

Maternal education and risk of iron deficiency anemia in children under 5 years of age

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ABSTRACT

Background: Iron deficiency anemia (IDA) is a common public health issue in young children, especially in low- and middle-income countries. There is growing evidence of the impact of maternal education on child health, nutrition and health seeking behaviour. Low maternal education can contribute to childhood IDA.

Methods: This cross-sectional analytical study was conducted at the Department of Pediatric Medicine, SKBZ, CMH, Muzaffarabad from 21-06-2024 to 30-06-2025, including 124 patients between the ages of 6-59 months. A proforma was used to record socioeconomic, demographic and clinical information. Education level of mother was classified as educated and non-educated. Anemia was measured from blood samples. Data were entered into SPSS version 27.0, and binary logistic regression was performed.

Results: Among 124 children aged 6–59 months, 33.9% had iron deficiency anemia (IDA). IDA was significantly more common among children of mothers with no formal education than among those with educated mothers (51.4% vs. 27.0%; $p=0.010$). Cow's milk consumption (45.3% vs. 21.7%; $p=0.005$) and malnutrition (45.5% vs. 24.6%; $p=0.015$) were also significantly associated with IDA. In the combined multivariable logistic regression model, maternal education (AOR=3.72, 95% CI: 1.53–9.06; $p=0.004$) and malnutrition (AOR=3.20, 95% CI: 1.40–7.33; $p=0.006$) remained independently associated with higher odds of IDA.

Conclusion: Iron deficiency anemia (IDA) in children under 5 is strongly associated with maternal education and malnutrition. Education and nutrition of mothers may reduce IDA.

Keywords: Iron Deficiency Anemia, Maternal Education, Preschool Children, Malnutrition, Socioeconomic Status

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Introduction

Iron deficiency anemia (IDA) continues to be a major cause of malnutrition worldwide, particularly among young children (before the age of five years), in low- and middle-income

settings. It has been estimated that a large proportion of anemia in this age group is due to iron deficiency, which can have a major impact on growth, neurodevelopment and immunity. (1-2) Young children are particularly susceptible to iron deficiency due to the rapid growth and consequently high nutritional demand in this age group. (3) Moreover, IDA is associated with long-term neurodevelopmental disorders and loss of productivity at a later stage of life,

highlighting its public health significance. (4) There are many factors that drive the development of IDA in children, including factors related to nutrition, environment and socioeconomic status (5-6). These include maternal factors, especially maternal health, nutrition and childcare behaviours' which are critical to child health outcomes. (7)

Furthermore, the risk of IDA is compounded by factors such as household food insecurity and low dietary diversity, especially in low-income settings. (8). Maternal education is an important social determinant of child nutrition and health-care seeking. Research has shown that maternal education is linked to better dietary diversity, health care-seeking behaviour and child anemia in studies from resource limited settings. (9,10)

Maternal education is associated with optimal infant and young child feeding practices, early recognition of disease, and has access to preventive interventions, which in turn facilitates a lower risk of IDA. (6,9) On the other hand, low maternal education is associated with inappropriate feeding practices, delayed presentation to health care and increased vulnerability to nutritional deficiency in children. (8,10).

Iron deficiency anemia (IDA) remains a significant public health burden among malnourished children less than five years old in resource-limited settings with socioeconomic inequality and poor maternal education. Although a number of studies have suggested maternal education is a predictor of child health, there is little evidence quantifying the extent of association between maternal education and IDA in the local context. Estimating the prevalence of iron deficiency anemia among children presenting to the outpatient department of a tertiary care hospital can help determine the burden of the condition in this vulnerable population. Additionally, assessing the association

between maternal education and iron deficiency anemia may help identify children at increased risk and inform targeted nutritional and health-education interventions.

Methods

This cross-sectional analytical study was conducted in the Department of Pediatric Medicine, SKBZ, Combined Military Hospital (CMH), Muzaffarabad, from 21 June 2024 to 30 June 2025. Ethical approval was obtained under reference number Ethical Committee/DME-1124, dated 20 June 2024. Written informed consent was obtained from the parent or legal guardian of each child before enrollment. Children aged 6-59 months of either sex who presented to the pediatric outpatient department during the study period were considered eligible. A non-probability consecutive sampling technique was used. The required sample size was calculated using a 95% confidence level, an 8% margin of error, and an anticipated prevalence of iron deficiency anemia of 28.9% among children under five years of age, based on previously published literature. (11) The calculated sample size was 124 children.

Children were included if they were between 6 and 59 months of age, of either sex, had a parent or legal guardian willing to provide informed consent. Children were excluded if they had a known parasitic infestation, including helminthic infection associated with chronic blood loss; a known malabsorption disorder such as celiac disease or cystic fibrosis; a congenital anomaly or chronic congenital condition likely to substantially affect nutritional or hematological status, including significant congenital heart disease; chronic renal disease or renal failure; acute infection or active inflammatory disease at the time of enrollment; current iron supplementation or therapeutic iron treatment; a known recent history of

significant hemorrhage or blood loss; or any other documented chronic medical condition considered likely to interfere with the assessment of iron status. Children with incomplete essential clinical, anthropometric, or laboratory information were also excluded from the final analysis.

Demographic, and clinical information was collected using a predesigned proforma. It was reviewed for content, clarity, completeness, and relevance to the study objectives, and necessary modifications were made before its final use. Variables included age, sex, weight, current breastfeeding, cow's milk consumption, formula milk consumption, residence (rural or urban), immunization status, family size, socioeconomic status, maternal education, and nutritional status. Milk-feeding practices were recorded as separate dietary variables because children aged 6 -59 months could receive more than one type of milk concurrently. Current breastfeeding, cow's milk consumption, and formula milk consumption were assessed independently; therefore, these categories were not mutually exclusive and their percentages could exceed 100% when considered collectively. For children aged ≥ 24 months, milk consumption was considered as one component of the overall dietary pattern, alongside family foods and complementary foods, rather than as the sole source of nutrition.

Nutritional status was assessed using the World Health Organization (WHO) Child Growth Standards for children aged 0–5 years. Weight, height or length, age, and sex were used to calculate age- and sex-specific anthropometric Z-scores. Weight-for-age Z-score was used to assess underweight, height/length-for-age Z-score to assess stunting, and weight-for-height/length Z-score to assess wasting. A Z-score below -2 standard deviations from the WHO reference

median was considered indicative of an anthropometric deficit, while a Z-score below -3 standard deviations was considered severe. For the purposes of the present study, a child was classified as malnourished if he or she had at least one relevant anthropometric indicator below -2 standard deviations according to the predefined WHO criteria. Children who did not fulfill these criteria were classified as not malnourished.

Dietary information was obtained from the child's parent or primary caregiver using a structured questionnaire. Milk intake was recorded as a dietary variable and was not used as an inclusion criterion. The type of milk consumed was recorded as breast milk, infant formula, cow's milk, or a combination of milk sources where applicable. Breastfeeding history was recorded separately from current milk consumption. Where information was available, exclusive breastfeeding during the first six months of life was defined as feeding the infant only breast milk without other foods or liquids, except medicines, vitamins, minerals, or oral rehydration solution when medically indicated. Current breastfeeding after six months was recorded separately and was not considered equivalent to exclusive breastfeeding. For children aged 6–23 months, milk consumption was assessed in conjunction with complementary feeding, whereas for children aged 24–59 months, milk was considered one component of the overall diet rather than the sole source of nutrition. The dietary assessment therefore distinguished current milk intake from the child's previous breastfeeding history and recognized the changing nutritional contribution of milk with increasing age.

Socioeconomic status was assessed using the modified Kuppaswamy socioeconomic status scale. The scale considers relevant socioeconomic characteristics, including parental education, occupation, and monthly

family income. The income component was categorized according to the version of the modified Kuppuswamy scale. For analytical purposes, socioeconomic status was categorized into high, upper-middle, lower-middle, and low socioeconomic groups according to the predefined scoring system. Place of residence was classified as rural or urban based on the child's residential location. Immunization status was determined from the child's immunization card where available and/or caregiver history and was categorized as immunized or unimmunized according to the predefined study criteria. Family size was recorded as the total number of household members and categorized according to the predefined study categories.

Maternal education was recorded according to the highest level of formal education completed by the child's mother. Mothers were initially categorized as illiterate, primary education (grades 1–5), middle education (grades 6–8), high school education (grades 9–10), intermediate education (grades 11–12), or graduate/postgraduate education. For the primary analysis, mothers with no formal education or only primary education were categorized as having no or low formal education, whereas mothers who had completed education beyond primary level were categorized as educated. This categorization was used to examine the association between maternal educational attainment and iron deficiency anemia in the child.

Venous blood samples were collected under aseptic conditions by trained healthcare personnel and transported promptly to the institutional laboratory for analysis. Complete blood count was performed using an automated hematology analyzer according to standard laboratory procedures. Anemia was defined using age-specific WHO hemoglobin thresholds: hemoglobin <10.5 g/dL for

children aged 6–23 months and <11.0 g/dL for children aged 24–59 months. Serum ferritin was measured as an indicator of body iron stores using a standardized laboratory assay. Serum ferritin <12 µg/L was considered indicative of iron deficiency in children aged 6–59 months in the absence of acute infection or inflammation. Because serum ferritin is an acute-phase reactant and may be falsely elevated during infection or inflammation, children with clinically apparent acute infection or inflammatory disease were excluded from enrollment. Iron deficiency anemia (IDA) was operationally defined as the coexistence of age-specific anemia and serum ferritin <12 µg/L. Children who did not fulfill both criteria were classified as not having IDA.

Data were analyzed using IBM SPSS Statistics version 27.0. Continuous variables were assessed for distribution and summarized as mean ± standard deviation for approximately normally distributed variables or median (IQR) for non-normally distributed variables. Categorical variables were summarized using frequencies and percentages. The prevalence of iron deficiency anemia was calculated as the proportion of children fulfilling the predefined diagnostic criteria among the total study population. Associations between categorical variables and iron deficiency anemia were initially assessed using the Pearson chi-square test or Fisher's exact test where appropriate. Maternal education and other clinically relevant variables were considered for multivariable analysis. Binary logistic regression was performed with iron deficiency anemia as the dependent variable. Adjusted odds ratios with corresponding 95% confidence intervals were calculated to quantify the strength and precision of associations. Maternal education was retained as the principal explanatory variable in the multivariable model, while other variables

were included based on their clinical relevance and potential role as confounders. Multicollinearity among explanatory variables was assessed before interpretation of the final model. The overall significance of the regression model was assessed using the likelihood-ratio chi-square test, and model calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit test. A two-sided p-value of <0.05 was considered statistically significant.

Results

A total of 124 children aged 6–59 months were included in the study. Of these, 71 (57.3%) were males and 53 (42.7%) were females. Forty children (32.3%) were aged 6–23 months, whereas 84 (67.7%) were aged 24–59 months. The mean age of the participants was 34.59 ± 16.05 months. The mean body weight was 12.37 ± 4.46 kg.

Regarding milk-feeding practices, 24 (19.4%) children were currently breastfed, 64 (51.6%) consumed cow's milk, and 60 (48.4%) received formula milk. Among the study participants, 74 (59.7%) were from rural areas and 50 (40.3%) were from urban areas.

Regarding socioeconomic status, 32 (25.8%) children belonged to the high socioeconomic group, 30 (24.2%) to the upper-middle group, 27 (21.8%) to the lower-middle group, and 35 (28.2%) to the low socioeconomic group. Maternal education varied across the study population. Twenty mothers (16.1%) were illiterate, 15 (12.1%) had primary education, 26 (21.0%) had middle-level education, 14 (11.3%) had high-school education, 23 (18.5%) had intermediate education, and 26 (21.0%) were graduates. For the primary analysis, mothers were categorized into educated and no/low formal education groups according to the predefined study criteria. Overall, 89 (71.8%) mothers were classified as educated, whereas 35 (28.2%) were classified as having no/low formal education. Regarding

immunization status, 59 (47.6%) children were immunized and 65 (52.4%) were unimmunized. Most families, 70 (56.5%), had ≤ 2 members, while 54 (43.5%) had >2 members (table 1).

Table-1: Frequency distribution of different variables (n=124)

Variable	Frequency, n	% age
Sex		
Male	71	57.3%
Female	53	42.7%
Age group		
6-23 months	40	32.3%
24-59 months	84	67.7%
Mean age (months)	34.59 ± 16.05	
Mean weight (kg)	12.37 ± 4.46	
Milk-feeding practices*		
Currently breastfed	24	19.4%
Cow's milk consumption	64	51.6%
Formula milk consumption	60	48.4%
Residence		
Rural	74	59.7%
Urban	50	40.3%
Socioeconomic status		
High	32	25.8%
Upper middle	30	24.2%
Lower middle	27	21.8%
Low	35	28.2%
Maternal education		
Illiterate	20	16.1%
Primary	15	12.1%
Middle	26	21.0%
High school	14	11.3%
Intermediate	23	18.5%
Graduate	26	21.0%
Education group		
Educated	89	71.8%
No formal education	35	28.2%
Immunization status		
Immunized	59	47.6%
Unimmunized	65	52.4%
Family size		
≤2 members	70	56.5%
>2 members	54	43.5%

*Milk-feeding practices were recorded as separate, non-mutually exclusive variables; children could receive breast milk together

with cow's milk and/or formula milk. Therefore, percentages do not sum to 100%. Based on the nutritional-status classification used in the study, 55 (44.4%) children were classified as malnourished and 69 (55.6%) as not malnourished. Overall, 42 (33.9%) children had iron deficiency anemia, whereas 82 (66.1%) did not have iron deficiency anemia (figure 1).

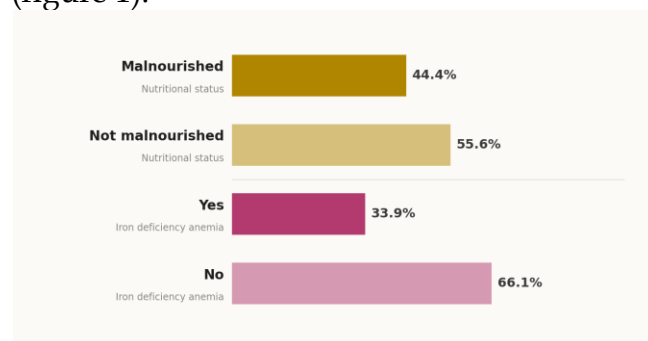


Figure 1: Nutritional Status & Iron Deficiency Anemia

Table 2 illustrates the relationship between the education of mothers and iron deficiency anemia in children under five years of age. Of 89 children of educated mothers, 24 (27.0%) had anemia whereas 65 (73.0%) did not have anemia. In contrast, in 35 children with no education in the mother, 18 (51.4%) were anemic and 17 (48.6%) were non-anemic. Overall, of 124 children 42 (33.9%) were found to have iron deficiency anemia and 82 (66.1%) were non-anemic. The difference in anemia prevalence in the two groups was statistically significant ($p = 0.010$).

Table-2: Association between maternal education and iron deficiency anemia

Maternal education	Iron deficiency anemia		Total	p-value
	Yes	No		
Education	24(27.0%)	65(73.0%)	89(100.0%)	0.010
No education	18(51.4%)	17(48.6%)	35(100.0%)	
Total	42(33.9%)	82(66.1%)	124(100.0%)	

Table 3 shows that iron deficiency anemia was not significantly associated with gender, age, residence, socioeconomic status, maternal education and immunization status, or family size ($p > 0.05$). However, there was a

significantly higher rate of anemia between the children who were drinking cow milk (45.3% vs. 21.7%; $P=0.005$) and the malnourished child population (45.5% vs. 24.6%; $P=0.015$).

Table-3: Stratification of IDA with respect to different variables

Variables		IDA		p-value
		Yes	No	
Gender	Male	20(28.2%)	51(71.8%)	0.120
	Female	22(41.5%)	31(58.5%)	
Age groups	6-23 months	14(35.0%)	26(65.0%)	0.855
	24-59 months	28(33.3%)	56(66.7%)	
Milk type	Cow milk	29(45.3%)	35(54.7%)	0.005
	Formula milk	13(21.7%)	47(78.3%)	
Residence	Rural	25(33.8%)	49(66.2%)	0.980
	Urban	17(34.0%)	33(66.0%)	
Socio-economic status	High	11(34.4%)	21(65.6%)	0.341
	Upper middle	11(36.7%)	19(63.3%)	
	Lower middle	12(44.4%)	15(55.6%)	
	Low	8(22.9%)	27(77.1%)	
Maternal education	Illiterate	12(60.0%)	8(40.0%)	0.098

	Primary	6(40.0%)	9(60.0%)	
	Middle	6(23.1%)	20(76.9%)	
	High	3(21.4%)	11(78.6%)	
	Intermediate	6(26.1%)	17(73.9%)	
	Graduate	9(34.6%)	17(65.4%)	
Immunization status	Immunized	21(35.6%)	38(64.4%)	0.699
	Un-immunized	21(32.3%)	44(67.7%)	
Malnutrition	Yes	25(45.5%)	30(54.5%)	0.015
	No	17(24.6%)	52(75.4%)	
Family size	≤2	23(32.9%)	47(67.1%)	0.786
	>2	19(35.2%)	35(64.8%)	

A combined multivariable binary logistic regression model was performed to identify independent factors associated with iron deficiency anemia. The overall model was statistically significant ($\chi^2=18.285$, $p=0.003$) and demonstrated good fit according to the Hosmer-Lemeshow test ($p=0.675$). After adjustment for the covariates included in the model, children of mothers with no formal education had significantly higher odds of iron deficiency anemia compared with

children of educated mothers (AOR=3.72, 95% CI: 1.53–9.06; $p=0.004$). Similarly, malnourished children had significantly higher odds of iron deficiency anemia (AOR=3.20, 95% CI: 1.40–7.33; $p=0.006$). Residence, socioeconomic status, and immunization status were not independently associated with iron deficiency anemia (table 4).

Table-4: Combine Multivariable logistic regression analysis for risk of iron deficiency anemia

Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Maternal education (No education)	3.72	1.53 – 9.06	0.004
Malnutrition (Yes)	3.20	1.40 – 7.33	0.006
Residence (Rural)	1.07	0.47 – 2.44	0.873
Socioeconomic status (Low)	0.38	0.15 – 1.00	0.051
Immunization (Unimmunized)	0.73	0.32 – 1.64	0.443

Discussion

The present study checked the frequency of iron deficiency anemia (IDA) and associated with the maternal education in children under five years of age. The frequency of IDA identified in the current study (33.9%) is much higher than the global pooled prevalence of 16.42% (95% CI: 10.82–22.01) reported by Gedfie et al in a 2022 systematic review and meta-analysis of under-five children from various continents. It is noteworthy that the same review found IDA prevalence

substantially increased within the Asian continent specifically (at 23.37% (95% CI: 12.88–33.87) and noted that the prevalence at 33.2% documented by a single study was reported from Pakistan (11). IDA prevalence at 33.9% in the present study is therefore consistent with the upper limit of what has been recorded in the regional literature and reflects the enduring burden of IDA in this geographical setting.

At the national level, Habib et al. examined data from the National Nutrition Survey from Pakistan in 2018 and found the IDA

prevalence to be 28.6% for children <5 years, a modest decrease from 35.6%(12). The higher prevalence rate of 33.9% in the current study may be explained by the hospital-based recruitment approach with an inherent selection bias of recruiting a clinically symptomatic population, as well as the socioeconomic profile of the families accessing the military hospital in a semi-urban setting and a post-conflict situation. These contextual factors may have concentrated risk in the recruited sample compared to nationally representative surveys.

Moscheo et al., in a comprehensive practical review, published 2022, reported that incidence of IDA in children aged zero to four years is as high as 39% in industrialised nations and 48.1% in the developing world, highlighting the disproportionate autism burden on lower income settings (13). Similarly, a cross-sectional study conducted by Kajoba et al. in southwestern Uganda reported incidence of IDA to be 44.5% in children aged six to twenty-three months of age, further contextualizing high burden noted in the present study within a developing country hospital setting. (14).

Our study showed independent-effect strong association of lack of maternal formal education on childhood IDA. Uneducated mothers were nearly four times as likely to have children with IDA than their educated counterparts (AOR = 3.72 [95% CI: 1.53-9.06], $p = 0.004$). This association remained after adjustment for confounders such as residence, socioeconomic status, immunization status, malnutrition, milk type and family size, giving considerable strength to the causal plausibility of this relationship.

This finding is in agreement with Chandran et al, who performed a multivariable analysis in Madhya Pradesh, India, and found that children of less-educated mothers showing

significantly greater hemoglobin deficiencies. (15) The mechanistic basis for this association is well-recognized in the literature: the effects of maternal education on childhood nutritional outcomes occur through knowledge of the importance of iron-rich complementary feeding, uptake of iron supplementation programmes, recognising the early symptoms of anaemia, and seeking healthcare services timely.

Furthermore, Chouraqui JP et al., reported that kids from mothers with at least secondary education attained 48% lower odds (AOR = 0.52; 95% CI: 0.32-0.86) of co-existence of undernutrition and anemia compared with children of uneducated mothers (16).

A survey carried out in 2026 to look at the relationship between IDA and stunting in pediatric populations found that stunted children had a 1.31-fold to 6.785-fold higher risk of developing IDA, with an OR of 2.27 (95% CI: 1.30-3.95), providing evidence of the synergistic and mutually reinforcing relationships of growth faltering and iron insufficiency.(17) The present study adjusted estimate of 3.20 is within the upper range of this spectrum, which is consistent for the extent of malnutrition

The coincidence of malnutrition and IDA in LMICs has been well documented. Liu et al. in a Global Burden of Disease study confirmed that iron deficiency continued to be the leading cause of nutritional anemia among children of this age, with significant clustering in South Asian and sub-Saharan African countries where the prevalence of undernutrition is concurrently high. (18)

A statistically significant relationship was found between cow milk consumption and an increased frequency of IDA (45.3% vs. 21.7%; $p = 0.005$). Cow's milk is known to be characteristically low in iron content and is the source of calcium and fractions of the milk

protein casein, which are competing inhibitors of non-heme iron absorption in the gastrointestinal tract. Moreover, in young children, high volume intakes of cow's milk may displace the intakes of iron-rich weaning food, which further compromise elemental iron intake.

Oktarina C, in a summary review discussed that unrestricted consumption of cow's milk before twelve months of age is a major modifiable risk factor for IDA and that formula milk, which is usually iron-fortified, is superior for those who are not exclusively breastfed. (19) The observation in the present study that children on formula milk had significantly lower rates of IDA supports this dietary recommendation and has direct implications for counselling by pediatric practitioners. Gedfie et al found similar results in their meta-analysis, showing a higher incidence of iron deficiency in children non-consumers of iron-fortified milk (12).

Residence, socio-economic status, immunization status, gender, age, weight and family size did not show statistically significant independent associations with IDA. A cross-sectional study from Uganda by Kajoba et al. showed a similar finding that in adjusted analyses of the association between caregiver education and IDA, caregiver education was a better predictor than place of residence or household wealth, suggesting that educational attainment might mediate the link between socioeconomic position and child nutritional outcomes. (14)

A study from Northeast Thailand also showed that caregiver awareness of knowledge of complementary feeding practices as well as complementary feeding practices were significant risk factors in anemia risk in children under five years of age (prevalence of 36.9%), supporting the notion that educational

interventions aimed at primary caregivers are a cost-effective upstream approach. (20)

Strategies to improve maternal education should include strengthening female literacy programs, particularly in underserved and rural communities, and incorporating practical maternal nutrition education into antenatal, postnatal, and child-health services. Healthcare providers and community health workers should provide mothers with counseling on appropriate complementary feeding, iron-rich foods, prevention of excessive cow's milk consumption, recognition of anemia, and timely healthcare-seeking. Integrating regular nutrition screening and targeted educational interventions into routine pediatric and maternal health services may help reduce the burden of IDA among young children.

Limitations of Study

There are several limitations of this study that must be noted. Conducted at least in one military hospital in Muzaffarabad, the findings may have a limited generalizability to the entire pediatric population of Azad Kashmir because they may include patients with higher level of clinical illness or those who are more socioeconomic disadvantaged. In addition, the sample size of 124 may be too small to show significant associations in stratified analyses of residence, socioeconomic status and immunisation. Lastly, the modified Kuppuswamy socioeconomic scale introduced from India may not accurately represent the socioeconomic strata in Azad Kashmir which releases the potential risk of misclassification bias.

Conclusion

Iron deficiency anemia (IDA) in children under 5 is strongly associated with maternal education and malnutrition Strengthening female literacy and integrating maternal

nutrition education into antenatal, postnatal, and routine child-health services, particularly through community-based health education and counseling on appropriate feeding practices, may help reduce the burden of childhood IDA.

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