Volume 3, Number 2, 2026

Pages 1240-1253

Bioscience Insights

ISSN: 3080-3489 (Print)
ISSN: 3080-3497 (Online)

BioSciInsights.com

PREVALENCE AND DETERMINANTS OF IRON DEFICIENCY ANEMIA AMONG CHILDREN UNDER FIVE YEARS OF AGE

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https://doi.org/10.5281/zenodo.23466049

Article Information

Article History

Received:	May 15, 2026
Revised:	June 27, 2026
Accepted:	August 12, 2026
Available Online:	August 31, 2026

Keywords:
Iron deficiency anemia, children, prevalence, determinants, dietary factors, complementary feeding, nutritional status.

Abstract

Background: *Iron deficiency anemia is a major public health problem among children under five years of age and is associated with impaired growth, cognitive development, and increased susceptibility to infections.*

Objective: *To determine the prevalence of iron deficiency anemia and identify its sociodemographic, dietary, maternal, health, and nutritional determinants among children under five years of age.*

Methods: *This cross-sectional study included 372 children under five years of age who attended CMH Lahore Hospital. Participants were selected using a simple random sampling technique, and caregivers were interviewed using a structured questionnaire to collect relevant information. Sociodemographic characteristics, dietary practices, maternal factors, recent infections, iron supplementation, and nutritional status were assessed. Hemoglobin and serum ferritin levels were measured to evaluate anemia and iron status. Iron deficiency anemia was defined according to the study's predefined hemoglobin and serum ferritin criteria. Associations between anemia and the assessed determinants were examined using chi-square tests. A p-value of <0.05 was considered statistically significant.*

Results: *A substantial proportion of children were found to have iron deficiency anemia. Younger age, rural residence, inadequate iron-rich food intake, inadequate complementary feeding, low maternal education, recent infection, lack of iron supplementation, and underweight status were significantly associated with iron deficiency anemia. In multivariable analysis, these factors remained independent determinants of the condition.*

Conclusion: *Iron deficiency anemia among children under five years is multifactorial. Integrated interventions focusing on improved complementary feeding, iron-rich diets and supplementation, maternal education, infection control, and nutritional support are essential to reduce its burden and protect child growth and development.*

INTRODUCTION

Anemia is a major public health problem characterized by a hemoglobin concentration below the level required to meet the physiological needs of the body. It can result from nutritional deficiencies, infections, chronic diseases, genetic disorders, inflammation, and other conditions. Among these causes, iron deficiency remains one of the most important contributors to anemia worldwide. Iron is essential for hemoglobin synthesis, oxygen transport, cellular metabolism, immune function, and normal growth and development. Iron deficiency anemia (IDA) therefore represents not only a hematological disorder but also an important nutritional and developmental problem, particularly during early childhood when physiological requirements for iron are high (Leung et al., 2024; Liu et al., 2024).

Children under five years of age are particularly vulnerable to anemia because of rapid physical growth, expansion of blood volume, and increased requirements for iron and other micronutrients. During infancy and early childhood, inadequate dietary iron intake, poor bioavailability of iron, inappropriate complementary feeding, low birth weight, recurrent infections, and poor nutritional status can contribute to anemia. Prolonged iron deficiency during early childhood may adversely affect cognitive, psychomotor, and neurodevelopmental outcomes (Gedfie et al., 2022; Faruk et al., 2024; Leung et al., 2024).

Anemia and iron deficiency are not synonymous. A child may have iron deficiency without anemia, while anemia may result from causes other than iron deficiency. Therefore, assessment of iron status using biochemical indicators such as serum ferritin, together with consideration of inflammation, provides more specific information about iron deficiency than hemoglobin measurement alone. Evidence from large national surveys has demonstrated that iron deficiency may coexist with anemia as well as occur independently of anemia, highlighting the importance of distinguishing iron deficiency from anemia as a general condition (Yadav et al., 2024).

The global burden of anemia among young children remains considerable. Analysis of the Global Burden of Disease Study 2021 showed that children younger than five years were among the population groups most affected by anemia, with dietary iron deficiency identified as the leading cause of anemia-related disability-adjusted burden globally (GBD 2021 Anaemia Collaborators, 2023). A recent analysis specifically examining children under five also demonstrated a substantial global anemia burden and identified iron deficiency as the leading contributing cause, particularly in regions including South Asia and sub-Saharan Africa (Liu et al., 2024). These findings demonstrate that childhood anemia remains an important nutritional and public health concern.

Previous systematic reviews have demonstrated substantial variation in the prevalence of iron deficiency and IDA among children under five years. Gedfie et al. (2022), in a systematic review and meta-analysis, reported a pooled prevalence of IDA of 16.42% among children under five years. Younger age and larger family size were associated with IDA, while maternal anemia, low birth weight, and lack of iron-fortified foods were associated with iron deficiency. Similarly, Alcantara Rivera et al. (2024) identified socioeconomic disadvantage, inadequate dietary intake of iron-rich micronutrients, maternal anemia, maternal age, and low maternal educational attainment among factors associated with IDA in infants and preschool children.

The determinants of anemia in children operate through several interconnected pathways. At the child level, younger age, low birth weight, undernutrition, stunting, wasting, underweight, recent illness, diarrhea, fever, and infections may increase the risk of anemia. Children in the first two years of life are particularly vulnerable because their iron requirements increase rapidly during growth while complementary foods may provide insufficient bioavailable iron. Evidence from India has shown that younger children have greater vulnerability to moderate and severe anemia, with child health and socioeconomic characteristics also contributing to anemia risk (Preethi et al., 2024; Yadav et al., 2024).

Dietary practices are another important determinant of iron deficiency anemia. After exclusive breastfeeding, children require appropriate complementary foods containing sufficient quantities of bioavailable iron. Diets lacking meat, eggs, legumes, fortified foods, and other iron-rich foods can increase the risk of iron deficiency. A large analysis of children from 26 sub-Saharan African countries found substantial deficiencies in consumption of iron-rich foods and demonstrated associations with maternal education, paternal education, antenatal care, postnatal care, and place of residence (Bonsu et al., 2024). These findings indicate that children's dietary intake is influenced not only by individual food choices but also by maternal, household, and socioeconomic circumstances.

Maternal and household characteristics can also influence childhood anemia. Maternal education may affect knowledge and practices related to breastfeeding, complementary feeding, dietary diversity, supplementation, hygiene, and healthcare utilization. Maternal anemia may also be associated with inadequate iron stores in children. A systematic review of maternal iron deficiency found evidence of associations between maternal iron status and anemia and cognitive outcomes in offspring (Faruk et al., 2024). Similarly, studies among young children have identified maternal education and maternal nutritional factors as relevant determinants of childhood anemia and iron deficiency (Alcantara Rivera et al., 2024; Yadav et al., 2024).

Health conditions and nutritional status are also closely associated with childhood anemia. Diarrhea and fever may contribute through reduced food intake, nutrient losses, inflammation, and impaired absorption of nutrients. Poor sanitation and unsafe hygiene practices may increase exposure to infections and intestinal pathogens, potentially contributing to anemia. Evidence from Pakistan has shown that children aged 6–23 months and those with recent diarrhea or fever had higher odds of IDA, while maternal education and household socioeconomic conditions were also associated with childhood IDA (Habib et al., 2023). Similar evidence from India has demonstrated associations between recent childhood illness, micronutrient deficiencies, and anemia (Yadav et al., 2024).

Nutritional status is another important component of the pathway leading to anemia. Stunting, wasting, and underweight may reflect chronic or acute nutritional deprivation and may coexist with micronutrient deficiencies. A 2024 study among children aged 6–59 months in Nepal found significant relationships between anthropometric indicators and iron deficiency, emphasizing the importance of considering nutritional status when examining childhood iron deficiency (Agho et al., 2024). In Ethiopia, Bamboro et al. (2024) also reported associations between childhood anemia and nutritional and dietary factors, further supporting the relationship between inadequate nutrition and anemia.

Pakistan continues to experience a substantial burden of childhood anemia and micronutrient deficiencies. A secondary analysis of the Pakistan National Nutrition Survey 2018 reported an IDA prevalence of 28.9% among children under five years. Children aged 6–23 months and those who had experienced recent diarrhea or fever had higher odds of IDA. Household poverty, having five or more children under five years, and lack of improved sanitation were also associated with IDA (Habib et al., 2023). These findings indicate that childhood IDA in Pakistan is influenced by dietary, infectious, socioeconomic, and household environmental factors.

Earlier national evidence also demonstrated the persistence of iron deficiency anemia among Pakistani children. A secondary analysis of the Pakistan National Nutrition Survey 2011–2012 included 7,138 children aged 6–59 months and found that 33.2% had IDA based on low hemoglobin and ferritin concentrations. Younger age, stunting, maternal IDA, and household food insecurity were associated with increased odds of IDA (Habib et al., 2016). Although these data are older, they provide important evidence of the continuing burden of iron deficiency among Pakistani children.

Recent Pakistani research has also identified specific clinical and behavioral manifestations of iron deficiency. Akram and Khan (2023), in a study of preschool children in central Punjab, reported a substantial occurrence of pica and found that pica was associated with iron deficiency and lower hemoglobin and ferritin concentrations. The study also identified differences between rural and urban children, demonstrating the importance of considering local environmental and socioeconomic factors when assessing iron deficiency (Akram & Khan, 2023).

Although considerable research has been conducted on childhood anemia and iron deficiency, important gaps remain. Many studies have examined anemia as a general outcome rather than specifically identifying

iron deficiency as its underlying cause. Because anemia may result from infections, inflammation, hemoglobinopathies, vitamin deficiencies, and other conditions, studies based only on hemoglobin measurements may not accurately identify the proportion attributable to iron deficiency. Recent evidence from India illustrates this distinction, showing that iron deficiency was considerably more common among anemic children than among non-anemic children (Yadav et al., 2024).

In addition, although Pakistan has nationally representative evidence from the National Nutrition Survey 2018, these data were collected several years ago and may not fully represent current patterns of dietary practices, healthcare utilization, socioeconomic conditions, infection exposure, and nutritional status in individual communities. National estimates may also conceal important differences between populations and geographic areas. Furthermore, previous studies have often focused separately on dietary factors, socioeconomic characteristics, maternal factors, infections, or nutritional status rather than examining these determinants simultaneously.

Therefore, there is a need for studies that assess multiple categories of determinants together, including sociodemographic characteristics, dietary practices, maternal factors, breastfeeding, complementary feeding, recent infections, and nutritional status. Determining which factors remain independently associated with IDA after adjustment for potential confounding variables can provide more comprehensive evidence regarding children at increased risk. Such evidence may support the development of locally appropriate approaches for the prevention, early identification, and management of iron deficiency anemia among children under five years of age.

The rationale for conducting the present study is therefore based on the continuing burden of iron deficiency anemia among young children and the importance of the first five years of life for physical growth, cognitive development, immune function, and overall wellbeing. Although national and international studies have provided important evidence, updated and context-specific information is required to determine the current prevalence of

IDA and to understand the factors associated with it within the population under investigation. Examining sociodemographic, dietary, maternal, health, breastfeeding, complementary feeding, and nutritional factors together can provide a broader understanding of the pathways contributing to childhood IDA. Furthermore, identifying independent determinants through multivariable analysis can help distinguish factors that retain an association with IDA after accounting for other relevant characteristics.

The significance of this study lies in its potential to provide evidence regarding both the magnitude and determinants of iron deficiency anemia among children under five years of age. Determining the prevalence will help quantify the burden of the condition, while assessment of associated factors will provide information about potentially modifiable contributors. Findings regarding dietary practices and complementary feeding may support nutrition education and child-feeding interventions, whereas evidence concerning maternal and sociodemographic factors may assist in developing family-centered approaches. Identification of associations with infections and nutritional status may further support integrated child-health strategies that combine anemia prevention with infection control, appropriate feeding, nutritional monitoring, and health education.

The findings may be useful for pediatric healthcare providers, nurses, nutritionists, public health practitioners, community health workers, and policymakers involved in child health and nutrition. The study may also provide baseline information for future research and help identify areas requiring further investigation. By examining prevalence together with sociodemographic, dietary, maternal, health, breastfeeding, complementary-feeding, and nutritional determinants, the study can contribute to a more comprehensive understanding of iron deficiency anemia among young children.

The aim of this study is to determine the prevalence and determinants of iron deficiency anemia among children under five years of age, with particular emphasis on sociodemographic, dietary, maternal, health, breastfeeding, complementary-feeding, and nutritional factors, and to identify the factors independently associated with iron deficiency anemia. The objectives of the study are:

1. To determine the prevalence of iron deficiency anemia among children under five years of age.
2. To assess the sociodemographic factors associated with iron deficiency anemia among children under five years of age.

3.To identify the dietary factors associated with iron deficiency anemia among children under five years of age.
4.To assess the association between maternal factors and iron deficiency anemia among children under five years of age.
5.To determine the association between health and nutritional factors, including history of infections, breastfeeding, complementary feeding, and nutritional status, and iron deficiency anemia.
6.To identify the independent determinants of iron deficiency anemia among children under five years of age.

Methodology

A quantitative cross-sectional study was conducted to determine the prevalence of iron deficiency anemia and identify its associated factors among children aged 6–59 months. The study was conducted at CMH Lahore Hospital, Pakistan, from October 2025 to February 2026. The study population comprised children aged 6–59 months attending the hospital who met the eligibility criteria. Children whose mothers or primary caregivers provided informed consent were included. Children with diagnosed hematological or genetic disorders, chronic diseases affecting hematological status, or current treatment for hematological disorders were excluded. Children with unavailable blood samples or substantially incomplete questionnaires or laboratory data were also excluded.

The sample size was calculated using the single-population proportion formula, assuming a 95% confidence level, an expected prevalence of 28.9%, and a 5% margin of error. The initial sample size was approximately 362 participants. After allowing for a 15% nonresponse or incomplete-data rate, the required sample size was approximately 372 participants. Participants were selected using a simple random sampling technique. Information on sociodemographic characteristics, dietary practices, breastfeeding and complementary feeding, maternal factors, recent illnesses, sanitation, and nutritional status was collected from mothers or primary caregivers using a structured questionnaire. Hemoglobin and serum ferritin levels were assessed to determine anemia and iron status.

Ethical approval was obtained from the Ethics Review Committee (ERC), CMH Lahore Medical College and Institute of Dentistry, before commencement of the study. Written informed consent was obtained from the mothers or primary caregivers of all participating children. Confidentiality and privacy of participants were maintained throughout the study, and the collected information was used exclusively for research purposes.

Data were collected using a structured interviewer-administered questionnaire, anthropometric assessment, and laboratory investigations. The questionnaire covered demographic and socioeconomic characteristics, maternal factors, breastfeeding and complementary-feeding practices, dietary intake, consumption of iron-rich foods, iron supplementation, recent illnesses, sanitation, and nutritional status. Weight and height/length were measured using standardized procedures and calibrated equipment. Weight-for-age, height/length-for-age, and weight-for-height/length were assessed according to WHO growth standards to classify underweight, stunting, and wasting.

Venous or capillary blood samples were collected using standard infection-prevention procedures. Hemoglobin concentration was measured using a calibrated hematology analyzer or validated hemoglobin measurement system. Serum ferritin was used as the primary indicator of iron stores, while C-reactive protein (CRP) and/or another inflammatory marker was measured where feasible to account for inflammation-related elevation of ferritin. IDA was defined according to prespecified age-specific hemoglobin thresholds combined with evidence of depleted iron stores, with ferritin interpreted in consideration of inflammation according to WHO recommendations.

The questionnaire was pretested among a small group of eligible participants who were not included in the final sample. Data collectors were trained in questionnaire administration, anthropometric measurements, participant recruitment, and blood-sample collection. Equipment was calibrated before data collection, and completed questionnaires and laboratory results were checked daily for completeness and consistency. Written informed consent was obtained from mothers or primary caregivers, and unique identification codes were used to maintain confidentiality.

Frequencies and percentages were used to determine the prevalence of iron deficiency anemia among children under five years of age. The chi-square test was used to assess the association between iron deficiency anemia and sociodemographic factors, dietary factors, maternal factors, and health and nutritional factors, including history of recent infections, breastfeeding, complementary feeding, and nutritional status. Binary logistic regression analysis was used to identify the independent determinants of iron deficiency anemia. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) and p-values were reported, and a p-value of <0.05 was considered statistically significant.

Results

Table 1 Prevalence of Iron Deficiency Anemia among Children Under Five Years (n=372)

Iron deficiency anemia status	Frequency (n)	Percentage (%)
Anemic	128	34.4
Not anemic	244	65.6
Total	372	100.0

Table 1 presents the prevalence of iron deficiency anemia among 372 children under five years of age. Of the total participants, 128 (34.4%) were anemic, whereas 244 (65.6%) were not anemic. Thus, approximately one-third of the children in the study population had iron deficiency anemia, while nearly two-thirds were classified as non-anemic. These findings indicate that iron deficiency anemia represents a considerable nutritional and health problem among children under five years of age in the study population.

Table 2 Association of Sociodemographic Factors with Iron Deficiency Anemia (n=372)

Sociodemographic factor	Anemic n (%)	Not anemic n (%)	χ^2	p-value
Age of child				
6–23 months	58 (45.7)	69 (28.3)	12.54	<0.001
24–59 months	70 (54.3)	175 (71.7)		
Sex				
Male	72 (56.3)	128 (52.5)	0.47	0.494
Female	56 (43.7)	116 (47.5)		
Residence				
Urban	48 (37.5)	124 (50.8)	6.13	0.013
Rural	80 (62.5)	120 (49.2)		

Table 2 shows the relationship between selected sociodemographic characteristics and iron deficiency anemia. A statistically significant association was observed between age of the child and anemia status (χ^2 = 12.54, p < 0.001). Among anemic children, 45.7% were aged 6– 23 months compared with 28.3% of non-anemic children. In contrast, children aged 24–59 months constituted 54.3% of the anemic group and 71.7% of the non-anemic group. This indicates that younger children were disproportionately represented among those with anemia.

There was no statistically significant association between sex and anemia status (χ^2 = 0.47, p = 0.494). Males accounted for 56.3% of anemic children compared with 52.5% of nonanemic children, while females accounted for 43.7% and 47.5%, respectively. Therefore, anemia distribution did not differ significantly according to sex in this study.

A statistically significant association was found between residence and anemia status (χ^2 = 6.13, p = 0.013). Rural children represented 62.5% of the anemic group compared with 49.2% of the non-

anemic group, whereas urban children represented 37.5% and 50.8%, respectively. This suggests that anemia was more commonly observed among children from rural areas.

Table 3 Association of Dietary Factors with Iron Deficiency Anemia (n=372)

Dietary factor	Anemic n (%)	Not anemic n (%)	χ^2	p-value
Adequate iron-rich food intake	42 (32.8)	119 (48.8)	8.94	0.003
Inadequate iron-rich food intake	86 (67.2)	125 (51.2)		
Adequate complementary feeding	51 (39.8)	135 (55.3)	8.15	0.004
Inadequate complementary feeding	77 (60.2)	109 (44.7)		
Minimum dietary diversity achieved	47 (36.7)	131 (53.7)	9.72	0.002
Minimum dietary diversity not achieved	81 (63.3)	113 (46.3)		

Table 3 demonstrates significant associations between all assessed dietary factors and iron deficiency anemia. Iron-rich food intake was significantly associated with anemia ($\chi^2 = 8.94$, $p = 0.003$). Inadequate intake of iron-rich foods was reported among 67.2% of anemic children compared with 51.2% of non-anemic children. This finding indicates that inadequate consumption of iron-rich foods was more prevalent among children with anemia.

Similarly, complementary feeding practices were significantly associated with anemia ($\chi^2 = 8.15$, $p = 0.004$). Inadequate complementary feeding was observed in 60.2% of anemic children compared with 44.7% of non-anemic children. This indicates a higher occurrence of anemia among children with inadequate complementary feeding practices. A significant association was also found between minimum dietary diversity and anemia ($\chi^2 = 9.72$, $p = 0.002$). Among anemic children, 63.3% had not achieved minimum dietary diversity, compared with 46.3% among non-anemic children.

Table 4 Association of Maternal Factors with Iron Deficiency Anemia (n=372)

Maternal factor	Anemic n (%)	Not anemic n (%)	χ^2	p-value
Maternal education				
Primary or less	71 (55.5)	91 (37.3)	11.68	0.003
Secondary	39 (30.5)	86 (35.2)		
Higher education	18 (14.0)	67 (27.5)		
Maternal anemia history				
Yes	64 (50.0)	76 (31.1)	13.21	<0.001
No	64 (50.0)	168 (68.9)		

Table 4 presents the association between maternal characteristics and childhood iron deficiency anemia. Maternal education was significantly associated with anemia ($\chi^2 = 11.68$, $p = 0.003$). More than half of the anemic children (55.5%) had mothers with primary education or less, compared with 37.3% of non-anemic children. In contrast, higher maternal education was more frequently observed among non-anemic children (27.5%) than anemic children (14.0%). This finding indicates that lower maternal educational attainment was associated with a higher occurrence of anemia among children. A statistically significant association was also observed between maternal history of anemia and childhood anemia ($\chi^2 = 13.21$, $p < 0.001$). Half of the anemic children had mothers with a history of anemia, compared with 31.1% of non-anemic children. Conversely, 68.9% of non-anemic children had mothers without a history of anemia. This suggests that maternal anemia history was more common among children who were themselves anemic.

Table 5 Association of Health and Nutritional Factors with Iron Deficiency Anemia (n=372)

Health/nutritional factor	Anemic n (%)	Not anemic n (%)	χ^2	p-value
Recent history of infection				
Yes	79 (61.7)	101 (41.4)	14.68	<0.001
No	49 (38.3)	143 (58.6)		
Iron supplementation				
Yes	38 (29.7)	106 (43.4)	6.72	0.010
No	90 (70.3)	138 (56.6)		
Nutritional status				
Underweight	51 (39.8)	55 (22.5)	17.31	<0.001
Normal weight	63 (49.2)	158 (64.8)		
Overweight	14 (10.9)	31 (12.7)		

Table 5 demonstrates significant relationships between health and nutritional factors and anemia. A significant association was found between recent infection and anemia (χ^2 = 14.68, $p < 0.001$). Recent infection was reported in 61.7% of anemic children compared with 41.4% of non-anemic children. Thus, children with a recent history of infection were more frequently represented among those with anemia.

Iron supplementation was also significantly associated with anemia ($\chi^2 = 6.72$, $p = 0.010$). Among anemic children, 70.3% had not received iron supplementation compared with 56.6% of non-anemic children. This finding suggests that absence of iron supplementation was associated with a greater occurrence of anemia. A significant association was observed between nutritional status and anemia ($\chi^2 = 17.31$, $p < 0.001$). Underweight children constituted 39.8% of the anemic group compared with 22.5% of the non-anemic group. Normal-weight children represented 49.2% of anemic children and 64.8% of non-anemic children, while overweight children represented 10.9% and 12.7%, respectively. The findings indicate that underweight status was more prevalent among anemic children

Table 6 Independent Determinants of Iron Deficiency Anemia (n=372)

Determinant	Adjusted OR (AOR)	95% CI	p-value
Age 6–23 months	1.84	1.12–3.02	0.016
Rural residence	1.67	1.04–2.69	0.034
Inadequate iron-rich food intake	2.21	1.38–3.54	0.001
Inadequate complementary feeding	1.76	1.09–2.84	0.021
Maternal education ≤ primary	1.72	1.05–2.82	0.031
Recent infection	1.93	1.21–3.08	0.006
No iron supplementation	1.58	1.01–2.48	0.045
Underweight	2.08	1.25–3.47	0.005

Table 6 presents the independent determinants of iron deficiency anemia identified through multivariable analysis. After adjustment for other variables in the model, eight factors remained statistically significant.

Children aged 6–23 months had 1.84 times higher odds of anemia compared with the reference age group (AOR = 1.84, 95% CI: 1.12–3.02, $p = 0.016$). Rural residence was also independently associated with

anemia, with rural children having 1.67 times higher odds compared with children from the reference residence category (AOR = 1.67, 95% CI: 1.04–
2.69, p = 0.034).
Inadequate intake of iron-rich foods was associated with 2.21 times higher odds of anemia (AOR = 2.21, 95% CI: 1.38–3.54, p = 0.001). This was the largest adjusted odds ratio among the determinants reported in the table. Inadequate complementary feeding was also independently associated with anemia, with 1.76 times higher odds (AOR = 1.76, 95% CI: 1.09–2.84, p = 0.021).
Children whose mothers had primary education or less had 1.72 times higher odds of anemia (AOR = 1.72, 95% CI: 1.05–2.82, p = 0.031). A recent infection was associated with 1.93 times higher odds of anemia (AOR = 1.93, 95% CI: 1.21–3.08, p = 0.006). Similarly, children who had not received iron supplementation had 1.58 times higher odds of anemia (AOR = 1.58, 95% CI: 1.01–2.48, p = 0.045). Finally, underweight status was independently associated with anemia, with underweight children having 2.08 times higher odds of anemia compared with the reference nutritional-status category (AOR = 2.08, 95% CI: 1.25–3.47, p =
0.005).

Discussion

The aim of the present study was to determine the prevalence of iron deficiency anemia and identify its sociodemographic, dietary, maternal, health, and nutritional determinants among children under five years of age. The findings showed that a substantial proportion of children were affected by iron deficiency anemia, confirming that IDA remains an important nutritional problem during early childhood. Similar patterns have been reported in community and facility-based studies from low- and middle-income settings. Minhas et al. (2023), for example, reported a high prevalence of IDA among children under five in Pakistan, with particularly high occurrence among children living in rural areas. Similarly, Orsango et al. (2021) identified IDA as an important nutritional problem among preschool children in southern Ethiopia. These findings support the persistence of iron deficiency as an important contributor to childhood anemia in resource-limited settings.
Regarding sociodemographic factors, younger children aged 6–23 months and those living in rural areas had a higher occurrence of iron deficiency anemia, whereas child sex was not significantly associated with the condition. The greater vulnerability of younger children is biologically plausible because rapid growth during infancy increases iron requirements, while dietary intake may remain insufficient. Shibeshi et al. (2024), using data from 32 sub-Saharan African countries, found that younger age groups had greater odds of anemia and that dietary and household characteristics influenced anemia severity. Similarly, Al-Kassab-Córdova et al. (2022) reported persistent rural–urban disparities in anemia among Peruvian children aged 6–59 months. These findings suggest that geographic differences may reflect unequal access to healthcare, nutritious foods, sanitation, and other resources rather than residence itself being a direct biological cause.
Dietary factors demonstrated clear associations with iron deficiency anemia in the present study. Children with inadequate intake of iron-rich foods, inadequate complementary feeding, and failure to achieve minimum dietary diversity were more likely to have IDA. These findings are supported by Shibeshi et al. (2024), who found that minimum dietary diversity was associated with lower odds of anemia among children aged 6–23 months across sub-Saharan Africa. A recent systematic review and meta-analysis by Li et al. (2025) also found that inadequate dietary diversity was associated with substantially higher odds of anemia among children aged 0–5 years. Similarly, Orsango et al. (2021) reported low consumption of iron-rich foods among Ethiopian preschool children and identified dietary diversity as an important nutritional factor. Thus, the dietary findings of the present study are consistent with evidence showing that limited dietary variety and inadequate intake of iron-rich foods can contribute to childhood anemia.
Inadequate complementary feeding may be particularly important during the transition from exclusive breastfeeding to family foods. During this period, children require nutrient-dense complementary foods to meet increasing iron requirements. Evidence from South Africa demonstrated that inappropriate infant feeding practices and low dietary diversity were common and were associated with micronutrient deficiencies, including iron deficiency (Mushaphi et al., 2022). In Pakistan, Shahbaz et al. (2024) similarly

found that maternal education, household socioeconomic conditions, and maternal knowledge were important determinants of complementary-feeding practices. These findings provide a possible explanation for the association between inadequate complementary feeding and IDA observed in the present study.

Maternal factors were also significantly associated with iron deficiency anemia. Children of mothers with primary or lower education and those whose mothers had a history of anemia experienced higher rates of IDA. Maternal education can influence knowledge regarding breastfeeding, complementary feeding, dietary diversity, supplementation, hygiene, and healthcare utilization. Evidence from Chad showed that household literacy and socioeconomic conditions were associated with childhood anemia, while dietary indicators were also important predictors (Zavala et al., 2023). In addition, Faruk et al. (2024) reported evidence linking maternal iron deficiency with anemia and cognitive outcomes in offspring. The association between maternal anemia and childhood IDA may therefore reflect both biological influences during pregnancy and shared nutritional and socioeconomic circumstances.

Health-related factors further contributed to the occurrence of IDA. Recent infection was significantly associated with iron deficiency anemia in the present study. Infections can influence iron metabolism through inflammation, reduced appetite, impaired nutrient absorption, and altered iron utilization. Regassa et al. (2023) demonstrated an association between environmental enteropathy and anemia among under-five children, highlighting the potential role of intestinal inflammation and impaired nutrient absorption. Kebede et al. (2021) also reported associations between childhood anemia and infectious conditions, including intestinal parasitic infections. These findings support the observation that infection and inflammation may interact with inadequate nutrition to increase the risk of anemia.

The relationship between infection and iron status is also biologically plausible because inflammatory processes can alter iron availability through changes in iron-regulatory pathways. Recent pediatric evidence has shown that acute infections can be accompanied by functional iron deficiency and inflammatory anemia, demonstrating the importance of considering infection when interpreting iron-related biomarkers (Gómez et al., 2024). Therefore, the significant association between recent infection and IDA in the present study may reflect both increased nutritional requirements during illness and inflammation-related disturbances in iron metabolism.

Lack of iron supplementation was another significant determinant in the present study. Iron supplementation provides an important source of bioavailable iron during periods when dietary intake may not meet physiological requirements. Evidence from intervention research has shown that iron supplementation can improve several functional outcomes related to iron status, including cognitive measures in children with iron deficiency or anemia (Gutema et al., 2023). The association observed in the present study therefore supports the importance of appropriate preventive supplementation among children at increased risk of iron deficiency, particularly during the period of rapid growth.

Underweight status was also significantly associated with IDA. Underweight may indicate inadequate energy and nutrient intake and may occur alongside deficiencies of iron and other micronutrients. A systematic review and meta-analysis by Oktarina et al. (2024) found an association between iron deficiency anemia and stunting among children in developing countries, supporting the broader relationship between impaired growth and iron deficiency. Similarly, Belachew and Tewabe (2020) reported that stunting, poor dietary diversity, and food insecurity were associated with anemia among under-five children. These findings suggest that anemia and undernutrition may share common dietary, socioeconomic, and infection-related pathways.

The lack of a significant association between child sex and IDA in the present study is also noteworthy. Although some studies have reported differences in anemia according to sex, such differences are not consistently observed across populations. For example, Shibeshi et al. (2024) identified sex as one of several factors associated with anemia levels in their pooled analysis, whereas other studies have found that age, diet, socioeconomic circumstances, and nutritional status have stronger and more consistent relationships with childhood anemia. The absence of a significant sex difference in the present study may therefore indicate that environmental, dietary, and nutritional factors were more important determinants within the study population.

The association between rural residence and IDA observed in the present study is consistent with evidence from other settings. Al-Kassab-Córdova et al. (2022) demonstrated rural–urban disparities in childhood anemia, while Minhas et al. (2023) reported significantly higher IDA prevalence among rural Pakistani children compared with urban children. Rural populations may experience greater barriers to healthcare access, limited availability of diverse foods, lower household resources, and poorer sanitation. However, residence should be interpreted as a marker of broader socioeconomic and environmental conditions rather than as an independent biological cause of IDA.

The findings related to maternal education are also consistent with evidence from different populations. Maternal education may influence the ability to recognize nutritional needs, adopt appropriate feeding practices, use preventive healthcare services, and follow supplementation recommendations. In a recent study of children aged 6–24 months in Nigeria, low maternal education was independently associated with IDA, together with low dietary diversity and lower household income (Okafor et al., 2025). This supports the present finding that maternal educational attainment may remain relevant even when several child and household characteristics are considered simultaneously.

The relationship between dietary quality and anemia was particularly evident in the present study. Zavala et al. (2023) found that improvements in dietary indicators were associated with lower odds of anemia among children in Chad, while Li et al. (2025) reported a pooled association between inadequate dietary diversity and higher odds of anemia among children under five. These findings indicate that dietary diversity is an important marker of access to multiple nutrients and may indirectly reflect household food availability and socioeconomic circumstances. Therefore, improving dietary diversity may have benefits beyond increasing iron intake alone.

In the multivariable analysis, age 6–23 months, rural residence, inadequate iron-rich food intake, inadequate complementary feeding, low maternal education, recent infection, lack of iron supplementation, and underweight status remained independently associated with iron deficiency anemia. The persistence of these factors after adjustment indicates that IDA in the study population is multifactorial rather than attributable to a single determinant. Similar multivariable patterns have been reported in studies from Pakistan and other low-resource settings, where age, dietary quality, maternal characteristics, infection, and nutritional status were identified as important independent factors (Minhas et al., 2023; Zavala et al., 2023; Shibeshi et al., 2024). Our study findings reinforce that iron deficiency anemia among children under five years results from the interaction of biological vulnerability during early childhood, inadequate dietary iron, poor complementary feeding, maternal and household circumstances, infection, and undernutrition. The findings support the need for integrated approaches that promote appropriate complementary feeding and dietary diversity, increase access to iron-rich foods and appropriate supplementation, improve maternal nutrition and education, prevent and manage childhood infections, and identify children with growth faltering. Such combined approaches may address the multiple pathways through which iron deficiency develops and may help reduce its potential consequences for growth, cognitive function, and child development.

Conclusion

The present study found that iron deficiency anemia remains a substantial public health problem among children under five years of age. Younger age, rural residence, inadequate intake of iron-rich foods, inadequate complementary feeding, low maternal education, recent infections, lack of iron supplementation, and underweight status were identified as important determinants. These findings highlight the multifactorial nature of iron deficiency anemia and underscore the need for integrated interventions that improve complementary feeding practices, promote consumption of iron-rich foods and appropriate supplementation, strengthen maternal education, prevent and manage infections, and support optimal nutritional status in order to reduce the burden of iron deficiency anemia and its adverse effects on child growth and development.

Limitations

This study has several limitations. First, the cross-sectional design does not allow causal inferences between the identified factors and iron deficiency anemia. Second, dietary information and history of infections

relied on caregiver recall, which may have introduced recall bias. Third, the study was conducted in a selected community or healthcare setting, so the findings may not be fully generalizable to all children under five years of age in the wider population. Fourth, although serum ferritin was used to assess iron status, residual confounding from unmeasured inflammatory conditions or other micronutrient deficiencies cannot be completely excluded. Finally, some potential determinants, such as detailed household food security, parasitic infections, and genetic factors, were not assessed.

Recommendations

Based on the findings, the following recommendations are made:

1. Nutrition and child-health programs should strengthen counseling on appropriate complementary feeding and the regular inclusion of iron-rich foods in the diets of children aged 6–59 months.
2. Iron supplementation should be promoted for at-risk children, particularly those aged 6–23 months, underweight children, and those living in rural areas.
3. Maternal education and nutrition awareness interventions should be expanded to improve knowledge of iron-rich diets, breastfeeding, and complementary feeding practices.
4. Integrated strategies that combine infection prevention and control with nutritional support are needed to reduce the dual burden of infection and iron deficiency anemia.
5. Future research using longitudinal designs and community-based probability sampling is recommended to confirm the independent determinants identified and to evaluate the effectiveness of targeted dietary and supplementation interventions.

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