THE PREVALENCE OF ANEMIA IN CENTRAL AND EASTERN CHINA: EVIDENCE FROM THE CHINA HEALTH AND NUTRITION SURVEY

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Abstract. Although China has experienced rapid economic growth over the past few decades, significant health and nutritional problems remain. Little work has been done to track basic diseases, such as iron-deficiency anemia, so the exact prevalence of these health problems is unknown. The goals of this study were to assess the prevalence of anemia in China and identify individual, household and community-based factors associated with anemia. We used data from the 2009 China Health and Nutrition Survey (CHNS), including the measurement of hemoglobin levels among 7,261 individuals from 170 communities and 7 provinces in central and eastern China. The overall prevalence of anemia was 13.4% using the WHO's blood hemoglobin thresholds (1968). This means in China's more developed central and eastern regions up to 180 million people may be anemic. Some vulnerable subgroups were disproportionately affected by anemia. Seniors (aged 60 years and above) were more likely to be anemic than younger age cohorts, and females had higher anemia prevalence among all age groups except among children aged 7 to 14 years. We found a negative correlation between household wealth and the presence of anemia, suggesting anemia prevalence may decline as China's economy grows. However, the prevalence of anemia was greater in migrant households, which should be experiencing an improved economic status.

Keywords: malnutrition, anemia, prevalence, rural health, urban health, China

INTRODUCTION

Iron deficiency anemia is the most common nutritional deficiency worldwide, affecting approximately a quarter of the world's population, mostly in developing countries (Benoist *et al*, 2008; Luo *et al*, 2011b). Vital aspects of human health are adversely affected by anemia, including physical activity, temperature regulation, behavior and immune function (Dallman, 1986; Benoist *et al*, 2008). Previous studies have linked iron deficiency and anemia with cognitive impairment and altered brain function (Scrimshaw, 1990; Yip, 2001). Improved iron status has been shown to increase labor participation, productivity and income among adults (Basta *et al*, 1979; Edgerton *et al*, 1979; Li *et al*, 1994; Scholz *et al*, 1997; Thomas *et al*, 2006). In 2002 iron deficiency anemia was one of the most important factors contributing to

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the global burden of anemia (WHO, 2002).

A recent study by the WHO of the worldwide prevalence of anemia showed anemia prevalence varies considerably by location (Benoist *et al*, 2008). Although there are many reasons for these differences by location, an important correlate is income. As incomes rise in a particular region, the number of individuals with anemia typically falls (WHO, 2002). Given the unprecedented economic growth in China over the past few decades, and the associated rising incomes (National Bureau of Statistics, 2011), one might expect health outcomes to have improved, but a number of indicators suggest health and nutritional problems persist throughout the country (World Bank, 2001; Du *et al*, 2002).

There are signs that China's public health system has not been successful in eliminating many diseases and conditions–including anemia–that typically affect countries at earlier stages of development. For example, intestinal worms are still found in large numbers of China's rural population (Zhang *et al*, 2013) and there are reports of continued vitamin A deficiency (Hu *et al*, 2001; Jiang *et al*, 2006). Some studies suggest iron-deficiency anemia is still widespread among non-urban segments of the population in China, especially in poor areas (Luo *et al*, 2010; Luo *et al*, 2011a, b).

Outside of poor areas, systematic studies of anemia using well-documented, reliable methodologies are surprisingly rare, although some do exist (Chen *et al*, 2005; Piao *et al*, 2005; Li, 2009). However, these studies tend to have either a narrow geographic or population focus or fail to adequately report their methodologies and sampling protocols, making it difficult to gauge external validity.

However, some of these studies are still useful in piecing together a picture of the anemia problem in China. For example, Luo *et al* (2010; 2011a, b) found a high anemia prevalence (20%-50%) among students in rural primary schools in China's poor western provinces. The China Development Research Foundation also found an anemia prevalence of 50%-70% among 6-12 month old babies in Qinghai and Yunnan Provinces (Huo and Li, 2012). These studies, representative of various parts of China, can be used to help better understand the nutritional status of more than 12 million children aged 8-12 years and nearly 10 million infants and babies (Luo *et al*, 2011a; National Bureau of Statistics, 2011). If anemia is so prevalent among these age groups, it is possible other population subgroups in western China—such as women and the elderly—also have a high prevalence of anemia. Unfortunately, there are few detailed studies of anemia among these population subgroups.

The focus of nutrition literature among certain subpopulations, while of policy interest to some (*eg*, education officials charged with raising educational performance which could be affected by the nutritional status of the student population), might be missing anemia among other population subgroups. A 2008 WHO study found anemia prevalence varies widely across subpopulations in the developing world, even within a given country (Benoist *et al*, 2008). Anemia prevalences among women, seniors (>60 years) and children (<15 years) are consistently higher than prevalences among men and other adult groups in numerous country studies (Looker *et al*, 1997; McLean *et al*, 2009).

Given that only a handful of studies have been conducted in western China, where anemia prevalence are likely to be highest, it is not surprising that even fewer data have been collected regarding anemia prevalence in non-poor areas of the country, such as coastal and central regions. This lack of attention is perhaps due to the fact that one would not expect a high prevalence of anemia in these areas, given higher average income levels (National Bureau of Statistics, 2011). China has spent considerable resources in its efforts to address new and rapidly increasing problems associated with a country with newfound wealth, such as heart disease, diabetes and cancer (Wang *et al*, 2011), presumably under the assumption that diseases like anemia are already under control. However, considerable heterogeneity exists in anemia prevalence even within a single country (or region). China could be neglecting a nutrition-based public health problem among particular subpopulations. Even mild to moderate prevalences of a disease, such as anemia, in a country with a population the size of China would mean anemia might be affecting tens of millions of individuals. At risk populations with an even higher prevalence of anemia may go unnoticed.

The objective of this study was to assess the prevalence of anemia among various population subgroups in central and eastern China's relatively non-poor urban and rural areas. To do this, we first documented the overall anemia prevalence. Next, we examined the prevalence of anemia among different population subgroups, focusing on differences between males and females; differences by age cohort; and differences between urban and rural areas. We attempted to identify characteristics and economic factors associated with high and low prevalences of anemia.

MATERIALS AND METHODS

The data in this study came from the eighth China Health and Nutrition Survey (CHNS, 2009). The CHNS is the only large-scale longitudinal, household-based survey in China (Popkin *et al*, 2010). In 2009 it covered nine provinces (comprising approximately 56% of China's population): Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong.

Ethical approval for the study was granted by the Institutional Review Board at the University of North Carolina at Chapel Hill, the China-Japan Friendship Hospital, the Chinese Ministry of Health, the Institute of Nutrition and Food Safety, and the China Centers for Disease Control (CDC). All subjects gave their informed consent prior to participation. The use of CHNS data in this paper was approved by both the Institutional Review Board at Stanford University (Protocol ID 24554) and by the CHNS team themselves.

To identify the prevalence of anemia in non-poor areas of China, we excluded poorer provinces of Guangxi and Guizhou from our analyses. The sample used in this paper covers seven provinces, including nearly half (49%) of the population residing in central and eastern China. We excluded Guangxi and Guizhou from this study in order to make sure our study examined anemia prevalence only in non-poor areas of China. We did this because the best studies of anemia in recent years have been conducted in poor areas. We wanted this study to evaluate the "rest of China." When we did include Guangxi and Guizhou in our analyses, the anemia prevalence was not significantly different; the overall prevalence of anemia was 1% higher (results not shown). The studied provinces varied substantially in terms of geography, economic development, public resources and health indicators.

In each studied province, sampling was based on multistage, random clustering. Counties in the sample provinces were stratified by income (low, middle and high) and a self-weighting sampling scheme was used to randomly select four counties in each province. The provincial capital and one lower income city were also included in the study. Villages and townships in each county and urban and suburban neighborhoods in each city were randomly selected as the smallest community units in the sample. Twenty households from each community unit were then randomly selected and all household members were surveyed. The sample in this paper consists of 170 communities: 28 urban neighborhoods, and 29 suburban neighborhoods, 29 towns, and 84 villages.

We obtained our data from the eighth CHNS (2009) because it is the only wave to include fasting blood test results for all household respondents aged 7 years and older. The WHO definition of anemia (WHO, 1968), was used to classify subjects as having anemia or not using a hemoglobin (Hb) level. Therefore, in this paper we used data from only 7,313 individuals for which hemoglobin levels were available. There were 52 pregnant women in this sample, we did not include these women in our analysis because the sample size was too small and their biology was different from the other adults in the sample. After excluding pregnant women, the final sample consisted of 7,261 individuals from 3,304 households. In our sample, 47.4% of the subjects were male and 52.6% were female. The sample consisted of both urban and rural residents; 31.2% lived in urban areas and 68.8% lived in rural areas. We defined urban as including both urban and county town neighborhoods. Rural residents included not only those who lived in villages, but also those who lived in suburban villages and neighborhoods. The numbers were robust enough to differentiate between these groups. About 6.0% of the subjects were aged 7-14 years (children), 68.8% were aged 15-59 years (adults) and 25.2% were aged ≥60 years (seniors). The CHNS age distribution was slightly older than that found in the 2009 Chinese census. The CHNS sampling frame included approximately 3% more individuals aged ≥60 years than the census and 3% fewer children (Yan *et al*, 2012).

Data collection

The CHNS survey included eight distinct questionnaire instruments; the data used in this paper came from four of those instruments: the community form, the household form, the adult form, and the child form. We also used the supplemental block that included the results of blood tests. The community form collected data from knowledgeable respondents, prices were obtained to determine a representative basket of commodities. Household and individual information were collected during home visits by interviewers. The interviews spanned 3 days. Household assets and individual demographic indicators, such as age, gender, education and ethnicity, were included.

As part of the survey, individuals aged > 7 years were asked to visit a neighborhood clinic to have a fasting blood sample collected. Individuals unable to attend the clinic had their blood samples collected at home. To avoid missing children at boarding schools and migrant workers, special efforts were made to schedule visits in the early morning or during the weekend when these participants were at home. All interviewers had 7 days of training provided by the data collection teams and their efforts were overseen by site visits to monitor data collection at each site by the staff from the University of North Carolina, the China CDC and the China-Japan Friendship Hospital (Yan *et al*, 2012).

Following an overnight fast (Yan *et al*, 2012), 12 ml blood was collected by venipuncture and immediately tested for glucose and hemoglobin A1c (HbA1c) levels. Plasma and serum samples were then frozen and stored at -86°C for laboratory analysis at a later time. HbA1c levels were measured on whole blood with an automated glycol hemoglobin analyzer using high-performance liquid chromatography (model HLC-723 G7; Tosoh, Tokyo, Japan). All samples were analyzed at the national central lab in Beijing (medical laboratory accreditation certificate ISO 15189:2007) with strict quality control (Yan *et al*, 2012).

Variables

We used anemia prevalence as the dependent variable in our analysis. The WHO guidelines specify hemoglobin levels associated with anemia by age and gender (WHO, 1968). We used these guidelines throughout our analysis. The cutoff hemoglobin levels for determining anemia are as follows: 115 g/l for children aged 5-11 years; 120 g/l for children aged 12-14 years; 120 g/l for females aged ≥15 years; and 130 g/l for males aged ≥15 years. In this study anemia was a dummy variable equal to one if an individual was anemic.

We included a number of independent variables in the analysis. An individual's age and education are commonly correlated with their demand for health care (Grossman, 1972). Income and commodity prices affect an individual's ability to access health care (which is importantly distinct from maximizing health). The literature provides substantial evidence that these variables are important for analyzing health status (Grossman, 2000). Therefore, in our study gender, age, education and ethnicity were the main individual demographics examined. We also included household assets and food prices as economic variables to identify correlates of anemia in China.

The definitions of our variables are as follows: We used female as a dummy variable equal to one if the individual was female. Age and education were both continuous variables. Age was measured in years, and the traditional Chinese system of age was translated into the standard definition of age used in the Western literature. Education was measured in years of attainment. Han was a dummy variable equal to one if the individual was ethnic Han Chinese and zero if not.

Although the CHNS includes data regarding a number of economic variables for the sampled households, we chose household assets rather than income as an indicator of household wealth. We did this because, according to Deaton (1997), assets are often measured with less error than income. To measure assets, the CHNS household asset data includes 16 home appliances and other consumer durables. To calculate an asset index, we used the coefficients from principal component analysis (PCA) to generate a weight for each of the 16 items. The weights were then used to sum up the 16 household assets and create a single measure of wealth.

We also included a variable to measure each household's migration status. China's rapid economic growth has triggered a large-scale internal migration (Cai *et al*, 2008). Migration may affect nutrition via a nutrition investment effect and/or via a time allocation effect (de Brauw and Mu, 2011). On the one hand, income growth that is frequently associated with migration is believed to be one of main reasons for the rise in nutritional investment and improved health outcomes (Du *et al*, 2004) while on the other hand, if one or more members of a household migrate, the remaining members of the household have to take up some or all of the tasks the migrants did prior to migration. If there is less time to invest in nutrition, such as meal preparation or access to nutritious foods, the health status of the individual might be affected (Mu and Van de Walle, 2011).

Although the CHNS did not explicitly collect information regarding migration, we were able to make inferences from the household roster of each sampled household. We classified a migrant household as one having one or more individuals listed in the 1997 survey, but not in the 2009 survey. This broad classification means migration may have been overestimated. Deaths and marriages were accounted for separately. Migration was a dummy variable equal to one if the individual was living in a household that had a migrant in it.

RESULTS

To show there was little difference in the means for key variables between the sample we used (individuals with Hb levels) and the full sample (including individuals without Hb levels), we present the descriptive statistics for both samples in Table 1.

Anemia prevalence

The overall average Hb level was 141.4; however, the Hb levels varied by subgroup (Table 2). The mean Hb level for children aged 7-14 years was 135.4 g/l; the mean Hb level for adults aged 15-59 years was 142.8 g/l; and the mean Hb level for seniors aged ≥60 years was 138.9 g/l. Across all age groups and locations (urban/rural), males have consistently higher Hb levels than their female counterparts.

Of the 7,261 subjects examined, 13.4% were anemic (Table 3). The prevalence of anemia increased with age (Table 3). When looking at men and women together (and not distinguishing between urban and rural), anemia prevalence was highest among seniors (18.4). This prevalence is 6.6 percentage points higher than the prevalence among other adults (18.4-11.8), while the prevalence among other adults was 0.6 percentage points higher than that among children (11.8-11.2).

As in the case of Hb levels, the data show substantial anemia prevalence gaps between males and females in all categories, except for children (Table 3). In the full sample, the anemia prevalence among females (17.8%) was almost twice that of males (8.5%). When looking at the different age cohorts, the prevalence of anemia among adult women and men accounts for the largest absolute anemia gap both in percentage point terms (11.6 percentage points = 17.2-5.6) and in percentage terms [207% = (17.2-5.6)/5.6]. Although the overall anemia prevalence among seniors was higher than among other adults (as reported above), the gap between women (20.5) and men (16.1) was smaller both in absolute percentage points (4.4 percentage points) and in percent terms [27% = (20.5-16.1)/16.1] among seniors. The female-male anemia gap among children was only 2.2 percentage points (12.4-10.2), or 21.6% [(12.4-10.2)/10.2]. When looking at anemia prevalence by gender across all age cohorts, anemia was highest among senior women (20.5%).

Table 1
Descriptive statistics.

Variables	Mean (*n*)		Standard deviation		*p*-value
	Hb sample[a]	Full sample[b]	Hb sample[a]	Full sample[b]	
Female	53% (7,261)	52% (8,473)	50%	50%	0.21
Age (years)	47.7 (7,236)	47.3 (8,440)	17.5	18.1	0.16
Education (years of attainment)	7.5 (7,254)	7.6 (8,465)	4.2	4.2	0.14
Han	94% (7,261)	93% (8,473)	24%	25%	0.20
Household asset index[c]	0.96 (7,259)	0.95 (8,471)	0.43	0.43	0.78
Rural household	67% (7,261)	66% (8,473)	47%	47%	0.19
Migrant household	58% (7,261)	57% (8,473)	49%	49%	0.21
Price of lean pork (RMB)	11.1 (7,205)	11.2 (8,438)	2.0	2.1	0.54

Data source: CHNS dataset, 2009.
[a]Hb sample: those for whom a hemoglobin level was available.
[b]Full sample: those for whom a hemoglobin level was available plus those for whom a hemoglobin level was not available.
[c]As a proxy for wealth, we constructed an asset index summarizing assets owned by households. This asset index was constructed using the first principal component of variables indicating ownership of 16 different durable assets, for example color television, washing machine, refrigerator, air conditioner, computer and camera, etc.
Hb, hemoglobin.
RMB, Renminbi (Chinese currency).

One of the most surprising results derived from our data was the near equivalence of Hb levels and anemia prevalences between urban and rural individuals (Tables 2 and 3). When looking at all individuals (total) in the full sample (Table 3), we see anemia prevalences among individuals living in urban and rural areas varied by only 0.3 percentage points (13.6-13.3). The same was true for men (the urban-rural gap was 0.3 percentage points) and among women (0.7 percentage points). The same urban-rural pattern held for adults (less than one percentage point = 11.2-12.0) and seniors (less than three percentage points = 20.4-17.3).

According to our data, the only statistically significant ($p<0.05$) urban-rural gap was for boys aged 7-14 years (Table 3). The urban-rural gap for children was 6.0 percentage points (6.8-12.8) or 88% [(12.8-6.8)/6.8]. When splitting the gap between boys and girls, it is clear the urban-rural gap among boys (9.9 percentage points = 12.9-3.0 or 330%) was fully driving the gap. The urban-rural gap among girls was very small (only 0.9 percentage points = 11.8-12.7).

There was also considerable variation in anemia prevalences by province. Anemia prevalences ranged from a low of 8.1% in Liaoning Province to 22.9% in Hunan Province (Table 4). The results of multiple regression analysis of anemia levels using provincial dummies as the set of explanatory factors (results not

Table 2
Mean hemoglobin levels in g/l by age group and locations of residence (N).

	Full sample			Children (7-14 years)			Adults (15-59 years)			Seniors (≥60 years)		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
All	141.4	151.3	132.5	135.4	137.0	133.3	142.8	154.3	132.8	138.9	147.2	131.5
	(7,261)	(3,442)	(3,819)	(438)	(245)	(193)	(4,993)	(2,339)	(2,654)	(1,830)	(858)	(972)
Urban	140.6	150.5	131.9	138.0	141.1	134.0	142.6	154.1	132.5	136.6	144.5	130.2
	(2,265)	(1,060)	(1,205)	(118)	(67)	(51)	(1,480)	(693)	(787)	(667)	(300)	(367)
Rural	141.8	151.6	132.8	134.4	135.4	133.1	142.9	154.3	132.9	140.2	148.7	132.4
	(4,996)	(2,382)	(2,614)	(320)	(178)	(142)	(3,513)	(1,646)	(1,867)	(1,163)	(558)	(605)

Data source: CHNS dataset, 2009. The number of observations is in parentheses.

Table 3
Percent prevalence of anemia (WHO, 1968) by age group and location of residence (N).

	Full Hb sample			Children (7-14 years)			Adults (15-59 years)			Seniors (≥60 years)		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
All	13.4	8.5	17.8	11.2	10.2	12.4	11.8	5.6	17.2	18.4	16.1	20.5
	(7,261)	(3,442)	(3,819)	(438)	(245)	(193)	(4,993)	(2,339)	(2,654)	(1,830)	(858)	(972)
Urban	13.6	8.3	18.3	6.8	3	11.8	11.2	5.2	16.4	20.4	16.7	23.4
	(2,265)	(1,060)	(1,830)	(118)	(67)	(51)	(1,480)	(693)	(787)	(667)	(300)	(367)
Rural	13.3	8.6	17.6	12.8	12.9	12.7	12	5.8	17.6	17.3	15.8	18.7
	(4,996)	(2,382)	(2,614)	(320)	(178)	(142)	(3,513)	(1,646)	(1,867)	(1,163)	(558)	(605)

Data source: CHNS dataset, 2009. The number of observations is in parentheses.

Table 4
Percent prevalence of anemia (WHO, 1968) by age groups and province (*N*).

Province	Full sample			Children (7-14 years)			Adults (15-59 years)			Seniors (≥60 years)		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Liaoning	8.1	5.2	10.6	10	18.2	5.3	8.1	3.0	12.3	8.0	9.4	6.7
	(848)	(385)	(463)	(30)	(11)	(19)	(593)	(268)	(325)	(225)	(106)	(119)
Heilongjiang	8.3	4.8	11.6	3.9	2.9	5.6	8.0	4.0	11.7	10.4	8.9	12.0
	(960)	(475)	(485)	(52)	(34)	(18)	(726)	(351)	(375)	(182)	(90)	(92)
Jiangsu	12.7	10.5	14.7	9.1	9.5	8.6	10.6	6.6	14.1	17.7	18.0	17.4
	(1,205)	(581)	(624)	(77)	(42)	(35)	(761)	(350)	(411)	(367)	(189)	(178)
Shandong	9.3	6.2	12.0	1.8	3.0	0	9.1	5.5	12.3	11.2	9.0	12.9
	(1,028)	(484)	(544)	(56)	(33)	(23)	(695)	(329)	(366)	(277)	(122)	(155)
Henan	12.0	5.3	17.9	9.6	5.6	15.0	10.6	3.1	17.2	16.3	11.1	20.8
	(1,069)	(506)	(563)	(94)	(54)	(40)	(705)	(326)	(379)	(270)	(126)	(144)
Hubei	18.4	11.8	24.3	20.3	22.6	17.9	15.2	7.7	22.2	27.3	22.2	30.9
	(980)	(457)	(523)	(59)	(31)	(28)	(683)	(327)	(356)	(238)	(99)	(139)
Hunan	22.9	14.2	30.7	21.3	16.7	27.3	19.2	8.5	28.5	34.8	31.0	38.2
	(1,175)	(556)	(619)	(75)	(42)	(33)	(830)	(388)	(442)	(270)	(126)	(144)

Data source: CHNS dataset, 2009. The number of observations is in parentheses.

Table 5
Probit analysis of correlation among individual-, household-, and community-based factors and anemia (Z statistic).

Independent variables	Full sample	Location	
		Urban	Rural
Female	0.093 (11.44)[c]	0.093 (6.73)[c]	0.091 (9.31)[c]
Age	-0.003 (-3.14)[c]	-0.003 (-1.63)[a]	-0.003 (-2.47)[b]
Age-squared	0.000 (4.63)[c]	0.000 (2.99)[c]	0.000 (3.29)[c]
Education	0.001 (0.66)	0.001 (0.38)	0.001 (0.7)
Han	-0.066 (-3.45)[c]	0.011 (0.32)	-0.094 (-4.19)[c]
Household assets	-0.025 (-2.26)[b]	-0.032 (-1.6)	-0.018 (-1.41)
Migrant household	0.016 (1.99)[b]	-0.005 (-0.38)	0.025 (2.53)[b]
Price of lean pork	0.001 (0.55)	-0.004 (-1.04)	0.003 (1.20)
Rural	-0.000 (-0.03)		
Observations	6,937	2,146	4,791
R-squared	0.0703	0.0949	0.0719

Data source: CHNS dataset, 2009.
[a] indicates $p<0.10$.
[b] indicates $p<0.05$.
[c] indicates $p<0.01$.

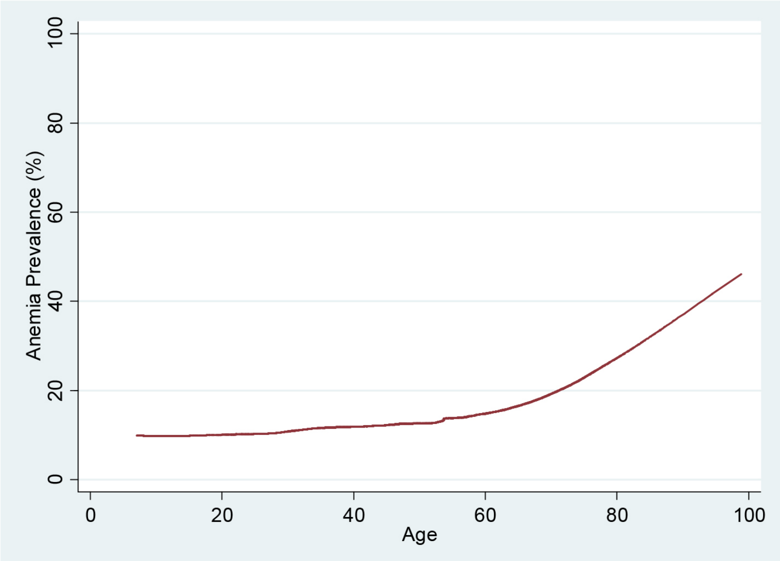
shown for sake of brevity) demonstrate statistically significant province effects. Anemia prevalences in Hunan (22.9%) and Hubei (18.4%) were higher than in Shandong, Heilongjiang and Liaoning Provinces (all of which have an anemia prevalence <10%).

Correlates of anemia

To identify potential correlates of anemia, we grouped the survey variables into three types: individual-based (*eg*, gender, age, education and ethnicity), household-based (*eg*, household assets and migration) and community-based (price of lean pork, urban/rural residence and province). We then conducted a multivariate probit regression of these variables for anemia. In the search for possible patterns among different sub-groups, we began by performing regressions on the full sample before running them for specific subsamples. The regression model can be specified as:

$$Y_i = \alpha_0 + \alpha_1 Female_i + \alpha_2 Age_i + \alpha_3 Age_i^2 + \alpha_4 Education_i + \alpha_5 Han_i + \alpha_6 Asset_{ij} + \alpha_7 Migration_{ij} + \alpha_8 Price_{ik} + \alpha_9 Rural_{ik} + \alpha_{10} Province_{im} + e_i$$

where Y_i is a dummy variable equal to one if the individual i was anemic; $Female_i$ is a dummy variable equal to one if the individual i was female; Age_i and $Education_i$ are both continuous variables for individual i; and Han_i was a dummy variable equal to one if the individual i was Han (and zero if non-Han). $Asset_{ij}$ was the wealth index of household j to which the individual i belongs; $Migration_{ij}$ was the dummy variable equal to one if individual i was in a household j which had a migrant individual in it. The variable, $Price_{ik}$, was the price for lean pork



Data source: CHNS dataset, 2009.
Fig 1–Lowess plot of correlation between anemia and age.

in community k to which individual i belongs. The variable, $Rural_{ik}$, was a dummy variable equal to one if community k was rural. $Province_{im}$ represents a set of 9 province-level dummy variables, and e_i was an error term. We presented the results of the probit analysis after they had been translated into marginal effects.

The multivariate results largely support the results of the descriptive analysis, described in the previous section. For example, anemia was almost twice as prevalent in females as in males. All else being equal, females–both urban and rural–were 9.3 percentage points more likely to be anemic than males (Table 5).

The correlation between age and anemia is less straightforward. The marginal effect of the linear term for age was negative and statistically significant, suggesting that higher ages are associated with lower anemia prevalences. The marginal effect of the quadratic term, however, was positive and significant, suggesting a more complex relationship. Importantly, the magnitudes of both marginal effects were small. To see this relationship more clearly, we used a Lowess plot for age versus anemia (Fig 1). From age 5 to 60 years, the anemia prevalence was relatively constant (11%-14%). After age 60, the anemia prevalence rises consistently with age. With everything else equal, just as in the descriptive statistics, the anemia prevalences in children and adults were about the same, while among seniors it was higher.

Two additional variables were negatively correlated with anemia. The marginal effect of the Han variable was negative and significant. The magnitude of anemia prevalence among the Han population was 6.6 percentage points lower than among the non-Han population. The marginal effect of the asset variable was also negative and significant, and indicates that for every point the asset index rises, anemia prevalence falls by 2.5 percentage points.

The mild effect of migration suggests a modest correlation between migration and anemia; this marginal effect was positive and significant. The magnitude of the marginal effect indicates that migrants, on average, experience higher anemia prevalences than do non-migrants, by 1.6 percentage points.

There were three variables that had a zero correlation with anemia prevalence: education, the price of lean pork, and urban / rural residency. The latter is consistent with the descriptive statistics, which showed the anemia prevalence among rural and urban individuals in the sample to be statistically identical.

When running the regression analysis separately on the urban and rural population subsets, the correlations between each of the individual-, household- and community-based factors and anemia remain fundamentally unchanged (Table 5). The marginal effects of the gender variables were negative and significant for both rural and urban areas. The age-anemia patterns are also similar when comparing urban and rural areas. The marginal effects of variables that were insignificant in the regression using the full sample (education and price of lean pork) were also insignificant in both the urban and rural samples. The magnitude and sign on the marginal effect of the asset variable are consistent in both the urban-only and the rural-only regressions, although the *t*-ratios were lower in the region-specific regressions compared to the regression using the full sample. The only divergence between the anemia correlates in the urban sample and the rural sample occured in the case of the Han and migration variables. The marginal effects of the Han and migration variables were identical for the full sample and rural-only regressions, but not for the urban-only regression.

DISCUSSION

Our analysis of the CHNS data broadly maps out the prevalence of anemia in seven provinces of central and eastern China. These provinces were chosen (out of the nine in the full data set) because they were the non-poor provinces in the CHNS data set. This part of the CHNS data allowed us to examine current anemia prevalence in a part of China where there has been little nutritional surveying done in recent years. The overall anemia prevalence among the full sample of individuals was 13.4% using age-specific WHO thresholds for anemia.

Is this a high anemia prevalence? From several perspectives, the answer may be "it is not that high," but there are uncertainties. Compared with previous studies conducted within China, our results suggest that China's anemia prevalence might be falling over time. Piao *et al* (2005) found China's anemia prevalence was 20.1% in 2002. This implies the anemia prevalence decreased during 2002-2009. However, it is important to note the Piao *et al* (2005) study included all 31 provinces, while our study only included richer provinces in eastern and central China. If we were to include the poorer, western provinces in our sample, we likely would find the overall anemia prevalence in 2009 might be higher than 13.4%, suggesting the national anemia prevalence may not have fallen as much as expected, given the rapid growth in income that occurred during the 2000s.

Looking at the rest of the world, an anemia prevalence of 13.4% may not be so bad. The WHO global database on anemia gives a world anemia prevalance of 24.8% for its 192 member states over the period 1993-2005 (Benoist *et al*, 2008). Our results, from China's more developed areas, show the anemia prevalence in China was slightly lower than the global average. In fact, the prevalence we found in our analysis was closer to that of developed countries than that of developing countries (WHO, 1989, Benoist *et al*, 2008).

Despite improvements over time, and the relatively lower anemia prevalence in China compared to the rest of the world, our data suggest anemia remains a public health problem in China. If we assume the prevalence we found is representative of all China (as stated above, this is a conservative assumption), then by extrapolating to the entire population of China, we estimate that more than 180 million people in China are anemic. If the prevalence of anemia in western China is twice as high, then the overall anemia prevalence in China may be even higher. Regardless of the exact number, one of the main findings of this study is that even in 2009 anemia is still a serious problem in China. Such a large-scale health problem surely merits policy attention.

While the overall anemia prevalence for China is classified as "mild" (under 20%) according to WHO standards (WHO, 2001), the prevalence among some subpopulations is higher. Anemia was common among seniors. This is especially true for female seniors. Since more than one in five female seniors is anemic, the WHO would classify the level of anemia for them as "moderate."

In the case of all age cohorts except for children, there are large and significant gender gaps in anemia prevalence. Anemia prevalence among adult women is more than three times that of adult men. The gap is still significant, but less wide, for senior men and women. Since these prevalences have already been corrected for fundamental physiological differences between men and women (*ie*, menstruation), our results suggest there may be a gender-based nutrition problem among women in China. Future research should focus on identifying household dynamics that may contribute to this gender gap; certain behavior may improve the nutritional status of men at the expense of women. Similar research should also examine similar dynamics between seniors and individuals in younger age cohorts.

The relatively low anemia prevalence we found among children (11.2%), most of whom are in school (given the age range of the individuals in the cohort was 7-14), is in stark contrast with results from studies that draw mostly on samples of children from poor areas. In studies of anemia prevalence in poor areas, Luo *et al* (2010) found an anemia prevalence among children of 21.5% in Shaanxi Province. Luo *et al* (2011) found an anemia prevalence among children of 24.9% in Qinghai Province and Ningxia Autonomous Regions. We can deduce that children in the CHNS sample (who come mainly from middle and high income regions) have far lower anemia prevalences than their peers from low-income rural areas. Likewise, assuming our observed trend of adults and seniors having higher anemia prevalences than children continues to hold true for poor, rural areas, anemia prevalence among adults and seniors in poor, rural areas most likely constitutes a significant public health problem.

Despite the wide socioeconomic gap between rural and urban areas, we did not observe any significant differences in anemia prevalence between these two populations. From the descriptive statistics we observed a slightly higher anemia prevalence among rural children than their urban peers but this finding was not significant. While it is beyond the scope of this paper to explain this, it may be that income aside (recall that wealth was held constant), rural households may have more convenient access to meat (especially in non-poor rural areas). It may also be that other factors encourage rural households, who are poorer, to consume more meat and thus have a lower anemia prevalence. Such factors may make up for other non-income advantages that urbanites may have for improving nutrition.

The results of our multivariate regression analysis suggest if policy makers ignore the problem, it may disappear. As incomes rise, anemia prevalence should fall. However, migration—which, in China, essentially represents a household's transition into a higher income bracket—has not been associated with a lower anemia prevalence. Moreover, given the anemia disparities between women and men and between seniors and younger cohorts, there seem to be cultural dynamics at play that disproportionately disadvantage vulnerable subgroups, suggesting a role for government intervention.

Since we relied on cross sectional data in our analyses, we were not able to identify the causes of anemia. The main finding of this paper is that anemia remains a serious problem in central and eastern China, even though its prevalence is not as high as in western China. For a country that has the fiscal resources and organizational ability of China, there is an urgent need and institutional ability to address this problem, though the exact approach is still unclear.

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