Alarmingly High Anemia Prevalence in Western China

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Abstract

Despite rapid growth in China, it is unclear whether the poor have benefited in terms of nutrition. This paper's goal is to understand the prevalence of anemia among school children in western China. We report on results from seven cross-sectional surveys involving 12,768 age 8-12 students. Sample students were selected randomly from 283 primary schools in 41 poor counties of Ningxia, Qinghai, Shaanxi and Sichuan provinces. Data were collected through questionnaires and hemoglobin tests. The dataset represents 7 million age 8-12 children in poor western counties. The anemia prevalence was 34% using the WHO's hemoglobin cutoff of < 120g/L. Students who boarded at school and girls were more likely to be anemic. Assuming the sample population is representative of poor regions in western China, nearly 2.5 million 8-12 year old school children in the region may be anemic and many more iron deficient. Given China's growth, such high prevalence of anemia is surprising and illustrative of the large health disparities in the country. Iron deficiency remains a significant nutrition issue, though there appears to be no effort to address this issue.

Keywords: anemia; primary school students; rural China

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Introduction

Iron deficiency anemia is the most common nutritional deficiency worldwide. This condition affects approximately a quarter of the global population, mostly in developing countries (de Benoist *et al*, 2008; Yip, 2001). Vital aspects of human health are adversely affected by anemia, including physical activity, temperature regulation, behavior and immune function (de Benoist *et al*, 2008; Dallman, 1986). Furthermore, numerous previous studies have linked iron deficiency and anemia with cognitive impairment and altered brain function (Yip, 2001; Scrimshaw,1990).

Beyond immediate and long-term health consequences, anemia can also cause one to have difficulty concentrating, which can lead to poor learning. Literature over the past three decades shows links between iron deficiency (particularly during early childhood) with poor cognitive performance and motor/psychomotor development (Grantham-McGregor and Ani, 2001; Iannotti *et al*, 2006; Walter *et al*, 1989). Childhood anemia is also known to impair academic achievement, including grades, attendance and attainment (Halterman *et al*, 2001; Stoltzfus, 2001; Stoltzfus *et al*, 2001; Bobonis *et al*, 2006). Recognizing and treating anemia are especially critical since its effects on developmental and behavior have been shown to have long-lasting effects into adulthood (Lozoff and Georgieff, 2006; Lozoff *et al*, 2006; Lozoff *et al*, 2000; Algarin *et al*, 2003), hindering economic and social mobility (Bobonis *et al*, 2006).

Despite the unprecedented economic growth in China over the past few decades, it is unclear the extent to which anemia remains a problem in the country. According to the World Health Organization's "Global Database on Anemia" as well as international research, the prevalence of anemia generally decreases as incomes rise (de Benoist *et al*, 2008; Gwatkin *et al*,

2007). Yet paradoxically in China, a number of indicators suggest that many individuals, especially children, are not performing as well as might be expected. Literacy rates of students from poor rural areas fall far short of their urban counterparts (World Bank, 2001; Zhang and Kanbur, 2005) and gaps in educational attainment across China further support this conjecture (Knight and Shi, 1996). Although China has made strides in nutrition and health, especially as seen through height, weight and other indicators in cities, stunted and underweight in poor rural areas remain a significant public health problem (World Bank, 2001; Zhuo *et al*, 2009).

Anemia is likely the result of poor dietary quality, particularly in schools in poor rural areas such as Shaanxi Province where many students eat predominantly starch-based diets with minimal amounts of meat, vegetables and fruits (Kim *et al*, 2003; Food and Agriculture Organization of the United Nations, 1999; Luo *et al*, 2009). Although recent studies are available from local centers for disease control and health bureaus—some of which show a high prevalence of iron deficiency (Li, 2009; Chen *et al*, 2005), many do not adequately report their methodology and sampling. There are not many studies on the prevalence of anemia or iron deficiency that examine school-aged children, especially in poor rural areas. Indeed, we find no studies anywhere in the country in the past 10 years that report on the rates of anemia in China's schools. The main objective is to assess the extent of anemia in school-aged children from China's poor, rural areas. We also will seek to see if certain types of students have characteristics that are more correlated with anemia. Reported results in this study are based on seven surveys including 12,768 third to fifth grade students, mostly aged 8 to 12, from 283 randomly chosen elementary schools in 41 of the poorest counties in Ningxia, Qinghai, Shaanxi, and Sichuan Provinces, which are located in China's poor western region. The same research team conducted all seven surveys with identical sampling (schools and students) and measurement approaches

(testing for anemia, collecting information on structural correlates). Importantly, these data sets can be considered representative of western China's poor areas and can be used to understand the nutritional status of more than 13 million children (ages 8 to 12). Finally, this paper aims to provide an empirical foundation for policy action to address large-scale nutritional deficiencies and overcome some of the large health disparities that have risen during China's rapid growth.

Material and Methods

Defining Anemia

The normal hemoglobin distribution varies according to a number of factors, including age and altitude. The age range of our sample population results in some uncertainty about which Hb cutoff should be used to report anemia levels. Since we are focusing on third to fifth graders, most students are between eight and twelve years old. The WHO recommends a cutoff of 115g/L for children at age 5-11 and 120g/L for children at age 12-14 (United Nations Children's Fund; World Health Organization; United Nations University, 2001). However, although WHO standards are widely used to define anemia, some studies have defined anemia levels using different hemoglobin cutoffs. For these reasons we report the anemia levels with both cutoffs in this paper: 1) 120g/L for ages 8-12 (Table 2); and 2) 115 g/L for children under 12 and 120g/L for children over 12 (Appendix Table 1). Given that borderline Hb levels as well as iron deficiency without anemia have also been shown to affect cognitive performance, we primarily use 120 g/L as the cutoff for anemia for the majority of our analyses (Halterman *et al*, 2001).

In addition, in order to compare the prevalence of anemia among populations living at varying elevations, the hemoglobin density of populations at high altitudes must be adjusted downward to account for the reduced saturation of the blood using well accepted algorithms (Nestel, 2002; Hurtado, 1945).

Specifically, many students in our population sample attend schools at altitudes well above 1000 meters. For example, Qinghai students attend schools at a mean altitude of 2344 meters above sea level. Thus, we adjusted reported hemoglobin counts for any altitude over 1000 m using a curvilinear equation (below) developed by the Centers for Disease Prevention Control (CDC), Pediatric Nutrition Surveillance System (Nestel, 2002).

$$Hb_{adjustment} = -0.32 * (\text{altitude in meters} * 0.0033) + 0.22 * (\text{altitude in meters} * 0.0033)^2$$

Data

Student- and school-level data were collected on third, fourth and fifth grade elementary school students from 41 *poor counties* (defined below) in the four provinces, Ningxia, Qinghai, Shaanxi and Sichuan between October 2008 and April 2010. Conducting the study in four western China provinces allows us to identify anemia prevalence across widespread regions of the impoverished rural west. Over 737 million people live in rural regions of China, accounting for 56% of the population (National Bureau of Statistics of China, 2008). Even if we only consider the rural populations of the poor counties in our four sample provinces, the results in this paper are relevant for the school aged children of nearly 38 million people.

The four study provinces are among the poorest in China, based on per capita income. In Ningxia, the average per capita income is 3,180 RMB (where 7.62 RMB = 1 US Dollar), falling 23% below the mean national income. Qinghai's average per capita income (2,683 RMB) is even lower, 35% below the mean national income. Shaanxi's per capita income is 3,546 RMB, 14% below the mean national income. Lowest among our sample provinces, Sichuan has an average per capita income of 2,644 RMB, or 36% below the mean national income (National Bureau of Statistics of China, 2008).

In choosing our sample observations, we followed a uniform selection procedure. First, we obtained a list of all poor counties in each of the study regions. In China a *poor county* is a designation given by the National Statistics Bureau as a way of identifying counties that contain significant concentrations of people that live under the poverty line. There are 592 poor counties in China, making up about one third of the number of counties in which lives 20 percent of the population. There are 109 poor counties in the four study provinces. From these poor counties we took a random sample of 41 counties.

Inside each sample poor county, the survey team obtained a list of all townships and in each township we then obtained a list of all *wanxiao* (rural elementary schools with six full grades, grades 1-6). Sampled schools had over 400 students and at least 50 boarding students. With the implementation of school merger programs in rural China, more and more *jiaoxuedian* (small branch schools that still offer teaching services to younger first or second grade students in remote villages) are disappearing. Across rural areas, jiaoxuedian students are moving to dormitories of wanxiao. Many townships now have only one or two primary schools. Since boarding schools are becoming the main providers of education services in rural China, we specifically used the criteria of including only wanxiao, and schools with at least a certain number of total students as well as boarding students in this study. The students in the schools that are in our sampling frame account for most of the grade three, four and five students in the study areas. In total, we identified 368 schools that met our criteria and randomly chose 283 schools for inclusion into our study. The location, size, date and other information about the survey are summarized and grouped by province and study year in Table 1.

Data were collected by eight enumerator teams. In each team one person collected data on the school from principals and third, fourth and fifth-grade homeroom teachers, while others

collected individual and household socio-economic information from students. Trained nurses from the Xi'an Jiaotong University's School of Medicine measured hemoglobin levels on-site using a Hemocue Hb 201+ system. Age was taken from the birth records in each student's matriculation folder which is considered an accurate source. Finally, teams of enumerators used surveys to collect simple socioeconomic information about each student including gender, residence – at home or at school, and their parents' levels of education, residence, and occupation. We examine the relationship between these variables and anemia.

Results

Anemia in Qinghai, Ningxia, Shaanxi, and Sichuan

Across all of the schools surveyed (combining all 41 counties), we found the overall mean hemoglobin average was 124.6 g/L. Hemoglobin levels were normally distributed across all seven datasets, with a standard deviation of 12.5 (Table 2). In our sample, 4303 of the 12,768 students we surveyed had hemoglobin levels lower than 120g/L, resulting in a population anemia prevalence of 34% (Table 2). As Figure 1 indicates, however, the frequency of students with hemoglobin counts between 115g/L and 120g/L is high. If we were to instead use an anemia cutoff of 115g/L, anemia prevalence would be lower but still significantly high at 21%.

There was considerable variation in anemia prevalence (<120g/L) across the sample, ranging from 25.4 percent in Ningxia (Dataset 5) to 51.1 percent in Qinghai (Dataset 4). From a multiple regression of county dummies on anemia levels, the p-value of the test (an F-test of the joint significance of the dummies) indicated that there was a significant county effect ($p < 0.001$) within provinces. In other words, different counties in our sample had significant differences in anemia prevalence.

Beyond the variation observed among provinces and counties, we also observed significant variation among schools. Prevalence of anemia ranged widely across schools, for example more than 90% of 165 students in each of the four sample schools were anemic in Qinghai province while in another four schools in Ningxia province less than 10% of the 203 students were anemic. The differences between the prevalence of anemia in different schools are statistically significant, as evident from a multiple regression analysis with school dummies (results not shown).

According to the WHO, anemia should be considered a serious problem in populations with a 5% or greater prevalence of anemia (United Nations Children's Fund; World Health Organization; United Nations University, 2001). Of the 283 schools we sampled only 4 had anemia levels below 5%. Although there was significant variation across the sample, all 41 counties contained schools with anemia levels above this cutoff.

Structural Correlates of Anemia

We did not find a significant difference in anemia rates between children older than 12 and those younger than 12 (Table 2). Gender had a small but significant association with females more likely to be anemic than males (Table 3). In terms of household characteristics, higher levels of parental education were significantly associated with a lower prevalence of anemia (Table 3)

Since it is common in many rural areas in China for one or both parents to migrate to cities to find better work opportunities we investigated a possible association between anemia and whether the child's mother lives at home or not. The mother's place of residence was not associated with anemia. However, there was a trend that students who were "left behind" in the case that their mothers left home to work had slightly higher anemia levels (Table 3; see note "b"

at bottom of table). Finally, students who live in the school dormitories had significantly higher anemia levels than students who live at home (Table 3).

Discussion

We have shown that the prevalence of anemia is high among elementary school children in all sampled poor counties of the four study provinces, Ningxia, Qinghai, Shaanxi, and Sichuan. As our sample counties, schools and students were randomly selected (from poor counties in the four study provinces) and since the four study provinces are similar to the other poor provinces in western China, we believe this result extends to poor counties throughout China's impoverished western provinces. The overall anemia prevalence was 34% when using a blood hemoglobin cutoff of 120 g/L (which we used generally in this paper). When using a cutoff of 115 g/L for students between 5 and 11, 21% of students were classified as anemic. From these anemia levels, we can estimate that there are an additional 30-50% of students that are iron deficient.[26] To the extent that we did not study those students in grades three, four and five that were in smaller schools that did not meet our sampling criteria, it is likely that those students that we did not include were even poorer than the students in our sample schools. To the extent that this is true, and to the extent the anemia is negatively correlated with poverty, the results in our study should be considered a lower bound on the estimate of prevalence.

When we generalize our results to all poor counties in all eight poor provinces in western China (our four study provinces plus Yunnan, Guizhou, Gansu and Xinjiang) we estimate nearly 2.5 million 8 to 12 year old school children in these areas are anemic. This number is estimated from China's national census data to approximate the number of children in the 8 to 12 year old cohorts and in the rural areas of the poor counties in the eight western provinces and multiplying by 34%.

In the analysis of the correlates of anemia we found that anemia clearly should be a concern for education officials who have a mandate to keep their students healthy. Moreover, it should be pointed out that in these studies we only measured hemoglobin. Had we extended our analysis to other nutrients, we likely would have found many other concurrent deficiencies, such as zinc, vitamin A and vitamin C. Indeed, principles are the legal guardians of students while they are in school. Yet during an earlier survey, over 90 percent of principals expressed that anemia or other micro-nutrient deficiencies was not a problem among their students (mostly because they had no way of knowing the true levels of iron deficiency), or that they simply did not know what iron deficiency was (Luo *et al*, 2010).[30] This is especially concerning since boarding school students are more likely to be anemic. This finding aligns with results from our previous work, which indicate 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).[23]

An important aspect of our data is that unlike certain impoverished populations of children in India and the African continent, we did not observe many cases of severe anemia characterized by hemoglobin levels lower than 70g/L (United Nations Children's Fund; World Health Organization; United Nations University, 2001).[26] There were only four students in our sample that met this criterion.

Although we were unable to pinpoint the exact determinants of anemia, the main implication of this work is that anemia remains a serious and widespread health problem among children in rural Western China. Anemia is a serious public health problem undermining the human capital potential of poor rural children in Western China. Studies on nutrition in China's large cities (e.g., in Shanghai), showing prevalence rates below 5%, also suggest that there are large disparities in health outcomes within China despite the nation's rapid growth (Shi *et al*,

2005). The findings also should call national health officials to action to both undertake further research as well as begin to take concrete measures to prevent anemia in vulnerable populations.

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Table 1. Description of sample population

	Sample province	Number of sampled counties	Per capita income of sample area (PPP-adjusted, in USD) [a]	Number of sampled schools	Number of sampled students	Survey date
Dataset 1	Shaanxi	9	683.48	70	4151	October 2008
Dataset 2	Shaanxi	8	660.20	24	1476	June 2009
Dataset 3	Shaanxi	10	769.14	66	2066	October 2009
Dataset 4	Qinghai	5	813.91	37	1474	October 2009
Dataset 5	Ningxia	5	794.21	37	2658	October 2009
Dataset 6	Sichuan	3	1085.81	21	516	April 2010
Dataset 7	Shaanxi	1	579.02	28	427	April 2010
Total/ Avg	---	41	769.44	283	12768	---

Data sources: Authors' surveys.

[a] All values are reported in US dollars in real PPP terms by dividing all figures that were initially reported in yuan (Chinese currency) by the official exchange rate (7.62 yuan : 1 dollar in 2007) and multiplying by the purchasing power parity multiplier (1 : 2.27543) (International Monetary Fund, 2007; World Bank,2009).

Table 2. Hemoglobin counts and anemia (Hb < 120g/L) prevalence of sample students

	Below 12 years old	Above 12 years old	Total
Hemoglobin (g/L)			
Total[a]	124.5 (12.3)	125.4 (14.3)	124.6 (12.5)
Shaanxi—2008 (Dataset 1)	122.8	124.6	122.9
Shaanxi—2009a (Dataset 2)	124.7	125.1	124.8
Shaanxi—2009b (Dataset 3)	126.7	131.0	126.9
Qinghai—2009 (Dataset 4)	119.2	118.0	118.9
Ningxia—2009 (Dataset 5)	128.2	131.7	128.7
Sichuan—2010 (Dataset 6)	126.1	N.A.	126.1
Shaanxi—2010 (Dataset 7)	125.2	124.6	125.2
Anemia (%)			
Total	33.8	33.2	33.7
Shaanxi—2008 (Dataset 1)	37.7	33.0	37.5
Shaanxi—2009a (Dataset 2)	31.6	31.3	31.6
Shaanxi—2009b (Dataset 3)	26.8	15.5	26.2
Qinghai—2009 (Dataset 4)	50.3	53.1	51.1
Ningxia—2009 (Dataset 5)	26.3	19.8	25.4
Sichuan—2010 (Dataset 6)	24.8	N.A.	24.8
Shaanxi—2010 (Dataset 7)	33.2	32.1	33.1

Data source: Authors' survey

[a] Numbers in parentheses indicate the standard deviation of hemoglobin count distribution.

Table 3. Structural Correlates of Anemia (Hb < 120g/L)

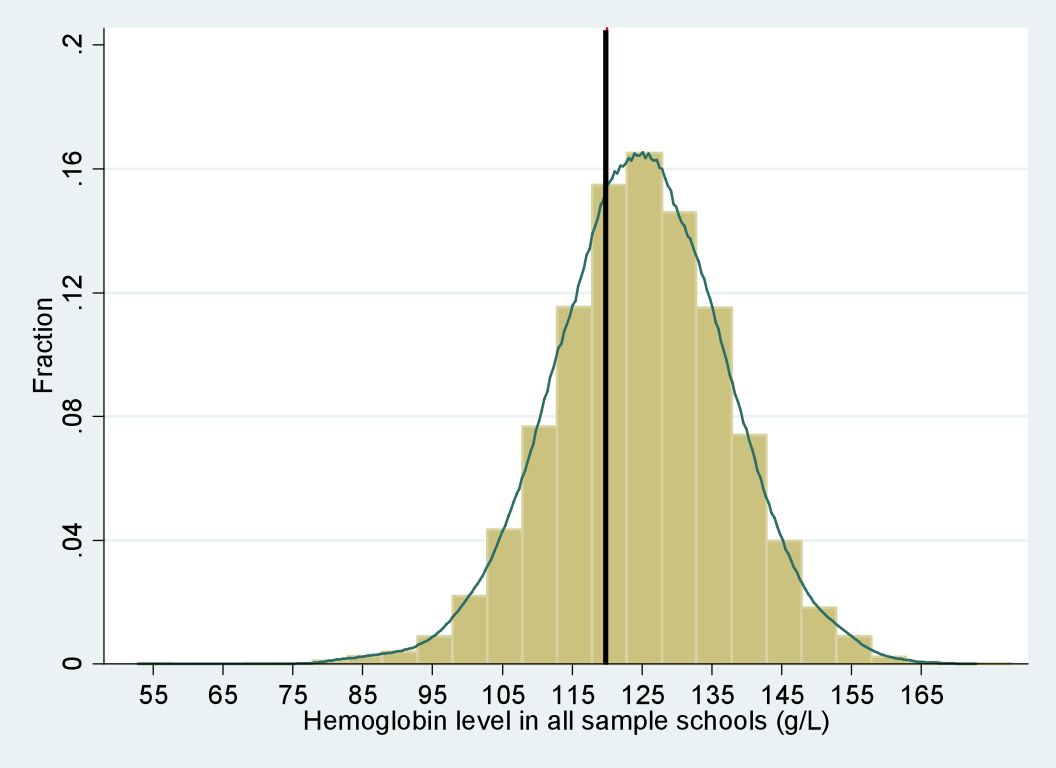
	Percentage Anemic	Percentage of Sample
Gender		
Male	32.4	54.1
Female	35.3	45.9
Difference [a]	-2.9***	
Mother's Education		
Primary school or below	34.2	61.2
Junior high or above	32.9	38.8
Difference [a]	1.3[b]	
Left-Behind		
Mother lives with child	33.1	82.5
Mother does not live with child	34.3	17.5
Difference [a]	1.2 [b]	
Boarding Status		
Lives at home	32.5	60.7
Lives at school	35.6	39.3
Difference [a]	3.1***	

Data source: Authors' survey

[a] *,**,*** indicates significance at 10%,5% and 1%.

[b] If anemia is defined by a 115 g/L hemoglobin cutoff for children between 5 and 11, the difference in anemia prevalence among students with mothers with differing educational attainment is significant at 10%.

Figure 1. Hemoglobin distribution in total sample population.



Appendix Table 1. Hemoglobin counts and anemia (Hb < 120g/L for below 12 y.o.; Hb < 115g/L above 12 y.o.) rates of sample students

	Below 12 years old	Above 12 years old	Total
Anemia (%)			
Total	19.5	31.8	20.7
Shaanxi—2008 (Dataset 1)	22.0	33.0	22.5
Shaanxi—2009a (Dataset 2)	18.0	31.3	19.2
Shaanxi—2009b (Dataset 3)	14.3	15.5	14.3
Qinghai—2009 (Dataset 4)	34.9	50.8	38.7
Ningxia—2009 (Dataset 5)	13.4	17.9	14.1
Sichuan—2010 (Dataset 6)	14.5	N.A.	14.5
Shaanxi—2010 (Dataset 7)	18.6	32.1	19.5

Data source: Authors' survey

[a] Numbers in parentheses indicate the standard deviation of hemoglobin count distribution.