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Prevalence of Anaemia Among Adolescent Girls in Rural Schools and Its Association With Dietary Habits

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ABSTRACT

Anaemia is common among adolescent girls in low- and middle-income settings, and rural schools are often described as a place where it is both easy to find and easy to address. Because the title of this article invites a local survey, it should be said at once that no new data are reported here. This narrative review instead asks what the published literature says about how anaemia is defined and measured in adolescent girls, how much of it is plausibly linked to iron deficiency, and how far everyday dietary habits explain it. It draws on work on iron physiology, dietary iron absorption, infection and inflammation, menstrual loss, and school-based supplementation and food-based programmes. Diet matters, but mainly through the bioavailability of iron and not only its quantity, and several other causes sit alongside it. Most survey evidence is cross-sectional, relies on short-recall dietary tools and cannot separate diet from poverty, infection and menstruation, so associations should be read as signals and not as effects. The review concludes that a rural school survey is useful when it measures haemoglobin carefully, records diet in a way that captures inhibitors and enhancers of absorption, and collects inflammation and infection information, and it sets out what such a design would contain.

Keywords: Anaemia; Adolescent girls; Iron deficiency; Dietary habits; Rural schools; Iron absorption; Narrative review

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Article Class: Narrative Review

1. Introduction

Anaemia in adolescent girls is one of those problems that everyone recognises and few measure well. The burden is carried mainly by low- and middle-income countries, and girls are exposed to it for reasons that are

partly biological and partly social (1, 2). Rural schools look like an obvious place to act, since girls are gathered together and a tablet or a mid-day meal can be delivered through existing systems (3). Convenience, however, is not the same as benefit.



The title of this article reads like the report of a local school survey. It is not one. No haemoglobin values, dietary records or pupil details were collected by the authors, and none are reported. What follows is a narrative review of the published literature on the same question: how common is anaemia in adolescent girls, how much of it can be put down to what they eat, and what a rural school survey would have to do before its dietary associations could be trusted. The aim is a fair account of what is known and what is merely repeated.

The question is harder than it looks, because diet is not one exposure. A girl can eat enough iron on paper and still absorb little of it. Dietary habits matter, but how much they matter is what the literature leaves unsettled.

2. Literature Review

2.1 Defining and Counting Anaemia

Anaemia is a low haemoglobin concentration, judged against thresholds that depend on age, sex, pregnancy and, in principle, altitude and smoking. It is a laboratory sign and not a diagnosis, and it can arise from many causes (4). Global analyses show that women and children carry a large share of the burden and that progress has been slow and uneven (5, 6). Ferritin and related markers of iron status rise with inflammation and can hide deficiency (7). A school nurse reading a survey needs the answer to a simple question: would this describe my pupils?

2.2 Iron Deficiency and Its Share of Anaemia

Iron deficiency is the most common single cause of anaemia worldwide, and the usual first suspect in adolescent girls (8, 9). Yet it is not the only one. A systematic analysis of national surveys found that the proportion of anaemia attributable to iron deficiency varies widely between countries and is often well below the figure

commonly assumed (10). Reviews of anaemia in low- and middle-income countries stress the same point: infection, inflammation, other nutrient deficiencies and inherited conditions all contribute (4, 11).

The consequences of deficiency are real, if sometimes overstated. Iron is needed for oxygen transport and for work in muscle, immune cells and the brain (12). Deficiency reduces physical work capacity (13, 14), and an association with lower school achievement has been reported, though it is open to confounding by poverty (15). Such differences are small individually, but they accumulate over the years of adolescence.

2.3 Diet, Absorption and Bioavailability

What a girl eats influences iron status through the amount of iron on the plate and, more strongly, through how much of it the gut takes up. Haem iron from meat and fish is absorbed far more readily than non-haem iron from cereals and pulses, and the absorption of the latter swings with the rest of the meal (16, 17). Ascorbic acid and other organic acids enhance it (18); phytate in unrefined cereals and legumes, and polyphenols in tea, inhibit it (Table 1) (19, 20).

These effects are demonstrable in the laboratory and in single-meal studies, but the step to habitual diets is bigger than it appears. A trial in Indian women showed that tea and ascorbic acid change absorption as predicted, though iron status modulated the result (21). A longitudinal study in Moroccan children linked a habitually low-bioavailability diet to deficiency (22). In settings where the staple is a cereal and meat is rare, diets are often dominated by inhibitors, and diversification is the standard recommendation (23, 24). This is why the same meal can look protective in one report and irrelevant in the next.

**Table 1.** Dietary factors that change how much iron is absorbed.

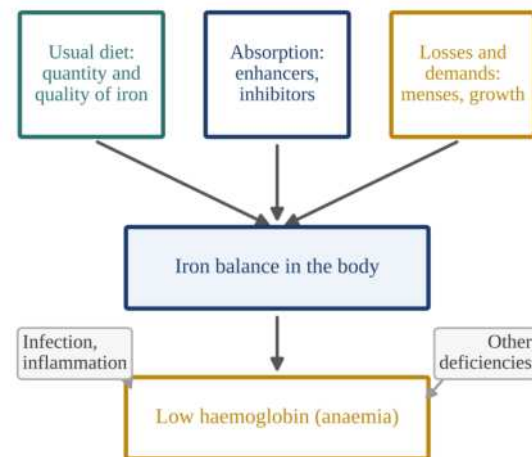
Factor	Direction	Common examples
Haem iron	Raises supply	Meat, poultry, fish; absorbed more readily (16, 17)
Ascorbic acid	Enhances	Citrus, guava, raw vegetables eaten with the meal (18)
Phytate	Inhibits	Cereals, pulses and their bran (17, 20)
Polyphenols	Inhibit	Tea and some vegetables (19, 21)
Calcium	May inhibit	Milk and milk products taken with the meal (16)
Soaking, fermenting	May help	Reduces phytate in cereals and pulses (23)

Note: Qualitative summary of the cited physiological literature; the size of each effect depends on the whole meal.

2.4 Other Causes Layered on Diet

Two demands set adolescent girls apart. Growth is fast, and from menarche onward menstrual blood takes iron with it every month, which pushes the requirement above that of boys of the same age (25, 26). Add to this the burden of infection. Hookworm was a major correlate of iron deficiency in school-aged children in an influential Zanzibar study (27), and inflammation raises hepcidin, which traps iron in stores and lowers haemoglobin even when intake is adequate (28, 29). The overall picture is summarised in Figure 1 and Table 2.

Folate, vitamin B12 and vitamin A also shape red cell production, and inherited haemoglobin disorders contribute in some regions, so a low reading is not automatically an iron problem (4, 6). Most of these causes are invisible in a school survey unless someone looks for them, which is the practical reason iron is blamed first, whether or not it is guilty. A single cause is rarely the whole story.



schematic, not data

Figure 1. Routes from diet and other causes to low haemoglobin in an adolescent girl (schematic, not data).**Table 2.** Causes of anaemia in adolescent girls that diet alone does not explain.

Cause	Mechanism	Why it matters at school
Menstrual loss	Iron leaves with blood each cycle (25)	Needs rise after menarche
Rapid growth	Higher demand for iron (26)	Peaks in early adolescence
Hookworm and other parasites	Chronic gut blood loss (27)	Depends on local sanitation
Inflammation	Hepcidin limits iron release (28, 30)	Can mask iron status
Other deficiencies	Folate, B12, vitamin A affect red cells (4)	Often untested
Inherited disorders	Alter red cell production (6)	Vary by region

Note: Several causes usually coexist in the same girl, which is why a single-cause reading is risky.

3. Materials and Methods

3.1 Scope

The review asks one question in two parts: how is anaemia in adolescent girls related



to everyday dietary habits in the published literature, and what does that literature imply for the design of a rural school survey? It does not describe any local population, and it does not offer advice to individual girls.

3.2 Literature Assembly

We did not run a formal systematic search and we do not claim one. This is a narrative synthesis, and the choice of sources reflects the authors' judgement of which reviews, trials and physiological studies best illuminate each point. Priority went to systematic reviews, consensus papers and widely cited primary studies. Because narrative selection is open to bias, we flag where the evidence is thin and quote no numerical results.

3.3 Appraisal Framework

Each source was read for four things: the design, what it measured, how diet or iron status was assessed, and whether the authors dealt with confounding by infection, inflammation and menstruation. Findings were then grouped by what a particular design can show, as sketched in [Figure 2](#). Where a source could not be interpreted with confidence, it was left out. None of these steps is difficult, but each one is easy to skip.

	Prevalence	Diet link	Cause	Remedy
Cross-sectional survey	strong	weak	little	little
Case-control	little	some	weak	little
Cohort	some	strong	some	weak
Controlled trial	little	weak	strong	strong

schematic, not data

Figure 2. Qualitative matrix of what each study design can and cannot tell us (schematic, not data).

4. Results

4.1 What Surveys of Adolescent Girls Report

Cross-sectional surveys in schools and communities form the bulk of the evidence on adolescent girls. They commonly report that anaemia is frequent, and they associate it with factors such as lower meat and vegetable consumption, regular tea drinking, a diet dominated by cereals, menstrual pattern, household poverty and maternal education ([31](#), [32](#)). Associations of this type are useful for generating hypotheses and for deciding where to look, but they cannot say what causes what, because anaemia and diet are measured on the same day from imperfect recall. The point is not that a survey is poor, only that its result travels less far than its abstract suggests.

4.2 What Interventions Suggest About Diet

The strongest indirect evidence comes from trials and reviews of interventions ([Table 3](#)). Daily iron supplementation improves haemoglobin in menstruating women ([33](#)), and intermittent schedules produce a comparable benefit with the attraction of fewer doses ([34](#)). A large effectiveness study of weekly iron and folic acid with counselling in India reported a fall in anaemia among schoolgirls, and the national programme that followed has been described in review ([35](#), [36](#)).

Food-based approaches are harder to evaluate. Reviews of fortified foods find benefits for haemoglobin, with results depending on the vehicle, the iron compound and the dose ([37](#)). Biofortified staples are promising but little tested in adolescents ([38](#)). Education alone changes knowledge more reliably than status ([39](#), [40](#)). In other words, trials show that giving iron works; they say much less about how



far everyday diet would have to change to do the same. A programme that works in a trial but loses most girls by the second term is not a programme a school would see working.

4.3 Safety and Context

Context shapes what is wise. A large trial of routine iron and folic acid in young children in a high-malaria setting was stopped early because of a higher risk of hospital admission and death in the supplemented group (41). The trial was in preschool children and cannot be extrapolated directly, but it explains why programmes in malaria-endemic areas are designed with care. Broader reviews place adolescent anaemia within the wider burden of undernutrition (42, 43), and Figure 3 sketches how a school programme can be layered. The caution is not specific to malaria: any programme that raises iron intake should attend to infection, adherence and follow-up. Read this way, an absent association in a small survey is not evidence of absence.

Table 3. Intervention approaches and the main caveat attached to each.

Approach	Evidence	Main caveat
Daily iron-folic acid	Improves haemoglobin (33)	Side effects, adherence
Weekly or intermittent dosing	Also effective (34, 35)	Needs a delivery system
Fortified foods	Supportive (37)	Depends on the vehicle eaten
Biofortified staples	Promising (38)	Few trials in adolescents
Deworming and hygiene	Plausible where parasites occur (27)	Effect varies with setting
Nutrition education	Weak on its own (39)	Hard to measure change

Note: Strength of evidence is the authors' qualitative reading of the cited reviews, not a formal grade.



Figure 3. Layers of a school-based anaemia programme, from screening to follow-up (schematic, not data).

5. Discussion

5.1 Interpretation

The main finding of this review is a conditional one. Diet is a plausible and often important contributor to anaemia in adolescent girls, mainly through the bioavailability of iron, but it operates alongside menstrual loss, growth, infection and inflammation (10, 44). A survey that records only how often foods are eaten, and reports a link with haemoglobin, will therefore overstate what diet explains, unless it also measures what sits in between. That is a modest claim, and it is the one the evidence will currently bear.

5.2 Limitations

The first limitation is the evidence itself. Most of what is known about school-age girls comes from cross-sectional surveys with weak dietary tools, and the best causal evidence comes from supplementation trials, which are not about diet. The second is the design of this article: a narrative review without a formal search can miss relevant studies and favour well-known ones. The third is generalisability, since findings may not transfer between regions with different staples and parasite burdens. Reviews of this kind are more useful when they say where the evidence stops than when they smooth it over.



5.3 Future Work

A convincing school survey would measure haemoglobin with a validated method and quality checks, repeat it for a subsample, and add a marker of inflammation so that ferritin can be interpreted (7). It would record diet with more than one recall, ask specifically about tea, citrus, meat and soaking practices, and note menstrual pattern and deworming history, then analyse diet together with these factors and not alone. A girl whose haemoglobin is measured twice, under the same conditions, tells us more than one who is measured once. These points apply with equal force to any school-based nutrition programme, not only to iron.

6. Conclusion

Anaemia among adolescent girls in rural schools is a real and measurable problem, and dietary habits are part of the explanation. The literature, however, does not allow a rural school survey of diet and anaemia to be read as a causal account. Most surveys cannot separate absorption, menstrual loss, infection and inflammation.

The practical message is encouraging. Supplementation, fortification and food-based approaches all have a basis in evidence, and good surveys can show where they are needed; the task is to measure carefully, report limits plainly and test what is recommended. Nothing in this reading argues against improving school diets; it argues for measuring what changes when they are improved.

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9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

N.H. conceived the review and wrote the sections on pulmonary and nutritional context. A.A. wrote the sections on iron physiology and paediatric aspects. B.S. wrote the sections on interventions and survey design. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No human participants were recruited and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

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