INDIAN JOURNAL OF MEDICAL SCIENCES

VOLUME 62

NUMBER 2

FEBRUARY 2008

ORIGINAL CONTRIBUTIONS

CASE REPORTS

LETTERS TO EDITOR

PRACTITIONERS' SECTION

Published by
Medknow Publications
A-109, Kanara Business Center, Off Link Road, Ghatkopar (E), Mumbai - 400075, India

EPIDEMIOLOGICAL CORRELATES OF NUTRITIONAL ANEMIA AMONG CHILDREN (6-35 MONTHS) IN RURAL WARDHA, CENTRAL INDIA

N. SINHA, P. R. DESHMUKH, B. S. GARG

ABSTRACT

BACKGROUND AND OBJECTIVES:* Nutritional anemia is associated with impaired performance of a range of mental and physical functions in children, along with increased morbidity. Iron supplementation at a later age may not reverse the adverse effects. National Nutritional Anemia Control Program was launched in India in 1970, but it failed to make any impact. The present study was undertaken to find out prevalence of anemia and its correlates in rural Wardha in children 6-35 months of age. *MATERIALS AND METHODS:* Seven hundred seventy-two children between 6 months and 35 months of age were studied for anemia by cluster-sampling method. The hemoglobin was estimated in the child by 'Filter paper cyanmethemoglobin method.' Pre-designed and pre-tested questionnaire was used to collect data on socio-demographic and other variables. Data was analyzed by SPSS 12.0.1. *RESULTS:* Mean hemoglobin level was 98.5 ± 12.9 gm/L. Prevalence of anemia was 80.3%. Only 1.3% children had severe anemia (hemoglobin <70 gm/L). The univariate analysis showed that anemia is significantly associated with age of the child, education of mother and father, occupation of father, socioeconomic status, birth order and nutritional status as measured by weight for age. The final model suggested that only educational status of the mother, occupation of the father, birth order and nutritional status of the child were significantly associated with anemia. *INTERPRETATION AND CONCLUSION:* For short-term impact, appropriate nutritional interventions remain the only operational intervention as only the nutritional status (weight for age) is a modifiable factor. But for long-term sustained impact, policy makers need to focus on improving maternal education and reducing family size.

***Key words:* Anemia, child health, childhood morbidity, cyanmethemoglobin, hemoglobin, reproductive health**

INTRODUCTION

Iron deficiency remains a major nutritional problem among infants and young children in India. The National Family Health Survey II (1998-99) documented a 73.6% prevalence of anemia in Indian children between 6 months and 35 months of age.[1] Studies conducted in different regions of the country over the past decades have also reported similar findings.[2-6] These data are of concern for several reasons. Iron deficiency is the most common cause of anemia in young children. Furthermore, anemia

Dr. Sushila Nayar School of Public Health, Mahatma Gandhi Institute of Medical Sciences, Sewagram, India

Correspondence:
Prof. Pradeep R. Deshmukh,
Dr. Sushila Nayar School of Public Health,
Mahatma Gandhi Institute of Medical Sciences,
Sewagram - 442 102, India. E-mail: prdeshmukh@gmail.com / prdeshmukh@yahoo.com

develops when iron deficiency is severe and prolonged. In a given population, individuals with iron deficiency or depleted iron stores may number two to five times the number of individuals with anemia.[7] Iron deficiency anemia is associated with impaired performance of a range of mental and physical functions in children, including physical capacity, mental development, cognitive abilities and social and emotional development.[8] Other health consequences include reduced immunity, increased morbidity and increased susceptibility to heavy metal poisoning.[8] Recent studies suggest that later iron supplementation may not reverse the effects of moderate-to-severe iron deficiency anemia occurring during the first 18 months of life.[9-12]

In India, the National Nutritional Anemia Control Program (NACP) was launched in 1970 to address the issue of anemia, but it failed to make a significant impact.[13] The intractable nature of this problem underscores the need to understand the epidemiology of childhood anemia and plan appropriate interventions. Hence the present study was undertaken to study the epidemiological correlates of nutritional anemia in children aged between 6 months and 35 months in the state of Maharashtra, where recent estimates place prevalence of anemia among children in this age group at 76%.[1]

MATERIALS AND METHODS

Study setting and study participants

This study was part of a cross-sectional study examining morbidity among children (0-35 months of age) in rural Wardha, central India. The study was conducted from May 2005 to April 2006 in three Primary Health Centres in 67 villages of Wardha district of Maharashtra state, namely, Anji, Gaul and Talegaon (population 88,187). The villages under these three Primary Health Centres are also a field practice area of the Department of Community Medicine, Mahatma Gandhi Institute of Medical Sciences, Sewagram.

Subjects were selected for the study using a 30-cluster sampling method.[14] From each of the 30 clusters, 33 children were selected as follows: 11 children aged 0-11 months, 11 aged 12-23 months and 11 aged 24-35 months; this gave a final sample of 990 children between 0 and 36 months of age to study the morbidity among children (0-35 months of age). Eleven children in each age group were selected by systematic random sampling after enumerating all the children in the age group from the selected cluster. Infants younger than 6 months of age were excluded from the anemia analysis, leaving a final sample of 772 children, to make the study consistent with other epidemiological studies conducted which focus on children of age 6-35 months - which may be because healthy children during the first six months of life are presumed to be protected against iron deficiency anemia.[15] The sample size was adequate to detect an 80% prevalence of anemia at 5% relative precision and alpha-error of 5% with design effect of 2. The study was approved by institutional ethical committee, and written informed consent was obtained from the mother of each study participant.

Data collection and hemoglobin estimation

Hemoglobin concentration was estimated in each child by the 'Filter paper cyanmethemoglobin method.'[16] Field workers obtained 20 μg of capillary blood via finger prick using a sterile disposable lancet [Pricon® Iscon Surgicals Ltd., Jodhpur (India)] and calibrated hemoglobin pipette. The sample was placed on Whatman 1 filter paper, labeled and transported to the laboratory for hemoglobin estimation.[16]

The investigator moved from house to house for data collection. At the time blood was collected, the investigator administered a questionnaire to the mother of the child to collect data on socioeconomic variables. The questionnaire was designed for the project and pre-tested in the target population prior to data collection. Socioeconomic status was defined as income below or above the poverty level as determined by the type of ration card the family had been issued. The Government of Maharashtra issues yellow ration cards to families below poverty line, while families above the poverty line receive orange ration cards. Families were defined as ‘nuclear’ if only the married couple and their dependent children resided in the family or as ‘joint’ if more than one married couple and/ or their children resided together. Parents’ educational status was determined by the parents’ years of schooling completed. Individuals who never attended school were categorized as ‘uneducated.’ Nutritional status was defined by NCHS reference values for ‘weight for age.’ Weight for age below 2 standard deviations (SD) was considered moderate underweight, while weight for age less than 3 SD was considered severe underweight.[17] Using WHO guidelines, anemia was defined as hemoglobin concentration less than 110 gm/L.[7] Mild anemia was defined as hemoglobin concentration less than 110 gm/L but greater than or equal to 100 gm/L, moderate anemia as hemoglobin concentration less than 100 gm/L but greater than or equal to 70 gm/L and severe anemia as hemoglobin concentration less than 70 gm/L.[7]

Statistical analysis

Prevalence of anemia was expressed as percentage. The prevalence of anemia was weighted by the number of children aged between 6 months and 36 months in a family, so that it becomes more representative of the population. The CSample program of Epi_info 6.04 (Center for Disease Control and Prevention, Atlanta, Georgia, USA) was used to calculate the confidence interval as data were collected by cluster sampling. The association of an independent variable with anemia was tested using chi-square test. Logistic regression was used to assess the relationship between independent variables and risk of having anemia. Unadjusted and adjusted odds ratios (ORs) were calculated to find out the strength of association. The final model was derived by backward likelihood ratio method. A P value <0.05 was considered statistically significant. Data were analyzed using SPSS 12.0.1 (SPSS for Windows, Rel. 12.0.1 2001. Chicago: SPSS Inc.).

RESULTS

Out of the 772 children studied, 18.8% children were 6-11 months of age, 40% were 12-23 months of age and 41.2% were 24-35 months of age. The mean age of study subjects was 20.8 ± 8.2 months. Male-to-female ratio was 1.15: 1. There were 18.9% children from families below poverty level. Half of the children were of first birth order, and 58.8% children were underweight.

The mean hemoglobin concentration in the

study population was 98.5 ± 12.9 gm/L. Prevalence of anemia was 80.3%. More than one-quarter of the children (27.7%) had mild anemia, approximately half (51.3%) had moderate anemia and 1.3% had severe anemia.

Table 1 shows the results of univariate analysis. The prevalence of anemia was highest (85.4%) among children between 6 months and 11 months of age. The prevalence of anemia differed significantly by age group (P = 0.007). The prevalence of anemia was 80.4 and 80.3% among male and female children respectively. It was significantly higher in scheduled caste (87.1%) and scheduled tribe (89.1%) children than in the children belonging to other castes (P < 0.001). Poverty status was also related to prevalence of anemia. Children from households below the poverty level were significantly more likely to have anemia (P = 0.014). Furthermore, a significantly smaller proportion of first-born children were anemic compared to second- or third-born children. Prevalence of anemia was 74.6% in first-born children and increased with increasing birth order of the child. Prevalence of anemia was significantly higher (91.9%) in severely underweight children compared to children with normal weight for age (74.1%) [Table 1].

Prevalence of anemia was significantly higher (96.6%) in children of uneducated mothers compared to children of educated mothers (P < 0.001). A similar relationship between father’s education and anemia was observed. Children whose fathers had 11 or more years

Table 1: Epidemiological correlates of anemia: individual and family characteristics

Variable	*Total number (%)*	*Anemia*			
		Proportion % (95% CI)	*P-value**	*Unadjusted OR 95% CI)*	*Adjusted OR (95% CI)*
Overall	772 (100)	80.3 (75.0-85.7)	-	-	-
Age (months)					
6-11	145 (18.8)	85.4 (78.6-92.2)	-	1	1
12-23	309 (40.0)	83.4 (81.0-89.0)	-	0.860 (0.496-1.494)	0.744 (0.406-1.365)
24-35	318 (41.2)	75.1 (65.6-83.1)	0.007	0.514 (0.303-0.872)	0.413 (0.228-0.747)
Sex					
Male	416 (53.9)	80.4 (74.1-86.6)	-	1	1
Female	356 (46.1)	80.2 (74.1-86.5)	0.986	0.987 (0.693-1.403)	1.210 (0.803-1.823)
Caste					
Open	24 (3.1)	79.2 (69.9-99.7)	-	1	1
Other backward class	457 (59.2)	74.9 (66.8-81.1)	-	0.779 (0.283-2.141)	0.709 (0.236-2.129)
Scheduled caste	171 (22.2)	87.1 (81.3-93.3)	-	1.770 (0.600-5.224)	1.558 (0.485-5.001)
Scheduled tribe	120 (15.5)	89.1 (80.4-97.2)	0.000	2.146 (0.685-6.717)	1.186 (0.335-4.201)
Socio-economic status					
Above poverty level	626 (81.1)	78.8 (73.4-84.2)	-	1	1
Below poverty level	146 (18.9)	87.4 (78.9-95.5)	0.014	1.873 (1.103-3.183)	1.152 (0.638-2.082)
Type of family					
Joint	427 (55.3)	79.5 (73.4-85.8)		1	1
Nuclear	345 (44.7)	81.3 (74.8-88.1)	0.540	1.122 (0.783-1.608)	0.851 (0.560-1.293)
Birth order					
1	387 (50.1)	74.6 (66.2-82.1)	-	1	1
2	320 (41.5)	85.9 (82.3-90.9)	-	2.072 (1.403-3.059)	1.705 (1.182-2.460)
≥ 3	65 (8.4)	87.5 (80.7-96.7)	0.000	2.382 (1.097-5.173)	2.089 (1.032-4.228)
Nutritional status (Weight for age expressed in Z-scores)					
Normal	318 (41.2)	74.1 (67.4-82.3)	-	1	1
Moderate underweight	330 (42.7)	82.1 (74.7-88.7)	-	1.597 (1.095-7.891)	1.495 (0.976-2.291)
Severe underweight	124 (16.1)	91.9 (86.0-97.5)	0.000	3.943 (1.970-7.891)	3.688 (1.751-7.764)

*P value for Chi-square test

of education were significantly less likely to be anemic than children of less educated or uneducated fathers. The lowest prevalence of anemia was observed in children of a mother and/ or father in service/ business as occupation (58.3 and 66.7% respectively) [Table 2].

Unadjusted and adjusted odds ratios were calculated for each variable and are shown in Tables 1 and 2. After adjusting for all other factors studied, children aged 24-35 months were significantly less likely to be anemic compared to children aged 6-11 months. While the decreased odds ratio of having anemia in the 12-23 month age range was not significant, the data suggest that as age increases the risk of anemia decreases. Poverty did not significantly increase the odds of a child having anemia. The adjusted odds ratio showed that children from families below the poverty level were only 1.15 times more likely to be anemic compared to children from families above the poverty level. However, a significant increase in the odds of a child having anemia was found as child's birth order increased. Compared to first-born children, second-born children were 1.7 times more likely and children born third or later were two times more likely to have anemia. Similarly, severely underweight children were at 3.6 times higher risk of anemia than children of normal weight for age [Table 1]. Similarly, risk of anemia increased as educational status of mother decreased. Children whose mothers were uneducated were four times more likely to be anemic compared to those children whose mothers received 11 years or more of education. Child with uneducated father was more likely to be anemic; but after adjusting for all other variables studied, the odds ratio was not statistically significant [Table 2].

The final model derived by multivariate logistic regression is shown in Table 3. The final model suggests that only educational status of the

Table 2: Epidemiological correlates of anemia: Parental characteristics

Variable	*Total number (%)*	*Anemia*			
		Proportion % (95% CI)	*P-value**	*Unadjusted OR (95% CI)*	*Adjusted OR (95% CI)*
Education of mother (completed years of schooling)					
≥ 11	193 (25.0)	71.6 (63.0-80.7)	-	1	1
1-10	510 (66.1)	82.2 (75.9-87.8)	-	1.833 (1.235-2.720)	1.139 (0.698-1.858)
Uneducated	69 (8.9)	96.6 (93.3-100.1)	0.000	11.313 (2.664-48.040)	4.360 (0.912-20.838)
Occupation of mother					
Housewife	516 (66.8)	78.6 (72.2-85.1)	-	1	1
Service and business	13 (1.7)	58.3 (15.1-84.9)	-	0.379 (0.118-1.218)	0.675 (0.188-2.422)
Any skilled laborer	16 (2.1)	84.6 (72.2-99.2)	-	1.490 (0.325-6.822)	1.027 (0.202-5.230)
Farm laborer	102 (13.2)	78.0 (69.5-88.8)	-	0.961 (0.572-1.612)	0.876 (0.468-1.642)
Unskilled work	125 (16.2)	91.2 (82.7-99.3)	0.007	2.808 (1.460-5.398)	1.256 (0.546-2.891)
Education of father (completed years of schooling)					
≥ 11	285 (36.9)	74.2 (67.7-81.7)	-	1	1
1-10	428 (55.4)	83.0 (76.6-88.8)	-	1.699 (1.179-2.448)	1.173 (0.787-1.748)
Uneducated	59 (7.7)	96.6 (81.7-101.8)	0.000	3.995 (1.179-2.448)	1.397 (0.534-3.650)
Occupation of father					
Service and business	112 (14.5)	66.7 (56.5-77.8)	-	1	1
Any skilled laborer	81 (10.5)	84.8 (80.7-93.8)	-	2.792 (1.345-5.794)	2.375 (1.057-5.339)
Mill and factory laborer	29 (3.8)	93.1 (84.5-102.9)	-	6.750 (1.522-29.937)	6.445 (1.376-30.184)
Farm laborer	284 (36.7)	74.3 (66.1-81.7)	-	1.445 (0.898-2.326)	1.303 (0.742-2.287)
Unskilled work	266 (34.5)	89.8 (83.4-95.1)	0.000	4.426 (2.527-7.752)	2.771 (1.301-5.903)

**P* value for chi-square test

Table 3: Correlates of anemia – final model by multiple logistic regression

Variable	*Odds' ratio*	*95% CI*
Education of mother (completed years of schooling)		
≥ 11	Reference	-
1-10	1.21	0.776-1.908
Uneducated	4.762	1.047-21.662
Occupation of father		
Service and business	Reference	-
Any skilled laborer	2.404	1.089-5.305
Mill and factory laborer	6.678	1.447-30.829
Farm laborer	1.329	0.783-2.256
Unskilled work	3.290	1.741-6.219
Birth order		
1	Reference	-
2	1.801	0.787-4.124
≥ 3	2.028	1.323-3.109
Nutritional status (Weight for age expressed in Z-scores)		
Normal	Reference	-
Moderate underweight	1.5319	1.009-2.325
Severe underweight	3.661	1.765-7.590

mother, occupation of the father, birth order and nutritional status of the child are significantly associated with anemia. Thus, the final model shows that especially, nutritional status of the child is the only modifiable factor in the short term, while rest of the factors need long-term interventions.

DISCUSSION

The overall prevalence of anemia in the present study was 80.3%. This finding is consistent with results of other studies conducted throughout India [Table 4].[1,18-24] NFHS-II found that nearly three-quarters of Indian children (73.4%) between 6 months and 35 months of age were anemic, with the prevalence reaching 76% in Maharashtra.[2] Data from NFHS-III showed that prevalence of anemia (in the 6-36 months age group) in rural India was 80.9%, with 25.1% having mild anemia, 51.7% having moderate anemia and 3.5% having severe anemia.[25] The District Level Household Survey (DLHS, 2002) conducted as part of Reproductive and Child Health-II (RCH-II) reported a prevalence of 99% for Wardha district.[23] In the present study, 1.4% children had severe anemia. DLHS 2002 did not report severe anemia from Wardha,[23] while NFHS-II reported it to be 4% in Maharashtra.[1] Minor differences in prevalence may be

Table 4: Prevalence of iron deficiency anemia among pre-school children

Study region	*Reference*	*Method used*	*Age group*	*Prevalence (%)*	*Hemoglobin cut-off (gm/dl)*
North India:					
Delhi	Dhar *et al*, 1969[18]	Sahali's method	6 - 35 months	60	<12 gm/dl
	ICMR, 1977[19]	Cyanmethemoglobin method	1-3 years	83	<10.8 gm/dl
Ludhiana	Kapur *et al*, 2002[20]	Cyanmethemoglobin method	9-36 months	63.5	<11 gm/dl
	Uberoi *et al*, 1972[21]	-	<3 years	70	<11 gm/dl
South India:					
Hydrabad	ICMR, 1977[19]	Cyanmethemoglobin method	1-3 years	60.5	<10.8 gm/dl
Trivundum, Kerala	George K *et al*, 2000[22]	Cyanmethemoglobin method	0-6 years	11.4	<8.8 gm/dl
West India:					
Bombay	ICMR, 1977[19]	Cyanmethemoglobin method	1-3 years	79	<10.8 gm/dl
Maharashtra	NFHS-II, 1998-99[2]	Hemocue	6-35 months	76	<11 gm/dl
Wardha	DLHS-RCH-II, 2002[23]	Filter paper cyanmethemoglobin method	6-71 months	99 Mild-27.8 Mod-71.2	<11 gm/dl
East India:					
Kolkata	ICMR, 1977[19]	Cyanmethemoglobin method	1-3 years	38.9	PCV <33 %
Central India:					
Jabalpur,MP	Rao V *et al*,2005[24]	Sahali's method	0-6 years	71.1	<11 gm/dl
India:					
Combined data	ICMR, 1977[19]	Cyanmethemoglobin method	1-3 years	62.8	<10.8 gm/dl
India	NFHS-II, 1998-99[2]	Hemocue	6-35 months	74.3	<11 gm/dl
India	NFHS III[25]	Hemocue	6-35 months	80.9	<11 gm/dl

attributed to different methods used to estimate hemoglobin concentration [Table 3]. For instance, NFHS-II used HemoCue machines to measure hemoglobin concentration. The HemoCue has been shown to overestimate hemoglobin concentration.[26-27] Bhaskaram *et al.*[26] reported that the overestimation of hemoglobin concentration by HemoCue method was 1.19 gm/dl (CI: 0.98–1.40), while Kapil *et al.*[27] reported that HemoCue method overestimated the hemoglobin levels by 1.5 gm/dl in capillary blood samples as compared to the standard cyanmethemoglobin method.

The final model derived by multivariate logistic regression showed that the significant correlates of anemia in this age group included education of mother, occupation of father, birth order of the child and nutritional status as assessed by weight for age. These findings support the idea that greater levels of parental education in developing countries are associated with disproportionately positive returns on child health.[28] Cross-country comparisons using large data sets such as the World Fertility Survey and the Demographic and Health Surveys have shown that education in general and female education in particular strongly influence reductions in child morbidity and mortality.[29-31] In depth quantitative and qualitative research examining women's health-enhancing behavior has reached similar conclusions.[32-33] The positive influence of maternal education may be due to educated women being better able to access and utilize community resources and modern means of safeguarding their own health and that of their children.[34-36] Furthermore, educated women may be able to make independent decisions regarding their own and their children's health, leading to greater utilization of modern health facilities.[37-39]

The present study found that birth order significantly influenced risk of anemia. Children with two or more older siblings in the household were at significantly greater risk of anemia. Czajka-Narins also reported that a greater number of siblings is a risk factor for anemia.[40] This may be due to distribution of scarce resources within the family, and such conclusion warrants further research. Paternal occupation is an indirect indicator of socioeconomic status of the family in India as most women in rural India are involved in economically nonproductive work. In the present study, the prevalence of anemia was lowest among children whose fathers were in service/ business as occupations or were farm laborers. This finding may be attributed to the possibility of better household food security for farm laborers as compared to other laborers such as unskilled laborers and mill and factory laborers.

Being underweight, based on weight for age, is a composite measure of stunting and wasting and is recommended as the indicator to assess changes in the magnitude of malnutrition over time.[41] Findings from the present study strongly suggest that childhood underweight is a risk factor for anemia. Usually, the micronutrient deficiency often tends to coexist with other micronutrient and macronutrient deficiencies. These considerations must caution against a policy of sole reliance on the supplementation of a single nutrient as the answer to a given micronutrient deficiency disease problem. While there is certainly a place for single nutrients, the ultimate logical approach obviously must consist in dietary improvement. The quantity and quality of diet need to be improved as

the prevalence of anemia in the present study was as high as 74% even among the children who were normal by weight for age. Even where single nutrients may be employed to temporarily tide over a problem, they must be used as adjuncts to, and as reinforcements of, the basic approach of appropriate dietary improvement.[42] As reported by National Nutrition Monitoring Bureau (2002), the average daily intake of protein, energy and iron was 81.4, 56.9 and 33.3% of the RDA respectively in Maharashtra.[43] This further emphasizes the need for improving on the aforesaid issue.

To conclude, the prevalence of anemia among children between 6 months and 35 months of age in rural Wardha was found to be as high as 80.3%. The mean hemoglobin concentration of the study population was 98.5 ± 12.9 gm/L. The final model derived by multiple logistic regression suggests that nutritional status as defined by weight for age; and socio-demographic factors, including maternal education, paternal occupation and birth order, influence risk of anemia in the target population. Data suggest that the complex factors must be addressed by ensuring dietary adequacy. Nutritional interventions aimed at protein and energy requirements and micronutrient requirements of children may serve as a short-term solution. However, sustainability and delivery of these programs may require that related policies address complex issues pertaining to economic status, maternal education and family size.

However, the limitations of the study should be kept in mind. Firstly, hemoglobin concentration has been used as proxy indicator of iron deficiency. Other indicators such as serum ferritin have not been used. Secondly, the data on dietary intake were not collected, which is an important determinant of iron deficiency. Similarly, other determinants such as worm infestations and role of infections like malaria were also not studied. Lastly, it was a cross-sectional study and hence causal association could not be studied; also, as there were only few cases with severe anemia, the study did not allow analyzing the data by severity of anemia.

ACKNOWLEDGMENTS

We acknowledge with thanks the financial assistance from Aga Khan Foundation and USAID to conduct the study under Child Survival Grant with the cooperative agreement number GHS-A-00-03-00015-00.

REFERENCES

1. World Health Organization. Iron deficiency anemia. Assessment, Prevention and Control: A guide for program managers. World Health Organization: Geneva; 2001.
2. International Institute of Population Sciences. National family Health Survey-India (NFHS-II): Volume 1. Mumbai: IIPS; 1998-99.
3. Seshadri S, Hirode K, Naik P, Shah A, Gupta N. An effective intervention to reduce the prevalence of anemia in children. Indian J Med Res 1984;80:164-73.
4. Indian Council of Medical Research. Studies on preschool children. ICMR Tech Rep Ser No 26. National Institute of Nurition: Hyderabad; 1977.
5. Raman L, Pawashe AB, Vasanthi G, Parvati CH, Vasumathi N, Rawal A. Plasma ferritin in the assessment of iron status on Indian infants. Indian Pediatr 1990;27:705-13.
6. Gomber S, Kumar S, Rusia U, Gupta P, Agarwal KN, Sharma S. Prevalence and etiology of

nutritional anemias in early childhood in an urban slum. Indian J Med Res 1998;107:269-73.
7. Singla PN, Agarwal KN, Singh RM, Reddy EC, Tripathi AM, Agarwal DK. Deficiency anemia in pre-school children-Estimation of prevalence based on response to hematinic supplementation. J Trop Pediatr 1982;26:239-42.
8. Preventing Iron defieincy in women and children technical consensus on Key Issues. 7-9 October 1998, UNICEF, UNU, WHO, MI, Technical Group International Nutrition Foundation: USA; 1998. [Last cited on 2006 Dec 10]. Available from: http://www.cdc.gov.mill1.sjlibrary.org/mmwr/preview/mmwrhtml/00051880.htm.
9. Zlotkin S. Current issues for the prevention and treatment of iron deficiency anemia. Indian Pediatr 2002;39:125-8.
10. Scrimashaw NS. The consequences of hidden hunger for individuals and societies. Food Nutr Bull 1994;15(1). [Cited on 10 Dec. 2006]; Available from URL: http://www.unu.edu/unupress/food/8F151e/8F151E02.htm#The%20consequences%20of%20hidden%20hunger%20for%20individuals%20and%20societies
11. Drapper A. Child development and iron deficiency: Early action is critical for healthy mental, physical and social development. Oxford Brief, I. The Inter-national Nutritional Anemia Consultative Group: Washington, DC, USA; 1997. [Last cited on 2006 Dec 10]. Available from: http://inacg.ilsi.org/publications/pubslist.cfm?publicationid=238.
12. Stoltzfus R, Dreyfuss M. Guidelines for the Use of Iron Supplements to Prevent and Treat Iron Deficiency Anemia. The International Nuritional Anemia Consultative Group: Washington DC, USA; 1998. [Last cited on 2006 Dec 10]; Available from: http://www.ilsi.org/file/b2_VUHUQ8AK.pdf.
13. Kapil U. Prevention and control of iron deficiency anemia amongst young children. Indian Pediatr 2003;40:293-5.
14. Aga Khan Foundation. Primary Health Care Management Advancement Program: Assessing community health needs and coverage. Aga Khan Foundation: Geneva; 1993.
15. Godel JC. Breast-feeding and anemia: Let's be careful. CMAJ 2000;162:343-4.
16. Raghuramulu N, Madhavan Nair K, Kalyansundaram S, editors. A manual of laboratory techniques. 2nd ed. National Institute of Nutrition: Hyderabad; 2003.
17. World Health Organization. Physical status: The use and interpretation of anthropometry. World Health Organization: Geneva; 1995.
18. Dhar N, Agarwal KN, Taneja PN, Gupta S. Iron deficiency anaemia in children. Indian J Pediatr 1969;36:436-41.
19. Indian Council of Medical Research. Studies on preschool children. Indian Council of Medical Research. Technical Report Series No-26. National Institute of Nutrition: Hyderabad; 1977.
20. Kapur D, Agarwal KN, Sharma S, Kela K, Kaur I. Iron status of children aged 9-36 months in an urban slum Integrated Child Development services (ICDS) project in Delhi. Indian Pediatr 2002;39:136-44.
21. Uberoi IS, DeSweemer C, Taylor CE. A story of anaemia among rural Punjabi children. Indian J Med Res 1972;60:793-9.
22. George KA, Kumar NS, Lal JJ, Sreedevi R. Anaemia and nutritional status of pre-school children in Kerala. Indian J Pediatr 2000;67:575-8.
23. Government of India. District Level Health Survey: Government of India, Reproductive and Child Health Survey: Wardha; 2002. [Last cited on 2006 Dec 10]. Available from: http://www.rchindia.org/keyindi.htm.
24. Rao VJ, Yadav R, Dolla CK, Kumar S, Bhondeley MK, Ukey M. Under nutrition and Child morbidities among tribal preschool Children. Indian J Med Res 2005;122:43-7.
25. International Institute of Population Sciences (IIPS). Macro International. National Family Health Survey (NFHS III), 2005-06: Volume 1. IIPS: Mumbai; 2007.
26. Bhaskaram P, Balakrishna N, Radhakrishna KV, Krishnaswamy K. Validation of hemoglobin estimation using Hemocue. Indian J Pediatr 2003;70:25-8.

27. Kapoor SK, Kapil U, Dwiwedi SN, Anand K, Pathak P, Singh P. Comparison of Hemocue method with cyanmethemoglobin method for estimation of hemoglobin. Indian Pediatr 2002;39:743-6.
28. Boyle MH, Racine Y, Georgiades K, Snelling D, Hong S, Omariba W, *et al*. The influence of economic development level, household wealth and maternal education on child health in the developing world. Soc Sci Med 2006;63:2242-54.
29. Bicego G, Boerma JT. Maternal education and child survival: A comparative study of survey data from 17 countries. Soc Sci Med 1993;36:1207-27.
30. Hobcraft J. Women's education, child welfare and child survival: A review of the evidence. Health Transition Review 1993;3:159-75.
31. Murthi M, Guio A, Dreze J. Mortality, fertility and gender bias in India: A district-level analysis. Population Development Review 1995;21:745-82.
32. Bhuiya A, Streatfield K. Mothers' education and survival of female children in a rural area of Bangladesh. Population Studies 1991;45:253-64.
33. Bourne KL, Walker GM. The differential effect of mothers' education on mortality of boys and girls in India. Population Studies 1991;45:203-19.
34. Cleland JG, Van Ginneken JK. Maternal education and child survival in developing countries: the search for pathways of influence. Soc Sci Med 1988;27:1357-68.
35. Barrera A. The role of maternal schooling and its interaction with public health programs in child health production. J Develop Eco 1990;32:69-91.
36. Goodburn E, Ebrahim GJ, Senapati S. Strategies educated mothers use to ensure the health of their children. J Trop Pediatr 1990;36:235-9.
37. Caldwell J. Education as a factor in mortality decline: An examination of Nigerian data. Population Studies 1979;33:395-413.
38. Caldwell J. Routes to low mortality in poor countries. Population Development Review 1986;12:171-220.
39. Govindswamy P, Ramesh BM. Maternal Education and the Utilization of Maternal and Child Health Services in India. National Family Health Survey Subject Reports, No. 5, Mumbai: International Institute for Population Sciences and Macro International, Demographic and Health Surveys (DHS): Calverton, Maryland; 1997.
40. Czajka-Narins DM, Haddy TB, Kallen DJ. Nutrition and social correlates in iron deficiency anemia. Am J Clin Nutr 1978;31:955-60.
41. Cogill B. Anthropometric indicators measurement guide. Food and Nutrition Technical Assistance Project, Academy for Educational Development. Washington DC; 2003.
42. Gopalan C. 'Micronutrient' Deficiencies - Public Health Implications. 1994. [Last cited on 2006 Dec 10]; Available from: http://nutritionfoundationofindia.res.in/archives.asp?archiveid=22andback=bydate.asp.
43. National Nutrition Monitoring Bureau. Diet and nutritional status of rural population. National Nutrition Monitoring Bureau Technical Report No. 21. National Institute of Nutrition, Indian Council of Medical Research: Hyderabad; 2002.

Source of Support: Aga Khan Foundation and USAID, **Conflict of Interest:** None declared.