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Anemia in Rural China's Elementary Schools: Prevalence and Correlates in Shaanxi Province's Poor Counties

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Despite growing wealth in China, a significant share of children across rural China still have no access to iron-rich foods, vitamins, and other micronutrients. Such poor diets may result in high incidences of nutritional problems, including anemia. The objective

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of the study was to increase understanding of the extent of anemia, and identify structural correlates of anemia in poor Shaanxi province's primary schools. The article shows that the overall anemia rate is 21.5 percent when using a blood hemoglobin cutoff of 115 g/L (39 percent with a cutoff of 120 g/L). We find that those students that are boarding at school and eat lunch away from home are more likely to be anemic. Children with anemia are found to have lower height for age (HAZ) scores. If this part of Shaanxi province is representative of all poor counties in China, these findings mean millions of children in poor rural China may be anemic.

KEYWORDS anemia, primary school students, educational performance, rural China

Iron deficiency anemia is a debilitating health condition that affects hundreds of millions of people worldwide, mostly in developing countries (Yip 2001). Prolonged iron deficiency impairs hemoglobin production, limiting the amount of oxygen that red blood cells carry to the body and brain. Consequently, anemia leads to lethargy, fatigue, and prolonged physical impairment. In the extreme, severe anemia can be life threatening because it reduces the body's ability to tolerate trauma and bleeding. Moreover, a large body of research links both anemia and iron deficiency not serious enough to impair hemoglobin synthesis with cognitive impairment and altered brain function (Yip 2001).

In addition to short- and long-term health consequences, anemia is doubly burdensome because it also has serious implications for the educational performance of those with the disease. Iron deficiency and anemia has been shown to lead to impaired cognitive and motor ability. Consequently, childhood anemia has been shown to be negatively correlated with educational outcomes, such as grades, attendance and attainment (Halterman et al. 2001; Stoltzfus 2001; Stoltzfus et al. 2001; Miguel and Kremer 2004; Bobonis, Miguel, and Puri-Sharma 2006). Early identification and treatment of anemia are crucial since without intervention these cognitive impairments can be irreversible, even after iron status is restored (Lozoff et al. 2000). Anemia may therefore limit children's opportunities for social and economic mobility and may be an important contributor to the intergenerational transmission of poverty (Bobonis et al. 2006).

In almost all countries of the world, the prevalence of anemia falls when incomes rise. Indeed, the World Health Organization's "Global Database on Anemia" and some other studies reveal that countries with higher income levels tend to have a lower incidence of iron deficiency anemia (Gwatkin et al. 2007; de Benoist et al. 2008). Incomes across China have risen, even in rural areas. Yet despite growing wealth and China's government growing commitment to provide quality education, a number of studies show that a significant share of children across rural China are so severely iron deficient as to be classified anemic. For example, a recent study in Shaanxi Province run by the provincial Center for Disease Control found anemia in as many as 40% of freshmen in a rural junior high school (Xue et al. 2007). A study in Guizhou found anemia rates to be as high as 50 to 60% (Chen et al. 2005). Although these studies are small-scale and nonrepresentative, they still give rise to concerns that anemia may be a serious problem in rural China, at least for a segment of the population. Such a finding would be important since China in the past has been shown to have highly unequal distribution of income (Khan and Riskin 2001). If large shares of China's population were still suffering from a disease such as anemia, it would suggest that the efforts of the government in recent years to reduce inequality still have not been sufficient and more effort is needed in targeting nutritional deficiencies.

In this article, we report on the results of a large survey of over 4,000 fourth grade students, mostly ages 9 to 11, from 70 randomly chosen elementary schools in 9 of the poorest counties in Shaanxi Province, which is located in China's poor northwest region. The objective of this work is simple: we want to increase our understanding of the extent of anemia in Shaanxi Province's poor areas, and identify structural correlates of anemia in this region. Finally, we hope to begin a process through which we are able to assess the effect of anemia on health and educational performance. These insights also may illuminate the reasons for continued existence of anemia in a rapidly developing population.

Before presenting the data, one important issue needs to be considered when reading the present article. Since we are focusing on fourth graders in the sample schools, this means that the typical student is somewhere between nine and twelve years old. This age range results in some uncertainty about what cutoff should be used to report anemia levels. The World Health Organization (WHO) recommends a cutoff of 115 g/L for children aged 5–11 and 120 g/L for children between the ages 12–14. We report the results of both cutoffs; however, in most of the analysis we use the conservative cutoff of 115 g/L.

DATA

We collected data on fourth grade elementary school students from rural counties in Shaanxi Province. The data set, collected in October 2008, contains student- and school-level information from 70 primary schools. One of the benefits of doing the study in Shaanxi Province, a province with a population of 36 million, is that there are three distinct regions in the province. Each is representative for different geographic areas of western China. Southern Shaanxi is located in a mountainous, subtropical area. Northern

Shaanxi is centered on the Loess Plateau and borders the Ordos Desert. Central Shaanxi is representative of the plains region of northern China and is the wealthiest in terms of income per capita (in relative terms) when compared to Southern and Northern Shaanxi.

The sample selection procedure used a randomized sampling approach. In choosing our sample, we obtained a list of all counties in each of the three regions. Each of the counties on the list was given a poverty ranking. The poverty ranking was taken from a paper by Olivier and others (2008), which produced a high quality poverty map of Shaanxi. The village-specific poverty indicators from the poverty map were aggregated to produce county-level indicators of poverty. Once each county was assigned a poverty indicator, we chose the eight poorest counties in Shaanxi. Of these, six were in Southern Shaanxi and two were in Northern Shaanxi. For comparison, we chose one county in Central Shaanxi.[1] The location of the study counties are shown in figure 1.

Inside each sample county, the survey team obtained a list of all townships. The townships were ranked by per capita gross value of industrial output (GVIO), which allows researchers to more accurately divide the sample into wealth quantiles (Rozelle 1996). In each township we then obtained a list of all *wanxiao* (or all elementary schools with six full grades, 1st to 6th). Sampled schools had more than 400 students and at least 100 boarding students. As a result, of 115 schools in the sampling frame, we randomly selected 70 of them for inclusion into our final sample. The 70 schools were from 62 different towns. Table 1 shows a summary of the counties in the study and the number of schools in each.[2]

Four teams of six enumerators gathered the data set. In each team, one person collected data on the school from the principal and the school's fourth-grade homeroom teacher, while three collected individual and household socio-economic information from the students. Two trained nurses from the Jiaotong University's School of Medicine in Xi'an carried out the hemoglobin tests and took anthropomorphic measures. To collect the anthropometric measures, the nursing teams used a set of high quality equipment that is approved by the Chinese Center for Disease Control for measuring the physical development of

[1]We selected Chunhua county as the comparison county for the Central Region. Chunhua county's per capita income level is the highest of all of our counties. It is just slightly below the average for Shaanxi. We also choose Chunhua because it is one of the places in which a non-governmental organization (NGO), Plan International, planned to do a future intervention. There were four boarding schools chosen to be part of the sample in Chunhua.

[2]In the 115 schools that met the criteria of number of students and number of boarding students there was significant heterogeneity among the different regions that made up our sampling frame. For example, in the case of Suide and Zhashui counties less than eight boarding schools were part of the sampling frame. In contrast, in the case of Yang and Xunyang counties there were 20 and 36 schools, respectively. Consequently, the distribution of sample sizes in terms of schools (as well as students) is uneven across the nine sample counties.

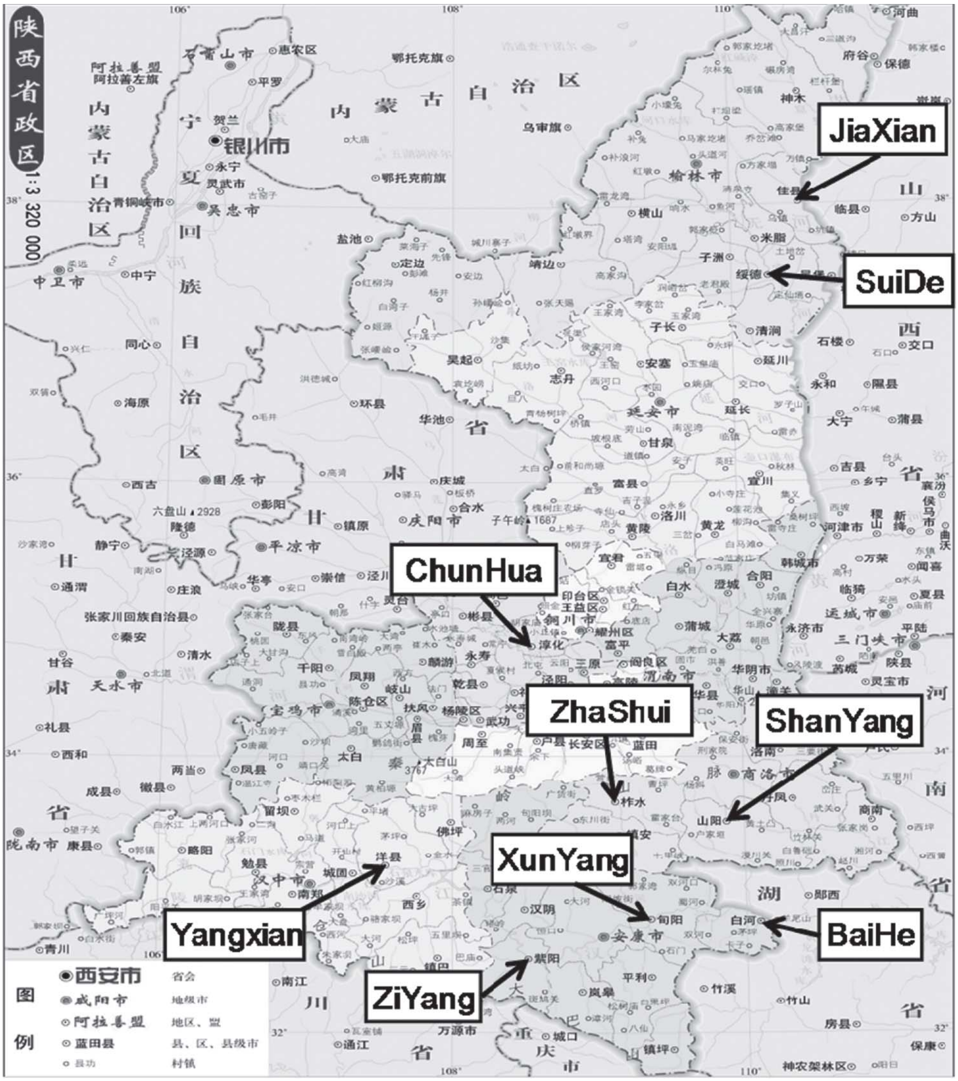

FIGURE 1 Map of sample counties. *Source*: Authors' survey.

students. Age information was taken from the birth records that are part of each student's matriculation folder. The age data from school matriculation forms are thought to be relatively accurate in China. Hemoglobin levels were measured onsite using a Hemocue Hb 201+ system.

The first part of the student survey collected data on the basic socioeconomic information about each student. These questions included details about the student's gender, age, and family structure. They also asked about where the student lived—at home or in the school's boarding dormitories. Each student also took a form home to his/her parents who filled out information on their levels of education, age, and occupation.

TABLE 1 The Distribution of Sample Schools and Students across Counties

	Number of schools	Number of students	Percentage of students
Total sample	70	4,158	100
By county			
Baihe	7	387	9.3
Chunhua	4	309	7.5
Jiaxian	6	245	5.9
Shanyang	8	488	11.8
Suide	6	363	8.8
Xunyang	21	1,234	29.7
Yangxian	9	572	13.8
Ziyang	4	308	7.4
Zhashui	5	243	5.9
By gender			
Female		1,849	44.5
Male		2,309	55.5

Source: Authors' survey.

The second part of the survey consisted of a series of tests: a standardized math test, a cognitive test, and a psychological test. The math test was based on a subset of a test originally created for The Trends in International Mathematics and Science Study (TIMSS). The cognitive test was developed to test for cognitive reasoning ability and was developed by the World Bank. Professor Bucheng Zhou (Zhou 1991) developed the psychological test of well-being, the Mental Health Test (MHT). The Zhou MHT contains 100 yes/no questions. Lower test scores, correspond to a healthier mental state. The MHT has a reliability of 0.84–0.88 and a retest reliability of 0.78–0.86.

A short form was also passed out to all homeroom teachers. The form included a list of all students in the class. The homeroom teacher provided the final grades for math and language from the academic year before (i.e., from the previous June). In all of the counties, the final grades for math and language are fully based on a standardized, countywide final exam that is written and graded by a panel of teachers who do not know the names of the students when they are grading the exam.

Anemia in Shaanxi Province

Although incomes across China have risen, we find that anemia is still widespread.[3] Across all of the schools surveyed (combining all nine counties), we found the population hemoglobin average was 122.8 g/L. Hemoglobin levels were normally distributed with a standard deviation of 11.0 (figure 2).

[3]Of course, given the cross section nature of our data, it is impossible to say if the rate of anemia has fallen or not. It is possible that in the past it was even higher. With our data, we can only say that anemia still affects a large share of the student-aged population in 2008–2009.

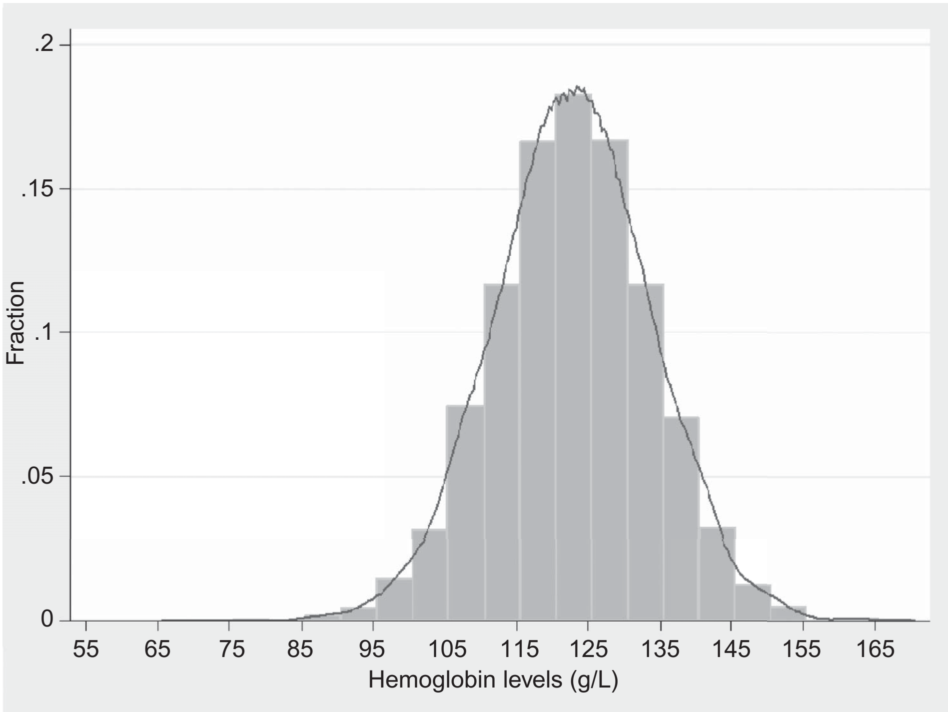

FIGURE 2 Histogram of hemoglobin levels (g/L) across the entire sample population. Black vertical line shows the cutoff for anemia. *Source*: Authors' survey.

Any student with hemoglobin levels below 115 g/L was considered anemic as per WHO guidelines for children between 5–11 (United Nations Children's Fund, World Health Organization, and United Nations University 2001). This cutoff is visualized in figure 2 with a vertical black line. Using this cutoff, we calculated that across all school and counties, 895 of the 4158 students we surveyed were anemic resulting in a population incidence of 21.5% (table 2). As figure 2 shows, however, the frequency of students with hemoglobin counts between 115 g/L and 120 g/L are high. If we were to use an anemia cutoff of 120 g/L the anemia rates would be 39%.

An important aspect of our data is that unlike certain impoverished populations of children in India and Africa, we did not observe many cases of severe anemia characterized by hemoglobin levels less than 70 g/L (United Nations Children's Fund, World Health Organization, and United Nations University 2001). We found only one student who met this criterion.

Although the average incidence of anemia in the entire population was 21.5% (using the 115 g/L cutoff), this disguises geographical variation among counties and schools (table 2). Indeed, there was significant variation in anemia rates among different counties. When we ran a multiple regression of county dummies on anemia rates, the p-value of the test that

TABLE 2 The Distribution of Hemoglobin Levels and Anemia Prevalence across Counties

	Hemoglobin level (g/L)	Number of students with anemia	Percentage of students with anemia
Total sample	122.8	895	21.5
By county			
Baihe	121.6	91	23.5
Chunhua	124.4	53	17.2
Jiaxian	124.7	36	14.7
Shanyang	123.4	86	17.6
Suide	123.4	66	18.2
Xunyang	119.0	406	32.9
Yangxian	123.6	98	17.1
Ziyang	131.2	23	7.5
Zhashui	127.1	33	13.6

Source: Authors' survey.

there was no county effect was $p < .001$. Ziyang County had the lowest average anemia rate at 7.5%, Xunyang county had the highest average anemia rate at 32.9%. The variation among counties can be illustrated by histograms of hemoglobin levels across of all nine counties (figure 3).[4]

Beyond the variation observed among counties, we also observed significant variation among schools. When we ran a multiple regression of school dummies on anemia rates, the p-value of the test that there was no school effect was $p < .001$. The rate of anemia ranged between 0% and 66%.

Most schools had a prevalence rate of around 20%. However, it is important to note that there is a second peak around 40% suggesting a second population of schools with a higher proportion of anemic students. Only four schools out of 70 had average anemia rates below 5%, the WHO cutoff for a population to be considered to *not* have a serious anemia problem. Clearly according our findings on anemia should be a concern for school education officials who have a mandate to keep their students healthy. Unfortunately, during our survey (before the HemoCue test) when we asked the principals whether there was an anemia problem in their schools, over 90 percent of them said, "no", "it's not very serious", or "they did not know."

[4]When comparing anemia rates among schools, we find there are great variations within counties. For example, in Xunyang county there are schools with anemia rates that are less than 5%. In contrast, there are other schools in the same county in which the anemia rates are more than 40%. This great heterogeneity may mean that it was possible that we do not have a perfectly representative sample—especially given difficulties in sample selection that occurs in every study. In fact, our anemia rates may have been slightly underestimated in one county. According to an interview with the officials in Ziyang county, since one of the four original sample schools (that we randomly selected) had to be replaced with another one (due to our inability to access the school by car), we may have replaced a remote school (possibly with a higher rate of anemia) with a more accessible one (which may have had a lower rate of anemia). Fortunately, this happened in only one county.

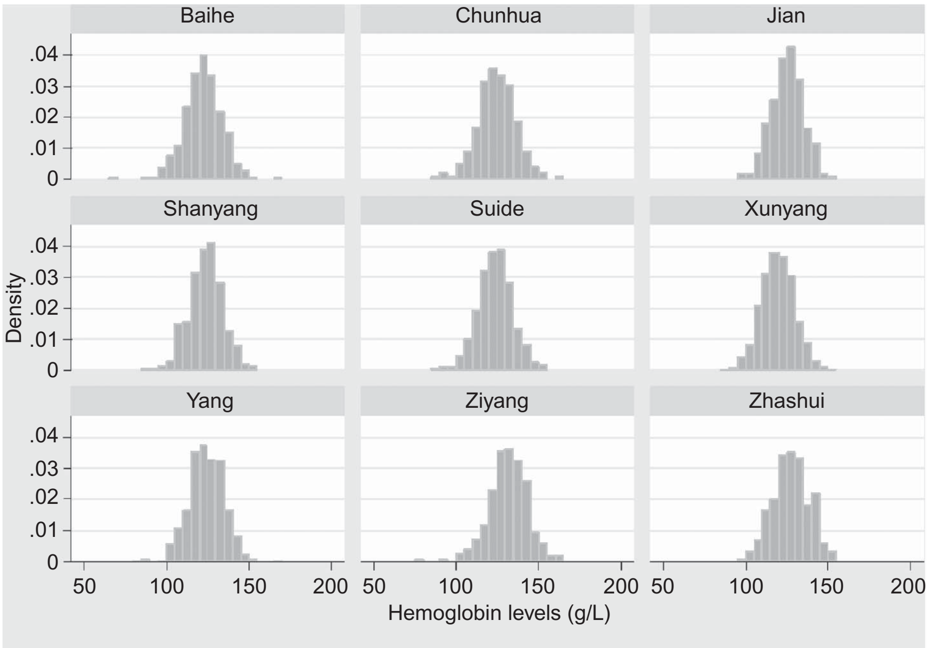

FIGURE 3 Histograms of hemoglobin levels in each county. Each subplot shows a different county. *Source*: Authors' survey.

From these data we can see that anemia in Shaanxi province is widespread. Without the knowledge of almost any principal (who are the legal guardians of the students when they are in school), anemia afflicts a significant proportion of 4th graders. It is important to note, however, that the actual prevalence of anemia varied significantly at the county and school level.

Structural Correlates of Anemia

The correlates of anemia can be broken into three general categories: individual, household, and school. Individual includes factors such as age and gender. Household includes parents' education and occupation. School includes factors such as whether a student boards at school and the types of school lunches that the student eats.

Males and females did not significantly differ in their anemia rate although there was a trend that females were slightly more likely to be anemic (table 3). Children at this age (pre-puberty) should not show large gender differences as blood loss from menstruation that can drastically affect iron status affects older, adolescent girls (Hallberg and Rossander-Hulten 1991). Furthermore, there was no significant correlation with age, although there was a trend that younger students had higher anemia rates (table 3).

TABLE 3 Individual and Household Characteristics (Gender, Education, and Occupation) that Correlate with Anemia

Item	Percentage of anemic students	Percentage of students
Female	21.8	44.5
Male	21.3	55.5
Age group: below 9	23.8	6.2
Age group: (9–10)	22.5	42.6
Age group: (10–11)	20.2	35.3
Age group: above 11	20.0	16.9
Father's education		
Primary school or below	24.6	37.6
Junior high school	20.1	45.1
High school	18.8	15.5
College or above	14.1	1.8
Mother's education		
Primary school or below	23.1	52.0
Junior high school	19.8	34.6
High school	18.9	11.9
College or above	19.0	1.5
Father's employment		
Formal employment or businessman	18.5	22.8
Other work (farmer, wage laborer, unemployed, etc.)	22.4	77.2
Mother's employment		
Formal employment or businessman	18.7	19.4
Other work (farmer, wage laborer, unemployed, etc.)	22.2	80.6

Source: Authors' survey.

In contrast to the individual level characteristics, household characteristics were correlated with anemia. The education of both the father and mother both were significantly correlated with anemia (table 3). The higher the level of education achieved, the lower the anemia rate.[5] This can be seen by noting that when a child's parents had a high school education, their children have lower anemia rates than children of parents who only finished primary school or are illiterate.

The profession of the father and mother is also significantly correlated with anemia rates (table 3). Children whose fathers worked as wage laborers/farmers had the highest anemia rates. When the father was self-employed or had formal employment, children had the lowest anemia rates. The mother's job also had a significant impact on anemia rates. From this analysis we cannot tell if this relationship is causal or what mechanisms might contribute to the correlation. From the pattern of results, however, it seems plausible that anemia is associated with parents that have lower income professions (wage earners/farmers), which may limit the care they can give to the child.

[5]The only exception is when the mother's education is college or above.

TABLE 4 School Characteristics that Correlate with Anemia

Item	Percentage of anemic students	Percentage of students
Residence		
At home	20.0	63.3
At school	24.3	36.7
Lunch		
Eat at home or bring lunch from home	19.0	56.0
Eat at school cafeteria	24.3	44.0

Source: Authors' survey.

We next examine school determinants or aspects of the students' school life that correlate with anemia rates (table 4). Students who live in the school dormitories had significantly higher anemia rates than students who live at home. Furthermore, students who eat in the school cafeteria had significantly higher anemia rates than students who eat at home or bring lunches from home. These two findings are in line with findings from our previous work, which shows that boarding schools in rural Shaanxi Province are ill equipped to deliver sufficient nutritional content in school lunches to their students (Luo et al., 2009). Luo and others (2009) reported that whereas 23% of students that lived in boarding school had height for age (and weight for age) z-score that was less than –2.00, only 11% of non-boarding school students did. Furthermore, our multiple regression analysis reveals students who lived in boarding school and ate lunch at school had lower hemoglobin counts and higher anemia rates (table 5).

Anemia and Correlations with Physical, Cognitive, Academic, and Psychological Outcomes

Having shown the prevalence and possible structural determinates of anemia, we next examine anemia's correlation with student welfare as measured by physical traits, cognitive abilities, academic performance, and psychological health.

According to our data, anemia has a strong correlation with the students' heights and weights (table 6). Although the body mass index (BMI) z-scores of all students were below normal, students with anemia had a significantly lower BMI than non-anemic students. Furthermore, while 15.0% of non-anemic students had stunted growth (as determined by a height-for-age z-score that was less than –2.00), 18.7% of anemic students were stunted. Thus in this population, anemia is associated with students that have impaired normal physiological development.

Using the suite of psychological tests contained in the Zhou MHT, we were able to measure by self-report how students were able to cope with

TABLE 5 The Multivariate Analysis of Hemoglobin Levels

	The test level of hemoglobin levels (g/L)		
Dependent variable	(1)	(2)	(3)
Boarding student or not (0 = not, 1 = yes)	−1.83 (−5.17)***	−1.03 (−2.37)**	−1.04 (−2.23)**
Eating lunch at school or not (0 = not, 1 = yes)		−1.33 (−3.15)***	−1.46 (−3.22)***
Age of student			0.07 (4.77)***
Education of father (1 = Primary school or below, 2 = junior high school, 3 = senior high school, 4 = college or above)			0.56 (2.04)**
Work of father (0 = other work [farmer, wage laborer, unemployed, etc.], 1 = formal employment or business man)			1.99 (1.99)**
Education of mother (1 = Primary school or below, 2 = junior high school, 3 = senior high school, 4 = college or above)			0.39 (1.43)
Work of mother (0 = other work [farmer, wage laborer, unemployed, etc.], 1 = formal employment or business man)			−0.96 (−0.90)
Constant	123.6 (579.46)***	123.8 (534.48)***	113.2 (56.88)***
Observations	4149	4149	4149
R^2	0.01	0.01	0.02

Note. t statistics are in parentheses. *Source:* Authors' survey.
*$p < .1$; **$p < .05$; ***$p < .01$.

TABLE 6 Correlated Impacts and Consequences of Anemia

Correlates	Anemic	Non-anemic
Body-mass index (*z*-score)	−0.40	−0.34
Height-for-age (*z*-score)	−1.09	−1.03
Stunted growth	18.7%	15.0%
Aggregate mental health test (max = 90)	40	39
Math score (max = 29)	18.5	18.7
Cognitive score (max = 22)	12.5	12.7
Math grade (max = 100)	70.2	70.4
Language grade (max = 100)	68.6	67.4

Source: Authors' survey.

different stressors (table 6). However, we did not find any significant trends in psychological state between students with or without anemia.

Students with anemia also performed more poorly than students without anemia on both the standardized math test and had lower school math grades. Without holding other potential confounding variables constant, the differences were not statistically significant. However as shown in the previous section, there are many correlates of anemia, and thus multiple regression is required to assess the causal effect of anemia on academic and cognitive performance.

To examine the correlation between anemia status and these performance measures we used multiple regression analysis and held constant a set of explanatory factors beyond anemia (the Appendix). By controlling for certain individual- (age), household- (number of siblings) and school-correlates (kindergarten, school dummy) we found that anemia was significantly correlated with reduced scores on the math test and math and language grades. We conclude that anemia was associated with decreased cognitive performance in this sample. Thus, our findings are consistent with a hypothesis that suggests that the epidemic of anemia in rural Shaanxi schools may (in part) underlie the reduced academic achievement of students from rural areas.

SUMMARY AND DISCUSSION

We have shown that anemia is epidemic in rural Shaanxi elementary schools. The overall anemia rate was 21.5% when using a blood hemoglobin cutoff of 115 g/L (the criteria that we used in the article generally). When using a cutoff of 120 g/L, 39% of students had hemoglobin counts that classified them as anemic. From these rates anemia we can estimate that there likely are an additional 30%–50% of students that are iron deficient (United Nations Children's Fund, World Health Organization, and United Nations University 2001). There was significant variation between counties and schools, but 66 out of 70 schools had large proportions (i.e., greater than 5%) of anemic students. We found that parental characteristics correlate with anemia rates, specifically education level and occupation. We also found that school environment was important; boarding students and students who ate lunch from the school cafeterias were more likely to be anemic. These findings point to poor nutrition from school-provided meals as a possible source of anemia.

Absolute impacts were difficult to discern because of the many correlates discussed above. The impact of anemia on schoolchildren took two forms: inhibited physical development and reduced cognitive performance. Children with anemia were shorter for their age and had a higher proportion of stunted growth. Beyond health and development, we also found that anemia significantly correlated with lowered academic achievement, as measured by math and language grades. Cognitive performance was also lower in anemic versus non-anemic students, as measured by a standardized mathematics exam.

Although we were not able to pinpoint the exact determinates of anemia, the main implication of this work is that anemia remains a serious health problem for educators in rural Shaanxi. However, none of the correlates we measured explain the whole extent of anemia, which suggests fundamental determinates we did not measure. Furthermore, our correlative analysis does not allow us to determine causality. It does raise significant issues such that more research in this area is needed.

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Appendix Multivariate Analysis about Impacts of Anemia

	Math score	Cognitive score	Math grades	Language grades	Height-for-age (z-score)	BMI z-score	Mental health score
Anemia	−0.322	−0.052	−1.709	−1.565	−0.089	−0.012	0.740
	(1.69)*	(0.37)	(2.32)**	(2.24)**	(2.11)**	(0.33)	(1.33)
Age	−0.037	−0.028	−0.132	−0.144	−0.035	−0.016	0.049
	(5.99)***	(6.02)***	(5.37)***	(6.17)***	(25.20)***	(13.00)***	(2.68)***
Kindergarten	0.374	0.060	1.778	0.786	−0.042	0.040	0.593
	(2.25)**	(0.48)	(2.77)***	(1.29)	(1.13)	(1.21)	(1.22)
Older siblings	−0.077	−0.063	−0.589	−0.764	−0.012	0.019	0.053
	(1.39)	(1.53)	(2.69)***	(3.67)***	(0.96)	(1.28)	(0.33)
Younger siblings	−0.267	−0.182	−0.743	−0.390	0.010	−0.047	0.445
	(4.05)***	(3.67)***	(2.58)***	(1.42)	(0.65)	(2.59)***	(2.30)**
Constant	23.758	16.349	88.386	87.511	3.343	1.66	32.820
	(30.90)***	(28.31)***	(29.19)***	(30.34)***	(19.35)***	(10.67)***	(14.56)***
Includes school dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3268	3268	3268	3268	3268	3268	3268
R^2	0.13	0.18	0.30	0.26	0.23	0.14	0.08

Note. Absolute value of t statistics in parentheses. *Source*: Authors' survey.
*significant at 10%; **significant at 5%; ***significant at 1%.