Journal of Affective Disorders 293 (2021) 484–491

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Attention Deficit Hyperactivity Disorder (ADHD) among elementary students in rural China: Prevalence, correlates, and consequences

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ARTICLE INFO

Keywords:
ADHD
Rural China
School-age children
Prevalence
Risk factors
Academic performance

ABSTRACT

Background: Attention deficit hyperactivity disorder (ADHD) is a widely recognized mental health problem in developed countries but remains under-investigated in developing settings. This study examines the prevalence, correlates, and consequences of ADHD symptoms among elementary school students in rural China.
Methods: Cross-sectional data were collected from 6,719 students across 120 rural primary schools in China on ADHD symptoms, demographic characteristics, and academic performance in reading and math. ADHD symptoms were evaluated using the caregiver-reported ADHD Rating Scale-IV.
Results: The prevalence of ADHD symptoms was 7.5% in our sample. Male students, students in lower grade levels, and students with lower cognitive ability showed a significantly higher prevalence of ADHD symptoms (ORs = 2.56, 2.06, and 1.84, respectively; $p<0.05$). Left-behind children showed a significantly lower prevalence of ADHD symptoms than did children who were living with their parents (OR = 0.74, $p < 0.05$). Adjusted regressions show that students with ADHD symptoms scored 0.12 standardized deviations lower in reading ($p < 0.05$) and 0.19 standardized deviations lower in math ($p < 0.01$).
Limitations: The ADHD Rating Scale-IV is a screening scale rather than a diagnostic test. Caregiver self-report measures also may underestimate ADHD symptoms for our sample.
Conclusions: ADHD is a common disorder among rural students in China and appears to be contributing to poor academic outcomes. The higher prevalence of ADHD among students with low cognitive ability also suggests that many rural children in China face multifactorial learning challenges. Taken together, the findings indicate a need for educators and policymakers in rural China to develop programs to reduce risk and support students with ADHD symptoms.

1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common and challenging childhood mental health problems (Bachmann et al., 2017; Centers for Disease Control and Prevention, 2019; Currie and Stabile, 2006; Hamed et al., 2015; Hoang et al., 2019; Leslie, 2002). The worldwide prevalence of ADHD has been estimated to be 7.2% (Thomas et al., 2015). To date, however, much of the existing research on ADHD has been conducted in developed countries, where the prevalence of ADHD ranges from 6.1% of children in Germany (Bachmann et al., 2017) to 9.4% of children in the United States (Danielson et al., 2018).

Literature from developed countries has shown that ADHD can have a negative impact on many aspects of a child's life, including academic achievement (Barkley et al., 1990; DuPaul and Stoner, 2014; DuPaul et al., 2013). In a meta-analysis, Frazier et al. (2007) found that students with ADHD score about 0.73 standard deviations (SD) lower in reading and 0.67 SD lower in math than do their peers without ADHD. In part due to poor learning outcomes, ADHD also is associated with a range of adverse outcomes in late adolescence and early adulthood (Calub et al., 2019), such as lower college graduation rates (Weyandt and DuPaul, 2013) and worse employment outcomes (Erskine et al., 2016).

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https://doi.org/10.1016/j.jad.2021.06.014
Received 16 October 2020; Received in revised form 13 May 2021; Accepted 13 June 2021
Available online 18 June 2021

Unfortunately, little is known about ADHD among students in developing contexts (Al-Sharbati et al., 2011; Bakare, 2012; Chinawa et al., 2014), despite the fact that they account for the majority of the world's school-age children (UNICEF, 2019). In particular, China has the world's second-largest child population (age 0–17 years), totaling 271 million children in 2015 (UNICEF, 2018). A study of children in urban and industrially developed rural areas of China found that 6.4% of students exhibit symptoms of ADHD (A. Liu et al., 2018). This may not be an accurate estimate, however, as no study to date has examined ADHD symptoms in China's underdeveloped rural areas, which are home to more than half of China's school-age children (National Bureau of Statistics of China, 2016a).

There is some evidence that students in developing and economically vulnerable settings, such as that of rural China, may be at higher risk of ADHD. A study in the United States found ADHD to be more prevalent in rural areas and among poor children (Danielson et al., 2018). A recent study in Ethiopia also found that children from low-income families showed higher rates of ADHD (Lola et al., 2019). Although, to our knowledge, there are no studies on ADHD in underdeveloped areas of rural China, other empirical studies from China have suggested that rural schoolchildren have higher rates of mental health problems, such as depression and anxiety, compared to their urban peers (H. Liu et al., 2018; Wang et al., 2015; Zhou et al., 2018). Given that studies have found ADHD to often be correlated with other mental health problems (Biederman et al., 1991; Jensen and Steinhausen, 2015; Melegari et al., 2018), the prevalence of ADHD symptoms among rural students in these less developed regions of China may be higher than reported in studies of urban students.

If the prevalence of ADHD is indeed relatively high among students in rural China, understanding the risk factors for ADHD may help targeted interventions to mitigate the potential consequences of ADHD among students. In the international literature, several factors have been linked to ADHD. A systematic review by Skounti et al. (2007) found that male students and younger students tend to have higher rates of ADHD. Studies in the United States also have linked ADHD to lower overall levels of ability across a number of neuropsychological functions, including cognition (Frazier et al., 2004).

Another possible risk factor for ADHD that deserves examination in the context of rural China is parental out-migration to urban areas. In rural areas of China, many parents out-migrate to cities for better employment opportunities, leaving children behind in the care of surrogate caregivers, typically grandparents. The net impact of out-migration on the mental health outcomes of left-behind children (LBCs), however, is not clear. On the one hand, wages from migrant work can increase a family's income (Démurger, 2015; McKenzie, 2005), which has been seen as a protective factor for mental health. On the other hand, decreased or absent parental care, substituted (in the case of China) by older, less educated paternal grandparents (Chang et al., 2019b; Hu, 2013; Wang et al., 2019), may contribute to lower-quality caregiving, which has been identified as a risk factor for ADHD (Hayslip and Kaminski, 2008). Studies of non-ADHD mental health problems among LBCs in rural China have returned mixed results regarding the role of parental migration in mental health. Some studies have found no impacts of parental migration on mental health (Li et al., 2017; Lu, 2012; Zhou et al., 2015), whereas others have found significant negative impacts (Chang et al., 2019a; He et al., 2012; Jia et al., 2010). It is, therefore, worthwhile to investigate whether LBCs in rural China also may be at higher risk of ADHD.

The overall goal of this study is to examine the prevalence, correlates, and consequences of ADHD symptoms among school-age children in rural China. To achieve this goal, we have three specific objectives. First, we report the prevalence of ADHD in rural areas in China. Second, we identify correlations between demographic characteristics and ADHD symptoms. Finally, we examine the relation between ADHD and student academic performance in reading and math.

Table 1
Distribution of Sample Schools and Students.

Sample	Schools (*n*)	Students (*n*)	Students (%)
Full sample	120	6719	100
County			
County A	37	2416	36
County B	25	1481	22
County C	58	2822	42
Grade			
Grade 5	120	3271	49
Grade 6	120	3448	51

2. Methods

2.1. Sample/participants

The data used for this study come from three counties in the southern part of the Jiangxi province in China. The total population of the three counties is over 2.3 million people (National Bureau of Statistics of China, 2016d). All three counties have been nationally designated as low-income counties (State Council Leading Group Office of Poverty Alleviation and Development, 2012). Per capita gross domestic product in the three counties was less than 3210 USD in 2015 (National Bureau of Statistics of China, 2016b), which is about 40% of the national average (Ganzhou Municipal Bureau of Statistics and Survey Office of the National Bureau of Statistics in Ganzhou, 2016; National Bureau of Statistics of China, 2016c). More than 80% of the population in the three counties have rural residency status, in comparison to 48% across Jiangxi and 44% nationally (Ganzhou Municipal Bureau of Statistics and Survey Office of the National Bureau of Statistics in Ganzhou, 2016; National Bureau of Statistics of China, 2016b). In addition, residents of all three counties are predominantly of Han ethnicity (Fang, 2017; Ganzhou Municipal Bureau of Statistics and Survey Office of the National Bureau of Statistics in Ganzhou, 2016). Thus, to some extent, the three counties are representative of low-income, rural, ethnically Han counties across China, which are home to over one-third of the country's total population.

We followed a three-step protocol to select a representative sample of schools and students from the three sample counties. First, we used official records from the local county education bureaus to create a population frame of all rural public primary schools in the three counties, totaling 458 schools. Next, we randomly selected schools in each county, using a probability proportionate to size sampling strategy. This resulted in 120 schools in total, including 37 schools (30.8%) in County A, 25 schools (20.8%) in County B, and 58 schools (48.3%) in County C. Third, we randomly selected two fifth grade classes and two sixth grade classes in each school. If a school had two or fewer classes for each grade level, all fifth and sixth grade classes were selected for inclusion. There are three reasons for selecting students from fifth grade and sixth grade—the two highest grades in primary school in China. First, students in fifth and sixth grades had the necessary literary and numeracy skills to enable them to complete our survey questionnaires, which asked students about demographic information. Our pilot survey showed that students in younger grades had trouble understanding and completing these questions. Second, to obtain an accurate assessment of their learning, academic achievement tests are usually given to students who have more than five years of formal schooling at the time of testing. This is a common practice in educational studies (Isdale et al., 2017; Wiberg, 2019). Third, primary school students in higher grades may face higher academic pressure compared to their younger peers and may spend more time on homework and remedial academic work under China's competitive education system (Ren et al., 2017). In this regard, ADHD likely presents a larger issue for learning among older students as they face increasing academic pressure. We invited all students ($N =$ 7756) to join the survey, for which the response rate was 86.82%, with 1037 students who declined to participate. This resulted in a total sample of 6719 students in 120 schools, including 3271 fifth grade students and 3448 sixth grade students. The sample distribution by school and grade is presented in Table 1.

The protocol for this study was approved by the Stanford University Institutional Review Board (IRB) (Protocol ID 32,594). Permission for this study also was received from the local Board of Education in Jiangxi province. The principles of the Declaration of Helsinki were followed throughout. Written informed consent was obtained from at least one parent for each child participant. Participants were assured that the information collected in this study was confidential and anonymous, and participation was voluntary.

2.2. Measures and instruments

In this study, we collected four modules of information from all participating students and their caregivers in May 2018. The first module concerned information on ADHD symptoms. The second module involved demographic characteristics of students and households. The third module concerned the cognitive ability of each student. The fourth module included data on student academic performance. Information on ADHD symptoms was collected from each student's caregivers in their home. Information on demographic characteristics, cognitive ability, and academic performance of each student was collected from the student themselves while at school during a normal class day.

ADHD symptoms. ADHD symptoms were assessed using the home version of the ADHD Rating Scale-IV (ADHD RS-IV). The ADHD RS-IV home version is a caregiver-reported rating scale that has been widely used in ADHD studies of school-age children (Demaray et al., 2003). The scale has strong discriminant validity both within the ADHD subtypes and between children with ADHD and without ADHD (DuPaul et al., 1998a, 1998b). The psychometric properties of the Chinese version of this scale also have been validated for use among children aged 6–17 years in China (Su et al., 2015).

The ADHD Rating Scale-IV asks the child's primary caregiver to rate the frequency of 18 ADHD symptoms that occurred over the past six months. The primary caregiver is defined as the person at home most often responsible for the student's care, typically the mother or paternal grandmother (in cases in which the parents have out-migrated and their child has been left behind in their rural hometown). Symptoms were rated on a four-point Likert scale, for which 0 = rarely or never, 1 = sometimes, 2 = often, and 3 = very often. Scores for each item were then summed to reach a total score that ranged from zero to 54 points. Previous studies have found that a cutoff point of 26 yields optimal sensitivity and specificity in distinguishing children at risk of ADHD among students in urban China (Su et al., 2015; Tong et al., 2016, 2017, 2018; Yang et al., 2017). Following these methods, we similarly consider children with scores above 26 to be at risk of ADHD. It is important to note, however, that this cutoff indicates only risk of ADHD, as any diagnosis of ADHD must be confirmed through diagnostic clinical interviews by trained healthcare professionals.

Demographic characteristics. We collected demographic information on student individual characteristics and household characteristics. Student characteristics include gender, grade, age, and boarding status. We also surveyed each student's primary caregiver on household characteristics, including LBC status (whether both parents have out-migrated for at least six months), education levels of the mother and father of each student, and the value of family assets. We created a standard family asset index using polychoric principal component analysis (PCA; Kolenikov and Angeles, 2009) based on whether the household owned certain common household items, livestock, or small businesses; the material used to construct their home; and the size of their home.

Cognitive ability. Although cognitive ability has multiple dimensions, in this study, we use IQ as a measure of cognitive ability. In each sample class, a randomly selected half of students were administered the Raven's Standard Progressive Matrices for Children (Raven IQ test), one of the most widely used intelligence tests in the world that measures levels of human cognitive ability (Borghans et al., 2016). The Raven test, originally designed by British psychologist J. C. Raven, is a nonverbal (language-neutral) test comprised entirely of pictorial questions related to spatial reasoning and pattern matching (Raven, 1938). The test is divided into five parts, each of which is sorted into 12 questions according to difficulty. The total score on these 60 questions is calculated based on an established norm to assign a final IQ. A score lower than 85 (one SD below the healthy mean of 100) indicates low cognitive ability.

Table 2
Summary Statistics for Full Sample.

Characteristic	*n*	Mean/%	SD
Demographic			
Gender (1 = Male)	6719	0.49	0.50
Grade (1 = grade 6)	6719	5.51	0.50
Boarding status (1 = Boarder)	6719	0.10	0.30
Left-behind child status (1 = LBC)	6719	0.49	0.50
Father's education (1 = Junior high and above)	6719	0.60	0.49
Mother's education (1 = Junior high and above)	6719	0.36	0.48
Family asset (1 = Bottom 1/3)	6719	0.37	0.48
Low cognitive ability (1 = Raven's IQ below 85)	3397	0.23	0.42
Academic performance			
Standardized reading score	6697	0.00	1.00
Standardized math score	3355	0.00	1.00
Standardized reading score in previous school year	6719	0.00	1.00
Standardized math score in previous school year	3355	0.00	1.00
ADHD variables			
ADHD (score)	6719	12.36	8.00
Risk of ADHD (1 = yes)	6719	0.07	0.26

Academic achievement. Academic achievement was measured using standardized reading and math tests. All students were administered a 30-minute standardized reading test. Due to time constraints on the part of the participating schools, we randomly selected half of the students in each sample class to also take a 30-minute standardized math test.

The reading and math tests were carefully designed and went through several rounds of pretesting to ensure the relevance of the questions that comprise the tests and that time limits were appropriate. The standardized reading test was constructed by professional psychometricians using test items from the Progress in International Reading Literacy Study (PIRLS), an international test of reading comprehension widely used throughout the world (Caygill and Chamberlain, 2004; Mullis et al., 2012, 2004; Tunmer et al., 2013), including in rural China (Gao et al., 2021). Test questions were translated into Mandarin Chinese and verified according to PIRLS translation guidelines (Foy and Drucker, 2013). The math test was designed by the research team with assistance from the local county education bureaus to ensure coherence with the national curriculum. Both tests were timed carefully and closely proctored by enumerators.

Standardized reading and math test scores of students also were collected in the year prior to the timing of the survey of this study (that is, during the previous academic year, in May 2017) by members of the research team as part of an unrelated study. In this paper, we include the standardized reading and math scores from the previous school year of sample students as a control variable in our analysis. All test scores were normalized according to the distribution of scores in each grade.

2.3. Data analysis

Our statistical analysis comprises three parts. First, we describe the summary statistics of all variables for the full sample. Second, we conduct a chi-square test to examine differences in demographic variables between students at risk and not at risk of ADHD. Using logistic regression models, we estimate the associations between demographic characteristics and risk of ADHD. We estimate odds ratios (ORs) and

Table 3
Prevalence of ADHD for Full Sample and by Demographics.

Characteristic	Total	At-risk of ADHD [*n* (%)]	χ2	*p*-value	95% CI
Full Sample	6719	503 (7.5)			0.07–0.08
Gender					
Female	3397	184 (5.4)	42.50	<0.001	0.05–0.06
Male	3322	319 (9.6)			0.09–0.11
Grade					
Grade 5	3271	290 (8.9)	17.52	<0.001	0.08–0.10
Grade 6	3448	213 (6.2)			0.05–0.07
Boarding status					
Non-boarder	6068	453 (7.5)	0.04	0.843	0.07–0.08
Boarder	651	50 (7.7)			0.06–0.10
Left-behind child status					
Non-LBC	3422	289 (8.4)	9.26	0.002	0.08–0.09
LBC	3297	214 (6.5)			0.06–0.07
Father's education					
Did not complete junior high	2701	229 (8.5)	6.42	0.011	0.07–0.10
Junior high and above	4018	274 (6.8)			0.06–0.08
Mother's education					
Did not complete junior high	4322	315 (7.3)	0.69	0.408	0.07–0.08
Junior high and above	2397	188 (7.8)			0.07–0.10
Family asset					
Top 2/3	4260	315 (7.4)	0.14	0.706	0.07–0.08
Bottom 1/3	2459	188 (7.6)			0.07–0.09
Levels of cognitive ability					
Normal level of cognitive ability	2610	161 (6.2)	21.33	<0.001	0.05–0.07
Low level of cognitive ability	787	87 (11.1)			0.09–0.13

Note. CI = confidence interval.

95% confidence intervals (CIs) for all variables. Finally, we conduct a multivariate regression analysis of the correlation between risk of ADHD and student academic performance, controlling for demographic characteristics, reading and math scores from the previous school year, cognitive ability, and school fixed effects. All statistical analyses were conducted using STATA version 15.0; *p*-values less than 0.05 were considered statistically significant.

3. Results

3.1. Demographics

Table 2 presents the summary statistics for the full sample. The results show that about half (49%) of students were male, and 10% were boarders. In addition, 49% of sample students were LBCs, meaning that both parents had out-migrated for more than six months in the past year. Among the parents of sample students, 60% of fathers had completed junior high school or above, and 36% of mothers had done so. Finally, the results show that about one-quarter (23%) of sample students scored below 85 on the Raven's IQ test, indicating low levels of cognitive ability. The average ADHD scores for our sample students is 12.36 (SD = 8). Following the cutoff used in previous studies (Su et al., 2015), we similarly consider students with ADHD scores above 26 to be at risk of ADHD. Of our sample students, 7% are at risk of ADHD.

3.2. Prevalence of ADHD symptoms

Table 3 presents the portion of students at risk of ADHD and a comparison of the prevalence of ADHD risk by student demographic characteristics and levels of cognitive ability. In the full sample of 6719 students, 503 students were identified as at risk of ADHD. This represents an overall prevalence of about 7.5%.

Table 3 also shows significant differences in the portion of students at risk of ADHD by demographic characteristics, such as gender, grade level, LBC status, and cognitive ability. Specifically, the results show a higher prevalence of ADHD symptoms among boys (9.6%) than girls (5.4%) ($\chi2 = 42.50, p < 0.001$). The prevalence of ADHD symptoms also was higher among fifth grade students (8.9%) than sixth grade students (6.2%) ($\chi2 = 17.52$, $p < 0.001$). In contrast, LBC students showed significantly lower risk of ADHD (6.5%) than did their non-LBC peers (8.4%) ($\chi2 = 9.26$, $p < 0.002$). Finally, students with lower levels of cognitive ability were almost twice as likely to be identified as at risk of ADHD as compared to students with normal cognitive ability (11.1% versus 6.2%; $\chi2 = 21.3$, $p < 0.001$).

Table 4
Logistic Regression Analysis of Correlations between Student Demographics and Risk of ADHD.

Characteristic	Unadjusted OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
(1)	(2)	(3)	(4)	(5)
Gender				
Female	1.00	<0.001	1.00	<0.001
Male	1.85 (1.54–2.24)		2.56 (1.91–3.43)	
Grade				
Grade 6	1.00	<0.001	1.00	0.001
Grade 5	1.48 (1.23–1.78)		2.06 (1.36–3.14)	
Boarding status				
Non-boarder	1.00	0.843	1.00	0.077
Boarder	1.03 (0 0.76–1.40)		1.57 (0.95–2.59)	
Left-behind child status				
Non-LBC	1.00	0.002	1.00	0.038
LBC	0.75 (0.63–0.90)		0.74 (0.56–0.98)	
Father's education				
Did not complete junior high	1.00	0.011	1.00	0.204
Junior high and above	0.79 (0.66–0.95)		0.83 (0.61–1.11)	
Mother's education				
Did not complete junior high	1.00	0.408	1.00	0.142
Junior high and above	1.08 (0.90–1.31)		1.26 (0.93–1.72)	
Family asset				
Top 2/3	1.00	0.706	1.00	0.628
Bottom 1/3	1.04 (0.86–1.25)		0.93 (0.69–1.25)	
Cognitive ability				
Normal cognitive ability	1.00	<0.001	1.00	<0.001
Low cognitive ability	1.89 (1.44–2.49)		1.84 (1.36–2.48)	

Note. OR = odds ratio. Adjusted regressions control for gender, grade, boarding status, left-behind child status, father's education, mother's education, family asset value, and cognitive ability.

3.3. Risk factors for ADHD

To further investigate the differences in risk of ADHD among student subgroups identified in Table 3, we conducted a logistic regression analysis that examines the correlations between student characteristics and risk of ADHD. Table 4, Column (2) shows the unadjusted, while Column (4) presents the adjusted correlations after controlling for demographic characteristics and cognitive ability. The results confirm the findings in Table 3: Male students and students in grade 5 have significantly higher risk of ADHD, with ORs of 2.56 (95% CI: 1.91–3.43) and 2.06 (95% CI: 1.36–3.14), respectively. In contrast, LBC status is significantly correlated with a reduced risk of ADHD (OR = 0.74, 95% CI: 0.56–0.98). Finally, low cognitive ability is associated with a significantly greater in risk of ADHD (OR = 1.84, 95% CI: 1.36–2.48).

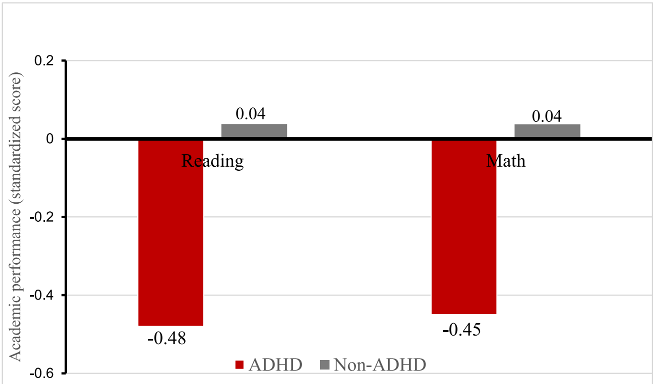

Fig. 1. Multivariate analysis of correlation between risk of ADHD and student academic performance.

3.4. ADHD symptoms and academic performance

Fig. 1 presents the average academic performance (measured by standardized reading and math test scores) of students who are at risk of ADHD and students who are not. The left side of the figure shows that the average standardized scores in reading among students at-risk and not at-risk for ADHD are 0.48 SD below the mean and 0.04 SD above the mean for the sample, respectively. The right side of the figure show the average standardized math scores among students at-risk and not at-risk for ADHD, which are 0.45 SD below the mean and 0.04 SD above the mean for the sample, respectively. Students who are at risk of ADHD scored lower in both reading and math compared to their peers who are not at risk of ADHD.

To check the robustness of these results, we examined the multivariate correlations between risk of ADHD and student academic performance in reading and math, by controlling for student demographic characteristics and cognitive ability. The results, presented in Appendix Table 1, confirm the finding in Fig. 1, showing that ADHD is significantly negatively correlated with student academic performance in both subject areas. Specifically, students at risk of ADHD score approximately 0.12 SD lower in reading ($p < 0.05$), and approximately 0.19 SD lower in math ($p < 0.1$), compared to their peers without ADHD.

4. Discussion

This study is the first to examine the prevalence and risk factors of ADHD symptoms among students in poor rural areas of China. Drawing on a sample of 6719 students in three low-income rural counties of Jiangxi province, the results show that 7.5% of rural students are at risk of ADHD. Male gender, lower grade level, non-LBC status, and low cognitive ability significantly predicted risk of ADHD, whereas parental education and family asset levels did not. Risk of ADHD was correlated with significantly lower performance in reading and math.

The prevalence of ADHD among our sample (7.5%) is generally consistent with the worldwide prevalence of 7.2% (Thomas et al., 2015) and lower than the prevalence of 9.4% in the United States (Danielson et al., 2018). The prevalence of ADHD among the rural students in our sample, however, is slightly higher than the reported prevalence of 6.4% in urban areas of China (A. A. Liu et al., 2018) and the prevalence of 5.7% found in a mixed sample of urban and rural children (Cui et al., 2020). This aligns with previous studies that have found the prevalence of ADHD to be higher in rural areas than urban areas in countries such as the United States (Danielson et al., 2018).

Several characteristics were correlated with increased risk of ADHD, including being male, being in a lower grade, and having low cognitive ability (i.e., cognitive delay). Overall, these correlations also are consistent with the international literature, which finds that ADHD is more common among boys than girls and among younger compared to older children (Skounti et al., 2007) as well as more common among students with cognitive delays (Frazier et al., 2004). The link between ADHD and cognitive ability among our sample may be particularly troubling due to the high prevalence of cognitive delays found among rural students in China. Past studies have found that about one-third (33%) of rural elementary school-age children in China exhibit cognitive delays and that these delays significantly hinder learning academic achievement (Zhao et al., 2019). In the current sample, approximately one quarter (23%) of students exhibited low cognitive ability. The higher prevalence of ADHD among this group suggests that a large share of rural children in China may be facing compounded, multifactorial learning challenges.

In contrast, neither paternal nor maternal education was significantly correlated with risk of ADHD among the sample. This finding is similar to that of other studies that use the same ADHD rating scale among children in China (Tong et al., 2016, 2018) as well as some international studies that have found that parental education, particularly maternal education, is not significantly correlated with ADHD (Breen, 1989; Rucklidge and Tannock, 2002; Russell et al., 2015). In contrast, a systematic review found that children of parents with lower education levels were more than twice as likely to have ADHD as compared to their peers (Russell et al., 2016). Unfortunately, it is unclear what may account for these differences, as these studies used differing measures for parental education.

The results also find that LBCs (whose parents have out-migrated for work) have significantly lower risk of ADHD than do non-LBCs. This is surprising, as a lack of parental involvement in adolescence has been recognized as a risk factor for ADHD in the international literature (Campbell et al., 2014; Ellis and Nigg, 2009; Hawes et al., 2013). This finding also differs from that of previous studies of LBC mental health in rural China, which have typically found that LBCs are at equal or even greater risk of mental health problems compared to non-LBCs (Chang et al., 2019a; He et al., 2012; Jia et al., 2010; Jia and Tian, 2010; Su et al., 2013; Wen and Lin, 2012; Zhang et al., 2006; Zhou et al., 2005). One possible explanation may be the positive income effects of parental out-migration, which have been proposed as a protective for LBC mental health (Démurger, 2015; Lu, 2012; McKenzie, 2005). An alternative possibility may be that ADHD symptoms are under-reported by caregivers of LBCs. There is evidence that grandparents (who typically take over caregiving duties for LBCs when parents out-migrate) are less able to accurately assess children's development compared to parents (Yue et al., 2019). It is possible that grandparents may be similarly unaware of ADHD symptoms or unable to recognize ADHD symptoms, indicating a need for further research on the factors that influence the development of ADHD symptoms among LBCs and non-LBCs in rural China.

Finally, our results find that the risk of ADHD is significantly negatively correlated with student academic performance. Even after controlling for demographic characteristics and cognitive ability, which have been shown to negatively influence student performance in reading and math (Calub et al., 2019; Laidra et al., 2007; Mayes et al., 2009), the risk of ADHD is negatively and significantly correlated with a 0.12 SD decrease in reading and 0.19 SD decrease in math scores. This is fairly consistent with the international body of research on ADHD and academic performance (Arnold et al., 2020; DuPaul and Langberg, 2015; DuPaul and Stoner, 2014). For example, an 8-year longitudinal study in the United States showed that ADHD diagnosis at 4 to 6 years of age predicted lower reading and math standardized achievement test scores in adolescence, even after controlling for cognitive ability (Massetti et al., 2008). Taken together, these findings indicate that ADHD is a widespread, under-recognized problem among rural students in China, which appears to be contributing to poor academic outcomes.

These findings have implications for policymakers and practitioners in health and education. First, considering that there are 271 million children in China, of whom 70% are rural, a prevalence of 7.5% means that approximately 14 million children in rural China are at risk of ADHD. Moreover, the fact that students with ADHD have lower levels of learning than their peers also suggests that untreated ADHD may be weakening the accumulation of human capital among a large share of China's future labor force. The correlation between ADHD and low cognitive ability, as well as the relatively high prevalence of ADHD and low cognitive ability in our sample, indicates that many rural children in China face multiple learning disabilities, creating consequences for their academic achievement. Raising awareness of ADHD and developing programs to identify and provide interventions for students at risk of ADHD should, therefore, be made a policy priority in rural regions of China. School-based behavioral interventions have been promoted as highly successful for supporting children with ADHD (DuPaul and Stoner, 2014; DuPaul et al., 2011), and recent studies have found such interventions to improve behaviors such as on-task performance and academic productivity for children with ADHD (Friedman and Pfiffner, 2020). Moreover, classroom-based interventions for ADHD have shown indirect effects on classmates who profit from fewer disturbances in the classroom of the learning process, leading to improved classroom functioning overall (Gaastra et al., 2016).

In addition, policymakers should consider interventions to address factors in early childhood that may contribute to the development of ADHD among rural children in China. Cognitive delays in rural China have been primarily attributed to a lack of engagement in interactive parenting practices, which is also recognized as risk factor for ADHD in the international literature (Campbell et al., 2014; Ellis and Nigg, 2009; Hawes et al., 2013). This suggests that early interventions to improve parenting practices among rural caregivers not only may reduce later cognitive delays but also may protect against the development of ADHD symptoms. Supporting cognitive development also may help children to develop better coping strategies to deal with ADHD symptoms or to be more responsive to treatment (Cheung et al., 2015; Gao et al., 2015).

5. Strength and limitations

This paper makes several contributions to the literature on ADHD among school-age children. Our study is the first to examine the prevalence of ADHD among students in poor rural areas of China, a population already at risk of low levels of academic achievement, human capital accumulation, and economic development (Rozelle and Johnson, 2020). Moreover, this is one of the first studies of a poor, underdeveloped setting to examine the relationship between ADHD and academic performance. Finally, because the study includes a rich set of student and family factors, drawn from a large sample of 6719 students, to more accurately and rigorously identify the unique risk factors associated with ADHD in rural China, the results offer new insights into factors that affect learning and achievement among rural schoolchildren of China as well as other low-income rural settings.

Conclusions based on the obtained findings, however, are limited by several factors. First, the ADHD rating scale used in this study is a screening scale rather than a diagnostic test. Therefore, the results indicate the share of children at risk of ADHD, rather than those who have been formally diagnosed. The ADHD measure also relies on caregiver self-reports, as parents have been consistently found to be valid and reliable reporters of ADHD diagnosis (Biederman et al., 2006, 1993; Faraone et al., 2005). Nevertheless, it is possible that ADHD rates may be underestimated for some groups of children, such as LBCs, whose grandparents may be less aware of ADHD symptoms. Second, the data were drawn from three rural, Han-majority counties in one province of China, and the results of our study may not be generalizable to other areas of China, such as ethnic minority regions or urban areas. Moreover, about 15% of the students originally sampled declined to participate in our survey. There might be a difference between participants and non-participants that could potentially bias our results. Unfortunately, we were not be able to collect data on the non-participants to examine any possible differences.

In addition, we did not collect data on the medical histories of the sample and, as such, did not have information on the levels of anxiety and depression of sample students that might correlated with ADHD symptoms. Thus, we were not able to adjust for other mental health conditions that might be influencing our analysis. Finally, the study design was cross-sectional, which limits our ability to draw causal inferences. Longitudinal research should be conducted in the future to examine the causal relationship between ADHD symptoms and academic performance as well as the long-term effects of ADHD on academic achievement and attainment.

Table A1
Multivariate Analysis of Correlations between Risk of ADHD and Reading and Math Test Scores.

Characteristic	Reading *b* (*SE*)	Math *b* (*SE*)
Risk of ADHD (1 = Yes)	−0.116* (0.049)	−0.194** (0.068)
Gender (1 = Male)	−0.087*** (0.025)	0.120*** (0.036)
Grade (1 = Grade 6)	0.031 (0.039)	−0.066 (0.052)
Boarding status (1 = Boarder)	0.020 (0.051)	0.075 (0.069)
Left-behind child status (1 = LBC)	0.013 (0.026)	0.001 (0.036)
Father's education (1 = Junior high and above)	0.008 (0.028)	0.089* (0.039)
Mother's education (1 = Junior high and above)	0.040 (0.029)	−0.013 (0.039)
Family asset (1 = Bottom 1/3)	0.029 (0.027)	−0.047 (0.038)
Low cognitive ability (1 = Raven IQ below 85)	−0.274*** (0.033)	−0.344*** (0.045)
Constant	−0.454 (0.267)	0.394 (0.363)
n	3385	1703
Controlled for academic performance in previous school year	Yes	Yes

* $p < 0.05$,.
** $p < 0.01$,.
*** $p < 0.001$.

Author contributions

Scott Rozelle, Matthew Boswell, Huan Wang and Sarah-Eve Dill contributed to research design and conduct of the study; Scott Rozelle, Huan Wang and Xiaodong Pang had a role statistical analysis, interpretation of the data and manuscript preparation. Xiaodong Pang, Sarah-Eve Dill, and Huan Wang drafted the manuscript, and Scott Rozelle, Manpreet Singh, and Sarah-Eve Dill critically revised the manuscript. Matthew Boswell and Xiaopeng Pang provided material support. Scott Rozelle and Huan Wang supervised.

Funding

This research was supported by Enlight Foundation. The funding source did not have a role in the design or conduct of the study; the collection, analysis or interpretation of data; the preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Table A1.

Declaration of Competing Interest

The authors declare no conflicts of interest.

Acknowledgements

The authors would like to thank the study participants.

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