



PREVALENCE AND RISK FACTORS OF IRON-DEFICIENCY ANAEMIA AMONG UNDER-FIVE CHILDREN: A CROSS-SECTIONAL STUDY

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Abstract

Background: Anaemia, predominantly iron-deficiency anaemia (IDA), is a major public-health problem among young children in India, with consequences for growth and cognitive development. Local data on prevalence, type and determinants inform control. **Objectives:** To estimate the prevalence of anaemia and IDA among under-five children and to examine associated dietary and socio-demographic factors. **Methods:** A cross-sectional study of 100 children aged 6–59 months measured haemoglobin (Hb) and ferritin (with CRP/AGP to flag inflammation) and recorded feeding, dietary and socio-demographic variables. Anaemia (Hb <11 g/dL), iron deficiency (low ferritin) and IDA were defined per WHO criteria. Associations used the chi-square and independent *t* tests. **Results:** Among 100 children (mean age 29.9 ± 15.7 months; mean Hb 10.7 ± 1.3 g/dL), anaemia prevalence was 53%, iron deficiency 44% and IDA 36%; among anaemic children, severity was mild in 28 and moderate in 25, and IDA accounted for about two-thirds. Iron deficiency was the leading identifiable cause of anaemia. Exclusive breastfeeding to 6 months was reported in 63%, iron supplementation in the last 3 months in 23% and inflammation in 19%. In this sample, associations of anaemia with exclusive breastfeeding, cow-milk intake, iron-rich food frequency and iron supplementation did not reach statistical significance. **Conclusion:** More than half of under-five children were anaemic and iron deficiency was the dominant identifiable cause, with IDA in about one-third. The high burden supports universal age-appropriate iron and dietary interventions and routine screening, consistent with national anaemia-control strategy.

Keywords: iron-deficiency anaemia; under-five children; haemoglobin; ferritin; prevalence; South India

INTRODUCTION

Anaemia is one of the most prevalent nutritional disorders of childhood and a major public-health problem in India, where national surveys have documented anaemia in the majority of young children [1,5]. Iron deficiency is the single most important cause, and iron-deficiency anaemia (IDA) is more common in South Asia than almost anywhere else in the world [3]. The condition matters not merely because of its frequency but because of its consequences: during infancy and early childhood, IDA is associated with impaired psychomotor development and cognitive function that may be irreversible, giving it long-term implications



for educational attainment and, at population scale, for economic productivity [3,10].

The determinants of childhood anaemia are multifactorial and overlapping. Inadequate dietary iron intake and poor bioavailability of iron from phytate- and fibre-rich cereal-based Indian diets are central, compounded by early or excessive cow-milk consumption, delayed or inappropriate complementary feeding, and low intake of iron-rich foods [1,3]. Beyond diet, anaemia in young children is consistently associated with maternal anaemia, poverty and food insecurity, and with inflammation and intercurrent infection, which depress haemoglobin and confound ferritin interpretation [6,7]. Community studies from rural India have shown that haemoglobin in toddlers is primarily related to iron status but that maternal haemoglobin, family wealth and food security are also important, so effective control must address the household and maternal context as well as the child's diet [6,7]. Micronutrient deficiencies frequently coexist, and other causes of anaemia—including vitamin B12 and folate deficiency (megaloblastic anaemia) and, in specific groups, chronic infection—contribute to the overall burden [4,8].

Accurate classification requires attention to iron biomarkers and inflammation. Because ferritin is an acute-phase reactant, concurrent measurement of C-reactive protein (CRP) and α 1-acid glycoprotein (AGP) is needed to distinguish true iron deficiency from anaemia of inflammation, and indices such as the soluble transferrin receptor/log-ferritin ratio improve discrimination [7,8]. Distinguishing IDA from non-iron-deficiency anaemia is important because it determines whether iron supplementation is the appropriate response and because indiscriminate iron in the setting of infection has been questioned [8]. National programmes have long promoted iron supplementation and dietary strategies, and home-fortification approaches such as micronutrient powders have shown efficacy comparable to iron drops for treating childhood anaemia [2,3].

Given the persistent burden and its developmental and economic costs, continued local documentation of anaemia prevalence, type and determinants remains important for guiding control [9,10]. The present study estimated the prevalence of anaemia and IDA among under-five children and examined associated dietary and socio-demographic factors. The objectives were to determine the prevalence and severity of anaemia, to classify iron deficiency and IDA using haemoglobin and inflammation-adjusted ferritin, and to explore associations with feeding, dietary and socio-demographic variables.

METHODS

Participants

One hundred children aged 6–59 months were included. Eligible children were those presenting for well-child or outpatient care without acute severe illness requiring admission.

Assessment and definitions

A structured proforma captured age, sex, residence, maternal education, household resource group, birth weight, exclusive breastfeeding to 6 months, timing of complementary feeding, iron-rich food frequency (days/week), cow-milk intake (mL/day), iron supplementation in the last 3 months and recent fever. Haemoglobin (Hb), ferritin, CRP and AGP were measured. Anaemia was defined as Hb <11 g/dL (WHO) and graded by severity; iron deficiency was defined by low ferritin (with an inflammation-adjusted cut-off using CRP/AGP), and IDA as anaemia with iron deficiency.

Statistical analysis

Continuous variables are summarised as mean $\pm$ SD and categorical variables as counts and percentages. Associations between anaemia and categorical factors (exclusive breastfeeding, iron supplementation,



recent fever) were tested with the chi-square test; continuous exposures (cow-milk intake, iron-rich food frequency) were compared between anaemic and non-anaemic children with the independent-samples *t* test. Two-sided $p < 0.05$ was significant. Analyses used Python (pandas, SciPy).

RESULTS

Participant characteristics

The 100 children had a mean age of 29.9 ± 15.7 months; 50% were male and 52% rural. Mean birth weight was 2761 ± 468 g. Exclusive breastfeeding to 6 months was reported in 63%, iron supplementation in the last 3 months in 23% and recent fever in 16%; inflammation (raised CRP/AGP) was present in 19%. Mean complementary-feeding start was 6.6 ± 2.1 months, mean iron-rich food frequency 3.6 ± 2.2 days/week and mean cow-milk intake 493 ± 267 mL/day (Table 1).

Prevalence of anaemia, iron deficiency and IDA

Mean Hb was 10.7 ± 1.3 g/dL and mean ferritin 24.6 ± 16.4 µg/L. Anaemia was present in 53%, iron deficiency in 44% and IDA in 36% (Figure 1; Table 2). Among the 53 anaemic children, severity was mild in 28 and moderate in 25, and IDA accounted for about two-thirds of anaemia (Figure 2). Iron deficiency was thus the leading identifiable cause of anaemia, consistent with the dominant role of iron deficiency reported in Indian community studies [6,7].

Associated factors

In this sample, the associations of anaemia with candidate determinants did not reach statistical significance: exclusive breastfeeding to 6 months (anaemia 47.6% vs 62.2%; OR 0.55, $p = 0.23$), iron supplementation (52.2% vs 53.2%; $p = 1.0$) and recent fever (43.8% vs 54.8%; $p = 0.59$) (Table 3). Cow-milk intake (anaemic 487 vs non-anaemic 500 mL/day; $p = 0.81$) and iron-rich food frequency (3.5 vs 3.7 days/week; $p = 0.63$) did not differ significantly, and anaemia prevalence varied little across residence, maternal education and household resource strata (Table 4). The direction of the breastfeeding association (lower anaemia with exclusive breastfeeding) is consistent with the protective role of appropriate infant feeding, although the effect did not reach significance in this sample.

DISCUSSION

In this cross-sectional study of 100 under-five children, anaemia affected 53%, iron deficiency 44% and IDA 36%, with iron deficiency the dominant identifiable cause and most anaemia mild to moderate in severity. These findings reproduce, in a South Indian setting, the high childhood-anaemia burden and the central role of iron deficiency documented across Indian national and community data [1,5,6,7]. Even at the lower end of reported ranges, a prevalence of one in two children confirms anaemia as a persistent public-health priority.

The predominance of iron deficiency has direct programmatic implications. Because IDA accounted for about two-thirds of anaemia here, and iron deficiency for the largest identifiable share overall, iron-focused interventions—age-appropriate supplementation, dietary diversification to increase iron-rich and bioavailable foods, and home fortification with micronutrient powders—are the logical mainstay, in line with national anaemia-control strategy and with evidence that home-fortification is as efficacious as iron drops [2,3]. At the same time, the finding that inflammation was present in about one-fifth of children is a reminder that ferritin must be interpreted alongside CRP/AGP, since anaemia of inflammation and true iron deficiency require different responses and indiscriminate iron in the setting of infection has been questioned [7,8]. Non-iron causes—including vitamin B12 and folate deficiency—contribute to the residual, non-iron-



deficiency anaemia and warrant consideration where iron replacement fails [4].

The absence of statistically significant associations with individual dietary and socio-demographic factors in this sample should be interpreted as a limitation of sample size and of the data rather than as evidence against well-established relationships. Large community studies have consistently shown that childhood haemoglobin is primarily related to iron status but is also shaped by maternal anaemia, family wealth and food insecurity, and that continued or excessive cow-milk intake and inadequate iron intake increase risk [6,7]. The direct indication here that exclusive breastfeeding was associated with lower anaemia is consistent with this literature, and the modest, non-significant gradients across socio-economic strata are compatible with the multifactorial, household-level determinants repeatedly described [6,7]. Adequately powered studies with multivariable adjustment and inflammation-corrected iron indices would be needed to quantify these effects locally.

The stakes justify action even in the face of imprecise individual-level associations. IDA in early childhood carries irreversible consequences for cognitive and psychomotor development, and at population scale imposes substantial intangible and economic costs; modelling for India has estimated large disability-adjusted life-year losses and production losses attributable to childhood IDA [3,10]. This strengthens the case for a preventive, population-level approach—universal age-appropriate iron and dietary interventions, maternal anaemia control, and attention to poverty and food security—rather than reliance on individual risk-factor targeting alone [1,6].

Practically, the findings support routine anaemia screening of under-five children, iron and dietary intervention as the default response given the dominance of iron deficiency, inflammation-aware interpretation of ferritin, and integration of child anaemia control with maternal and household nutrition programmes [1,2,7].

Table 1: Participant characteristics (N=100).

Characteristic	Value
Age, months (mean $\pm$ SD)	29.9 $\pm$ 15.7
Male sex, %	50
Rural residence, %	52
Birth weight, g	2761 $\pm$ 468
Exclusive breastfeeding to 6 months, %	63
Complementary feeding start, months	6.6 $\pm$ 2.1
Iron-rich food, days/week	3.6 $\pm$ 2.2
Cow-milk intake, mL/day	493 $\pm$ 267
Iron supplementation (last 3 months), %	23
Recent fever (2 weeks), %	16
Inflammation (raised CRP/AGP), %	19



Table 2: Prevalence and severity of anaemia and iron status (N=100).

Measure	Value
Mean Hb, g/dL	10.7 ± 1.3
Mean ferritin, µg/L	24.6 ± 16.4
Anaemia (Hb <11 g/dL), %	53
Iron deficiency, %	44
Iron-deficiency anaemia, %	36
Anaemia severity: mild / moderate (n)	28 / 25

Table 3: Association of anaemia with feeding and clinical factors.

Factor	Anaemia rate exposed vs unexposed (%)	OR	<i>p</i> value
Exclusive breastfeeding to 6 months	47.6 vs 62.2	0.55	0.23 (NS)
Iron supplementation (last 3 months)	52.2 vs 53.2	0.96	1.0 (NS)
Recent fever (2 weeks)	43.8 vs 54.8	0.64	0.59 (NS)

Table 4: Anaemia by dietary intake and socio-demographic strata.

Comparison	Anaemic	Non-anaemic	<i>p</i>
Cow-milk intake, mL/day	487	500	0.81 (NS)
Iron-rich food, days/week	3.5	3.7	0.63 (NS)
Anaemia by residence (rural / urban), %	55.8 / 50.0	—	—
Anaemia by household resource (low / middle / high), %	56.1 / 41.9 / 60.7	—	—

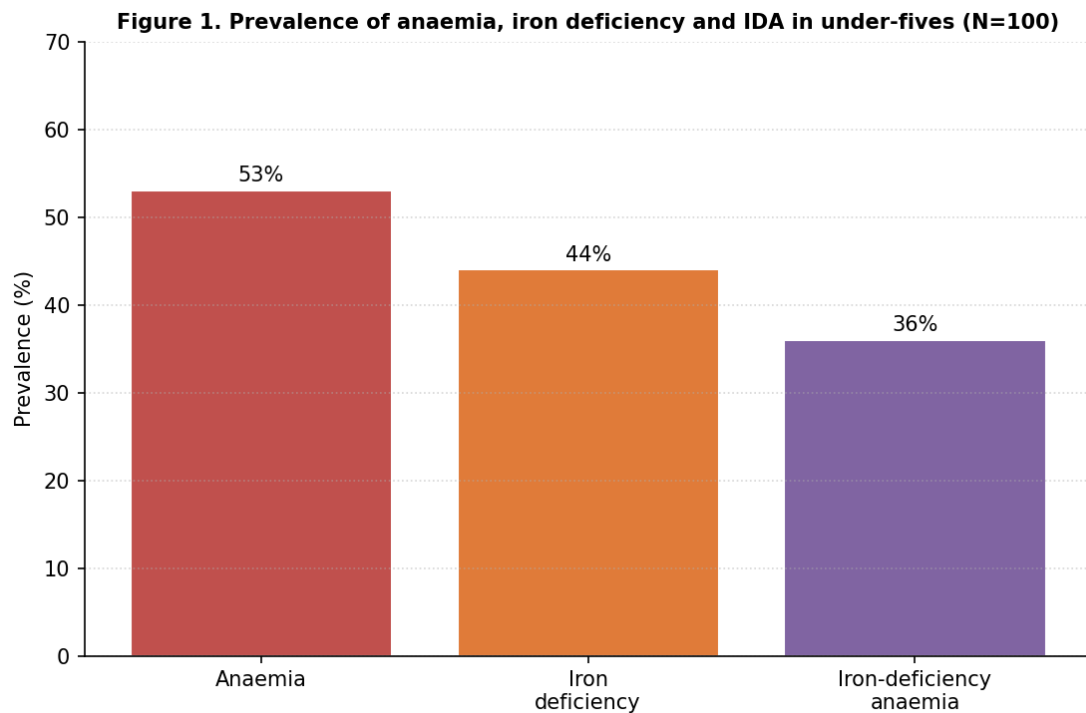


Figure 1: Prevalence of anaemia, iron deficiency and iron-deficiency anaemia among under-five children (N=100).

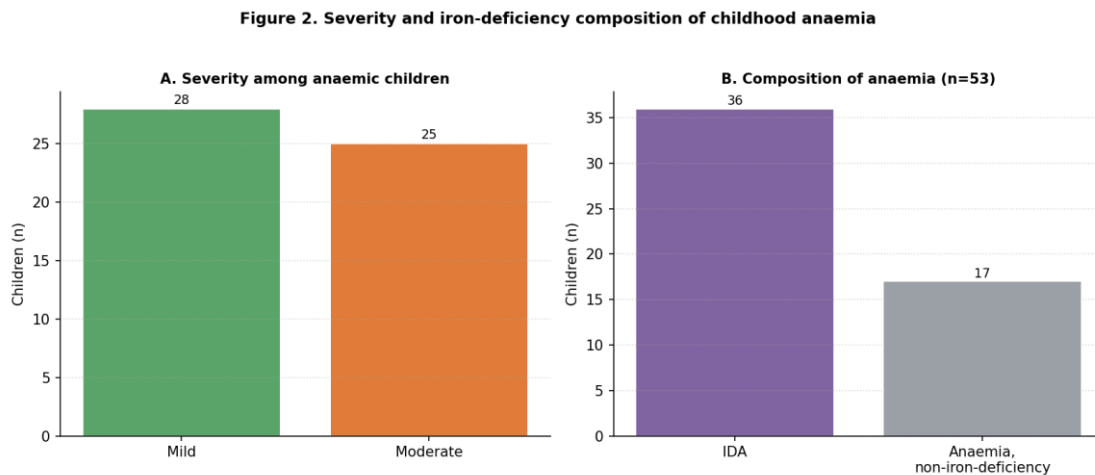


Figure 2: (A) Severity distribution among anaemic children; (B) composition of anaemia (iron-deficiency versus non-iron-deficiency), n=53.

CONCLUSION

In South Indian cohort, more than half of under-five children were anaemic, iron deficiency was the dominant identifiable cause, and IDA affected about one-third, with most anaemia mild to moderate. The high burden and the predominance of iron deficiency support routine screening and universal age-appropriate iron and dietary interventions, with inflammation-aware interpretation of iron biomarkers and



integration with maternal and household nutrition programmes.

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