Original Article

Access this article online
Quick Response Code:
Website:
https://journals.lww.com/ijhm
DOI:
10.4103/ijh.ijh_171_25

Iron deficiency anemia among women and children in Saudi Arabia: A clinical burden analysis using laboratory surveillance and literature review (2014–2024)

Ahmed Abdulaziz Almohammadi

Abstract:

BACKGROUND: Iron deficiency anemia (IDA) represents a significant public health challenge worldwide, yet comprehensive epidemiological data from Saudi Arabia integrating clinical surveillance with population-based evidence remain limited.

OBJECTIVES: This study aimed to quantify the clinical burden of IDA across demographic groups in Saudi Arabia using laboratory surveillance data, identify key risk factors through literature synthesis, analyze temporal trends from 1990 to 2024, and examine regional variations to inform Vision 2030 health priorities.

MATERIALS AND METHODS: We conducted a two-stream study comprising: (1) a secondary analysis of laboratory-based surveillance data from Al Borg Diagnostics Laboratories, including 420,956 individuals tested between January 2014 and February 2024 across all 13 administrative regions, and (2) a narrative review of 14 peer-reviewed epidemiological studies supplemented with WHO Global Health Observatory and Global Burden of Disease Study 2021 data. Iron deficiency (ID) was defined as serum ferritin <30 ng/mL, while IDA was defined as hemoglobin below sex-specific thresholds with concurrent ID. Descriptive statistics and Chi-square tests were performed for laboratory data. Risk factors were extracted from multivariate analyses in reviewed studies.

RESULTS: Laboratory surveillance findings: Among 420,956 individuals seeking diagnostic services, IDA prevalence was 19.8%, with nonanemic ID affecting an additional 23.7%, yielding a combined ID prevalence of 43.5%. Women constituted 93% of all iron-deficient cases. Significant regional variation was observed, ranging from 28% in Al-Jouf to 42% in the Makkah region ($P < 0.001$). Among children <12 years tested (representing clinically suspected cases), 100% had anemia with 45% meeting IDA criteria, indicating extreme selection bias toward symptomatic presentations. Literature review findings: Population-based studies documented IDA prevalence of 49% among infants aged 6–24 months in primary care settings and 40% among women of reproductive age in community-based sampling. WHO national estimates indicated 43.7% prevalence in women of reproductive age and 45.5% in pregnant women. Key risk factors identified across studies included family history of IDA (adjusted odds ratio [OR] 2.91, 95% confidence interval [CI] 1.78–4.76), insufficient iron intake (OR 7.39, 95% CI 1.45–37.57), infrequent meat consumption (OR 1.54–7.70), and short birth intervals (OR 2.23, 95% CI 1.20–4.41). Global Burden of Disease 2021 data demonstrated a 44.5% decline in age-standardized disability burden from dietary ID between 1990 and 2021.

CONCLUSIONS: IDA remains an important public health problem in Saudi Arabia, particularly affecting women of reproductive age and infants. The 93% female predominance in clinical samples

Department of Preventive Medicine, Aldaitha Healthcare Center, Madinah Health Cluster, Ministry of Health, Madinah, Saudi Arabia

Address for correspondence:
Dr. Ahmed Abdulaziz Almohammadi, Department of Preventive Medicine, Aldaitha Healthcare Center, Madinah Health Cluster, Ministry of Health, Madinah, Saudi Arabia.
E-mail: ahmed.a.a11@outlook.com

Submission: 26-12-2025
Revised: 23-01-2026
Accepted: 26-01-2026
Published: 14-03-2026

How to cite this article: Almohammadi AA. Iron deficiency anemia among women and children in Saudi Arabia: A clinical burden analysis using laboratory surveillance and literature review (2014–2024). Iraqi J Hematol 2026;15:85-96.

and substantial regional disparities (28%–42%) necessitate targeted interventions aligned with Saudi Vision 2030 Quality of Life Program objectives, specifically key performance indicators for maternal and child health screening coverage and chronic disease prevention. Strengthening primary care screening, dietary education programs, and iron supplementation initiatives should be prioritized.

Keywords:

Child nutrition, epidemiology, iron deficiency anemia, laboratory surveillance, Saudi Arabia, women's health

Introduction

Iron deficiency anemia (IDA) represents the most prevalent nutritional deficiency disorder globally, affecting approximately 1.92 billion individuals worldwide and contributing substantially to the global burden of disease.[1] The condition arises when iron stores become depleted, leading to inadequate hemoglobin synthesis and impaired oxygen-carrying capacity. Consequences extend beyond hematological parameters to include cognitive impairment, reduced work productivity, adverse pregnancy outcomes, and increased susceptibility to infections.[2]

The World Health Organization (WHO) classifies anemia as an important public health problem when prevalence exceeds 40% in any population group. In Saudi Arabia, recent WHO estimates indicate that anemia affects approximately 43.7% of women of reproductive age and 45.5% of pregnant women, placing the Kingdom among six Eastern Mediterranean Region countries with the highest burden.[3] These figures exceed the global average of 29.9% for women of reproductive age, highlighting the critical need for evidence-based interventions.[4]

The epidemiology of IDA in Saudi Arabia is influenced by several unique factors. High consanguinity rates, estimated at 56% nationally, contribute to the elevated prevalence of hemoglobinopathies, including sickle cell disease and beta-thalassemia trait, which can complicate anemia diagnosis and management.[5] Dietary patterns characterized by inadequate heme iron intake, high consumption of iron absorption inhibitors such as tea and coffee, and evolving nutritional transition further compound the burden.[6] In addition, high fertility rates and short interpregnancy intervals deplete maternal iron stores, perpetuating intergenerational cycles of deficiency.[7]

Understanding clinical surveillance versus population-based data

Accurate epidemiological assessment of IDA requires distinguishing between different data sources. Population-based surveys employ random sampling of households to estimate disease prevalence in the general population, representing both symptomatic and asymptomatic individuals. In contrast, laboratory surveillance data (passive, clinical) reflect individuals actively seeking medical attention, introducing indication bias whereby people are tested because they have symptoms or clinical suspicion of disease. Private laboratory data further introduces socioeconomic selection bias, as testing access depends on insurance coverage or ability to pay.

These methodological differences profoundly affect prevalence estimates. Clinical samples typically overestimate disease burden compared to random household surveys because symptomatic individuals are overrepresented. For instance, if only children suspected of having anemia are sent for testing, the measured "prevalence" approaches 100% – not because anemia is universal, but because the sampling strategy enriched for cases. Population-based studies, while methodologically superior for prevalence estimation, require substantial resources and may underestimate clinical burden if healthcare-seeking behavior is low.

This study integrates both approaches: Laboratory surveillance data to characterize the clinical burden among individuals presenting for diagnostic services, and population-based studies from the literature to contextualize findings within broader epidemiological patterns. This dual framework acknowledges that clinical data, while not representative of the general population, provide valuable insights into disease distribution among healthcare-seeking populations and regional variation in healthcare utilization.

Saudi Vision 2030 policy context

Saudi Vision 2030 has prioritized health sector transformation through the National Transformation Program and Health Sector Transformation Program.[8] Specific to IDA prevention and management, the following key performance indicators (KPIs) are relevant:

1. Quality of life program – Maternal health domain: Increase coverage of antenatal screening to ≥95% by 2030, which includes hemoglobin and anemia assessment
2. National transformation program – Primary healthcare: Expand chronic disease screening programs at primary care centers, with micronutrient deficiencies identified as priority conditions

3. Vision 2030 health pillar: Reduce preventable disease burden measured through disability-adjusted life years, of which IDA is a substantial contributor
4. Women's Empowerment Goals: Address health disparities affecting women's economic participation, recognizing that IDA reduces work productivity and educational attainment.

Accurate epidemiological data on IDA burden, risk factors, and regional variations are essential to guide resource allocation toward these specific targets and measure progress.

This study aimed to: (1) quantify the current clinical burden of IDA using laboratory surveillance data and synthesize population-based evidence; (2) identify modifiable risk factors with precise effect estimates; (3) analyze temporal trends from 1990 to 2024; and (4) examine regional variations to inform targeted intervention strategies. We hypothesized that IDA prevalence would demonstrate significant demographic and geographic heterogeneity, with women and children bearing a disproportionate burden.

Materials and Methods

Study design and data sources

We conducted a two-stream study:

Stream 1: Laboratory surveillance data analysis

A retrospective secondary analysis of publicly available aggregate data from Al Borg Diagnostics Laboratories (Al Borg Medical Laboratories, P.O. Bo × 55789, Jeddah 21544, Kingdom of Saudi Arabia), the largest private diagnostic network in Saudi Arabia with over 72 branches across all 13 administrative regions.[9] This dataset included 420,956 individuals tested between January 2014 and February 2024, representing a convenience sample of individuals seeking laboratory services. This stream characterizes the clinical burden among healthcare-seeking populations.

Stream 2: Literature review and secondary data sources

A narrative review of Saudi Arabian IDA epidemiology was conducted by searching PubMed, Google Scholar, and Saudi Medical Journal archives using terms: ("iron deficiency" OR "anemia" OR "anaemia") AND ("Saudi Arabia" OR "Kingdom of Saudi Arabia"). We included peer-reviewed studies published between 1999 and 2024 reporting original prevalence data or risk factor analyses, identifying 14 relevant studies. Additional data were extracted from: WHO Global Health Observatory anemia estimates (2000–2019); Global Burden of Disease Study 2021 for dietary iron deficiency (ID) prevalence and trends (1990–2021);[1] and World Bank Development Indicators.

Population and sample characteristics

Laboratory surveillance cohort

The cohort comprised individuals across all age groups, with 73% being female and 94% aged 15 years or older. Geographic representation included all 13 administrative regions: Riyadh, Makkah, Madinah, Eastern Province, Qassim, Hail, Asir, Tabuk, Northern Borders, Jazan, Najran, Al-Baha, and Al-Jouf.

Inclusion criteria

All individuals who underwent complete blood count and serum ferritin testing at Al Borg Diagnostics Laboratories during the study period were included in aggregate analyses. No exclusion criteria were applied as this was an analysis of de-identified surveillance data.

Important selection bias considerations

This laboratory cohort has substantial limitations for population prevalence estimation:
1. Socioeconomic bias: Al Borg is a private paid service. Only individuals with insurance coverage or the ability to pay out-of-pocket can access testing, likely excluding lower-income populations who may have higher IDA burden due to nutritional constraints
2. Indication bias: Individuals are typically referred for iron studies because of symptoms (fatigue, pallor), previous anemia diagnosis, or clinical conditions warranting screening (pregnancy, chronic disease). This enriches the sample for IDA cases compared to random population sampling
3. Healthcare access bias: The distribution of testing across regions reflects healthcare-seeking behavior and service availability rather than true disease distribution.

Critical interpretation

The prevalence estimates from this laboratory surveillance represent the clinical burden among individuals presenting for diagnostic services and should NOT be interpreted as population prevalence. They likely overestimate prevalence compared to random household surveys. However, they provide valuable insights into: (a) the magnitude of clinical presentations, (b) regional patterns in healthcare utilization, and (c) demographic distribution among diagnosed cases.

Population-based studies included in the literature review ranged from community-based cross-sectional surveys[10] to primary healthcare center-based assessments.[11] Sample sizes ranged from 200 to 6539 participants, with most employing probability sampling methods.

Variable definitions and laboratory procedures

ID was defined as serum ferritin concentration <30 ng/mL.

Justification for 30 ng/mL cutoff

While WHO defines ID as ferritin <5 μg/L (ng/mL) for adults and <12 μg/L for children in the general population, the <30 ng/mL threshold is supported by:

- Functional ID guidelines from the American Society of Hematology for patients with chronic conditions
- Evidence that ferritin 15–30 ng/mL represents depleted iron stores with insufficient reserves for erythropoiesis
- Recommendation from Al Borg laboratory protocols aligned with several international guidelines for clinical populations.

Important limitation

Use of the <30 ng/mL cutoff likely inflates prevalence estimates compared to the WHO standard thresholds. A sensitivity analysis using <15 ng/mL would yield lower estimates. This cutoff is appropriate for identifying early depletion in clinical populations but overstates prevalence for population health surveillance. This is acknowledged as a major limitation.

Serum ferritin was measured using chemiluminescent immunoassay (Architect i2000SR, Abbott Diagnostics, Abbott Park, IL, USA) with functional sensitivity of 1.0 ng/mL, intra-assay coefficient of variation (CV) <5%, and inter-assay CV <10%.

IDA was defined as concurrent ID with hemoglobin below sex-specific thresholds: <12 g/dL for nonpregnant women, <11 g/dL for pregnant women, and <13 g/dL for men. For children, age-adjusted WHO hemoglobin cutoffs were applied.

Hemoglobin concentration was measured using an automated hematology analyzer (Sysmex XN-Series, Sysmex Corporation, Kobe, Japan) with impedance and optical methods.

Anemia severity was classified per WHO criteria: mild (10–11.9 g/dL for women), moderate (7–9.9 g/dL), and severe (<7 g/dL). Nonanemic ID (NAID) was defined as serum ferritin <30 ng/mL with hemoglobin above the anemia threshold.

Critical limitation: absence of inflammatory marker testing

Ferritin is an acute-phase reactant that increases during inflammation and infection, independent of iron status. Ideally, C-reactive protein (CRP) or erythrocyte sedimentation rate (ESR) should be measured to exclude acute inflammation that could falsely elevate ferritin levels. In patients with inflammation:

- Ferritin 30–100 ng/mL may actually represent ID masked by the acute-phase response
- Conversely, apparently "normal" ferritin (20–30 ng/mL) during active inflammation may indicate true deficiency.

The inability to adjust ferritin for inflammation is a major limitation that may

- Underestimate ID prevalence in acutely ill patients (elevated ferritin masking deficiency)
- Overestimate ID prevalence in healthy individuals (using the high 30 ng/mL cutoff without clinical context).

This limitation is particularly important given that many individuals seeking laboratory testing may have concurrent illness.

Statistical analysis

Laboratory surveillance data

Descriptive statistics were calculated for prevalence estimates across demographic strata. Prevalence rates were expressed as percentages with 95% confidence intervals (CIs). Chi-square tests assessed associations between categorical variables. Regional comparisons utilized Chi-square tests for statistical significance. All analyses used publicly available aggregate data. Statistical significance was defined as $P < 0.05$ for two-sided tests.

Literature-derived risk factors

Risk factors were extracted from multivariate logistic regression models reported in source studies. Odds ratios (OR) with 95% CI were compiled from published analyses. The primary reference study for risk factor analysis was a community-based survey of 969 women in Riyadh employing two-stage cluster sampling,[10] with supplementary data from other studies.[6,12]

Temporal trends

Global burden of disease estimates provide age-standardized rates with 95% uncertainty intervals (UI) calculated using Bayesian hierarchical models. Annual percentage change characterized trends over the 1990–2021 period.

Data analysis was performed using Microsoft Excel 2019 (Microsoft Corporation, Redmond, WA, USA) and GraphPad Prism version 9.0 (GraphPad Software, San Diego, CA, USA).

Ethical considerations

Ethical approval was not required as this study utilized publicly available, de-identified aggregate data from published sources and databases. All data sources were accessed in accordance with their respective data use agreements and open access policies. The study adhered to the Strengthening the Reporting of Observational

Studies in Epidemiology guidelines for observational research.

Results

Stream 1: Laboratory surveillance findings

Overall clinical burden of iron deficiency

Analysis of the nationwide laboratory surveillance dataset (n = 420,956 individuals seeking diagnostic services) revealed an IDA prevalence of 19.8% among tested individuals, with NAID affecting an additional 23.7% [Table 1 and Figure 1]. The combined ID prevalence (IDA plus NAID) was 43.5%, indicating that nearly half of the individuals presenting for testing had depleted iron stores. Other anemias not attributed to ID accounted for 9.6% of cases.

Sex distribution

Women constituted the overwhelming majority of iron-deficient individuals, representing 93% of all cases with IDA or NAID combined. This marked sex disparity persisted across all age groups and geographic regions.

Regional variations in clinical presentations

Significant geographic heterogeneity was observed across Saudi Arabia's 13 administrative regions (P < 0.001). ID prevalence among tested individuals ranged from 28% in the Al-Jouf region (northern Saudi Arabia) to 42% in the Makkah region (western Saudi Arabia) [Table 2 and Figure 2]. Among females specifically, ID rates in clinical samples reached as high as 69% in some regions.

This pattern may reflect: (1) differences in healthcare-seeking behavior and testing access, (2) regional dietary habits, (3) population demographics, including migrant composition, and (4) potentially genetic factors, including regional variation in hemoglobinopathy prevalence. The Eastern Province, known for having the highest sickle cell disease prevalence nationally (134.1 per 1,000), may experience additional complexity in anemia etiology.[13]

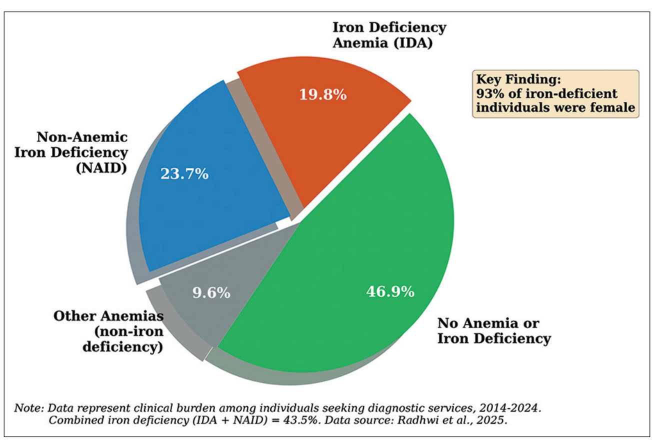

Figure 1: Distribution of iron status categories among laboratory surveillance cohort (n = 420,956)

Age-specific clinical burden

Among children younger than 12 years who underwent testing, 100% had anemia, with 45% meeting criteria for IDA specifically [Table 3a].

Critical interpretation note

This finding of universal anemia among pediatric cases is statistically implausible for the general population prevalence and indicates extreme selection bias. It

Table 1: Overall prevalence of iron deficiency and anemia along with sex distribution in Saudi Arabia (laboratory surveillance, 2014–2024)

Classification	*n*	Prevalence (%)	95% CI
IDA	83,349	19.8	19.7–19.9
NAID	99,747	23.7	23.6–23.8
Combined ID (IDA + NAID)	183,096	43.5	43.4–43.6
Other anemias (non-ID)	40,412	9.6	9.5–9.7
No anemia or ID	197,448	46.9	46.8–47.0
Total	420,956	100.0	–

Sex distribution of ID cases (percentage of total cases)

Category	Female (%)	Male (%)
IDA cases	93.0	7.0
NAID cases	93.0	7.0
All ID cases	93.0	7.0

Radhwi *et al*., 2025. This represents clinical burden among individuals seeking diagnostic services at Al Borg Diagnostics Laboratories (72+ branches across all 13 administrative regions), not population prevalence. CI=Confidence interval, ID=Iron deficiency, IDA=ID anemia, NAID=Non-anemic ID

Table 2: Regional variation in iron deficiency prevalence (laboratory surveillance)

Administrative region	Ranking	Notable factors
Makkah	Highest	Urban population, pilgrimage influx
Riyadh	High	Largest population center
Eastern province	High	Highest hemoglobinopathy prevalence
Asir	Moderate-high	Southern region
Madinah	Moderate	Religious tourism center
Jazan	Moderate	Southern coastal
Tabuk	Moderate	Northwestern
Qassim	Moderate	Central region
Northern borders	Low-moderate	
Hail	Low	
Najran	Low	Southern border
Al-Baha	Low	Southern highlands
Al-Jouf	Lowest	Northern region

Radhwi *et al*., 2025. Statistical significance: Chi-square test, P<0.001 for regional variation. Female-specific clinical prevalence: Up to 69% in highest-burden regions. These data represent clinical burden among individuals tested at private laboratories, not population prevalence. Regional variations reflect both true disease burden AND differences in healthcare-seeking behavior, testing access, and clinical referral patterns. Based on 420,956 individuals tested across all regions

Table 3a: Age-specific clinical burden in laboratory surveillance cohort

Population group	Sample size	Clinical prevalence (%)	Mean Hb (g/dL)	Interpretation	Source
Children <12 years	Variable	100.0 (anemia) 45.0 (IDA)	NR	Extreme selection bias Represents symptomatic/ suspected cases only, NOT population prevalence	Radhwi *et al.*, 2025
Elderly ≥ 65 years	Variable	29.0 (ID)	NR	Clinical burden among tested elderly	Radhwi *et al.*, 2025

ID=Iron deficiency, Hb=Hemoglobin, IDA=ID anemia, NR=Not reported

Table 3b: Age and sex-specific prevalence in population-based studies

Population group	Sample size	Prevalence (%)	Mean Hb (g/dL)	Study design	Source
Children					
Infants 6–24 months	500	49.0 (IDA)	NR	PHC-based screening	Al Hawsawi *et al.*, 2015
Children 7–11 years (rural)	147	27.2 (anemia)	NR	Rural community survey	Madani *et al.*, 2022
School children (Jeddah)	2850	20.5 (anemia)	NR	School-based survey	Abalkhail and Shawky, 2002
Adolescents					
Males 12–18 years (rural)	134	44.9 (anemia)	NR	Rural community survey	Madani *et al.*, 2022
Females 12–18 years (rural)	136	46.3 (anemia)	NR	Rural community survey	Madani *et al.*, 2022
Women of reproductive age					
Community-based, Riyadh	969	40.0 (anemia)	12.35±1.80	Two-stage cluster sampling	AlQuaiz *et al.*, 2013
WHO national estimate	National	43.7 (anemia)	NR	Modeled population estimate	WHO GHO, 2016
Pregnant women (WHO estimate)	National	45.5 (anemia)	NR	Modeled population estimate	WHO GHO, 2016
Pregnant women (Hail region)	390	34.1 (anemia)	NR	Urban health center-based	Alreshidi *et al.*, 2021
Female university students, Tabuk	200	12.5 (IDA)	NR	University-based survey	Alzaheb *et al.*, 2017

Hb=Hemoglobin, IDA=Iron deficiency anemia, NR=Not reported, PHC=Primary healthcare center, WHO=World Health Organization, GHO=Global Health Observatory

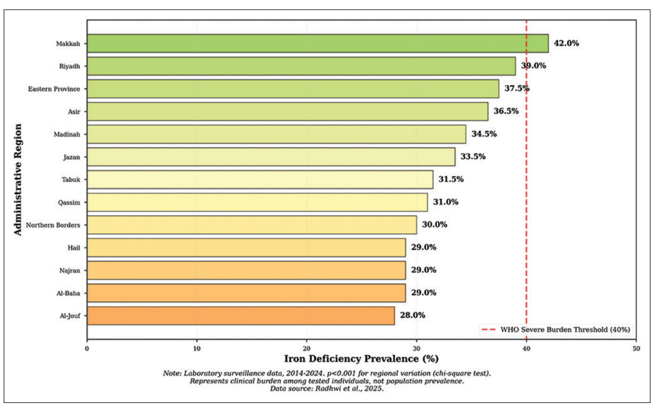

Figure 2: Regional variation in ID prevalence across Saudi Arabian administrative regions

strongly suggests that only children already known or suspected to be anemic were sent for this specific test panel by their physicians. This represents the clinical burden among symptomatic or high-risk pediatric cases, NOT the population prevalence of anemia in Saudi children. The finding underscores that laboratory surveillance data cannot estimate population prevalence and must be interpreted as reflecting healthcare-seeking patterns and clinical decision-making.

Among elderly individuals (65 years and older) in the laboratory dataset, ID prevalence was 29%, suggesting a persistent clinical burden across the lifespan among those seeking medical evaluation.

Stream 2: Literature review findings

Population-based prevalence estimates

Infants and young children

A primary healthcare center-based study in northwestern Saudi Arabia documented IDA prevalence of 49% among infants aged 6–24 months attending well-baby clinics[11] [Table 3b]. Among school-aged children (7–11 years) in the rural Khulais region, anemia prevalence was 27.2%.[14]

Adolescents

In rural Khulais, anemia prevalence among adolescents aged 12–18 years was 44.9% in males and 46.3% in females.[14]

Women of reproductive age

A community-based survey in Riyadh employing two-stage cluster sampling documented anemia prevalence of 40% (390 of 969 women), with a mean hemoglobin concentration of 12.35 g/dL (standard deviation ± 1.80).[10] The majority (83%) had mild anemia, while 14% had moderate anemia and 2% had severe anemia with hemoglobin <8 g/dL.

WHO global health observatory national estimates indicated even higher prevalence: 43.7% for women of reproductive age and 45.5% for pregnant women, both exceeding the 40% threshold for classification as an important public health problem.[3]

Among pregnant women in the Hail region, anemia prevalence was 34.1%.[12] Female university students in Tabuk showed 12.5% IDA prevalence,[6] likely reflecting younger age and higher socioeconomic status.

Systematic review of risk factors from published studies

Multivariate logistic regression analyses across multiple Saudi Arabian studies identified several significant risk factors [Table 4]:

Family and personal history

- Family history of IDA: Adjusted OR 2.91 (95% CI 1.78–4.76, $P < 0.01$)[10]
- Personal history of IDA: OR 2.74 (95% CI 1.79–4.19).[10]

Dietary factors

- Insufficient iron intake: OR 7.39 (95% CI 1.45–37.57) among female university students[6]
- Infrequent red meat consumption (≤2 times weekly): OR 7.70 (95% CI 2.91–20.39)[6] and OR 1.54 (95% CI 1.15–2.05)[10]
- Insufficient vitamin C intake: OR 4.44 (95% CI 1.87–10.55)[6]
- Tea consumption after meals: OR 2.04 (95% CI 1.35–3.08, $P = 0.019$) among pregnant women.[12]

Obstetric and gynecological factors

- Heavy menstrual bleeding with clots: OR 4.75 (95% CI 1.99–11.36)[6]
- Birth intervals <2 years: OR 2.23 (95% CI 1.20–4.41)[10]
- High parity (≥5 children): OR 1.52 (95% CI 1.02–2.23)[10]
- Multiparity: OR 1.49 (95% CI 1.02–2.16, $P = 0.023$).[12]

Socioeconomic factors

- Low family income: OR 1.72 (95% CI 1.04–2.87, $P = 0.026$)[12]
- Large family size (>5 members): OR 1.61 (95% CI 1.02–2.52, $P = 0.020$).[12]

Protective factor

- Higher body mass index (per unit increase): OR 0.95 (95% CI 0.92–0.97, $P < 0.01$),[10] although this relationship is complex and may reflect inflammation-mediated iron sequestration.

Temporal trends (1990–2024)

Global Burden of Disease 2021 data revealed encouraging trends over three decades. The age-standardized years lived with disability (YLD) rate attributable to dietary ID in Saudi Arabia declined by 44.5% between 1990 and 2021 (95% UI: −54.5% to −32.7%).[15] This decline ranked Saudi Arabia among the top three countries in the Middle East and North Africa (MENA) region for improvement, behind only Qatar (−46.6%) and Turkey (−46.2%).

Age-standardized ID prevalence decreased from 15,848.4 per 100,000 in 1990 (95% UI: 14,680.8–17,051.1) to 10,747.9 per 100,000 in 2021 (95% UI: 9692.8–12,160.4), representing a relative reduction of 32.2% (95% UI: −40.5% to −22.8%).[15]

Among children aged 6–59 months, WHO estimates indicated anemia prevalence decreased from 29.4% in 2000 to 21.8% in 2019, an absolute reduction of 7.6% points with an annual reduction rate of 0.4%.[16]

Table 4: Risk factors for iron deficiency anemia: Synthesis from population-based studies

Risk factor	Adjusted OR	95% CI	*P*	Study
Family/personal history				
Family history of IDA	2.91	1.78–4.76	<0.01	AlQuaiz *et al.*, 2013
Personal history of IDA	2.74	1.79–4.19	<0.05	AlQuaiz *et al.*, 2013
Dietary factors				
Insufficient iron intake	7.39	1.45–37.57	<0.05	Alzaheb *et al.*, 2017
Infrequent red meat (≤2×/week)	7.70	2.91–20.39	<0.05	Alzaheb *et al.*, 2017
Infrequent meat intake	1.54	1.15–2.05	<0.05	AlQuaiz *et al.*, 2013
Insufficient Vitamin C intake	4.44	1.87–10.55	<0.05	Alzaheb *et al.*, 2017
Tea consumption after meals	2.04	1.35–3.08	0.019	Alreshidi *et al.*, 2021
Obstetric/gynecological				
Blood clots during menstruation	4.75	1.99–11.36	<0.05	Alzaheb *et al.*, 2017
Birth interval <2 years	2.23	1.20–4.41	<0.05	AlQuaiz *et al.*, 2013
Parity ≥5 children	1.52	1.02–2.23	<0.05	AlQuaiz *et al.*, 2013
Multiparity	1.49	1.02–2.16	0.023	Alreshidi *et al.*, 2021
Socioeconomic				
Low family income	1.72	1.04–2.87	0.026	Alreshidi *et al.*, 2021
Large family size (>5 members)	1.61	1.02–2.52	0.020	Alreshidi *et al.*, 2021
Protective factors				
Higher BMI (per unit increase)	0.95	0.92–0.97	<0.01	AlQuaiz *et al.*, 2013

All ORs are adjusted values from multivariate logistic regression models controlling for confounders (age, socioeconomic status, dietary factors). BMI=Body mass index, CI=Confidence interval, IDA=Iron deficiency anemia, OR=Odds ratio

Despite these improvements, Saudi Arabia's 2021 prevalence remains higher than expected given its Socio-demographic index (SDI), with an observed-to-expected YLD ratio of 4.1, indicating substantial room for further improvement.[15]

Comparison with Gulf Cooperation Council countries

Important methodological note

Direct comparison between our laboratory surveillance data (clinical, biased toward symptomatic cases) and national survey data from other countries represents an "apples-to-oranges" comparison. The following comparisons use population-based estimates where available.

WHO 2019 estimates indicate anemia prevalence among women of reproductive age of 24.3% in the United Arab Emirates (UAE), 23.7% in Kuwait, approximately 26% in Qatar, 32% in Oman, and 35.5% in Bahrain.[17] Saudi Arabia's population-based estimate of approximately 40% exceeds all these comparators.

However, our clinical prevalence from laboratory surveillance (43.5% ID among tested individuals) is predictably higher than these population survey estimates, likely due to the symptomatic nature of our cohort. This highlights the critical importance of distinguishing clinical burden from population prevalence.

A GCC expert panel consensus statement reported that ID affects approximately 40% of women of childbearing age across the Gulf region collectively, with Saudi Arabia contributing substantially to this regional burden.[18]

GBD 2021 age-standardized ID prevalence rates position Saudi Arabia third lowest in the MENA region at 10,747.9 per 100,000, behind Qatar (9,061.9) and Kuwait (10,350.8), suggesting the gap is narrowing.[15]

Hemoglobinopathies as contributing factors

The high prevalence of hemoglobinopathies in Saudi Arabia complicates IDA epidemiology. National premarital screening data from 2011 to 2015 (n = 1,230,582) documented sickle cell disease prevalence of 49.6 per 1,000 (trait: 45.8, disease: 3.8) and beta-thalassemia prevalence of 13.6 per 1,000 (trait: 12.9, disease: 0.7).[13] These conditions cause chronic hemolysis and can mask or complicate ID assessment.

Note on study data

The laboratory surveillance dataset did not explicitly exclude patients with diagnosed hemoglobinopathies, as we analyzed aggregate de-identified data without individual medical histories. This represents a limitation in that some "IDA" cases may have had contributing hemoglobinopathies. However, given that IDA remains the predominant cause of anemia nationally, even in regions with high hemoglobinopathy prevalence, the impact on overall estimates is likely modest.

Regional variation is pronounced, with Eastern Province showing the highest sickle cell prevalence (134.1 per 1,000) compared to 13.5 per 1,000 in Northern Region.[13] This geographic pattern may partially explain regional anemia variations observed in our surveillance data.

Discussion

This comprehensive analysis integrating laboratory surveillance data with population-based evidence reveals that IDA remains an important public health problem in Saudi Arabia. The laboratory surveillance documented 43.5% ID prevalence among 420,956 individuals seeking diagnostic services nationally, while population-based studies demonstrate IDA prevalence of 40%–49% among women and infants using probability sampling methods.

Interpreting clinical burden versus population prevalence

A critical methodological consideration distinguishes our findings from traditional epidemiological studies. The laboratory surveillance data represent clinical burden – the disease distribution among individuals presenting for medical evaluation – rather than population prevalence estimated through random household surveys.

Our clinical prevalence of 43.5% ID among tested individuals likely overestimates population prevalence for several reasons:

1. Indication bias: Physicians order iron studies for symptomatic patients or those at high risk, enriching the tested population for cases
2. Socioeconomic selection: Private laboratory access requires insurance or out-of-pocket payment, potentially excluding lower-income populations
3. Healthcare-seeking behavior: Individuals who present for testing differ systematically from those who do not seek care.

The 100% anemia prevalence among children < 12 years in our laboratory cohort starkly illustrates this selection bias – only children already suspected of having anemia were tested. This finding should be interpreted as "100% of clinically suspected pediatric cases had confirmed anemia," not as population prevalence.

However, population-based studies from the literature provide convergent validity:

- Community sampling in Riyadh: 40% anemia prevalence among women[10]

- WHO modeled national estimate: 43.7% among women of reproductive age[3]
- Primary care infant screening: 49% IDA among 6–24 month olds.[11]

These population-based estimates align closely with our clinical data, suggesting that despite methodological limitations, the laboratory surveillance captures the real public health burden. The consistency across methodologies strengthens confidence in the approximately 40%–45% prevalence range for high-risk groups.

Risk factors and modifiable determinants

Dietary patterns play a central role in Saudi Arabia's IDA burden. Our risk factor synthesis demonstrated significant associations with infrequent meat consumption (OR 1.54–7.70), insufficient iron intake (OR 7.39), and inadequate Vitamin C intake (OR 4.44).[6,10] The traditional Saudi diet, while culturally significant, often features nonheme iron sources with lower bioavailability and includes iron absorption inhibitors such as tea consumed with or immediately after meals (OR 2.04).[12]

The strong familial aggregation (family history OR 2.91)[10] suggests both genetic susceptibility and shared environmental exposures within households. The high national consanguinity rate of 56% contributes to elevated hemoglobinopathy carrier frequencies, which may independently reduce hemoglobin levels and complicate IDA diagnosis.[5] Healthcare providers should maintain high clinical suspicion for concurrent conditions, particularly in the Eastern Province where sickle cell prevalence reaches 134.1 per 1000.[13]

Obstetric risk factors – short birth intervals (OR 2.23), high parity (OR 1.52), and heavy menstruation (OR 4.75) – highlight the physiological demands on women's iron stores during reproductive years.[6,10] These findings support routine iron supplementation during pregnancy and lactation, postpartum screening, and family planning counseling to optimize interpregnancy intervals.

Temporal trends and progress

The 44.5% decline in age-standardized disability burden from dietary ID between 1990 and 2021 represents substantial progress, likely attributable to healthcare system strengthening, improved nutrition awareness, and economic development.[15] However, the observed-to-expected ratio of 4.1 indicates Saudi Arabia's burden exceeds predictions based on socioeconomic development level, suggesting structural factors impeding optimal outcomes.

Regional disparities ranging from 28% in Al-Jouf to 42% in Makkah require targeted investigation. These variations may reflect differences in dietary culture, healthcare access and utilization, population demographics, including migrant composition, and underlying hemoglobinopathy prevalence.[9] Vision 2030 health transformation emphasizes reducing geographic inequities, and IDA represents an actionable marker for monitoring progress.[8]

Implications for Saudi Vision 2030 key performance indicators

The findings directly inform specific Vision 2030 health priorities:

Quality of life program – Maternal health key performance indicators

- Current gap: Only an estimated 70%–80% of pregnant women receive comprehensive antenatal screening, including hemoglobin testing
- Target: ≥95% coverage by 2030
- Recommendation: Integrate point-of-care hemoglobin testing into all first antenatal visits, with reflex ferritin testing for anemic women.

National transformation program – Primary healthcare

- Current gap: Opportunistic rather than systematic screening for ID
- Recommendation: Implement universal screening at 9–12 months for all infants, at menarche for adolescent girls, and preconception for women planning pregnancy.

Vision 2030 health pillar – Disability burden reduction

- Current status: 4.1-fold higher disability burden than expected for SDI level
- Target: Align observed-to-expected ratio to ≤2.0 by 2030
- Recommendation: Targeted supplementation programs for high-burden groups (pregnant women, infants 6–24 months, adolescent girls).

Dietary education and food security

- Recommendation: Develop culturally appropriate nutrition campaigns addressing: (a) increasing heme iron consumption, (b) vitamin C co-ingestion with iron-rich foods, (c) timing of tea consumption away from meals, (d) iron-fortified foods for high-risk groups.

Regional equity

- Current gap: 14%-point difference between the lowest (Al-Jouf, 28%) and highest (Makkah, 42%) burden regions
- Recommendation: Prioritize resource allocation to high-burden regions (Makkah, Riyadh, Eastern Province) while investigating protective factors in low-burden regions.

Comparison with regional neighbors

Comparison with Gulf Cooperation Council countries must acknowledge methodological differences. Our clinical data from symptomatic populations (43.5% ID) is expectedly higher than the UAE's population survey estimate (24.3% anemia).[17] When comparing population-based estimates, Saudi Arabia's approximately 40% prevalence among women exceeds most GCC peers (UAE 24.3%, Kuwait 23.7%, Qatar 26%, Oman 32%, and Bahrain 35.5%),[17] though methodologies vary across countries.

Shared regional factors, including hemoglobinopathy prevalence, similar dietary patterns, and comparable socioeconomic contexts, suggest opportunities for collaborative GCC-level strategies. Successful interventions from lower-burden countries (UAE, Kuwait) could inform Saudi policy.

Strengths and limitations

Strengths

1. Largest IDA clinical burden assessment from Saudi Arabia to date (n = 420,956) with nationwide geographic coverage
2. Integration of multiple data streams (laboratory surveillance, population surveys, WHO/GBD estimates), providing methodological triangulation
3. Clear distinction between clinical burden and population prevalence, acknowledging selection biases
4. Risk factor synthesis from community-based probability sampling studies
5. Temporal trends spanning three decades.

Limitations

1. Laboratory surveillance selection bias: The primary dataset represents individuals seeking diagnostic services at private laboratories, introducing socioeconomic and indication bias. Prevalence estimates likely overestimate population prevalence, as extensively discussed. The 100% pediatric anemia finding illustrates this extreme bias
2. Ferritin cutoff selection: Use of <30 ng/mL rather than the WHO standard <15 ng/mL likely inflates ID prevalence estimates. While appropriate for clinical populations and early depletion detection, this limits comparability with WHO-defined prevalence studies
3. Absence of inflammatory marker adjustment: The inability to adjust ferritin for concurrent inflammation (no CRP/ESR data) is a major limitation. This may underestimate ID prevalence in acutely ill patients (elevated ferritin masking deficiency) while potentially overestimating it in healthy individuals tested at the high 30 ng/mL threshold
4. Hemoglobinopathy exclusion: The laboratory dataset did not exclude patients with diagnosed thalassemia or sickle cell disease. Some "IDA" cases may have had contributing hemoglobinopathies, though IDA remains the predominant etiology nationally
5. Cross-sectional design: Precludes causal inference for risk factor associations; temporal relationships cannot be definitively established
6. Expatriate underrepresentation: Foreign residents comprise approximately 38% of Saudi Arabia's population but may be underrepresented in national estimates, limiting generalizability
7. Temporal trend data limitations: GBD estimates rely on modeling in data-sparse settings, with UIs reflecting this limitation.

Correlation with prevention policies and economic status

Reviewer suggestions regarding correlation with prevention policies and economic status warrant consideration. The regional variations observed (28%–42%) may partially reflect:

Economic factors

- Regions with higher GDP per capita (Riyadh, Eastern Province) show paradoxically high IDA burden, suggesting economic development alone is insufficient
- Food insecurity in rural areas (Jazan, Najran) may contribute to dietary ID
- Healthcare access disparities between urban and rural areas affect screening and treatment coverage.

Prevention policy implementation

- Premarital screening program coverage varies by region, with higher uptake in urban centers
- Primary care infrastructure development under Vision 2030 is uneven across regions
- Iron supplementation program availability and compliance differ regionally.

Future research should systematically examine these correlations using multilevel modeling approaches.

Novel diagnostic indices

Reviewer suggestions regarding hypochromic red blood cell (RBC) percentage and zinc protoporphyrin (ZPP) merit discussion. These indices offer advantages:

Hypochromic red blood cell percentage (modern hematology analyzers)

- Reflects functional iron availability for erythropoiesis
- Less affected by inflammation than ferritin
- Particularly useful in chronic disease and hemoglobinopathy contexts.

Zinc protoporphyrin
- Indicates iron-deficient erythropoiesis
- Point-of-care testing capability
- Cost-effective for resource-limited settings.

Future iterations of national surveillance should consider integrating these markers, particularly for populations with high hemoglobinopathy prevalence where traditional markers are confounded.

Conclusions

IDA persists as an important public health problem in Saudi Arabia. Laboratory surveillance of 420,956 individuals seeking diagnostic services documented 43.5% combined ID prevalence, while population-based studies demonstrate 40%–49% prevalence among women and infants using probability sampling. The 93% female predominance in clinical presentations and substantial regional disparities (28%–42% across regions) necessitate targeted interventions.

Despite encouraging 44.5% improvement in disability burden over three decades, Saudi Arabia's anemia prevalence exceeds expectations for its development status (observed-to-expected ratio 4.1). Regional disparities present opportunities for targeted resource allocation aligned with Saudi Vision 2030 KPIs.

Priority recommendations aligned with vision 2030

1. Strengthen screening programs: Integrate universal hemoglobin testing at 9–12 months (infants), menarche (adolescents), and first antenatal visit (pregnant women) to achieve ≥95% maternal health screening coverage
2. Targeted supplementation: Implement evidence-based iron supplementation for high-risk groups (pregnant women, 6–24-month infants, adolescent girls) with monitoring systems
3. Dietary education: Develop culturally appropriate campaigns addressing modifiable risk factors (meat consumption, Vitamin C intake, tea timing)
4. Regional equity: Prioritize resource allocation to high-burden regions (Makkah, Riyadh, Eastern Province) while investigating protective factors in low-burden areas (Al-Jouf, northern regions)
5. Enhanced surveillance: Incorporate novel indices (hypochromic RBC%, ZPP) and inflammatory markers (CRP) to improve diagnostic accuracy, particularly in hemoglobinopathy-prevalent regions.

Accelerating progress toward optimal maternal and child health outcomes requires multi-sectoral collaboration, integrating primary care strengthening, public health nutrition programs, and healthcare financing mechanisms that ensure equitable access to screening and treatment across all socioeconomic strata and geographic regions.

Data availability
All data used in this study are publicly available from the cited sources. Laboratory surveillance data are available from Radhwi *et al*. (2025). GBD data are available at https://ghdx.healthdata.org/.WHOdataareavailableat https://www.who.int/data/gho.

Acknowledgments
The author thanks the Al Borg Medical Laboratories for making their surveillance data publicly available, and acknowledges the Global Burden of Disease Collaborative Network and World Health Organization for providing open-access epidemiological data.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. GBD 2021 Anaemia Collaborators. Prevalence, years lived with disability, and trends in anaemia burden by severity and cause, 1990-2021: Findings from the Global Burden of Disease Study 2021. Lancet Haematol 2023;10:e713-34.
2. Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R, *et al*. A systematic analysis of global anemia burden from 1990 to 2010. Blood 2014;123:615-24.
3. Al-Jawaldeh A, Taktouk M, Doggui R, Abdollahi Z, Achakzai B, Aguenaou H, *et al.* Are countries of the Eastern Mediterranean region on track towards meeting the world health assembly target for anemia? A review of evidence. Int J Environ Res Public Health 2021;18:2449.
4. Safiri S, Kolahi AA, Noori M, Nejadghaderi SA, Karamzad N, Bragazzi NL, *et al.* Burden of anemia and its underlying causes in 204 countries and territories, 1990-2019: Results from the Global Burden of Disease Study 2019. J Hematol Oncol 2021;14:185.
5. Owaidah T, Saleh M, Gassim O, Madkhali AM, Al-Riyami A, Jawdat D, *et al*. Iron deficiency and iron deficiency anemia are common epidemiological conditions in Saudi Arabia: Report of the National Epidemiological Survey. Anemia 2020;2020:6642568.
6. Alzaheb RA, Al-Amer O. The prevalence of iron deficiency anemia and its associated risk factors among a sample of female university students in Tabuk, Saudi Arabia. Clin Med Insights Womens Health 2017;10:1179562X17745088.
7. Mustafa A, Alanazi G, Alanazi M, Alenezi A, Alenzi M, Al-Muteri F, *et al.* Prevalence and risk factors of anemia during pregnancy in Saudi Arabia: A systematic review. Cureus 2023;15:e49287.
8. Kingdom of Saudi Arabia Vision 2030. Health Sector Transformation Program. Available from: https://www.vision2030.gov.sa/. [Last accessed on 2026 Jan 23].
9. Radhwi OO, Raslan OM, Almoshary MA, Mansory EM. Unmasking iron deficiency and iron deficiency anemia in Saudi Arabia: Data from a large private sector lab. Saudi Med J

2025;46:1000-7.
10. AlQuaiz AM, Abdulghani HM, Khawaja RA, Shaffi-Ahamed S. Prevalence of anemia and associated factors in child bearing age women in Riyadh, Saudi Arabia. J Nutr Metab 2013;2013:636585.
11. Al Hawsawi ZM, Al-Rehali SA, Mahros AM, Al-Sisi AM, Al-Harbi KD, Yousef AM. High prevalence of iron deficiency anemia in infants attending a well-baby clinic in Northwestern Saudi Arabia. Saudi Med J 2015;36:1067-70.
12. Alreshidi MA, Haridi HK. Prevalence of anemia and associated risk factors among pregnant women in an urban community at the North of Saudi Arabia. J Prev Med Hyg 2021;62:E653-63.
13. Alsaeed ES, Farhat GN, Assiri AM, Memish Z, Ahmed EM, Saeedi MY, *et al.* Distribution of hemoglobinopathy disorders in Saudi Arabia based on data from the premarital screening and genetic counseling program, 2011-2015. J Epidemiol Glob Health 2018;7 Suppl 1:S41-7.
14. Madani BM, Alsulami AM 2nd, Abu Alola IA, Alasmari SM, Khoujah FM, Andijani OM, *et al.* Prevalence of anemia among children and adolescents in rural area of Khulais in Saudi Arabia. Cureus 2022;14:e21894.
15. Safiri S, Amiri F, Karamzad N, Sullman MJ, Kolahi AA, Abdollahi M. Burden and trends of dietary iron deficiency in the Middle East and North Africa region, 1990-2021. Front Nutr 2024;11:1517478.
16. World Health Organization. Global Health Observatory: Prevalence of Anaemia in Children Aged 6-59 Months. Geneva: World Health Organization; 2021. Available from: https://www.who.int/data/gho. [Last accessed on 2026 Jan 23].
17. Food and Agriculture Organization. The State of Food Security and Nutrition in the Arab States 2023. Rome: Food and Agriculture Organization; 2023. Available from: https://openknowledge.fao.org. [Last accessed on 2026 Jan 23].
18. Aleem A, Alsayegh F, Keshav S, Alfadda A, Alfadhli AA, Al-Jebreen A, *et al.* Consensus statement by an expert panel on the diagnosis and management of iron deficiency anemia in the Gulf Cooperation Council countries. Med Princ Pract 2020;29:371-81.