DEMOGRAPHIC RESEARCH

Descriptive Finding

"At three years of age, we can see the future": Cognitive skills and the life cycle of rural Chinese children

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Contents

"At three years of age, we can see the future": Cognitive skills and the life cycle of rural Chinese children

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Abstract

BACKGROUND
Although the Chinese education system has seen massive improvements over the past few decades, there are still large academic achievement gaps between rural and urban areas that threaten China's long-term development. In addition, recent literature underscores the importance of early childhood development (ECD) in later-life human capital development.

OBJECTIVES
We analyze the life cycle of cognitive development and learning outcomes in rural Chinese children by first exploring whether ECD outcomes affect cognition levels, then determining whether cognitive delays persist as children grow, and finally examining connections between cognition and education outcomes.

METHODS
We combine data from four recent studies that examine different age groups (0–3, 4–5, 10–11, 13–14) to track cognitive outcomes.

RESULTS
First, we find that ECD outcomes for children in rural China are poor, with almost one in two children who are cognitively delayed. Second, we find that these cognitive delays seem to persist into middle school, with almost 37% of rural junior high school

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students who are cognitively delayed. Finally, we show that cognition has a close relationship to academic achievement.

CONCLUSION
Our results suggest that urban–rural gaps in academic achievement originate at least in part from differences in ECD outcomes.

CONTRIBUTIONS
Although many papers have analyzed ECD, human capital, and inequality separately, this is the first paper to explicitly connect and combine these topics to analyze the life cycle of cognitive development in the context of rural China.

1. Introduction

Although China's education system has seen significant improvement over the past two decades, large gaps in performance still exist between urban and rural children in China due to substantial structural inequalities. These structural inequalities severely limit the potential of rural students. For example, although overall school access has improved significantly (Chung and Mason 2012), rural schooling facilities are still much worse than urban facilities, despite recent and substantial efforts to address this gap (Wang et al. 2018). Health issues such as anemia (Li et al. 2018), intestinal worms (Liu et al. 2017), and myopia (Nie et al. 2018) continue to plague rural students, dragging down their academic ability and increasing the urban–rural gap.

Although there are many potential reasons for these education gaps in China, new research suggests that differences in early childhood development (ECD) may be contributing to these gaps. Indeed, healthy ECD is increasingly understood to be a key component of a successful life cycle of human capital accumulation and has been linked to a variety of positive long-term outcomes in health, education, employment, and adult earnings (Attanasio et al. 2014; Currie and Almond 2011; Heckman, Stixrud, and Urzua 2006; Heckman et al. 2010; Knudsen et al. 2006). Unfortunately, the inverse is true as well: poor ECD, as may be caused by malnutrition or insufficient stimulation, is linked with developmental delays in toddlers and can lead to low levels of human capital accumulation and poorer outcomes later in life (Grantham-McGregor et al. 2007). Differences in these human capital outcomes may perpetuate poverty, leading to social inequities and even slow economic growth (Heckman and Masterov 2007; UNICEF 2016; Wang et al. 2019; Yousafzai et al. 2014).

Despite the well-documented economic and social benefits of ECD investments, poor cognitive development remains a significant problem among young children in

developing countries. A recent *Lancet* review paper estimates that 250 million children (43%) under the age of 5 in low- to middle-income countries are at risk for development delays and reduced cognition, suggesting that poor cognitive development remains an important issue in underdeveloped countries and regions (Black et al. 2017). Recent work demonstrates that there are still high rates of cognitive delay in China (Wang et al. 2019a). Such delays in early childhood have implications for education and later-life accumulation of human capital because delayed children are more likely to drop out of school, and those who remain tend to have lower achievement rates than do their peers (Black et al. 2017; Grantham-McGregor et al. 2007).

Given the persistence of poor cognitive outcomes in underdeveloped areas, it is possible that disparities in ECD outcomes perpetuate the substantial education gaps that exist between China's urban and rural children. A recent study found that almost 15% of students among four rural counties in Shanxi and Shaanxi provinces dropped out of junior high school before completion. Students from poorer families with worse academic performance than their peers were much more likely to drop out (Yi et al. 2012). Unless children receive the necessary quantity (years of schooling) and quality (learning) of education (Wang et al. 2019a), large shares of rural students will be unable to develop the human capital needed to participate in the future knowledge-based, high-income economy that China hopes will be emerging in the near future.

The overall goal of this study is to examine the life cycle of learning outcomes and the association of cognitive development levels with these learning outcomes. There is a Chinese proverb that translates to "At three years of age, we can see a child's future." Our objective is to test this proverb empirically, using data on children's cognitive development in China. We have three specific objectives. First, we will review the empirical literature on rural China and examine the nature of ECD outcomes and developmental delays in rural China today. Second, we will study whether poor cognitive outcomes persist through an individual's early life cycle beyond age 3. Third, we will investigate the relationship between cognition and academic outcomes in schools.

2. Methods

To meet our objectives, we draw on analyses from four different papers. These four papers each examine the cognitive development of one of the four age cohorts that we analyze. The first paper, "Are Infant/Toddler Developmental Delays a Problem across China?" (Wang et al. 2019a), examines ECD outcomes across a large sample of infants and toddlers, aged 0 to 3, in rural China. The second study, "The Persistence and Fade-out Paradox: New Evidence on Medium Run Effects of an Early Childhood
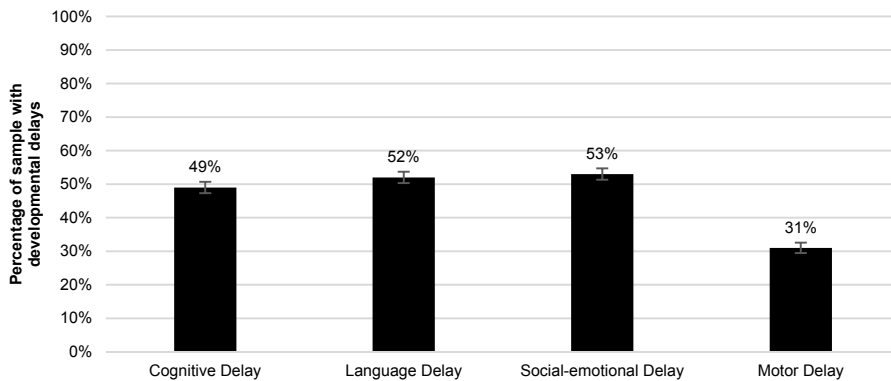
Development Intervention" (Wang et al. 2019b), focuses on young children, aged 4–5 years. The third manuscript, "Better Cognition, Better School Performance? Evidence from Primary Schools" (Zhao, Wang, and Rozelle 2019), concerns the nature of cognition and academic performance in rural Chinese elementary schools among third and fourth graders, around 9 to 10 years old. Finally, the fourth paper, "IQ, Grit, and Academic Achievement: Evidence from Rural China" (He et al. 2019), investigates the effects of cognitive and noncognitive abilities (otherwise referred to as "grit") on academic achievement among rural seventh graders (who are around 13 years old). These four papers all used similar randomized sampling strategies and were conducted by the same research group. More detail on these studies can be found in our Supplementary Materials.

3. Results

3.1 The nature of ECD in rural China

Our analysis of ECD outcomes in rural China shows that infants and toddlers have a high prevalence of developmental delays. In our sample, 49% of infants were cognitively delayed, 52% had language delays, and 53% had socio-emotional delays (Figure 1, first three bars). In other words, in these three key variables, nearly half of all those in our sample had measures that were less than −1 standard deviation below the average of international norms. Whereas the level of motor delays was less (31%; Figure 1, fourth bar), more than twice as many infants and toddlers in our sample had motor delays as compared with their counterparts in healthy populations. Although not shown in Figure 1, 85% of individual infants/toddlers were delayed in at least one dimension. This overall level of cognitive/noncognitive delay is many times higher than the 15% rate that we expect to find in a healthy population.

Unfortunately, this conclusion is consistent with those of other studies that examine cognitive development in rural China. A large ($N = 1,442$) 2014 survey of rural households in Shaanxi province found that one in two rural toddlers were cognitively delayed (Yue et al. 2017). Such findings are confirmed by other studies (Dill et al. 2019; Luo et al. 2015). Moreover, these rates of cognitive/noncognitive delays are much higher than those found in urban China. Studies that survey infants and children from urban areas in China find rates of cognitive delays that range from 5% to 16%, a range that is much lower than found in rural areas but that is consistent with healthy populations found elsewhere in the world (Dill et al. 2019).

Figure 1:   Developmental delays in 6–30 month children

3.2 Persistence of cognitive delays

The results of studies in China also suggest that these cognitive delays in infants persist, or at least do not significantly improve, as children grow. Table 1 and Figure 2 illustrate this by showing the tracking of cognitive scores and the amount of cognitive delay in each age cohort: infants, toddlers, children, and youths. In the case of infants (as described in the previous section), 49% exhibited cognitive delays. As seen in the table, when these infants and toddlers grow into young children (4–5 years old), we see this situation improve only modestly: 43.4% of children are cognitively delayed. The average cognitive score is only 2.8 points above 85, the cutoff value for cognitive delay and far below the mean that would be expected in a healthy population (100 points).

Table 1:   **Average cognition and rates of cognitive delay in each age cohort**

	Age cohort			
	Infants and toddlers (2 to 3 years old)	Young children (4 to 5 years old)	Older children (10 to 11 years old)	Youth (13 to 14 years old)
Average IQ	--	87.8	87.5	87.4
95% CI	--	(88.80–86.80)	(118.41–56.71)	(88.53–87.15)
Percentage of sample with cognitive delays	49%	43.4%	36.5%	37.4%
95% CI	(50.69%–47.30%)	(47.48%–39.26%)	(37.4%–35.6%)	(39.12%–35.68%)

Data sources: Column 1: Wang et al. (2019a).
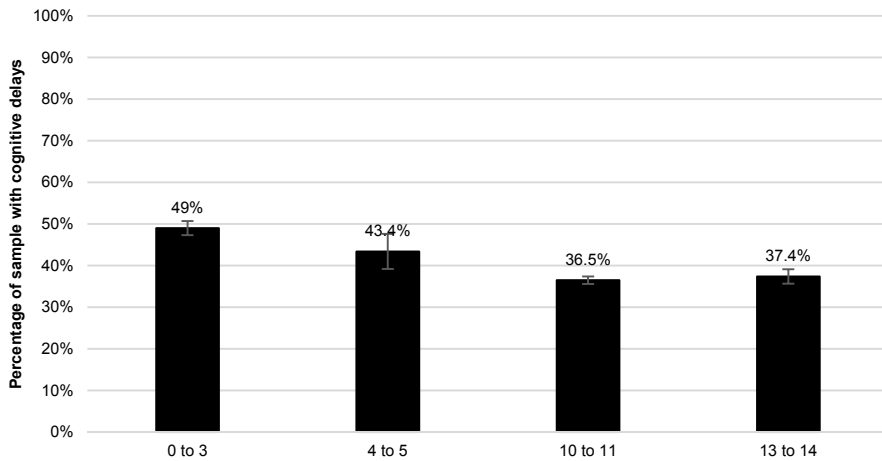Column 2: Wang et al. (2019b).
Column 3: Zhao, Wang, and Rozelle (2019).
Column 4: He et al. (2019).
Note 1: Cognition scores are measured by Bayley's III for column 1, Weschler Preschool and Primary Scale of Intelligence (WPPSI) for column 2, Raven Intelligence Quality (IQ) scale for column 3, and a weighted average of Wechsler Intelligence Scale for Children (WISC-IQ) and Raven's Standard Progressive Matrices (Raven IQ) for column 4.
Note 2: For all columns, cognitive delay is measured by the share of young children with cognition scores less than –1 standard deviations (at 85 IQ cutoff).

Figure 2:   **Percentage of children with cognitive delays in each age group**

Data source: Authors' review.
Note 1: This figure displays the same data as can be found in Table 1 Percentage with Cognitive Delays.
Note 2: Confidence intervals at the 95% level are (50.69%–47.30%) for ages 0–3, (47.48%–39.26%) for ages 4–5, (37.4%–36.5%) for ages 10–11, and (39.12%–35.68%) for ages 13–14.

In regard to the next age group (elementary school–aged children), our results show that older children have an average Raven's cognition score of 87.5 points and 36.5% are cognitively delayed. The average score, 87.5 points, is, again, just above the cutoff value for cognitive delay and far from what one would see with a healthy population. Similarly, although 36.5% (the rate of delay of elementary school–aged children in our sample) is better than 43.4% (the rate of delay of preschool-aged children in our sample), this still means that more than one in three rural Chinese children are cognitively delayed.

This situation does not appear to improve when these elementary school–aged children grow into youths (junior high school–aged children). According to the data, these children have a weighted average of Raven's and Weschler Intelligence Scale for Children (WISC or WISC-IQ) cognition scores that reveals an average cognition score of 87.4 and a 37.4% prevalence of cognitive delays. This suggests that cognitive delays in infancy persist as children mature, as one in three youths are still cognitively delayed. In fact, we can demonstrate this persistence empirically. This is because the sample that we use for infants/toddlers and small children is based on a cohort that consists of the same children. By studying how cognition changes in this cohort, we can empirically demonstrate that cognitive outcomes persist over time (more information can be found in our Supplementary Materials). This persistence is supported by the literature: Cognitive scores change very little over time from 3 to 18 years of age (Brooks-Gunn et al. as referenced in Heckman 2013).

3.3 Cognition and academic performance

To address our final objective, in this section, we explore the relationship between cognition and academic achievement. As can be seen in Table 2, IQ and academic performance of older children who are in rural elementary schools are highly correlated, regardless of the exact specification (Row 1). When controlling for individual and family effects (only), a 1-point increase in IQ is associated with an increase in math scores of 0.037 standard deviations (SDs) (Column 1). When we add additional controls for school characteristics (by adding school fixed effects), a 1-point increase in IQ predicts a 0.034 SD increase in math scores (Column 2). Similar results are found when adding class fixed effects (Column 3).

Table 2: **Multivariate analysis of correlates of IQ scores and standardized math scores (dependent variable) for primary school students in Henan and Anhui provinces using regression models both with and without school fixed effects**

Variable names [a]	Without school fixed effect (1)	With school fixed effect (2)	With class fixed effect (3)
IQ scores	0.037 ($p < 0.01$)	0.034 ($p < 0.01$)	0.034 ($p < 0.01$)
	(0.001)	(0.001)	(0.001)
School fixed effects	no	yes	yes
Class fixed effects	no	no	yes
Family characteristics [a]	yes	yes	yes
Individual characteristics [b]	yes	yes	yes
Baseline math scores	no	no	no
Observations	3,109	3,109	3,109
R-squared	0.348	0.433	0.463

Data Source: Author's survey from Zhao, Wang, and Rozelle (2019).
Note: Standard errors in parentheses below coefficients.
[a]: Family characteristics are controlled by variables that measure number of siblings a respondent has, household assets, mother's and father's age and education, and father's drinking habits and smoking habits.
[b]: Individual characteristics are controlled variables that indicate gender and if respondent has attended preschool.

Assuming that the relationship between IQ and math scores is linear, the difference in math scores between a student with an IQ of 85 (the cutoff value for cognitive delay) and a student with an IQ of 100 (the mean value in a healthy population) is approximately 0.5 SDs. Similarly, there is a difference of 0.44 SDs when comparing the average IQ score of our sample (87.04 points) with the average IQ score of a healthy population (100 points). For perspective, a difference of 0.5 SDs represents approximately one semester to one year's worth of learning (Dill et al. 2019); this means that the average elementary student in rural China is about one semester to one year behind.

We also examine the correlations of cognition and academic achievement among rural Chinese youth who are attending junior high school. As with fourth and fifth graders in elementary school, there is a strong correlation between cognition and academic performance among rural youth. The dependent variable in Table 3 is standardized achievement scores on math tests administered at the end of the seventh grade. Two different measures of IQ are used in these regressions, depending on the sample: WISC-IQ from the WISC test and SPM-IQ from the Raven's test. These regressions control for baseline math ability (as collected from math scales

administered by the research team at the beginning of the year) as well for family, individual, and class characteristics.

Table 3: **Value-added relationship between cognitive IQ and academic achievement for the entire sample of junior high school students in Gansu and Shaanxi provinces**

Independent variable names	Dependent variable: Standardized Math Scores	
WISC-IQ scores	0.03 (p < 0.01) (0.00)	
SPM-IQ scores		0.01 (p < 0.01) (0.00)
Class Fixed Effects	Yes	Yes
Family characteristics [a]	Yes	Yes
Individual characteristics [b]	Yes	Yes
Baseline math scores	Yes	Yes
Observations	472	2,507
R-Squared	0.685	0.548

Data source: Table 3 in He et al. (2019).
Note 1: Standard errors are in parentheses below coefficients.
Note 2: SMP-IQ scores are cognition scores as determined by the Raven's IQ test. WISC-IQ scores are cognition scores as determined by Weschler Intelligence Scale for Children.
[a]: Family effects are controlled by variables that measure parental education, household assets, and if one or both parents have migrated for work.
[b]: Individual effects are controlled by gender and if they are boarding at their school.

Our results indicate that both measures of IQ are strongly correlated with increased academic achievement in the case of rural youth who are attending junior high school (Table 3). When using WISC-IQ as our cognition measure, we find that a 1-point increase in WISC-IQ predicts a standardized math achievement score increase of 0.03 points (Column 1). Using Raven's (SPM-IQ), a 1-point increase Raven's IQ leads to a 0.01 SD increase in math score (Column 2). The results from both tables, therefore, suggest that cognition is a predictor of academic achievement in rural schools. Additional figures found in our Supplementary Materials also confirm the strong correlations between cognition and academic achievement. When examining the connection between IQ and math test scores in primary school students, we find that an increase of 20 IQ points (as measured by WISC-IQ scores) from 80 points to 100 points results in about a 1 SD increase in math scores (Figure 1S). When examining this connection in middle schoolers, we find a similar trend: A 20 IQ-point increase from an

IQ of 80 to 100 was associated with a 0.5 SD increase in test scores. As noted earlier, this change in SDs represents about a year's worth of learning, providing further evidence that cognition and academic achievement are closely linked.

4. Conclusion

China has made huge strides in expanding and improving its education system. Despite these major improvements, however, substantial gaps in academic achievement still exist between rural and urban students. Our study seeks to explain this urban–rural achievement gap by tracing it back to differences in ECD outcomes. To do so, we use data that were used in four recent papers to explore the life cycle of cognitive development and learning achievement.

Our results show that high rates of cognitive delay exist among rural infants and toddlers and persist as children age, and that cognition is a strong predictor of academic achievement into junior high school. During early childhood, around 50% of rural children are found to be cognitively delayed. As children age into elementary school and then into junior high, rates of delay continue to be around 40%. In both elementary and junior high school, IQ is very strongly correlated with academic achievement. Academic achievement in junior high has profound consequences for children in China, as standardized tests at this age determine access to further education. In other words, our findings suggest that the traditional proverb "At three years of age we can see a child's future" remains relevant in China today.

These results, however, leave one major question unanswered: What are the factors that ultimately cause these high levels of delays? Heckman (2013) shows that cognitive delays often have roots in the first three years of life, as this is the key age when cognitive skills are developed; in essence, poor cognition in children is due to poor ECD as babies. Our results support this conclusion. This leads to another question: Why are ECD outcomes so poor in rural China? Prior research suggests that these poor ECD outcomes – and thus, low levels of cognition, and ultimately, academic achievement – found in rural China have two main causes: poor nutrition and insufficient psychosocial stimulation (such findings are beyond the scope of this study but nevertheless important) (Dill et al. 2019; Luo et al. 2015; Yue et al. 2017). Rates of anemia, a micronutrient deficiency caused by insufficient iron intake and known to affect children's ability to learn, have been found to be around 50% among infants and toddlers in rural China (Luo et al. 2015). Previous research also finds that rural caregivers generally do not provide sufficient psychosocial stimulation to their children. Only 59% of caregivers reported that they played with their children the previous day, with even lower rates for other psycho-stimulating activities (Wang et al. 2019a).

Interactive parenting has been shown to be significantly connected to ECD outcomes; children of parents who sang, read, or played with them were less likely to be developmentally delayed and more likely to obtain positive ECD outcomes (Dill et al. 2019). To be clear, these low levels of interactive parenting and sufficient nutrition are due not to parental apathy but, rather, to a lack of parental knowledge. Most families care about their children and want to invest in their development, but many do not know how best to provide a healthy environment for good ECD outcomes (Dill et al. 2019; Yue et al. 2017).

The findings in this paper also may explain the origins of the rural/urban academic gap in China. Rates of early childhood cognitive delay are substantially higher among rural children than among their urban counterparts. If this cognition gap persists at older ages, and cognition has a causal effect on academic achievement, intervening to improve ECD outcomes among rural children may be a promising approach for reducing future inequality in China.

In addition to exacerbating inequality, poor levels of human capital in rural China may directly threaten China's economic future. Over two-thirds of China's children (and nearly three-quarters of infants and toddlers) come from rural areas in China (Wang et al. 2019a). This means that a majority of China's future labor force will have been born and spent their early years in rural areas. Given the persistence of cognitive outcomes, unless something is done soon to address cognitive delay among rural children, a significant portion of China's future workforce will be cognitively delayed. China's future growth will depend on industrial upgrading and transitioning to an innovation-based economy. Given high rates of cognitive delay, it is unclear whether China's labor force will have the skills to support this transition (Wang et al. 2019a).

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