors account for clustering at the village level.
* $p < 0.10$;.
** $p < 0.05$;.
*** $p < 0.01$.

levels of cognitive development, it did not matter. When a country is poor, most of its residents are engaged in subsistence farming, an activity that does not require high levels of cognition. If a country is lower-middle income (and developing quickly), most of its residents are engaged in low-wage, low-skill manufacturing and/or construction, and, likewise, there is no need to have a large share of the labor force endowed with high levels of cognition. When a country reaches higher levels of middle income and strives to graduate to a developed country in which the economy relies mostly on jobs that are high-wage and high-skill, however, a much larger share of the labor force needs higher levels of cognition and an ability to learn how to learn, which comes with higher levels of educational attainment. Indeed, as China's wages rise, there will be increasingly fewer assembly-line factories that will employ Chinese workers. Low-wage, low-skill jobs will lose out to either offshoring or automation. Hence, for China to become a prosperous, stable country, it will need workers who can handle a wider variety of jobs, and these jobs will require most individuals to be able to grow up to be college students, or at least high school students, so that they will have enough ability to learn the skills needed to take on the new technologies and ever-changing jobs that define a high-income, developed country.

This problem is not unique to rural China. In fact, high rates of ECD delays have recently been recognized as a significant problem in many other middle-income countries as well, such as Colombia, Mexico, and South Africa, as shown in Table 9, in which rates of cognitive delays were found to be 40%, 36%, and 39% respectively (Attanasio et al., 2015; Fernald et al., 2006; Rademeyer and Jacklin, 2013). These results suggest that poor early cognitive development is a common problem among developing countries that are at or near the levels of income per capita that characterize China today.

We then ask why rates of interactive parenting are so low in rural China and other developing countries as compared to developed countries (and even to urban China; Xu et al., 2011). The answer likely lies in the fact that, in rural China and the poor rural and

Table 9
Early childhood developmental delays across middle-income countries.

Study location	GDP per capita (PPP)	Measure of development	Sample size	Infant age (months)	Share of children with cognitive delays
Healthy population		BSID III			15%
Rural China	$16,600 (China overall)	BSID III	3343	6–30	49%
Colombia	$14,500	BSID III	1420	12–24	30–40%
Mexico	$19,500	BSID II	896	12.5–23.5	36%
South Africa	$13,400	BSID III	122	3–12	39%

Data sources
1. Central Intelligence Agency of the United States (2018).
2. Authors' survey.
3. Rozelle, S. (2016, November 15). "Human Capital Roots of the Middle Income Trap: Rural China's Health, Nutrition, and Education" (presentation, Xi'an, China).
4. Attanasio et al., 2015.
5. Fernald et al. (2006).
6. Rademeyer & Jacklin (2013).

urban communities in other middle-income countries, the changes over the past several decades have come quickly. In one generation, living standards for many in rural China increased by a factor of one hundred (Cai, 2016), an enormous rate of change. The same growth took place over several generations in most high-income Western countries, which gave ordinary citizens time to adapt and prepare their children to thrive within modernizing societies and economies. In contrast, those in rural China (and poor communities in other middle-income countries) did not have the same duration in which to adjust their parenting techniques to raise children to be adequately prepared to meet the challenges of a high-skill economy.

The results of this study suggest that increased investment into early childhood development is necessary to not only ensure the healthy development of these Chinese toddlers but also to promote the overall development of China. Developmental delays early in life can impair children in the long term, harming their ability to succeed in the classroom (Heckman et al., 2010). Weak academic performance can hinder the ability of children to attain higher levels of education once they grow up, causing them to drop out of school, thereby limiting their future career prospects and earnings (Gertler et al., 2014). This, in turn, could potentially reduce the stock of the country's human capital, as workers who possess the advanced skills and knowledge gained through secondary and tertiary education would be fewer in number. Without the necessary levels of human capital, which is important for long-term growth (Madsen and Murtin, 2017), it would be more difficult for China to make the transition from a middle-income, industry-based economy to a high-income, knowledge-based economy (Khor et al., 2016; Wang et al., 2018).

By examining developmental outcomes in four of China's five major rural subpopulations across different regions of China, this study has highlighted a real and overlooked issue across broad swaths of China. The data suggest that the high rates of developmental delays among children are being caused by poor parenting. Ironically, despite this problem's seriousness, the previous literature is all but silent on this matter. As a result, we recommend that future studies expand upon ours by conducting surveys of wider scope, sampling rural subpopulations on China's eastern coast and in areas that this study did not explore. We also know that, although our samples were randomly chosen from areas from across each of our study's four subpopulations, we do not suggest that our results are *representative* in a statistical sense. Through our mutual efforts, we will come one step closer to further identifying the extent of the problem and, ultimately, to developing effective solutions for improving the early development of children—the future—in China.

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Supplementary materials

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