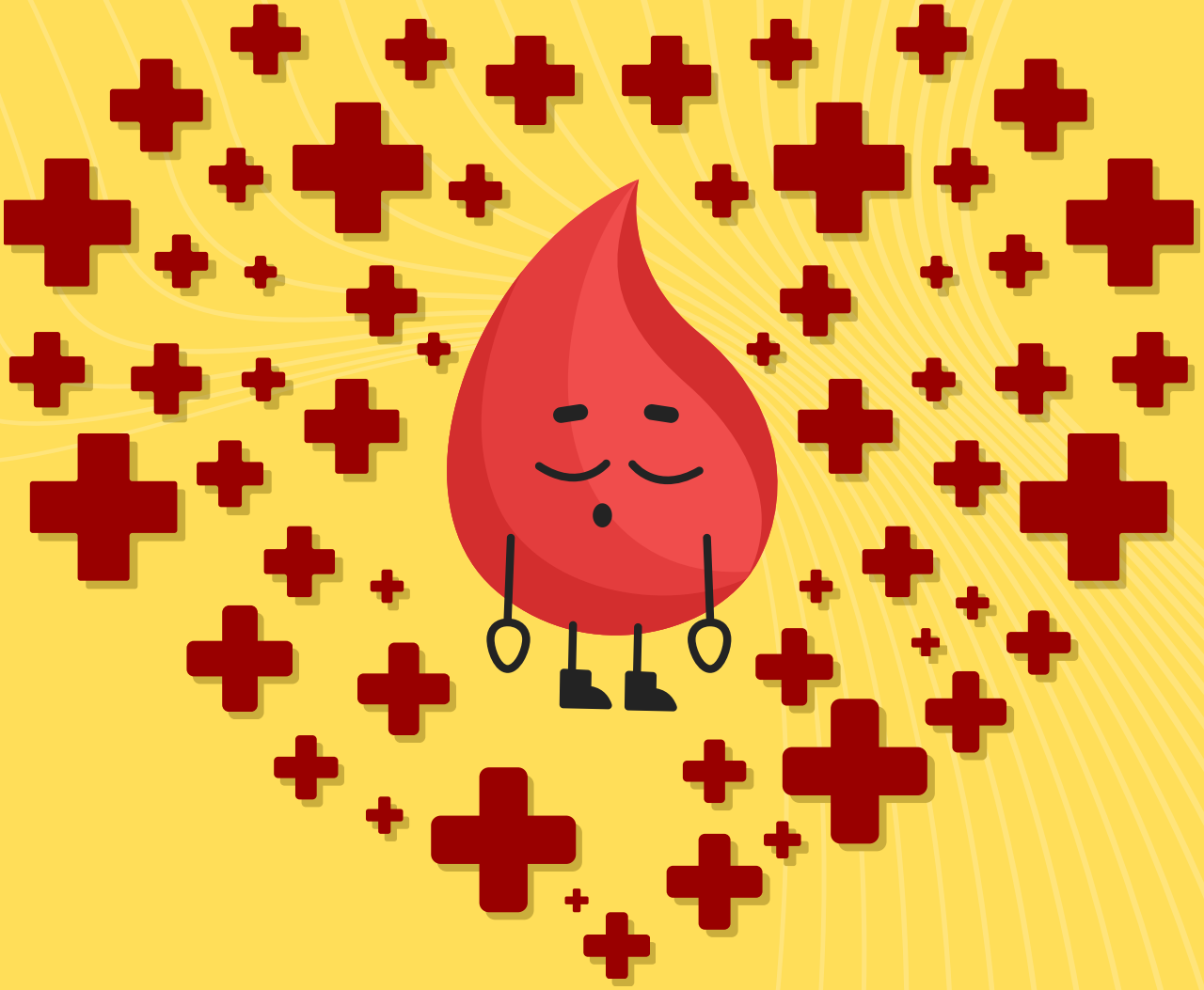
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Anemia in India:

Beyond Iron Supplementation to Comprehensive Clinical and Public Health Strategies

Pranjal Patil | Sneha Yadav | Shraboni Dey



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THE RISE

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Executive Summary

In India, anemia is one of the biggest public health challenges, with 57% of women and nearly two-thirds of children affected by it. Its effects go far beyond low hemoglobin levels, leading to poor maternal and newborn outcomes, and reduced productivity. Despite decades of implementing national policies, anemia continues to remain widespread because it has been treated as a single condition, while in reality it has multiple causes that are at times overlooked by policymakers.

Anemia in India comprises different disorders with distinct causes, including nutritional deficiencies (Iron & vitamin deficiencies), hereditary disorders (thalassemia and sickle cell disease), anemia due to chronic disease, inflammation and infection. Most screening programs rely on hemoglobin testing, which confirms a person is anemic but dies not establish the cause. Tests such as serum ferritin, C-reactive protein (CRP) and hemoglobin electrophoresis are important confirmatory tests that help identify specific causes, but are rarely available at the primary health care setting, making cause specific treatment difficult. Poor water, sanitation and hygiene (WASH) can contribute to recurrent infections, while poor adherence to iron treatment further undermines efforts to address anemia.

India's Anemia Mukt Bharat (AMB) program has established a nationwide, multisectoral response through nutrition, iron supplementation, deworming, screening, and behavior change. However, evidences show that an iron-folic acid centred approach alone cannot address anemia arising from non-nutritional or mixed causes. A more comprehensive response requires stronger diagnostic capacity alongside existing interventions. Potential improvements include non-invasive screening techniques, better digital integration through ABDM and e-Aushadhi, and the utilization of ferric carboxymaltose (FCM) as a diagnosis-confirmed intervention for patients who have been diagnosed with severe iron deficiency anemia. The experiences of Peru, Vietnam, and Thailand offer lessons in community participation, data use and cause-specific interventions, highlighting alternatives to one-size-fits-all approach.



To address these gaps, the report proposes a three-tier policy framework to combat anemia. The first tier focuses on Diagnostic and Data Infrastructure, using the proposed “National Anemia Etiology Dashboard” to track cause-specific surveillance of anemia. The second tier improves service delivery by improving diagnostic skills among frontline healthcare workers and encouraging timely referrals. The third tier promotes community ownerships and behavioural interventions by promoting the role of ASHA workers. Collectively, these tiers aim to ensure that resources are directed at appropriate areas to eliminate the underlying causes of anemia.

A realistic transition towards this approach is feasible, and most importantly, the need of the hour. By shifting gears from a predominantly iron-centred programme to one that is precise, data-driven, and community-owned, India can climb the ladder of improving maternal health, promoting healthier child development, increasing productivity, and building a healthier future generations.



Introduction

Anemia remains a major public health challenge in India. Despite its widespread prevalence, it continues to be overlooked and underestimated. Anemia is a condition wherein the number of red blood cells or the hemoglobin concentration in blood is lower than normal, leading to reduced oxygen-carrying capacity of blood. This leads to reduced supply of oxygen in the tissues, further leading to health consequences.

Anemia has significant long-term effects on the body. In adults, it increases the risk of cardiovascular complications, including myocardial ischemia, arrhythmias, left ventricular hypertrophy, and, in severe or prolonged cases, high output heart failure and multiorgan dysfunction. (1) Several research studies also indicate long-term changes in brain function regulation involving the midbrain and hippocampal pathways, which are essential for memory, learning and emotional regulation. (2)

The burden becomes even more severe during pregnancy, when physiological demands increase significantly. Maternal anemia is often associated with fatigue, and reduced exercise tolerance. It also increases susceptibility to infections, peripartum haemorrhage, and maternal morbidity and mortality. In fact, the World Health Organization estimates that anemia contributes to nearly 20% of maternal deaths in developing countries. (3)

In order to tackle it, India has been implementing several programmes, such as the Anemia Mukt Bharat and Weekly Iron and Folic Acid Supplementation (WIFS) Program.

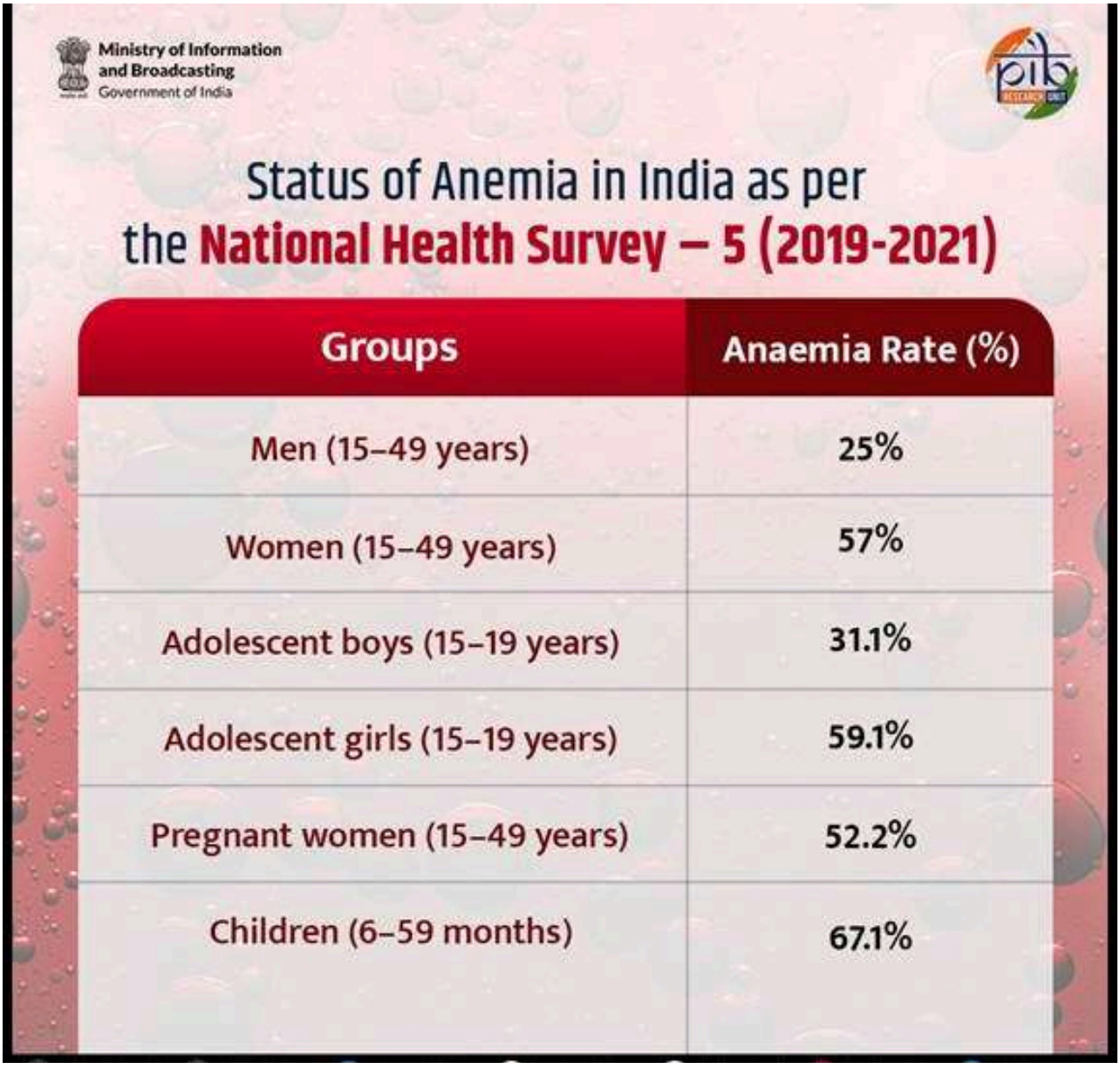
These programmes combine Iron and Folic Acid supplementation with deworming, nutrition interventions, behaviour change campaigns, and point-of-care screening strategies to reduce anemia across different population groups, including children, adolescents, women of reproductive age, pregnant women, and lactating mothers.

Despite these initiatives, India continues to face high burden of anemia, highlighting persistent limitations in current anemia management strategies. One major concern has been the continued tendency to attribute anemia majorly to iron deficiency. Even today, the diagnosis revolves around basic complete blood count (CBC) and hemoglobin level testing. A comprehensive workup, like tests such as hemoglobin electrophoresis, is needed to distinguish between the different types of anemia, which may share overlapping hematologic findings.

Furthermore, indiscriminate prescription of iron supplementation to individuals who are not iron deficient can result in side effects such as nausea, constipation, abdominal discomfort, bloating, and an unpleasant metallic taste, leading to poor treatment compliance. Moreover, certain population groups like men, older adults and people with chronic illnesses, have received comparatively less attention in anaemia-focused public health strategies. The WHO also recognizes that anemia has multiple causes, including nutritional deficiencies, inflammation, infections, chronic diseases and inherited red blood cell disorders.

The purpose of this study is to understand why anemia continues to be highly prevalent despite decades of national supplementation and public health programs, and to identify the social and behavioral barriers limiting the success of the existing anemia control programs.

The study also seeks to examine the complexity of different types and causes of anaemia, explore the disconnect between policy implementation and actual patient outcomes at the community level, and understand the social factors associated with the condition. Finally, it aims to propose necessary policy, technological and community-level suggestions to strengthen anemia management in India.



Methodology

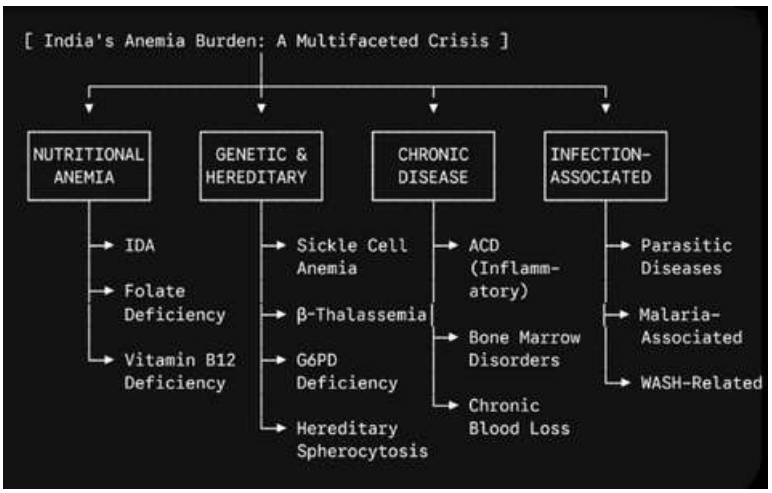
This study uses a mixed-methods approach, combining evidence from published scientific literature with real-world patient perspectives to provide a more comprehensive understanding of anemia in India.

Chapter 1

Understanding Anaemia in India: Causes, Consequences and Diagnostic Gaps

Despite decades of anemia control efforts, India continues to carry one of the world's heaviest anemia burdens. While Iron Deficiency Anemia (IDA) has remained the major focus of public health interventions, anemia in India is clinically heterogeneous. This chapter aims to map the burden and the spectrum of anemia across India, exploring the clinical and diagnostic limitations associated with its management, and highlight the emerging issues that arise when this multifaceted crisis is approached through an iron-deficiency lens.

While iron deficiency remains a major contributor, a significant percentage of anemia cases also emerge from various other causes, including micronutrient deficiencies (such as Vitamin B12 and folate), genetic hemoglobinopathies (including thalassemia and sickle cell disease), and anemia of chronic inflammation. A one-size-fits-all approach centred on iron supplementation may therefore risk oversimplifying the management of anemia, highlighting the need for distinct diagnostic pathways, appropriate clinical evaluation, and targeted treatment strategies.



India's Anemia Burden: A Multifaceted Crisis

1. Nutritional Types of Anemia:

1. Iron Deficiency Anemia: It is the most common nutritional form of anemia that occurs when the body does not have sufficient iron to produce adequate hemoglobin. It is associated with inadequate dietary intake, poor absorption, increased physiological requirements, or chronic blood loss.

2. Folate Deficiency Anemia: It is a type of nutritional anaemia that occurs when the body does not have enough folate (vitamin B9) to produce healthy red blood cells. It is commonly associated with poor nutrition, malabsorption, and increased physiological demands during pregnancy.

3. Vitamin B12 Deficiency: It is a nutritional anemia that occurs when inadequate vitamin B12 levels impair normal red blood cell production, resulting in abnormally large and immature red blood cells. Inadequate dietary intake can increase the risk of deficiency, particularly among people following vegetarian or vegan diets without sufficient B12 sources or supplementation.

2. Hereditary types of Anemia:

1. Sickle cell Anemia: It is a hereditary blood disorder caused by a mutation in the β-globin gene, leading to the production of abnormal hemoglobin (HbS). This causes red blood cells to become sickle-shaped, making them fragile. An estimated 82,500 children are born with sickle cell disorders each year in India. It is particularly prevalent among tribal populations in states such as Maharashtra, Odisha, Chhattisgarh, and Gujarat.(6)

2. β-Thalassemia: It is a genetic blood disorder in which the body cannot produce adequate amounts of normal hemoglobin due to reduced or absent synthesis of β-globin chains. It is notably common among Sindhi, Punjabi, Gujarati, and certain Mediterranean-descendant communities, where carrier prevalence remains high.

3. G6PD Deficiency-Associated Hemolytic Anemia: Glucose-6-phosphate dehydrogenase (G6PD) deficiency is an inherited condition in which red blood cells may be destroyed following exposure to oxidative stress. Episodes may be triggered by certain drugs, infections, or foods such as fava beans.

4. Hereditary Spherocytosis: This inherited disorder, caused by defects in red blood cell membrane proteins, leads to the production of spherical red blood cells, that are prone to premature destruction. It often remains undiagnosed until later stages of life.

Other types of anemia:

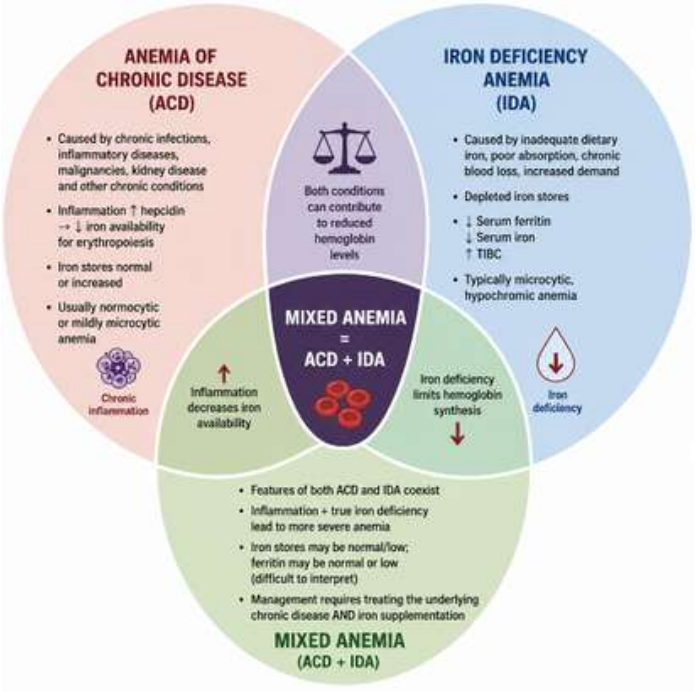
1. Aplastic anemia: It is a rare condition in which the bone marrow stops making enough blood cells, including red blood cells, white blood cells, and platelets. Fanconi anemia is a rare inherited genetic disorder that can cause aplastic anemia. These bone marrow disorders can lead to severe fatigue and infections.

2. Anemia of Chronic Disease (ACD): It commonly occurs in association with chronic inflammatory and systemic illnesses such as tuberculosis, chronic kidney disease (CKD), rheumatoid arthritis, HIV and cancer. In these conditions, inflammation increases the production of hepcidin, a hormone that regulates iron availability. Elevated hepcidin reduces iron absorption from the intestine and limits the availability of iron for red blood cell production. Management required addressing the underlying condition and distinguishing ACD through appropriate diagnostic evaluation.

3. Infection-Associated Anemia: Persistent infections can contribute to anemia through inflammation, destruction of red blood cells, or blood loss. Although infection-associated anemia may overlap with anemia of inflammation, the mechanisms vary depending on the infection. Iron supplementation alone may not resolve the condition without appropriate treatment of the underlying infection. Improved water, sanitation and hygiene (WASH) conditions can also help prevent infections that contribute to anemia.

4. Parasitic Disease-Associated Anemia- Parasitic diseases such as hookworm infections and malaria transmitted by the Anopheles mosquito also contribute significantly to India's anemia burden. Hookworm-related anemia is associated with chronic intestinal blood loss and is a concern in areas with inadequate sanitation. Malaria-associated anemia results from the destruction of red blood cells and is particularly relevant in endemic regions, including some tribal areas.

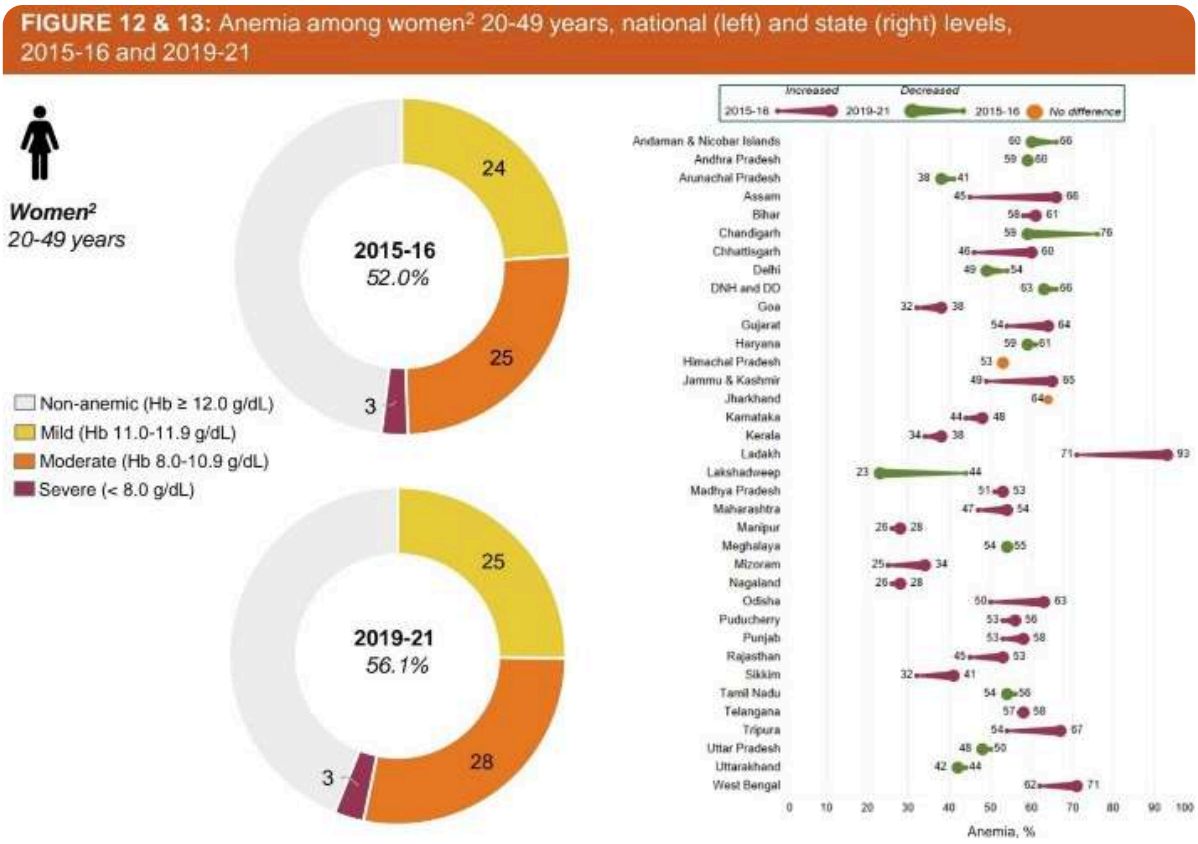
5. Anemia Due to Chronic Blood Loss: It is caused due to prolonged blood loss, which may result from gastrointestinal bleeding, hemorrhoids, peptic ulcer disease, or malignancies. Because the blood loss is gradual, patients may remain asymptomatic for long periods until severe anemia develops.



Prevalence and Geographical Distribution of Anemia in India

Anemia affects individuals across all age groups - children, adolescents, pregnant women, and adults, in both rural and urban communities. According to the National Family Health Survey-5 (NFHS-5, 2019–21), 67.1% of children aged 6–59 months were anemic. The burden remains equally alarming among adolescent girls, at 59.1%, reflecting the combined impact of rapid growth, menstrual blood loss, and inadequate nutrition.

Among women aged 15–49 years, 57% are anemic, including 52.2% of pregnant women. Maternal anemia can increase the risk of adverse maternal and neonatal outcomes, including low birth weight and preterm delivery. Among men aged 15–49 years, 25% were anemic.(4) This variation occurs not only across the age groups but also across the geographical regions in India.



Source: NFHS-4 and NFHS-5 unit-level data [IFPRI estimates]

- **Northern India**

Northern India carries a substantial burden of anemia, particularly among women and children. States such as Punjab, Haryana, Rajasthan, Uttar Pradesh, and Jammu & Kashmir continue to report high prevalence despite relatively better healthcare infrastructure in some regions. Union Territories like Ladakh, with its high-altitude environment, difficult terrain, scattered settlements, and challenges in accessing healthcare services, presents a distinct regional context for addressing childhood anemia. NFHS-5 reported anemia prevalence of 92.8% among children aged 6–59 months in Ladakh.

• **Eastern and Central India**

Eastern and central India also report a high burden of anemia in the country. West Bengal (71.4%), Bihar (63.5%), Jharkhand, Odisha, Madhya Pradesh, and Chhattisgarh consistently report some of the highest anemia prevalence among women and children.

• **Western India**

Western India demonstrates marked regional variation. While states such as Maharashtra report a moderate burden, Gujarat remains one of the worst-affected states, with nearly 80% of children aged 6–59 months being anemic according to NFHS-5. Persistent nutritional deficiencies, socioeconomic disparities and access to healthcare services continue to contribute significantly to the disease burden.

• **North-Eastern India**

The North-East shows considerable heterogeneity. States such as Assam (65.9%) continue to report a high prevalence of anemia among women, whereas Nagaland and Manipur have comparatively lower childhood anemia rates (approximately 43%), illustrating the influence of regional dietary patterns, socioeconomic conditions, and healthcare access.

• **Southern India**

Southern India generally reports the lowest prevalence of anemia in the country. Kerala, in particular, consistently performs better than most states, with anemia affecting 36.3% of women aged 15–49 years and 39.4% of children aged 6–59 months (NFHS-5). Better female literacy, stronger primary healthcare systems, improved maternal health services, and higher nutritional awareness are considered important contributors to these comparatively favorable outcomes.

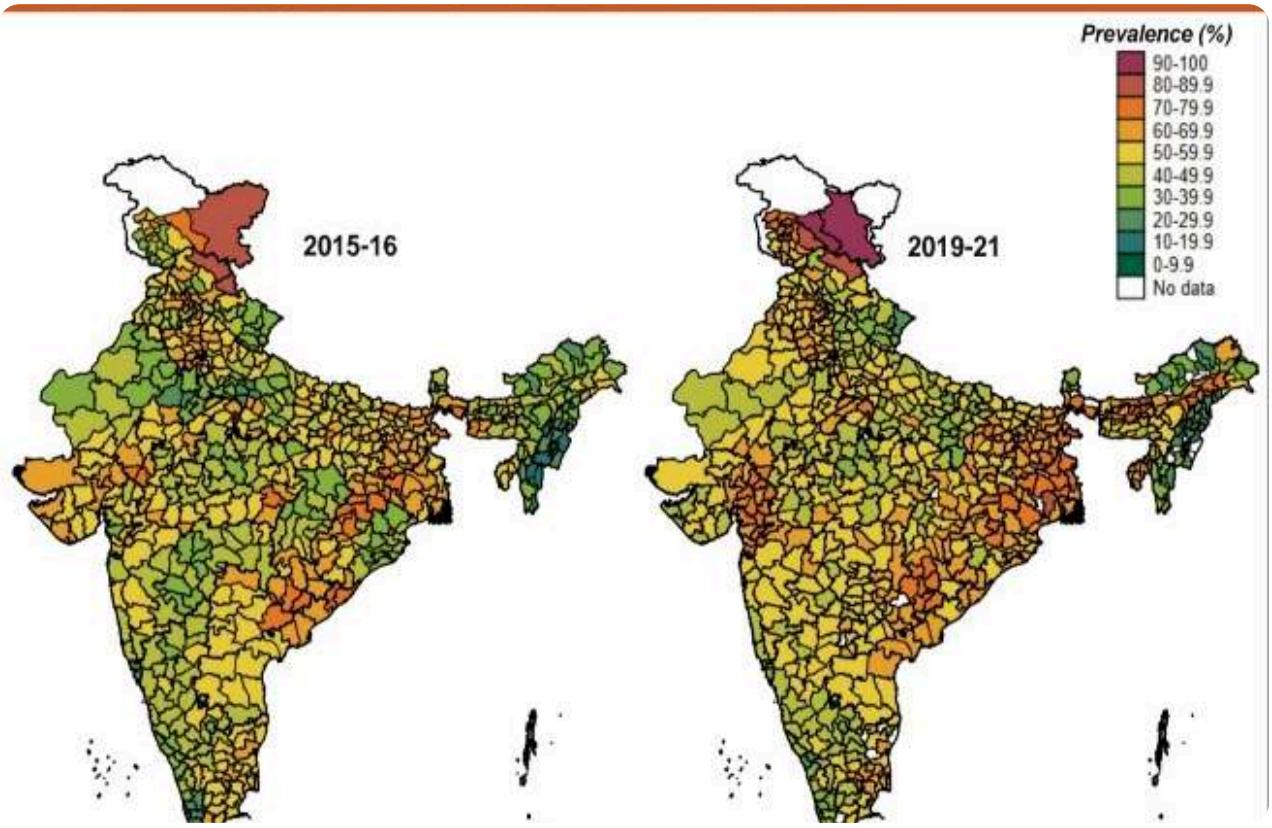


Determinants of Anemia

Beyond its overall prevalence and geographical distribution, anemia is influenced by a range of nutritional, socioeconomic, environmental and infectious factors. These factors may interact, shaping the risk of anemia across different population groups.

1. Socioeconomic and Educational Factors

One of the most striking revelations from India's national health data is that wealth provides no absolute immunity against anemia. While it is easy to assume that iron deficiency is exclusively a disease of poverty, the numbers reveal something else. According to NFHS-5 (2019–21), 52.8% of women in the wealthiest 20% of the population were anemic. This proves that income alone does not guarantee adequate nutritional quality or protect against other underlying causes of anemia.



Source: NFHS-4 and NFHS-5 unit-level data [IFPRI estimates]

Educational attainment also demonstrates a direct association with anemia prevalence. Women with no formal schooling have anemia prevalence of 64%, however, among women who have completed 12 or more years of education, the anemia prevalence drops to 51%. For example, in Kerala literacy can be one of the factors that beautifully mirrors the positive impact of education on healthcare. Kerala reports one of the lowest anemia prevalences in India, with NFHS-5 (2019–21) estimating anemia in 36.3% of women aged 15–49 years, 31.4% of pregnant women, 39.4% of children aged 6–59 months, and 17.8% of men aged 15–49 years.

2. Burden Among Vulnerable Communities

Anemia disproportionately affects marginalized communities. According to national health data, 65.3% of women belonging to Scheduled tribes were anemic, compared to 52.8% of women in the general or non-marginalized caste categories. For many tribal populations, deep geographic isolation, food insecurity, limited dietary diversity and barriers to healthcare compound the risk anemia.The gender gap due to menstruation and childbearing in women is also substantial. While 57% of women aged 15-49 are anemic in India, only 25% of men in the exact same age bracket suffer from it.

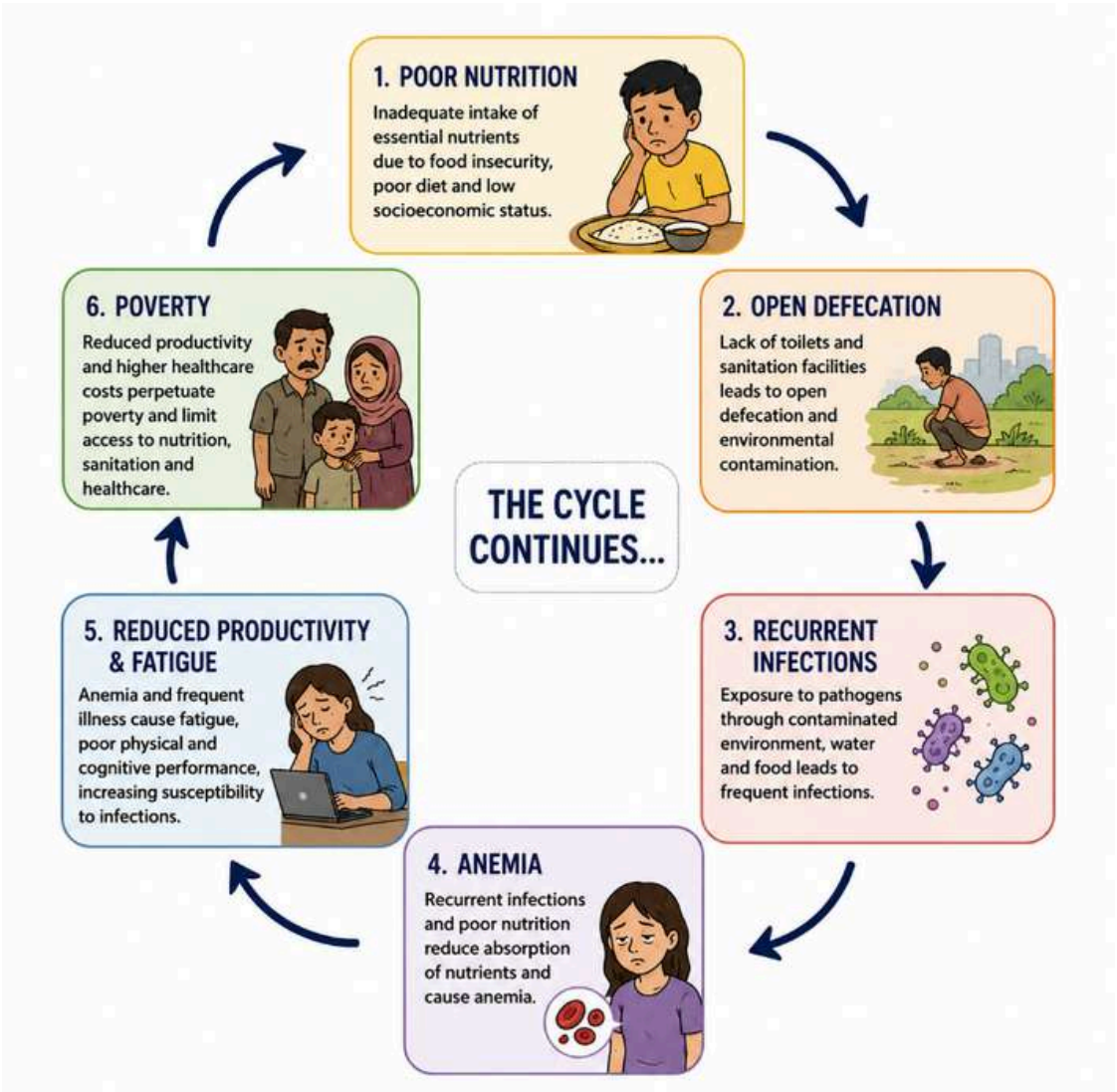
3. Water, Sanitation, Hygiene (WASH), and Infections

Poor water, sanitation, and hygiene (WASH) conditions remain a major public health challenge in many low- and middle-income countries, particularly in rural and underserved communities. Limited access to safe drinking water, open defecation, inadequate sanitation facilities, and poor hygiene practices contribute substantially to the burden of infectious diseases. These conditions increase exposure to enteric pathogens, intestinal parasites, and recurrent gastrointestinal infections, all of which can contribute to anemia through blood loss, inflammation and impaired nutritional absorption.



For instance, in areas of open defecation, eggs of hookworm infestation like *Ancylostoma duodenale* and *Necator americanus* can contaminate the soil. The larva that gets hatched from the egg then penetrates the soles of bare feet or other exposed skin. After entering the bloodstream, the adult worm feeds on intestinal mucosa and leads to continuous microscopic blood loss everyday, contributing to iron-deficiency anemia. Malaria provides another example of infection-associated anemia. It is particularly prevalent in regions with stagnant water and is more widespread in tropical and subtropical areas such as India and parts of Africa. It leads to destruction of red blood cells (hemolysis) and suppression of bone marrow function, thereby reducing red blood cell production and impairing hemoglobin synthesis.

Therefore, a vicious cycle can be observed here.



Issues in Anemia Management

Although anemia is widely recognised as a public health concern in India, its effective management remains challenging. These challenges include difficulties in identifying the underlying cause, limited access to advanced diagnostic tests, and gaps in laboratory infrastructure and human resources.

- **Diagnostic Limitations and Etiology-Based Evaluation**

Hemoglobin (Hb) estimation is widely used to identify anemia in India. However, Hb levels confirm the presence of anemia but do not establish its underlying cause. More comprehensive diagnostic approach is required to differentiate iron deficiency anemia from anemia associated with chronic inflammation, vitamin deficiencies, hemoglobinopathies and other conditions. (7)

Red blood cell indices, including Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Red Cell Distribution Width (RDW), can provide useful clues about the type of anemia but remain underutilized.

Iron studies are important when iron deficiency is suspected, but interpreting their results can be challenging, especially when inflammation is also present. Total Iron-Binding Capacity (TIBC), which indirectly reflects the blood's capacity to transport iron, is typically elevated in iron deficiency anemia but may be normal or reduced in anemia associated with chronic inflammation because transferrin production decreases.

Similarly, serum ferritin, one of the most commonly used indicators of iron stores, is also an acute-phase reactant. During infection or inflammation, ferritin levels may increase independently of iron status, potentially making underlying iron deficiency. As a result, patients with depleted iron stores may appear to have normal or elevated ferritin concentrations.



These limitations highlight why anemia diagnosis may require multiple tests interpreted together, rather than relying on a single iron marker alone.

C-reactive protein (CRP) is an inflammatory biomarker that increases during acute and chronic inflammatory conditions. When interpreted alongside iron studies, an elevated CRP may indicate the presence of inflammation that could contribute to anemia or complicate the interpretation of iron status.

Erythrocyte sedimentation rate (ESR) is another marker of systemic inflammation that is frequently elevated in chronic infections and inflammatory disorders. Although non-specific, it can support the diagnosis of anemia of chronic disease when interpreted in conjunction with clinical findings and other laboratory investigations.

The situation becomes even more complex in cases of mixed anemia, where iron deficiency co-exists with chronic inflammation.

1. Limited Accessibility to Advanced Diagnostic Interventions

Limited diagnostic capacity at primary healthcare facilities often makes it difficult to identify the underlying cause of anemia. Most primary care settings rely primarily on hemoglobin estimation and lack access to advanced investigations required to differentiate different types of anemia, such as hemoglobin electrophoresis, High-Performance Liquid Chromatography (HPLC), and genetic testing. This equipment is essential to diagnose the hereditary causes of anemia like sickle cell anemia and thalassemia.

In some patients, anemia may have multiple underlying causes, such as iron deficiency coexisting with chronic inflammation or other nutritional deficiencies. Identifying these overlapping causes may require additional investigations guided by the patient's clinical presentation.

Depending upon the suspected etiology, a comprehensive diagnostic workup, including investigations such as sputum cytology and culture, stool examination and culture, CBNAAT, liver function tests (LFTs), and renal function tests (RFTs) is important to identify the underlying etiology. Inconsistent availability can interrupt treatment, reduce patient adherence, and delay recovery.

The absence of inflammatory markers and specialized diagnostic tests may result in delayed recognition of the root cause of anemia and can affect appropriate management strategies.

2. Limitations in the Laboratory Infrastructure and Human Resources

Wide disparities in laboratory infrastructure and quality control across healthcare facilities affect the accuracy and standardization of anemia diagnosis across India. India also faces a stark imbalance between the large number of individuals affected by anemia and the limited availability of hematologists and trained healthcare providers, especially in underserved rural regions.

- **Clinical limitations**

Anemia usually presents with vague symptoms like fatigue, weakness, dizziness, and poor concentration. It may overlap with several other conditions like depression, malnutrition, and sleep deprivation. This leads to delayed diagnosis and healthcare-seeking.

1. Poor Treatment Adherence and Follow-ups

Many patients experience side effects like nausea, constipation, abdominal discomfort, bloating, and an unpleasant metallic taste, which leads to poor treatment compliance. Counselling regarding anemia management remains inadequate, and patient follow-up and adherence to iron supplementation are often poorly documented and monitored.

2. Limited Access to Specialized Care

Patients with complex conditions such as thalassemia and sickle cell disease often require specialist evaluation, repeated blood transfusions, and long-term follow-up which require referral to tertiary care centres that may be located far from rural areas.

3. Health System Constraint

Nutrition, sanitation, education, and healthcare programs frequently operate independently rather than as an integrated framework, thereby reducing their overall effectiveness. In addition, frequent shortages of iron tablets pose a significant challenge to anemia control efforts.

4. Research and Evidence Gaps

Research gaps further limit progress. While epidemiological data on anemia prevalence is abundant, there is a shortage of large-scale clinical trials and longitudinal studies tracking non-iron deficiencies like vitamin B12 and genetic causes of anemia. These gaps limit the evidence available to guide etiology-specific prevention and treatment strategies.

Further research is needed to evaluate the use and accessibility of diagnostic biomarkers, including ferritin and inflammatory markers such as C-reactive protein (CRP), particularly where inflammation complicates the assessment of iron status. Hepcidin may also have diagnostic value, although its routine clinical use remains limited.



- **Implementation/behavioral Issues**

1. Treatment Adherence due to Pill Fatigue

In many communities, healthcare access is reactive rather than preventive; that is, people seek help only when symptoms become severe. Pill fatigue is when a person gets tired or frustrated with taking medications regularly for a long time, which may lead to missed doses or treatment discontinuation. Treatment adherence, meanwhile, refers to the extent to which patients follow their prescribed treatment, including medication use and follow-up appointments.

One major Indian study found that adherence to iron-folic acid tablets was below 50% among pregnant women nationally (8). A Haryana study reported that around 21.6% of women were non-compliant (9), while another study in Surat found that about 38.3% of women were not fully compliant. (10) These findings indicate the existing challenges in maintaining adherence to treatment of anemia.(11)



Story of Renu

At first, it was subtle, just a heaviness in her limbs after household work, a sense that climbing stairs took slightly more effort than before. She brushed it off. There was always something more important than her own fatigue: her children's school routines, their exams, the household responsibilities, her husband's long working hours. Afterall, why would she waste money at the hospital for such a pitiful thing like weakness?

So, she adjusted. She learned to live within her weakness. The daily fatigue and breathlessness slowly became her normal.

Her close friend, Asha, saw how she was becoming increasingly pale and exhausted. Concerned, she eventually took her to the nearest primary health centre. The doctor there examined her and said, "Your hemoglobin is 6.5 g/dL. You need to take these iron tablets regularly for at least four weeks and follow up in a month."

She took the tablets, and started feeling much better. After two weeks, her fatigue subsided, and she stopped taking them. No follow-up took place.
Years passed by, and her condition worsened. She had a hemoglobin of 2.1 g/dL, a level so low that it is almost incompatible with human life. The doctors were astonished to see her walking into the clinic on her two feet with normal consciousness.

Renu's story reflects how delayed healthcare-seeking, premature discontinuation of treatment and gaps in follow-up can compound the burden of anaemia. Across India, many women continue to face similar barriers

2. **Treatment Adherence due to Hesitancy associated**

Similar to conditions like tuberculosis, treatment of anemia is associated with long term use of medications. This may be misinterpreted by the patients as if they are suffering from a serious or chronic disease.

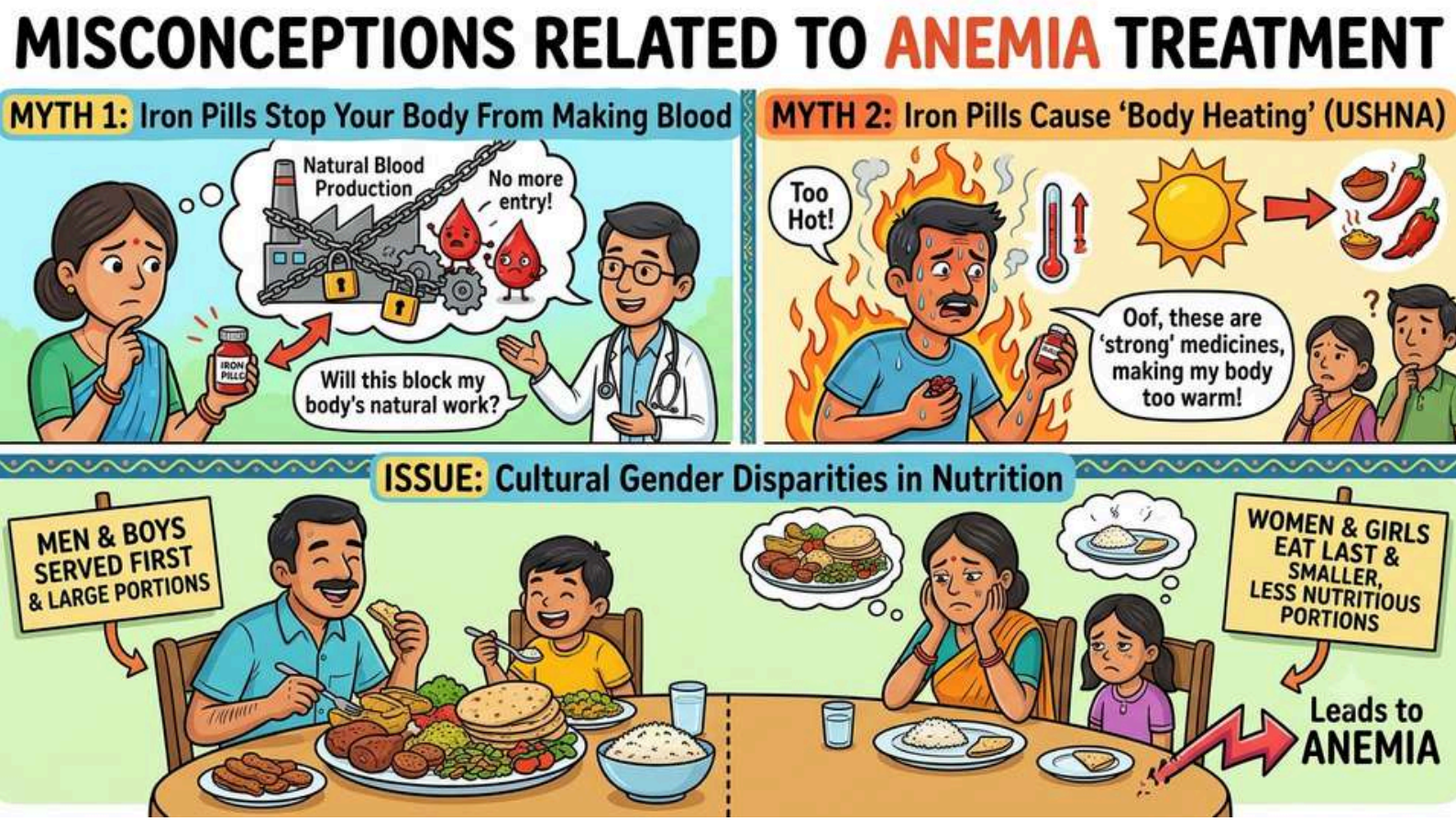
Furthermore, there have been misconceptions regarding the usage of iron tablets. Several patients believe that it will lead to dependency, i.e., patients would have to take the iron pills lifelong. Others believe that these pills would permanently suppress their body's natural capacity for blood production (erythropoiesis). Clinically, however, this is entirely inaccurate; iron therapies do not suppress bone marrow function, but rather act as essential substrates to replenish depleted iron stores and support haemoglobin production.

There is also a local belief in some Indian communities that iron pills are "strong medicines" that cause "heating of the body" (*ushna*). These beliefs may further discourage adherence to iron supplementation.

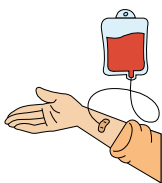
Collectively, these factors explain why many patients ultimately opt for alternative therapeutic modalities. Some believe that ayurvedic medication may be more beneficial, thus abruptly discontinuing the regimen.

While certain Ayurvedic formulations have demonstrated potential benefits in managing mild or preventative cases of anemia, there is a need for evidence-based interventions in severely anemic patients. Clinical management must focus on improving treatment adherence while empathetically guiding patients who wish to integrate traditional therapies into their care. Moreover, some communities also favour dietary approaches to replenishing iron over medical supplementation, including traditional practices such as cooking in iron utensils (tawas).

While dietary changes do play an important role in the prevention and long-term management of anemia, they cannot replace medical treatment when clinically indicated, particularly in severe cases. The data on dietary habits also highlight that while heme iron from meat is biologically easier for the human body to absorb, eating meat does not automatically protect against iron deficiency. In fact, the national health survey shows a remarkably tiny gap in anemia rates between meat-eaters and strict vegetarians. Women who consume fish, chicken, or meat daily experience an anemia prevalence of 55.1%, while those who never consume meat, fish, or eggs sit just slightly higher at 57.2%.



AI-Generated Representational Image showing Misconceptions Related to Anemia Treatment



Crucially, a purely nutritional approach overlooks the clinical heterogeneity of anemia. Hereditary etiologies such as sickle cell disease and thalassemia are entirely unresponsive to dietary modifications alone, requiring specialized hematological care, regular blood transfusions, and structured medical management.

Other Limitations to Anemia Management

In several traditional households, to date, men are often served food first, while women and girls eat later and consume smaller and less nutritious portions. As a result, many women consume fewer iron-rich foods, and girls may begin suffering from nutritional deficiencies as early as childhood. In some communities, the health and nutrition of boys are consciously or unconsciously prioritised over girls, thus affecting their overall health and development. Early marriage, adolescent pregnancy, short birth intervals, and delayed treatment-seeking for heavy menstrual bleeding also contribute to chronic anemia among women.

Conclusion

Anemia affects millions of people every day, often limiting their ability to learn, work, and live healthy lives. Behind every statistic is a child struggling to concentrate in school, a mother facing complications during pregnancy, or an individual living with constant fatigue. The causes of anemia are complex and interconnected, and no single solution can address the problem effectively.

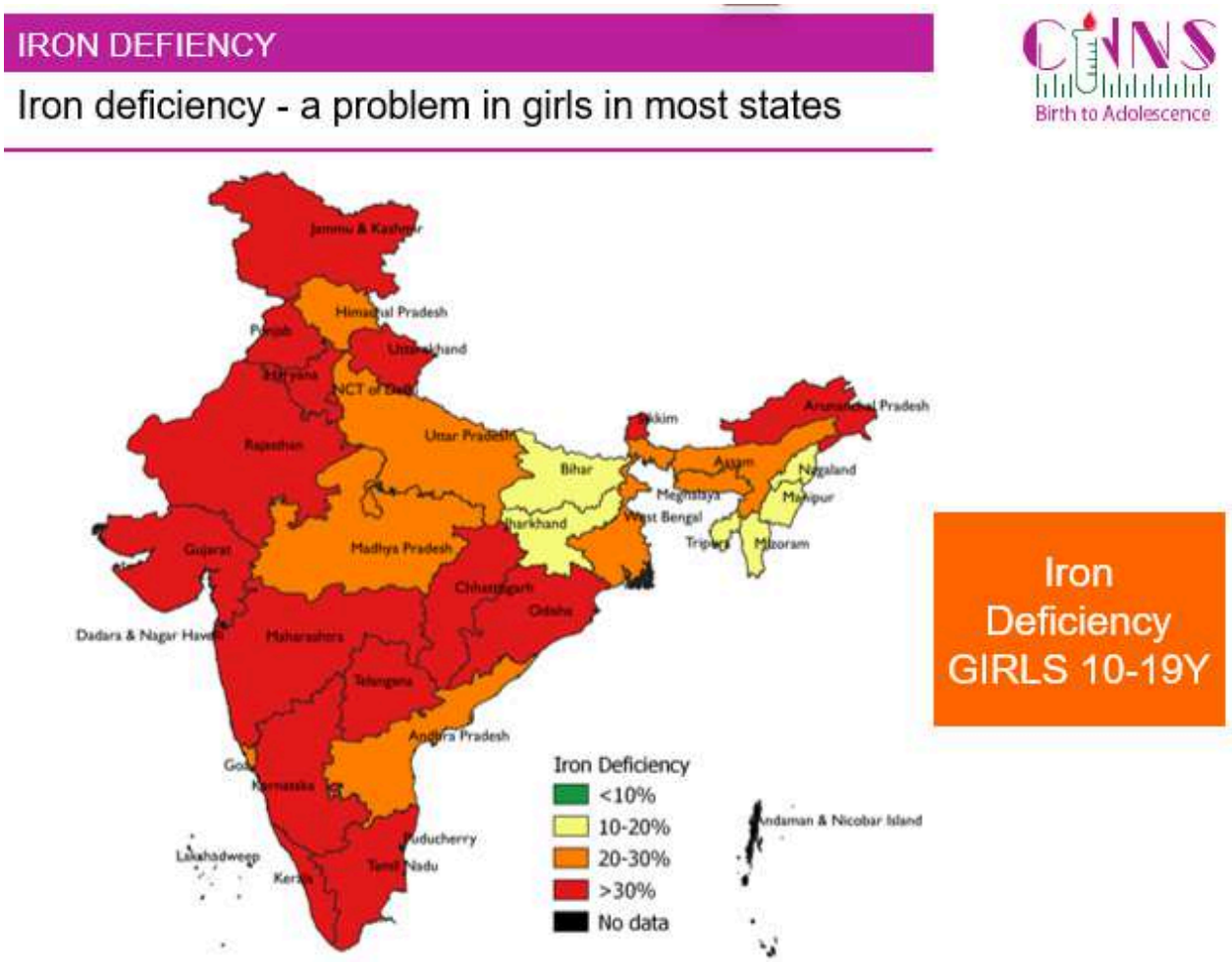
Therefore, a coordinated effort involving healthcare, nutrition, education, and social welfare sectors is required. With early investment in prevention, early detection, and access to proper nutrition and treatment, society can reduce the burden of anemia and help individuals reach their full potential. Addressing anemia is not only a public health priority but also a crucial step toward building a healthier, more equitable future for all.

Chapter 2

Existing Responses, Limitations, Innovations & Proposed Frameworks

India's fight against anemia has come a long way - from basic iron supplementation to a closer comprehensive life-course strategy. The Anemia Mukt Bharat (AMB) programme, launched in 2018 under POSHAN Abhiyaan framework, is arguably the country's most ambitious attempt yet: it reaches preschoolers, school-age children, adolescents, women of reproductive age, pregnant women, and lactating mothers all under one umbrella.

And yet anemia rates remain high. That gap between effort and outcome suggests that the problems holding this program back are structural, not just related to execution.



Souce CNNS data

Policy Limitations in Current Anemia Management

A key limitation of India's anemia-control efforts is the emphasis on iron deficiency, despite the fact that anemia can arise from multiple nutritional and non-nutritional causes. National data and clinical research both point to a complex picture, with some cases arising from vitamin deficiencies, inflammation, hereditary blood disorders and other underlying conditions that required different management approaches.

Operational Gaps in Managing Non-Nutritional Anemia

The Anemia Mukt Bharat programme's 6*6*6 strategy does recognize the need to address non-nutritional causes of anemia, including screening, referral, and management of these anemia cases.(14) However, gaps in diagnostic capacity and access to appropriate treatment can limit the implementation of these provisions. Patient with conditions such as Vitamin B12 or folate deficiency, or hemoglobinopathies such as β-thalassemia trait or sickle cell disease, may require interventions beyond routine iron-folic acid supplementation. When the underlying cause is not identified, treatment may not adequately address the patient's condition.



Source: Ministry of Health and Family Welfare, Government of India, Anemia Mukt Bharat Portal

Healthcare System Capacity and Diagnostic Gaps

AMB guidelines provide for the referral of severe or non-responsive cases onward. But day-to-day screening at the primary healthcare level is still relies on haemoglobin estimation, which identifies anemia but does not establish its cause. Tests like serum ferritin, transferrin saturation, peripheral smear, MCV, MCH, or hemoglobin electrophoresis remain largely out of reach at primary healthcare settings.Digital hemoglobinometers are used for point-of-care anemia screening in community and primary healthcare levels. Devices such as the HemoCue Hb 301 System and TrueHb Hemometer require a small capillary blood sample obtained through a finger prick and can be used outside sophisticated laboratory settings. (7) However, these devices have *limitations*:

1. These devices are screening tools and may not always match the accuracy of automated hematology analyzers (the laboratory gold standard). Consequently, surveys such as the Diet and Biomarkers Survey in India (DABS-I) incorporated venous blood collection and laboratory analysis to provide more accurate assessment of anemia and nutritional biomarkers.

2. Finger-prick (capillary) blood can produce different hemoglobin values compared to venous blood, affecting anemia prevalence estimates.

3. Accuracy can vary depending on sample collection techniques, operator training, device handling and quality-control procedures. Temperature, humidity, and field conditions can affect device performance. One Indian community study noted TrueHb overestimated hemoglobin in extreme cold conditions.

5. These devices only measure hemoglobin levels. They cannot differentiate between iron deficiency anemia, thalassemia, anemia of Inflammation, vitamin deficiencies, or other hematological disorders.

Lack of Recent, Reliable National Data

India's anemia surveillance is scattered across systems that may not be fully interoperable. Pregnant women's hemoglobin records are maintained on the Janani Portal; while children's health data are recorded through platforms such as RBSK and U-WIN. Although the revised Anemia Mukt Bharat Abhiyaan guidelines envisage integrating these records through a unified portal, the extent of implementation remains to be assessed.

Good policy needs good data, and right now India lacks updated national anemia estimates. NFHS-6 didn't include hemoglobin or anemia estimates, largely because of concerns over the accuracy of the sampling method used in earlier rounds. So, the country is still relying on NFHS-5 (2019-2021) for its most recent nationally representative NFHS-based anemia estimates. That's a meaningful evidence gap - it makes it harder to gauge the current burden, track trends, judge whether existing programs are working, or build genuinely data-driven policy.

2.2 Precision Public Health Framework and Policy Recommendations

Tier 1 - Diagnostic & Data Infrastructure

1. Strengthen Localized Etiology-Based Surveillance

Finding anemia isn't the hard part - figuring out *why* it occurs is. That means moving past hemoglobin as the only measure, since it cannot establish the underlying cause on its own. Where clinically indicated and feasible, patients should undergo additional investigations, including serum ferritin, vitamin B12, folate, inflammatory markers like C-reactive protein (CRP), and other iron studies, to guide appropriate treatment.

One nuance worth flagging: serum ferritin does double duty as both an iron-storage marker and an acute-phase reactant.

During infection or chronic inflammation, ferritin can stay elevated even when iron stores are genuinely low, potentially masking iron deficiency. Total iron-binding capacity (TIBC) is usually raised in iron deficiency but can be normal or low during inflammation, further complicating diagnosis.

Advanced biomarkers such as soluble transferrin receptor (sTfR) and hepcidin have proven to be very beneficial in differentiating iron deficiency from inflammation associated anemia. Soluble transferrin receptor levels are relatively unaffected by inflammatory processes and therefore provide a more reliable indicator of tissue iron deficiency. In contrast, hepcidin levels are generally elevated in anemia of inflammation and suppressed in pure iron deficiency anemia. However, these tests remain largely unavailable in most rural healthcare settings due to cost and lack of laboratory equipment.



Addressing this issue requires improved diagnostic methods that use inflammatory markers like C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), alongside iron studies. Strengthening laboratory infrastructure and expanding access to advanced biomarkers would aid in more accurate diagnosis and targeted treatment.

2. Develop District-Level Anemia Risk Maps

Effective treatment starts with knowing what's actually driving anemia in a given place, because iron deficiency is far from the only culprit. State- and district-level risk maps would let policymakers see, at a glance, where iron and non-iron causes cluster - vitamin deficiencies here, infections there, genetic blood disorders somewhere else. Where reliable diagnostic data are available, these maps can help local health facilities identify patterns and tailor interventions, instead of defaulting to the same iron tablets everywhere. This is essentially the founding idea behind the proposed National Anemia Etiology Dashboard - a system built to track different types of anemia across India's geography.

3. National Anemia Etiology Dashboard

This proposed dashboard would bring together relevant haemoglobin data from existing health information systems. It could also incorporate confirmatory results from district labs, such as ferritin, CRP, and haemoglobin electrophoresis. With that combined picture, the Health Ministry could assess district-level patterns in anaemia and its possible causes. The dashboard could help policy-makers direct budgets and resources towards locally relevant interventions, based on confirmed needs and clinical guidelines.

(Link to the dashboard: https://docs.google.com/spreadsheets/d/1uYrb7LNFgbnaFWX-f8GllzUh8qB0HFy1LwyRM8JmtAg/edit?gid=1804702817#gid=1804702817)

4. Mandatory Reflex-Testing Protocol

Before a patient who isn't responding to oral iron under AMB gets escalated to IV iron, the underlying reasons for treatment failure should be assessed. Where clinically indicated, tests such as serum ferritin and CRP, at least - should be non-negotiable. Relevant results could be integrated into the Ayushman Bharat Digital Mission (ABDM)-linked health record, to support clinical decision-making.



5. Subsidized Private-Lab Voucher Scheme

Plenty of districts simply don't have PHCs equipped to run confirmatory tests anemia tests yet. In the meantime, subsidized vouchers for nearby private labs could bridge that gap - giving patients a real diagnosis and the right treatment now, instead of waiting years for public infrastructure to catch up.

Tier 2 - Service Delivery (On-the-Ground Implementation)

1. Empowering Community Health Workers for Early Anemia Management

Better community-level surveillance, run by trained frontline workers, means earlier diagnosis and better follow-through on management.

Peru offers a useful proof of concept here. Community health workers have been used actively to manage anemia. Health workers made regular home visits, kept household-level health records, screened children early with portable hemoglobin devices, educated families on nutrition, and stayed on top of treatment adherence through continuous follow-up. Parents and local governments were both pulled into the effort, turning anemia prevention into a shared community effort. The payoff was substantial: childhood anemia in that district dropped from 65% to 12%.

2. Frontline Worker Diagnostic Literacy Training

Right now, ASHAs and ANMs are trained to support iron and folic acid (IFA) tablet distribution - not to read biomarkers. A short, structured training module that teaches them when to escalate (say, no response after 8 weeks of IFA, or a family history pointing toward hemoglobinopathy) would turn them into an actual triage layer, not just a distribution point.

3. AI-Assisted Triage Tool for ASHAs

Picture a simple decision-support app - not diagnostic AI, just a rules-based flowchart - that takes an Hb value plus symptoms and basic history, and tells the health worker whether to continue the IFA regimen, refer for confirmatory testing, or escalate urgently in line with the approved guidelines.

It's a direct extension of the diagnostic literacy training above, providing standardized decision support that frontline workers can use in the field without replacing clinical judgment.

4. Newer Screening Technologies

Non-invasive hemoglobin screening could meaningfully strengthen community-based anemia detection, especially in resource-limited areas. These tools are quick, easy to use, and cheap enough to support large-scale screening and follow-up - which means earlier diagnosis, faster referral, and better real-time surveillance.

Non-invasive Hb tests, based on spectrophotometry or photoplethysmography, don't demand specialized training. Health workers with minimal preparation can run them, which matters a lot in remote or underserved areas. (12)



NON-INVASIVE Hb TEST: SPECTROPHOTOMETRY
Utilizing dynamic multispectral light analysis and algorithms

NON-INVASIVE Hb TEST: PHOTOPLETHYSMOGRAPHY
Utilizing fingertip pulse waveforms and algorithms

The economics may also be favourable, depending upon the technology and setting. Traditional invasive testing needs lab equipment, consumables, and trained personnel, running roughly ₹40-60 per test.

Non-invasive screening for anemia or other blood disorders, by contrast, costs about ₹5-7 per test, device included - take EzeCheck as an example. (20)

Two real-world tools illustrate what this looks like in practice. The Sanguina Smartphone App estimates hemoglobin non-invasively through colour-sensitive, algorithm-based analysis of fingernail bed images, and has been validated in the United States.(21) EzeCheck, meanwhile, captures patient information through an Android app connected via Bluetooth, giving immediate results and remote data access for rapid treatment planning - and doing it affordably. (13)

5. Integrated Digital Ecosystem for Longitudinal Anemia Management

Eliminating anemia at scale means moving past siloed nutritional programs and toward a properly integrated digital health ecosystem. Bringing ABDM together with supply-chain systems like e-Aushadhi gives that structural backbone - closing treatment gaps, optimizing resources, and maintaining continuity in patient care.

ABDM's unique ABHA IDs make a single longitudinal health record possible. That matters enormously for a condition like anemia, which plays out over years - fragmented systems have historically lost patient histories along the way, and an integrated record lets clinicians actually track a patient over time and make better-informed decisions. (19)

e-Aushadhi complements this from the supply side. Built by C-DAC, it's a web-based drug inventory system tracking procurement, warehouse stock, batch numbers, expiry dates, and distribution across the public healthcare chain. It is designed to improve visibility into medicine availability - from state warehouses down to district hospitals, CHCs, and PHCs. Early warning alerts let administrators redistribute stock before shortages actually hit, cutting down on treatment interruptions.



Paired with ABDM, this kind of inventory system helps sustain continuity of care, provided the systems are effectively integrated.

Cost-effectiveness studies on this are still thin, but the logic holds up: digital supply-chain systems should generate savings by reducing emergency procurement, cutting down on expired stock, sharpening forecasting, and keeping essential anemia medicines consistently available.

The policy priority should be to assess and strengthen interoperability between existing systems, improve data quality, and explore predictive analytics and automated demand forecasting where feasible. (7)

6. Clinical Interventions: Ferric Carboxymaltose (IV Iron) in Severe Peripartum Anemia

Iron deficiency anemia during pregnancy is a serious public health problem in India, and oral iron - the default approach -may be insufficient. Poor compliance, driven by gastrointestinal side effects like nausea, constipation, and bloating, along with poor absorption, undermines it constantly. For severe maternal anemia, Ferric Carboxymaltose (IV FCM) is an established treatment option in India's maternal healthcare guidelines, alongside iron sucrose. (16)

FCM is a dextran-free, carbohydrate-stabilized iron complex, administered intravenously to deliver iron without relying on gastrointestinal absorption.



Representational Image of Women with Severe Anemia

A study published in the Journal of the Association of Medical Physicists of India (JAMP) tracked pregnant women with severe iron deficiency anemia at an Indian tertiary care hospital, measuring hematological response at the 2- and 4-week marks post-infusion. The results were striking: mean hemoglobin climbed from a baseline of 8.06 ± 0.29 g/dL to 11.48 ± 0.56 g/dL within just two weeks, reaching 11.84 ± 0.58 g/dL by week four. (15)

Where oral iron works slowly toward raising hemoglobin, FCM produces an immediate spike in serum ferritin - meaning maternal bone marrow has iron readily available for red blood cell production right through to delivery.
In Indian clinical settings that are often crowded or resource-constrained, FCM has real logistical advantages over older IV options like Iron Sucrose. Iron Sucrose is administered in divided doses, around 200 mg per session, requiring multiple visits to deliver a full replacement course. FCM, by contrast, can allow a larger dose to be administered in a single infusion, subject to the patient's weight, iron requirement and product-specific dosing guidance. (17)

Adherence is another point in its favor. Patients stopping oral tablets midway is a common problem - a one-time, supervised IV infusion sidesteps that entirely. And for women presenting with severe anemia late in pregnancy, when there is little time to improve hemoglobin before delivery, timely treatment is required. FCM's speed matters clinically: it substantially cuts reliance on packed red blood cell transfusions, sparing scarce blood bank resources and the risks that come with transfusion. (4)

India has responded to this evidence by institutionalizing IV iron therapy at a policy level. Anemia Mukt Bharat now formally includes both FCM and Iron Sucrose as clinical interventions for eligible pregnant and lactating women with severe anaemia and, where indicated, inadequate response to oral treatment.



Cost remains a real barrier, though. FCM likely saves money over time - fewer hospital visits, less travel, no expensive transfusions - but the upfront price is still steep for poor families paying out of pocket, unless it's available free through a government program.

Even with that caveat, FCM has become a genuinely important clinical tool in Indian obstetrics - reducing maternal morbidity, improving neonatal birth weight, and giving clinicians a dependable option against severe peripartum anemia.

India’s fight against anaemia requires a shift from a one-size-fits-all approach to evidence-based, etiology-specific interventions. Strengthening diagnostic capacity, improving frontline service delivery and improvement in integration of existing digital health systems is likely to address the existing gaps both in prevention and treatment.



Structure Of National Anemia Etiology Dashboard

The live Anemia Mukt Bharat (AMB) dashboard shows how many IFA tablets and deworming doses were given. It cannot show WHY a district is anemic. This workbook fills that gap. Each district is described by its dominant anemia type, its cause signals, its testing capacity, how cohorts respond to IFA, and its expanded testing data. These feed one Priority Score and one auto flag that tells a health officer when a district needs more than a hemoglobin test.

State	District	Any Anemia — Women (Total %)* [Report Here]	IFA Non-Responder Tracker					
			Beneficiary Group	Cohort Size (#)	Months Completed on IFA	% of Cohort Size responding	% of Cohort Size not responding	Response Status
West Bengal	Murshidabad	71.40%	Pregnant Women	30	3	10.00	90.00	Non-Responding
Bihar	Sheohar	63.50%	Children 6-59 months	30	2	91.00	9.00	Partially Responding

A cohort that does not respond to Iron Folic Tablets for a month is a signal of a non-iron cause. The diagnostics needs to then move beyond the Hb tests

Dominant Anemia Type	Dominant Anemia %	Causes/ Signals						
		Iron Deficiency Signal	Vitamin B9/ Folate Deficiency Signal	Vitamin B12 Deficiency Signal	Hemoglobinopathy Risk/ inherited blood disorder Risk	Infection Signal	Inflammation Signal	WASH (Water, Sanitation, and Hygiene)-related Signals
Aplastic Anemia	35.00%	High	Very Low	Moderate	Low	Moderate	Low	Very High
Iron Deficiency Anemia (IDA)	65.00%	Low	High	Very High	High	Very High	Very High	High

Shows at a glance the dominant anemia type in particular geography, depending on the causes.

Confirmatory Testing Available / Diagnostic Infrastructure	Expanded Testing (Point-of-Care)				Priority Score (1–10)	POC Suggested Etiology (Autoflagged)	Notes by Data Analyst (Main issue highlight based on demography)	Recommended Intervention Mi by Expert (Can be modified as System-generated Auto Flag)
	MCV, MCH, and MCHC Signal	Lab-test Ferritin (ng/mL)	Lab-test CRP (mg/L)	Reports are being ABHA Linked?				
Very Low	Low	Low	Low	Yes	6.3	Suspected: Iron Deficiency / Thalassemia (Microcytic) — confirm via ferritin/HPLC	District-level proxy from NFHS-5 state avg (71.4%); CRP reflex testing not yet standard at PHC level	Urgent tertiary hematology referral bone marrow work-up
Very Low	High	High	High	Yes	7.6	Suspected: B12/Folate Deficiency (Macrocytic) — confirm via B12/folate assay	High open-defecation burden inflates infection signal; not lab-confirmed	Standard IFA supplementation + dietary iron/fortification; monitor Hb response at 8 weeks

Adds cheap point-of-care and lab evidence beyond the Hb test, and recommends intervention according to the flagged dominant cause of anemia

Conclusion

India's Anemia Mukt Bharat programme deserves real credit for building a nationwide, multisectoral response to anemia at a scale few countries have attempted. Still, the persistence of high anemia levels highlights the limits of treating it primarily as a nutritional problem driven by iron deficiency. Anemia in India is multifactorial and can be due to many different causes, including genetic blood conditions, long-term infections or a deficiency of vital nutrients like Vitamin B12 & folate. A uniform, iron-centred approach risks overlooking these causes and delaying appropriate treatment.

To make real progress, India needs to strengthen diagnosis alongside treatment. Primary healthcare clinics and frontline workers (Doctors, nurses and ASHA workers) need access to reliable testing and clear referral pathways to identify the underlying causes of anemia. This would help ensure that treatment is tailored to patient's needs rather than relying on iron supplementation alone.

For critical cases, especially pregnant women who cannot afford to wait and require urgent treatment before delivery, intravenous iron formulations such as ferric carboxymaltose (FCM) can offer an important treatment option when clinically indicated. Further, these clinical interventions must be complemented by improvements in living conditions to ensure longitudinal impact. Access to clean water and proper toilets is important to stop the vicious cycle of parasitic worms- which live in the gut and ultimately lead to anemia. Nutrition schemes must go beyond iron supplementation to provide diverse diets containing protein and essential vitamins and minerals.

A proposed National Anemia Etiology Dashboard, tracking the disctribituion of different causes of anemia across districts, can guide this shift by directing appropriate interventions, from iron, IV therapy, deworming, to genetic counselling, where they are actually needed. Better integration of digital health and medicine-supply systems, including e-Aushadhi, could further support continuity of treatment.

What India needs now is a clear shift - from a passive, iron-centred distribution model to one that is precise, data-driven, and community-owned. Countries like Peru, Vietnam, and Thailand, offer potential lessons in combining nutrition interventions, sanitation, targeted medical care and strong community health systems. Drawing on relevant evidence and adapting interventions to local needs, India can pursue a phased transition, beginning with better diagnosis and referral at the primary-care level. By combining appropriate treatment with improved sanitation and access to nutritious, iron-rich and fortified foods, India can build a more effective and equitable response to anemia.



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