National Trends in Hemoglobin Concentration and Prevalence of Anemia among Chinese School-Aged Children, 1995-2010

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Objective To assess the trend of sex disparity in hemoglobin concentration and prevalence of anemia among Chinese school-aged children from 1995 to 2010.

Study design Data were collected from 360 866 children aged 7, 9, 12, 14, and 17 years during 4 cross-sectional surveys (1995, 2000, 2005, and 2010) of the Chinese National Surveys on Students Constitution and Health. Shifts in hemoglobin concentration distributions were compared by sex. Average shifts and sex differences were calculated with quantile regression models. Logistic regression was used to estimate the prevalence odds ratio of sex for prevalence of anemia in different surveys.

Results The mean hemoglobin concentration increased among Chinese children between 1995 and 2010, from 132.7 to 138.3 g/L in boys, and from 127.7 to 132.3 g/L in girls. The prevalence of anemia decreased from 18.8% in 1995 to 9.9% in 2010. It was higher in rural than urban children among all age groups. The prevalence odds ratios of girls versus boys for anemia increased in both urban and rural areas over time.

Conclusion Hemoglobin concentration and prevalence of anemia improved among Chinese school-aged children over time. Hemoglobin concentration improved faster in boys than girls and as a result the relative prevalence of anemia in girls compared with boys increased. Sex-specific preventive guidelines and public health policies for childhood anemia are needed in China. *(J Pediatr 2017;183:164-9).*

Anemia continues to be an important public health problem worldwide, and is considerably more prevalent in the developing world than in the developed world.[1,2] Over the past 2 decades, the importance of anemia as a public health problem has been increasingly recognized by health authorities and policymakers, and food fortification programs focused on anemia prevention have been implemented in many countries or regions.[3-6] As a result, the prevalence of anemia has decreased dramatically in these countries or regions.[3-6] However, a recent systematic analysis of global anemia has shown that south Asia and Africa are the regions with the highest prevalence of anemia. It is important to monitor the prevalence of anemia among Asian countries[7,8] and to better understand the trends in anemia burden over time.

Hemoglobin concentration is the common index used to define anemia.[1] Although there has been much research of low hemoglobin concentrations and anemia worldwide, most of this has focused on the children aged <5 years (0-59 months) and pregnant women; data for school-aged children are sparse. Also, in China there have been few reports of hemoglobin concentration and the prevalence of anemia among school-aged children, and these are generally outdated[9,10] or limited because of their regional composition.[11-13] However, China has been undergoing rapid economic transitions in recent decades. From 1995 to 2010, gross domestic product per capita increased from 5091 RMB (US$783; exchange rate: US$1 = RMB¥6.5) to 30 876 RMB (US$4750; exchange rate: US$1 = RMB¥6.50); average disposable income and food expenditure per capita also significantly increased over this period in both urban and rural areas.[14] At the same time, people's dietary patterns have changed significantly. The average intake of meat, especially pork, has continued to increase in China. Pork intake increased from 37.1 g/d in 1992 to 64.3 g/d in 2012.[15] Based on this background, we hypothesized that anemia would have decreased in prevalence over time. Analyzing the trends of hemoglobin concentration distribution may help us to clarify whether any decrease in anemia was the result of changes among the entire population, or whether these changes were concentrated in a subgroup of more specific individuals. Furthermore, it is also important for us to determine whether there was sex disparity in the prevalence of anemia, and whether the difference between boys and girls changed over time, which may help researchers and health policymakers to develop targeted intervention strategies.

This study used recent data from the Chinese National Survey on Students' Constitution and Health (CNSSCH, 2010), and earlier data (CNSSCH, 1995, 2000, 2005), which are a series of national surveys among representative school-aged children in China.[16-19] The objectives of the present study were to (1) describe the trends in hemoglobin concentrations and prevalence of anemia among a representative

CNSSCH	Chinese National Survey on Students' Constitution and Health
POR	Prevalence odds ratio

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sample of Chinese children over a 15-year period, (2) compare the differences of hemoglobin concentrations and prevalence of anemia among sex, age and urban/rural subgroups, and (3) identify whether the sex disparity in prevalence of anemia became larger or smaller, that is, whether the pace of change was different between boys and girls.

Methods

Data were obtained from the 1995, 2000, 2005, and 2010 cycles of the CNSSCH, a joint project of the Ministries of Education, Health, Science and Technology, the State Ethnic Affairs Commission, and the State Sports General Administration of People's Republic of China.[16-19] Determination of hemoglobin concentration was first implemented in 1995. The sampling procedure, as previously described in detail,[20] was the same in all CNSSCH surveys at different time points. At each survey year, the participants were primary and high school students aged 7-18 years, who were selected from the same areas in each province. All participants were selected by stratified cluster sampling, that is, sampling took place in classes selected randomly from each grade in the selected schools. The present study only included those of Han children aged 7, 9, 12, 14, and 17 years who had data on hemoglobin concentration collected. They came from 26 mainland provinces and 4 municipalities, excluding Tibet (where the Han ethnicity is a minority). Because Qinghai province did not collect hemoglobin concentrations in the 1995 CNSSCH and Chongqing was not a municipality until 1997, information on hemoglobin concentrations in Qinghai and Chongqing is missing from the 1995 CNSSCH. All eligible participants had lived in the area for ≥1 year. They received medical examinations before the national survey, to ensure that they had no overt physical or mental disorders. In each sex–age subgroup, there were 8 181-9 789 participants and the ratio of boy/girl or urban/rural approximately equaled to 1:1 in each survey. Thus, a total of 360 866 participants with complete records on age, sex, urban/rural area, and hemoglobin concentration were included in the analysis (**Table I**; available at www.jpeds.com).

This project was approved by the Medical Research Ethics Committee of Peking University Health Science Center (IRB00001052-13082). Informed consent was obtained verbally because written consent was difficult to obtain in the national surveys. The information of participants were anonymized and de-identified before analysis, and, thus, privacy is protected.

Hemoglobin concentration was measured by laboratory technicians for the selected students. Samples of capillary blood from the fingertip of each child were collected after discarding the first drop. Hemoglobin determination was detected with the cyanmethemoglobin method using a spectrophotometer recommended by the World Health Organization.[1] Data collection was supervised daily by trained field supervisors. Age-specific cut-off values of hemoglobin concentrations were used to define anemia. Hemoglobin concentration was divided into 4 categories for 3 different populations: (1) for children 5-11 years of age, ≥115 g/L normal, 110-114 g/L mild anemia, 80-109 moderate, and <80 g/L severe anemia; (2) for children 12-14 years of age and those nonpregnant women >15 years of age: ≥120 g/L normal, 110-119 g/L mild anemia, 80-109 moderate, and <80 g/L severe anemia; and (3) for those men aged >15 years of age: ≥130 g/L normal, 110-129 g/L mild anemia, 80-109 moderate, and <80 g/L severe anemia. Reference cutoffs were also based on capillary samples.[1,21]

Statistical Analyses

Differences in hemoglobin concentrations between the 1995 CNSSCH and the subsequent years were tested with multiple comparison method of least significant difference in ANOVA. The distributions of hemoglobin concentration for 1995 and 2010 CNSSCHs by sex were represented using kernel densities, which are nonparametric smoothed graphs independent of bin width when compared with histograms. We used quantile regression models to assess the trends of different percentiles of hemoglobin concentration and to test the differences between boys and girls. To test for trends across survey years, we regarded survey years as an ordinal variable in logistic regression for the prevalence of anemia. To assess sex disparities at each time point, we used logistic regression to estimate the prevalence odds ratio (POR) for anemia in girls versus boys with adjustment for urban-rural area and socioeconomic status; the latter is a 3-category variable (upper, moderate, or low) based on 5 different characteristics (regional gross domestic product, total yearly income per capita, average food consumption per capita, natural growth rate of population, and the regional social welfare index). The design effect of cluster sampling by school was also taken into account in the model. All analyses were conducted by using Stata12.1 (StataCorp, College Station, Texas) and SPSS 20.0 (IBM, Armonk, New York). A 2-sided P value of <.05 was considered significant.

Results

Fifteen-Year Shifts in Mean Hemoglobin Concentration

Figure 1 shows that the mean hemoglobin concentration increased continuously in both sexes between 1995 and 2010. The mean hemoglobin concentration was higher in boys than girls at each survey year overall. It increased from 132.7 to 138.3 g/L in boys, and from 127.7 to 132.3 g/L in girls; the increase in each 5-year interval was 0.6-3.3 g/L for boys and 0.6-2.8 g/L for girls. At each survey year, hemoglobin concentration in boys increased with age. In the girls aged 7-12 years, the mean hemoglobin concentration increased and then remained stable from 12 to 17 years. In most sex- and age-specific subgroups, the mean hemoglobin concentration was higher in urban than rural children (**Table II**; available at www.jpeds.com).

Distribution Shift in Hemoglobin Concentration Over Time by Sex

Figure 2 shows the hemoglobin concentration distribution curves by sex its shift over time. For both sexes, the distribution of hemoglobin concentration found bell-shaped curves that shifted toward the right from 1995 to 2010. Moreover, similar shifts can be seen for each separate age groups (data