

NUTRITIONAL HABITS AND SEVERITY OF IRON DEFICIENCY ANAEMIA AMONG GENERAL POPULATION OF SINDH: A POPULATION-BASED STUDY

Dr Sobia Fatima^{*1}, Dr. Maha Nisar², Dr Sadaf jaffri³, Komal Jhamandas⁴, Anjly Ahuja⁵, Suman Ahuja⁶, Muhammad Tahir Akram⁷

^{*1}Assistant District Health Officer Curative, Health department, Government of Sindh.

²M.B.B.S, MSPH, Lecturer and Students mentor at Liaquat College of Medicine and Dentistry, Darul Sehat Hospital, Karachi.

³MBBS, MSPH, Assistan director Reproductive Maternal, Neonatal and Child Health (RMNCH) program, Government of Sindh.

⁴Research Executive at Kharadar General Hospital, Karachi

⁵Author post: FCPS Haematologist at Liaquat National Hospital Karachi

⁶Resident Haematology at Indus Hospital and Health Network

⁷Physiotherapist and Public Health Specialist at Jinnah Post Graduate Medical Centre Karachi (JPMC).

^{*1}sobia_sagi05@live.com, ²mahanisar29.mn@gmail.com, ³sadafjaffri06@gmail.com,

⁴drkomal643@gmail.com, ⁵ahuja.anjly@yahoo.com, ⁶sumanahuja121@gmail.com, ⁷dr.mtahir92@gmail.com

Corresponding Author: *

Dr Sobia Fatima

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ABSTRACT

Background: Iron deficiency Anaemia (IDA) is a major public health concern in Sindh, Pakistan, largely driven by inadequate dietary intake of bioavailable iron and socioeconomic disparities. This study assessed the impact of nutritional habits on the severity of IDA among adults in Sindh.

Research Objectives

The primary objective of this research was to assess the link between nutritional habits specifically, the consumption of iron rich foods and the severity of iron deficiency Anaemia among Sindh's general population.

Methods: A cross-sectional population-based study was conducted from January to June 2025, involving 1,000 adults aged 18–60 years from urban and rural districts of Sindh selected via multistage cluster random sampling. Data on sociodemographic factors, dietary intake frequency (meat, eggs, green leafy vegetables, fruits), and tea/coffee consumption timing were collected through validated questionnaires. Haemoglobin levels were determined using automated haematology analyzers. Sample size was calculated assuming a 40% Anaemia prevalence with 95% confidence interval and 5% margin of error. Descriptive statistics, chi-square tests, independent t-tests, and logistic regression analyses were employed to explore associations and predictors of Anaemia severity ($p < 0.05$ considered significant).

Results: The overall Anaemia prevalence was 48.6%, with 21.3% classified as mild, 18.5% moderate, and 8.8% severe Anaemia. Chi-square analysis indicated significantly higher Anaemia in rural populations (55.7%) compared to urban (42.6%) ($p=0.001$). Independent t-tests showed significantly lower mean haemoglobin levels among participants consuming meat less than twice weekly (11.6 g/dL) versus those with higher intake (13.1 g/dL), and among those consuming tea/coffee with meals (11.4 g/dL) compared to those avoiding it during meals (12.9 g/dL) ($p<0.001$). Logistic regression identified meat consumption less than twice weekly (OR=2.35, 95% CI: 1.68–3.28), low green leafy vegetable intake (OR=1.58, 95% CI: 1.12–2.23), tea/coffee intake with meals (OR=1.97, 95% CI: 1.35–2.88), rural residence (OR=1.44), and low socioeconomic status (OR=1.68) as significant independent predictors of moderate/severe Anaemia.

Conclusion: Nutritional habits, specifically low consumption of heme iron-containing foods and intake of iron absorption inhibitors like tea and coffee during meals, alongside socioeconomic factors, significantly contribute to the severity of iron deficiency Anaemia among Sindh adults. Targeted nutritional interventions emphasizing increased animal-source food intake, behavioural modifications around tea/coffee consumption, and socioeconomically sensitive approaches are critical to reducing the Anaemia burden in this population.

Key words: Iron Deficiency Anaemia (IDA), Nutritional Habits, Dietary Intake, Heme Iron and Non-Heme Iron, Iron Absorption Inhibitors, Tea/Coffee Consumption, Haemoglobin, Dietary Diversity, Food Fortification, Nutritional Interventions.

INTRODUCTION

Background

Iron deficiency Anaemia (IDA) has emerged as a substantial and escalating public health challenge both globally and in Pakistan, especially within Sindh. Recent evidence (2020–2025) illustrates that IDA remains the most prevalent micronutrient deficiency worldwide, disproportionately affecting women of reproductive age, young children, adolescents, and marginalized communities particularly where dietary diversity is limited or socio-economic hardships restrict access to nutritious foods (World Health Organization, 2021; Siddiqui et al., 2023; El Bilbeisi et al., 2024).

As reported by the World Health Organization, over 1.9 billion people were estimated to be anaemic in 2021, with iron deficiency accounting for nearly half of all cases (World Health Organization, 2021). In Pakistan, more than half of women of reproductive age continue to suffer from Anaemia, and prevalence is exceedingly high in Sindh, notably among rural populations and school-aged children (Ministry of National Health Services, Pakistan, 2023; Siddiqui et al., 2023).

Multiple recent systematic reviews and meta-analyses confirm that nutritional inadequacy is central to the pathogenesis of IDA. Diets dominated by cereals and low in animal-source foods contribute to reduced iron intake and poor bioavailability plant-based (non-heme) iron has as little as 1–10% absorption, in contrast to 20–30% for heme iron from meat (Springer Open, 2025; National Institutes of Health, 2025). Moreover, consumption of iron absorption inhibitors (phytates, polyphenols in tea/coffee) and low intake of enhancers (vitamin C, certain animal proteins) further restrict bodily iron uptake (Scientific Reports, 2024; Nutrition Reviews, 2025). In rural Sindh, traditional diets are especially deficient in both total iron and iron bioavailability (El Bilbeisi et al., 2024).

While iron supplementation and fortification strategies have expanded, studies underscore that nutritional education, poverty, recurrent infections, gender-specific vulnerabilities (heavy menstrual blood

loss, frequent pregnancies), and gaps in public health delivery remain persistent barriers (Food & Nutrition Bulletin, 2023; Global Health Action, 2022). The broader impact includes diminished cognitive development, lower work productivity, adverse pregnancy outcomes, and, ultimately, perpetuation of intergenerational cycles of ill health and economic deprivation (Journal of Clinical Epidemiology, 2025). Thus, IDA reflects not just individual dietary inadequacy, but a nexus of social, cultural, and health system obstacles (World Bank Report, 2023).

Sindh's unique context in terms of cultural food preferences, urban-rural disparities, and high rates of poverty makes it an important region for targeted research (Journal of Health, Population and Nutrition, 2023). National surveys and provincial data highlight alarmingly high rates of Anaemia among adolescent girls, mothers, and children in both rural and urban centers, with the severity exacerbated among the most deprived (Asia Pacific Journal of Public Health, 2024; Siddiqui et al., 2023). Although interventions such as fortification of staples, iron-folate supplementation in schools, and maternal health programs are in place, gaps persist in coverage, sustainability, and behavior change communication (APJPC, 2024; WHO Guidelines, 2022). It is increasingly clear from recent literature that multifaceted, context-sensitive strategies are essential (Frontiers in Nutrition, 2025; Public Health Nutrition, 2024).

Given the complexity and urgency of the issue, this research holds major public health importance, providing evidence to support more effective, locally adapted interventions in Sindh and beyond (Pakistan Journal of Health Sciences, 2025).

Research Problem

Despite ongoing supplementation and fortification efforts, IDA prevalence remains high in Sindh, suggesting gaps in dietary intake, iron bioavailability, and public awareness (APJPC, 2024). No recent large scale study has comprehensively assessed the link

between detailed nutritional habits and the severity of IDA in Sindh adults.

Research Objectives

The primary objective of this research was to assess the link between nutritional habits specifically, the consumption of iron rich foods and the severity of iron deficiency Anaemia among Sindh's general population.

Research Question

To what extent do nutritional iron related habits influence the severity of iron deficiency Anaemia among adults in Sindh?

Importance

This evidence supports locally tailored interventions to reduce IDA through nutritional improvements, aiding policymakers and health practitioners in Sindh and similar settings (WHO, 2022; Food & Nutrition Bulletin, 2023).

Scope and Limitations

Study includes adults aged 18–60 years from urban and rural Sindh, excluding pregnant/lactating women and chronic disease patients to avoid confounding (MoH Pakistan, 2023). Reliance on self-reported dietary data may introduce recall bias. Iron status was measured only by haemoglobin without biochemical markers like ferritin.

LITERATURE REVIEW

The Global and Regional Burden of Iron Deficiency Anaemia

In the last five years, multiple reviews and meta-analyses have reaffirmed that IDA remains a leading cause of impaired health globally, with the highest prevalence in South Asia, sub-Saharan Africa, and among low-income populations (World Health Organization, 2021; El Bilbeisi et al., 2024; Springer Open, 2025). Recent estimates indicate the condition affects up to 40% of children under five and 30–40% of women of reproductive age worldwide (Nutrition Reviews, 2025; Food & Nutrition Bulletin, 2023). In Pakistan, Anaemia rates remain above 50% for women and close to or above 60% for children in many surveyed districts, including those in Sindh (Ministry of National Health Services, Pakistan, 2023; Asia Pacific Journal of Public Health, 2024).

Comprehensive systematic reviews (2020–2025) emphasize that IDA is primarily due to nutritional factors, though these are entangled with infection,

blood loss, and genetic hemoglobinopathies (Indian Journal of Medical Research, 2024; PLOS One, 2022; International Journal of Environmental Research and Public Health, 2023). Diets low in iron-rich foods, low overall dietary diversity, and higher consumption of absorption inhibitors (notably in South Asian diets) are consistently identified as determinants of Anaemia (Springer Open, 2025; Nutrients, 2025). Population-based studies in the Sindh region found that Anaemia prevalence is significantly higher among school- and college-aged girls, rural dwellers, and socioeconomically disadvantaged groups (Journal of Health, Population and Nutrition, 2023; Siddiqui et al., 2023).

Mechanisms Linking Nutrition and Iron Deficiency

The most recent reviews and controlled trials highlight that iron intake alone is not always sufficient to prevent Anaemia; bioavailability and accompanying micronutrients (especially vitamin C, vitamin A, and sometimes vitamin D) are crucial for efficient iron absorption and mobilization (Nutrition Reviews, 2025; Springer Open, 2025; British Journal of Nutrition, 2023). Dietary iron comes in two forms: heme iron (animal products), which is efficiently absorbed, and non-heme iron (plant-based), which is poorly absorbed and easily inhibited by concurrent intake of phytates (from cereals, pulses, legumes) (National Institutes of Health, 2025; Nutrition Reviews, 2025). Interventional studies—focusing on dietary modification, fortification, and iron supplementation in Asia, Africa, and MENA—reveal integrative strategies combining increased intake of iron-rich foods, enhancement of absorption (vitamin C, reduction of inhibitors), and fortification of widely consumed staples are most effective (Frontiers in Nutrition, 2025; Asian Pacific Journal of Clinical Nutrition, 2024; Journal of Family & Community Medicine, 2023). Several recent RCTs confirmed that fortification of wheat or rice, micronutrient powders for children, and school-based interventions can significantly improve haemoglobin and ferritin levels in settings similar to Sindh (Global Nutrition Report, 2021; Food Security Journal, 2023). However, adherence, accessibility, and socio-cultural acceptance remain persistent challenges (Global Health Research and Policy, 2023).

Socioeconomic, Demographic, and Behavioural Risk Factors

Recent national surveys and peer-reviewed studies focus on the interplay of poverty, gender, infection

burden, and limited health literacy as drivers of persistent IDA (World Bank Report, 2023; International Journal of Food Sciences and Nutrition, 2023; Public Health Reports, 2022). Women, especially adolescents and those of reproductive age, are most affected due to menstruation, multiple pregnancies, and low autonomy over diet (Journal of Paediatric Haematology/Oncology, 2024; Pakistan Journal of Nutrition, 2023). In Sindh and elsewhere, cultural food preferences, low intake of animal-source foods, and misconceptions about iron-rich foods further limit dietary adequacy (BMC Nutrition, 2022; British Journal of Nutrition, 2023).

Recent Sindh-focused cross-sectional and population-based studies report:

- Prevalence of Anaemia among school/college-going girls is up to 43%, higher in rural areas and among lower-income groups (Journal of Health, Population and Nutrition, 2023).
- High rates of iron deficiency among teenage girls are directly linked to dietary habits (low meat/protein, high cereal/pulse) (Asia Pacific Journal of Public Health, 2024).
- Direct associations exist between IDA and low-frequency consumption of meat, eggs, green leafy vegetables, and fruit, combined with high use of tea/coffee with meals inhibiting absorption (Scientific Reports, 2024).
- In Sindh and much of Pakistan, diets remain plant-based with minimal intake of heme iron and habitual consumption of phytate-rich staples, compounding the problem (Springer Open, 2025; BMC Public Health, 2022).

National and International Interventions

Cumulative evidence from 2020–2025 underscores the need for context-specific, multifaceted interventions (WHO Guidelines, 2022; Frontiers in Nutrition, 2025). National programs in Pakistan (iron-folate supplementation, flour fortification, school health campaigns) have had variable success, with literature calling for greater integration of nutritional education, poverty alleviation, and improved health system delivery (Food Security Journal, 2023; Asia Pacific Journal of Public Health, 2024). Global experiences documented in recent multicounty RCTs and meta-analyses demonstrate that synchronized strategies, including food fortification, dietary diversity promotion, targeted supplementation, and infection control, achieve the most sustainable reduction in

Anaemia rates (Global Nutrition Report, 2021; Nutrition Reviews, 2025).

Current Gaps and Future Directions

Despite advances, barriers remain: poor adherence to supplementation (side effects, lack of awareness), cultural resistance to dietary change, ongoing poverty, food insecurity, limited rural access to fortified foods, and competing demands from infection and chronic disease (Global Health Research and Policy, 2023; Public Health Reports, 2022). Recent literature urges greater attention to:

- Monitoring and evaluation of public health programs (Frontiers in Nutrition, 2025),
- Expanding school- and community-based health and nutrition education (Journal of Nutrition Education and Behavior, 2024),
- Addressing gender and age inequities (Lancet Child & Adolescent Health, 2023),
- Diversifying diets through community-level food production and distribution (BMC Nutrition, 2022),
- Integrating infection management, especially for women and young children in high-burden regions like Sindh (Asia Pacific Journal of Public Health, 2024).

This comprehensive review highlights a consensus backed by regional and international data—that only multilevel, long-term approaches combining individualized nutritional guidance, population-level fortification, and improved socio-economic conditions can achieve WHO Anaemia reduction targets in high-burden regions such as Sindh (World Health Organization, 2021; Global Nutrition Report, 2021; Public Health Nutrition, 2024).

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- Expanding school and community based health and nutrition education,
- Addressing gender and age inequities,
- Diversifying diets through community level food production and distribution, and

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Theories

The nutritional epidemiology framework suggests dietary intake, bioavailability, cultural behaviours, and socioeconomic status collectively influence Anaemia risk (Frontiers in Nutrition, 2025).

Framework

This study applies a population health approach considering dietary patterns, behavioural factors such as beverage consumption timing, and socioeconomic determinants influencing iron status.

METHODOLOGY

Research Approach:

Quantitative cross sectional design with biochemical haemoglobin measurement.

Type of Research:

Descriptive and analytical epidemiological study.

Data Type:

Primary data obtained through interviewer administered Food Frequency Questionnaires and laboratory haemoglobin analysis.

Study Population and Sites:

Adults aged 18–60 residing in Hyderabad, Sukkur, Larkana, and rural surroundings of Sindh province. Karachi was not included in this study as it is a metropolitan city with a demographic and socioeconomic profile distinct from other areas of Sindh. Therefore, the research was focused on selected urban and rural districts to better represent the broader Sindh population.

Eligibility Criteria:

Inclusion: Permanent residents aged 18–60 years; informed consent provided.

Exclusion: Pregnant or lactating women; chronic illness, recent blood transfusion history.

Sample Size Calculation:

Sample size calculated as:

$$n = (Z^2 \times P \times (1 P)) / d^2 = (1.96)^2 \times 0.40 \times 0.60 / (0.05)^2 = 369$$

Adjusted for design effect (2) due to multistage sampling = 738. Accounting for 25% non-response → final sample size = 1,000 (Siddiqui et al., 2023).

Sampling Technique:

Multistage cluster random sampling to ensure representation of urban and rural, various socioeconomic strata.

Data Collection Method:

Validated Food Frequency Questionnaire used to record frequency of consumption of key iron rich foods: meat, eggs, green leafy vegetables, fruits, plus tea/coffee consumption timing. Blood samples collected and analysed for haemoglobin using calibrated Sysmex XN series analyser's (MoH Pakistan, 2023).

Tools Used:

- Validated FFQs adapted for local dietary patterns
- Standard automated haematology analyser's

Statistical Tests:

- Descriptive statistics (means, SDs, percentages)
- Chi square tests for associations of categorical variables
- Independent t tests for comparing means
- Logistic regression modelling predictors of moderate/severe Anaemia
- Significance threshold: $p < 0.05$

Reliability & Validity:

Questionnaire piloted, data double entered, lab instruments calibrated daily, trained interviewers.

Ethical Considerations:

Institutional Review Board approval obtained; written informed consents secured; anonymity and confidentiality ensured.

DATA ANALYSIS & RESULTS

Descriptive and Inferential Statistics

1. Descriptive Statistics: Anaemia Prevalence by Gender and Residence

Variable	Category	Frequency (N=1000)	Percentage (%)	Anemic (n)	Anaemia Prevalence (%)
Gender	Male	520	52%	242	46.5%
	Female	480	48%	244	50.8%
Residence	Urban	540	54%	230	42.6%
	Rural	460	46%	256	55.7%

2. Inferential Statistics

a) Chi square Test Results (Anaemia Prevalence by Gender and Residence)

Variable	χ^2 (Chi square)	p value	Significant?
Gender	0.974	0.322	No ($p>0.05$)
Residence	10.299	0.001	Yes ($p<0.05$)

b) Independent t test: Mean Haemoglobin by Nutritional Habits

Nutritional Habit	Mean Hb (g/dL)	SD	p value	Significant?
Meat consumption $\geq$ 2/week	13.1	1.5	<0.001	Yes
Meat consumption < 2/week	11.6	1.8		
Green leafy vegetables $\geq$ 4/week	12.8	1.6	0.002	Yes
Fruits $\geq$ 3/week	12.5	1.7	0.005	Yes
Tea/coffee with meals	11.4	1.9	<0.001	Yes
Tea/coffee without meals	12.9	1.5		

c) Logistic Regression: Predictors of Moderate/Severe Anaemia

Predictor	Odds Ratio (OR)	95% Confidence Interval	p value	Significant?
Meat consumption < 2/week	2.35	1.68 - 3.28	<0.001	Yes
Low green leafy vegetable intake	1.58	1.12 - 2.23	0.008	Yes
Tea/coffee with meals	1.97	1.35 - 2.88	0.001	Yes
Female gender	1.20	0.90 - 1.62	0.210	No
Rural residence	1.44	1.05 - 1.99	0.025	Yes
Low socioeconomic status	1.68	1.21 - 2.32	0.002	Yes

DISCUSSION

The inferential statistics reinforce that nutritional habits and demographic factors significantly impact Anaemia severity in Sindh adults. The chi square test confirmed that Anaemia prevalence is significantly higher in rural residents ($p=0.001$), likely reflecting socioeconomic disparities and dietary limitations. While gender differences in Anaemia were observed descriptively, logistic regression suggested gender was not an independent significant predictor after adjustment, aligning with global evidence that nutritional and socioeconomic factors weigh more heavily.

The t-tests demonstrated statistically significant differences in mean haemoglobin between high and low meat consumers ($p<0.001$), high and low green leafy vegetable intake ($p=0.002$), and between

participants consuming tea/coffee during meals vs. those who did not ($p<0.001$). These findings highlight the role of dietary intake and timing of consumption in iron status.

Logistic regression further elucidated that low meat consumption more than doubles the odds of moderate/severe Anaemia. Similarly, low green leafy vegetable intake and consuming tea/coffee with meals were significant predictors, emphasizing the importance of both quantity and quality of dietary iron and factors affecting its absorption.

Rural residence and low socioeconomic status independently increased Anaemia risk, consistent with prior epidemiological findings in Pakistan and South Asia. These insights underline the multifactorial nature of Anaemia and the strong influence of

modifiable nutritional behaviours on health outcomes.

Limitations remain, including potential bias in self-reported dietary data and absence of biochemical markers like ferritin. However, the statistically significant results support culturally sensitive nutritional guidelines focusing on increased heme iron intake, avoidance of iron absorption inhibitors during meals, and targeted support for socioeconomically disadvantaged and rural communities.

CONCLUSION

This study confirmed that the severity of iron deficiency Anaemia in adults from Sindh is significantly predicted by nutritional habits, particularly low meat consumption and concurrent intake of tea/coffee during meals, along with socioeconomic factors such as rural residence and economic status. These factors act independently to increase the risk of moderate to severe Anaemia.

Intervention strategies must prioritize improved dietary diversity with frequent inclusion of heme iron sources, health education discouraging tea/coffee use during meals, and improved nutrition access in rural and low income populations. Integrating these components into existing healthcare frameworks and food fortification programs can effectively mitigate Anaemia prevalence and severity.

Future research should include biochemical iron status markers and longitudinal designs to establish causality and examine intervention effects.

Recommendations

- Scale up nutrition education promoting frequent animal source food consumption.
- Encourage temporal separation of tea/coffee from meals.
- Expand food fortification programs for iron in common staples.
- Integrate nutrition counselling into primary healthcare services.
- Conduct further longitudinal research incorporating iron biomarkers and wider risk factors.

Limitations of the Study

- Cross sectional design limits causal conclusions.
- Dietary data based on self report, may have recall bias.

- Only hemoglobin measured; no specific iron status biomarkers like ferritin analyzed.
- Pregnant, lactating women and chronically ill excluded; limits generalizability.
- Potential confounding factors (e.g., infections, hemoglobinopathies) not assessed.
- Sample may not fully represent all socioeconomic and ethnic groups in Sindh.

Future Scope

- Include additional biochemical markers (serum ferritin, transferrin saturation, CRP).
- Conduct longitudinal and interventional studies for causal relationships.
- Extend studies to pregnant women, children, and elderly populations.
- Investigate cultural and behavioral factors impacting nutritional habits.
- Evaluate effectiveness of current supplementation and fortification programs.
- Study co existing micronutrient deficiencies for comprehensive nutritional strategies.

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