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Original Article

A Review of Advanced Anemia Management Practices in Developed Countries and the Existing Gaps in Pakistan

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ABSTRACT

Background: Anemia remains a major public health and clinical challenge, particularly in low- and middle-income countries where nutritional deficiency, infection, maternal health barriers, poverty, and limited healthcare infrastructure sustain a high disease burden. Developed healthcare systems have increasingly shifted from hemoglobin-based recognition of anemia toward biomarker-guided diagnosis, individualized therapy, intravenous iron use, erythropoiesis-stimulating agents, Patient Blood Management, and surveillance-based prevention. In Pakistan, however, anemia remains highly prevalent among women of reproductive age and children under five, while diagnostic and therapeutic practices remain constrained by limited laboratory capacity, fragmented care pathways, and inconsistent policy implementation. **Objective:** This structured narrative review aimed to compare advanced anemia management practices in developed healthcare systems with current diagnostic, therapeutic, preventive, and policy-related approaches in Pakistan, and to identify key implementation gaps relevant to national anemia control. **Methods:** A structured narrative review was conducted using literature from PubMed, MEDLINE, Cochrane Library, Scopus, and Google Scholar covering 2015–2025. Eligible sources included peer-reviewed studies, systematic reviews, clinical guidelines, national surveys, government reports, and public health documents addressing anemia diagnosis, iron profiling, intravenous iron therapy, erythropoiesis-stimulating agents, Patient Blood Management, screening, fortification, and policy implementation. Evidence was synthesized thematically across diagnostic approaches, therapeutic strategies, health-system integration, and public health interventions. **Results:** Approximately 80 records were initially screened. Developed countries demonstrated more advanced anemia care through ferritin, transferrin saturation, inflammatory markers, intravenous iron, ESA-guided chronic kidney disease management, PBM programs, preoperative anemia correction, and structured surveillance. Pakistan showed persistent gaps, including hemoglobin-centered diagnosis, limited ferritin/TSAT/CRP access, reliance on oral iron, restricted IV iron and ESA availability, weak PBM integration, and inconsistent monitoring of nutrition and maternal-child health policies. **Conclusion:** Pakistan's anemia burden requires a coordinated national framework that strengthens diagnostic capacity, expands evidence-based treatment access, integrates PBM and maternal-child screening, and links public health policy with measurable surveillance and implementation outcomes. **Keywords:** Anemia; Iron Deficiency Anemia; Intravenous Iron; Ferritin; Transferrin Saturation; Patient Blood Management; Pakistan; Public Health Policy.

INTRODUCTION

Anemia remains one of the most widespread hematological and nutritional disorders globally, affecting women, children, older adults, and patients with chronic disease across diverse healthcare settings. The World Health Organization has consistently identified anemia as a major public health problem because of its close association with impaired physical capacity, reduced cognitive development, adverse pregnancy outcomes, increased susceptibility to infection, and diminished socioeconomic productivity (1). Although anemia may arise from multiple etiologies, including iron deficiency, chronic inflammation, renal disease, vitamin B12 or folate deficiency, hemolysis, and bone marrow disorders, iron deficiency anemia remains the most common form worldwide and accounts for a substantial

proportion of preventable anemia-related morbidity (2). The public health impact of anemia is particularly severe in low- and middle-income countries, where nutritional deficiency, poverty, infectious disease burden, reproductive health challenges, and limited healthcare access interact to sustain a high prevalence across vulnerable populations (3).

Over the past decade, the understanding of anemia has advanced substantially beyond the traditional concept of low hemoglobin concentration alone. Contemporary hematology increasingly recognizes anemia as a heterogeneous clinical syndrome requiring etiological classification, assessment of iron metabolism, and identification of coexisting inflammatory or chronic disease states. Advances in the biology of hepcidin, ferroportin, and inflammatory iron sequestration have clarified why hemoglobin estimation alone is insufficient to distinguish iron deficiency anemia from anemia of chronic disease or mixed anemia patterns (4). In response, developed healthcare systems have increasingly incorporated diagnostic biomarkers such as serum ferritin, transferrin saturation, soluble transferrin receptor, reticulocyte hemoglobin content, and C-reactive protein into routine diagnostic pathways, enabling more accurate classification and individualized treatment selection (5). This shift has been especially important in populations with chronic kidney disease, heart failure, malignancy, perioperative anemia, and inflammatory disorders, where misclassification may delay appropriate therapy or expose patients to ineffective supplementation (6).

Therapeutic approaches to anemia have also evolved considerably in high-income healthcare systems. While oral iron remains appropriate for many patients with uncomplicated iron deficiency, modern intravenous iron formulations have improved the management of moderate-to-severe iron deficiency, poor gastrointestinal absorption, intolerance to oral iron, and inflammation-associated functional iron deficiency (7). In patients with chronic kidney disease, erythropoiesis-stimulating agents, when combined with careful iron assessment and individualized hemoglobin targets, have become central to guideline-directed anemia management (8). Beyond individual pharmacological treatment, Patient Blood Management programs have emerged as multidisciplinary systems designed to identify and correct anemia early, reduce avoidable transfusions, minimize blood loss, and improve perioperative and hospital outcomes (9). These developments illustrate a broader transition in developed countries from reactive treatment of low hemoglobin toward proactive, protocol-based, and system-integrated anemia care.

In contrast, Pakistan continues to face a substantial anemia burden, particularly among women of reproductive age and children under five years. National survey data have shown persistently high anemia prevalence despite ongoing nutrition, maternal health, and food fortification initiatives (10). The persistence of anemia in Pakistan reflects not only nutritional deficiency but also broader structural barriers, including limited screening coverage, inconsistent surveillance, weak primary healthcare integration, inadequate access to advanced laboratory testing, fragmented referral systems, and variable implementation of national nutrition policies (11). In many clinical settings, diagnosis still relies predominantly on hemoglobin estimation, while ferritin, transferrin saturation, inflammatory markers, and other confirmatory investigations are either unavailable, unaffordable, or underused. Consequently, anemia management often remains empirical and centered on oral iron supplementation, even in clinical situations where further diagnostic stratification or alternative treatment approaches may be required (12).

The contrast between advanced anemia management in developed countries and current practice limitations in Pakistan highlights an important evidence and implementation gap. Existing literature describes global anemia burden, iron deficiency mechanisms, intravenous iron efficacy, erythropoiesis-stimulating therapy, and Patient Blood Management programs, but these advances have not been sufficiently synthesized in relation to Pakistan's healthcare context (13). A focused narrative synthesis is therefore needed to compare evidence-based anemia management practices in developed healthcare systems with diagnostic, therapeutic, and policy-related gaps in Pakistan. Such a synthesis can help

identify which components of advanced anemia care are most relevant, feasible, and adaptable for local implementation, while also clarifying where Pakistan-specific research and policy strengthening are most urgently required (14).

Therefore, this structured narrative review aimed to evaluate advanced anemia management practices in developed countries and compare them with current diagnostic, therapeutic, preventive, and policy approaches in Pakistan. The review specifically sought to identify gaps in laboratory capacity, treatment access, guideline implementation, Patient Blood Management integration, and public health strategy, with the broader objective of informing evidence-based recommendations for reducing the anemia burden in Pakistan.

MATERIALS AND METHODS

This study was designed as a structured narrative review with a comparative analytical approach to examine advanced anemia management practices in developed healthcare systems and to contrast them with existing diagnostic, therapeutic, preventive, and policy-related approaches in Pakistan. A narrative review design was selected because the objective was not to generate pooled quantitative estimates, but to synthesize diverse evidence from clinical guidelines, observational studies, interventional trials, systematic reviews, national surveys, and public health reports across multiple domains of anemia care. The synthesis was organized around four major thematic areas: diagnostic strategies, therapeutic interventions, Patient Blood Management practices, and health-system or policy-level approaches to anemia prevention and control.

A comprehensive literature search was conducted using PubMed, MEDLINE, Cochrane Library, Scopus, and Google Scholar. The search covered publications from January 2015 to December 2025 and focused on literature relevant to anemia management in developed countries and Pakistan. Search terms were combined using Boolean operators and included “anemia management,” “iron deficiency anemia,” “intravenous iron therapy,” “serum ferritin,” “transferrin saturation,” “erythropoiesis-stimulating agents,” “patient blood management,” “anemia guidelines,” “developed countries,” “Pakistan,” “maternal anemia,” “childhood anemia,” “food fortification,” and “national nutrition survey.” Additional records were identified through reference list screening of relevant review articles, clinical guidelines, and national reports to capture important sources not retrieved through database searching.

Eligible sources included peer-reviewed original research articles, systematic reviews, meta-analyses, clinical practice guidelines, national health surveys, government reports, and reports from recognized public health organizations. Studies were considered relevant if they addressed anemia diagnosis, iron profiling, intravenous iron therapy, erythropoiesis-stimulating agents, Patient Blood Management, screening programs, nutritional interventions, food fortification, maternal-child health strategies, or anemia-related policy implementation. Literature was included when it provided evidence on developed-country practices, Pakistan-specific anemia burden, healthcare delivery barriers, or comparative health-system gaps relevant to anemia management. Articles published in English were included.

Editorials, opinion pieces without substantive evidence, conference abstracts, duplicate publications, studies with insufficient methodological detail, and articles focused exclusively on hereditary anemias such as thalassemia or sickle cell disease were excluded. Studies addressing anemia as part of broader nutritional or chronic disease frameworks were included only when anemia-related outcomes, diagnostic approaches, or management strategies were clearly described. Priority was given to recent evidence, guideline-based recommendations, population-level surveys, and studies directly relevant to clinical or public health decision-making.

The selection process involved initial screening of titles and abstracts for relevance to the review objective, followed by full-text assessment of potentially eligible sources. Approximately 80 records were initially screened. Evidence was selected purposively according to its relevance to the review domains,

methodological strength, clinical importance, and applicability to Pakistan's healthcare context. Data were extracted into thematic categories, including study setting, population or target group, anemia-related focus, diagnostic method, treatment approach, public health intervention, policy relevance, and principal findings.

The synthesis followed a comparative thematic approach. Evidence from developed countries was first reviewed to identify established or emerging standards in anemia diagnosis and management, including biomarker-based evaluation, intravenous iron use, erythropoiesis-stimulating therapy, preoperative anemia correction, and Patient Blood Management programs. Evidence from Pakistan was then examined to identify current practice patterns, resource limitations, public health burden, implementation barriers, and policy gaps. Findings were compared across diagnostic capacity, treatment accessibility, healthcare infrastructure, guideline implementation, surveillance systems, and preventive public health strategies.

Because this was a narrative review, formal statistical pooling and meta-analysis were not performed. The evidence was synthesized descriptively, with emphasis on clinical relevance, consistency of findings across sources, and applicability to health-system strengthening in Pakistan. The review distinguished between evidence derived from clinical guidelines, trial-based therapeutic evidence, population survey data, and policy or implementation literature. Potential selection bias inherent to narrative reviews was addressed by using multiple databases, including guideline and national survey sources, applying predefined thematic domains, and prioritizing higher-quality and policy-relevant evidence.

RESULTS

The literature search covered five electronic databases—PubMed, MEDLINE, Cochrane Library, Scopus, and Google Scholar—and focused on evidence published between 2015 and 2025. Approximately 80 records were initially screened, including clinical guidelines, systematic reviews, interventional studies, observational studies, national surveys, and public health reports relevant to anemia diagnosis, treatment, Patient Blood Management, and policy implementation. The included evidence was organized into four synthesis domains: diagnostic approaches, therapeutic strategies, Patient Blood Management and health-system integration, and preventive or policy-level interventions. The review identified a consistent contrast between developed healthcare systems, where anemia care is increasingly biomarker-guided and protocol-based, and Pakistan, where management remains constrained by limited laboratory capacity, reliance on hemoglobin-based diagnosis, dependence on oral iron therapy, and inconsistent policy execution.

Table 1. Evidence Base and Thematic Structure of the Narrative Synthesis

Synthesis Domain	Evidence Sources Considered	Main Variables Extracted	Purpose in Comparative Synthesis
Diagnostic approaches	Clinical guidelines, observational studies, laboratory-based studies	Hemoglobin, serum ferritin, transferrin saturation, inflammatory markers, reticulocyte indices	To compare biomarker-based diagnosis in developed systems with basic diagnostic practices in Pakistan
Therapeutic strategies	Trials, guideline documents, review articles	Oral iron, intravenous iron, erythropoiesis-stimulating agents, transfusion practices	To assess differences in treatment availability, clinical indications, and treatment individualization
Patient Blood Management and clinical integration	Hospital-based PBM studies, perioperative care literature, guideline documents	Preoperative anemia screening, transfusion thresholds, multidisciplinary care, audit systems	To evaluate the extent to which anemia care is embedded into hospital systems
Public health and policy interventions	National surveys, nutrition reports, public health literature	Food fortification, maternal-child screening, supplementation, surveillance, policy implementation	To assess anemia prevention and control at population level
Pakistan-specific gaps	National reports, regional studies, clinical practice literature	Healthcare access, laboratory availability, treatment affordability, policy monitoring	To identify implementation barriers and health-system limitations

The diagnostic synthesis showed that developed healthcare systems increasingly rely on laboratory-based differentiation of anemia subtypes rather than hemoglobin concentration alone. Serum ferritin and transferrin saturation are central to identifying iron deficiency and functional iron restriction, while inflammatory markers such as C-reactive protein help interpret ferritin in the presence of infection, chronic inflammation, kidney disease, malignancy, or heart failure. This diagnostic model enables clinicians to distinguish absolute iron deficiency from anemia of chronic disease and mixed etiologies, reducing the likelihood of empirical treatment and improving treatment selection.

In Pakistan, diagnostic practice remains heavily dependent on hemoglobin estimation, particularly in primary care, rural settings, maternal-child health programs, and resource-limited hospitals. Advanced iron profiling, including ferritin, transferrin saturation, soluble transferrin receptor, and inflammatory markers, is less consistently available or affordable. This creates a substantial diagnostic gap, because patients with chronic disease, inflammation, pregnancy-related anemia, or persistent symptoms may receive oral iron without adequate etiological classification. The diagnostic disparity is especially important because anemia prevalence remains high among women of reproductive age and children under five years in Pakistan, where delayed or incomplete diagnosis may perpetuate poor clinical outcomes.

Table 2. Comparative Diagnostic Features of Anemia Management

Diagnostic Element	Developed Healthcare Systems	Current Pattern in Pakistan	Main Implication
Initial screening	Routine hemoglobin testing integrated with clinical pathways	Hemoglobin estimation commonly used as the primary diagnostic test	Detects anemia but often does not define etiology
Iron status assessment	Ferritin and transferrin saturation commonly used in guideline-based care	Limited availability and inconsistent use of ferritin and TSAT	Reduced ability to distinguish iron deficiency from inflammation-related anemia
Inflammatory assessment	CRP and related markers used to interpret ferritin and chronic disease states	Inflammatory markers less routinely incorporated into anemia workup	Greater risk of misclassification in chronic disease or infection
Advanced markers	Reticulocyte hemoglobin and soluble transferrin receptor used in selected settings	Rarely available outside specialized or private-sector settings	Limits precision in complex anemia cases
Diagnostic model	Etiology-based and algorithm-guided	Frequently empirical and resource-dependent	Treatment may be less individualized

Therapeutic evidence indicated that developed countries have moved toward individualized anemia treatment based on severity, etiology, comorbidity profile, and expected response to therapy. Oral iron remains appropriate for uncomplicated iron deficiency, but intravenous iron is increasingly used where rapid replenishment is required or where oral iron is ineffective, poorly tolerated, or biologically limited by inflammation. Newer intravenous iron preparations, including ferric carboxymaltose and iron sucrose, are described as enabling faster correction of iron deficiency and better clinical response in selected populations, including patients with chronic kidney disease and heart failure.

Erythropoiesis-stimulating agents represent another major therapeutic distinction, particularly in chronic kidney disease care. Developed healthcare systems use ESAs within nephrology services under defined monitoring protocols, usually alongside iron status assessment and individualized hemoglobin targets. In Pakistan, oral iron remains the dominant therapeutic approach, even though some patients may require intravenous iron, ESA therapy, or disease-specific management. Access barriers include cost, supply limitations, limited specialist availability, and variable clinician familiarity with advanced anemia treatment pathways.

The synthesis identified Patient Blood Management as one of the clearest system-level differences between developed countries and Pakistan. In developed healthcare settings, PBM programs provide an organized framework for identifying anemia before surgery, correcting iron deficiency, reducing avoidable blood loss, applying evidence-based transfusion thresholds, and auditing transfusion practices. These programs are multidisciplinary and often involve surgeons, anesthesiologists, hematologists, nephrologists, laboratory services, nursing teams, and hospital administrators. Their central purpose is

not only to treat anemia but also to reduce preventable transfusions and improve perioperative and inpatient outcomes.

Table 3. Therapeutic Comparison Between Developed Countries and Pakistan

Therapeutic Component	Developed Healthcare Systems	Current Pattern in Pakistan	Clinical Significance
Oral iron therapy	Used for uncomplicated iron deficiency and stable patients	Main treatment modality across many settings	Useful but insufficient for complex, severe, inflammatory, or refractory anemia
Intravenous iron therapy	Used for moderate-to-severe deficiency, intolerance to oral iron, CKD, heart failure, and perioperative anemia	Limited access and less routine use	Slower correction and persistent symptoms may occur when IV iron is indicated but unavailable
ESA therapy	Integrated into CKD and selected chronic disease pathways with monitoring	Restricted use, mainly in specialized settings	Limits standardized anemia control in CKD and chronic disease
Blood transfusion	Governed by restrictive thresholds and PBM principles	More variable practice depending on facility resources	Inconsistent transfusion practices may increase avoidable exposure to blood products
Treatment monitoring	Follow-up with hemoglobin, ferritin, TSAT, and clinical response	Follow-up often centered on hemoglobin and symptoms	Limits assessment of iron repletion and recurrence risk

Pakistan lacks broadly institutionalized PBM programs and protocol-based anemia pathways. Preoperative anemia correction is not consistently embedded into routine surgical planning, and anemia management is often fragmented across outpatient, inpatient, laboratory, and specialist services. This fragmentation reduces continuity of care and limits timely intervention, particularly for patients requiring surgery, pregnant women, children, and patients with chronic kidney disease or inflammatory disorders. The absence of structured PBM also reduces opportunities for clinical audit, transfusion stewardship, and standardized quality improvement.

Table 4. Patient Blood Management and Health-System Integration

System Component	Developed Healthcare Systems	Pakistan Context	Resulting Gap
Preoperative anemia screening	Commonly integrated into elective surgical pathways	Not consistently implemented across facilities	Missed opportunity for correction before surgery
Multidisciplinary PBM programs	Institutionalized in selected high-income systems	Largely absent or minimally implemented	Fragmented responsibility for anemia care
Transfusion stewardship	Evidence-based thresholds and audit mechanisms	Variable practice and limited monitoring	Higher risk of avoidable transfusion
Clinical governance	Protocols, monitoring indicators, and quality improvement cycles	Weak implementation of standardized anemia pathways	Limited accountability and inconsistent care
Follow-up systems	Structured monitoring after treatment or discharge	Follow-up often irregular and resource-dependent	Higher risk of recurrence, under-treatment, or delayed escalation

At the population level, anemia prevention in developed countries is supported by nutritional surveillance, food fortification, prenatal supplementation, early screening, and policy-driven monitoring. These interventions are strengthened by organized primary care systems, laboratory access, electronic records, and health insurance or public reimbursement structures that facilitate continuity of care. In contrast, Pakistan continues to experience a high anemia burden, with more than 40% of women of reproductive age and more than half of children under five reported to be affected in national survey data.

The policy synthesis showed that Pakistan has introduced nutrition and maternal-child health interventions, but their population-level effect is limited by inconsistent monitoring, variable enforcement, weak surveillance, and uneven access between urban and rural populations. Food insecurity, maternal malnutrition, parasitic infections, poverty, and inadequate access to preventive healthcare continue to interact with clinical service limitations. As a result, anemia in Pakistan represents both a biomedical condition and a health-system challenge requiring stronger integration between clinical diagnosis, nutrition programming, laboratory infrastructure, and public health surveillance.

Table 5. Public Health, Policy, and Implementation Gaps in Pakistan

Gap Area	Current Pattern	Population or System Affected	Synthesis Finding
Screening coverage	Inconsistent routine screening and follow-up	Women, children, pregnant patients, rural populations	High-risk groups may remain undiagnosed until symptoms become clinically significant
Laboratory access	Limited availability of ferritin, TSAT, CRP, and advanced markers	Public-sector and rural healthcare settings	Etiological classification remains weak
Treatment access	Heavy reliance on oral iron; limited use of IV iron and ESAs	Patients with severe, refractory, inflammatory, or chronic disease-related anemia	Treatment may not match disease mechanism or severity
Policy implementation	Nutrition and fortification programs exist but monitoring is inconsistent	National and provincial public health systems	Program impact is reduced by weak enforcement and surveillance
Healthcare integration	Limited linkage between clinical care, maternal-child health, nutrition, and laboratory systems	Primary care, hospitals, and public health programs	Anemia control remains fragmented rather than system-based

Across all synthesis domains, the review found that developed countries manage anemia through a more precise and integrated model of care. Diagnosis is based on hemoglobin measurement plus iron studies and inflammatory markers, while treatment selection is guided by anemia etiology, disease severity, patient comorbidity, and guideline-based thresholds. Intravenous iron therapy, ESAs, PBM programs, and preoperative anemia correction represent key features of advanced anemia care in these settings. These practices are supported by laboratory infrastructure, multidisciplinary care pathways, clinical governance systems, and surveillance mechanisms.

In Pakistan, the dominant pattern is a simpler and more resource-constrained model of anemia management. Hemoglobin-based diagnosis and oral iron supplementation remain central, while advanced testing and modern therapies are less consistently accessible. This pattern is particularly concerning because anemia is highly prevalent among women and children, and because many patients may have multifactorial anemia related to malnutrition, infection, inflammation, reproductive health, poverty, or chronic disease. The result is a persistent gap between the complexity of anemia as a clinical and public health condition and the diagnostic and therapeutic tools routinely available in many healthcare settings.

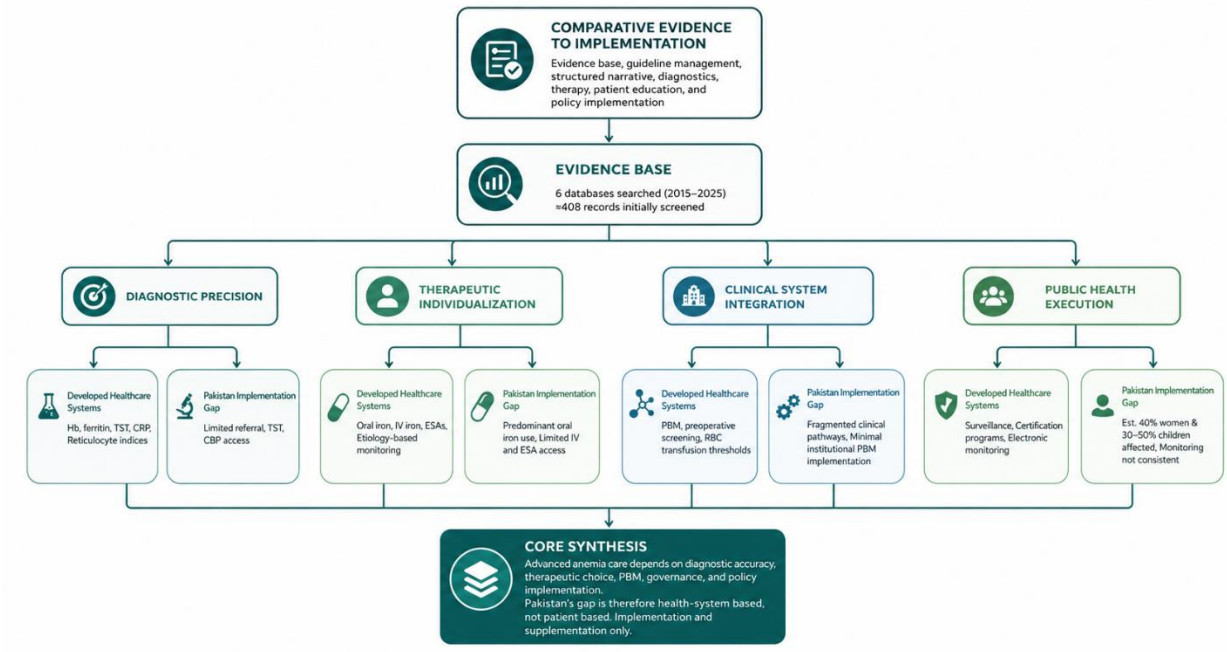

Figure 1. Comparative Evidence-to-Implementation Gradient in Anemia Management

The comparison also demonstrated that anemia management differs not only by clinical practice but by system organization. Developed countries increasingly treat anemia through structured pathways

embedded in nephrology, cardiology, perioperative medicine, obstetric care, primary care, and transfusion services. Pakistan's gaps are more structural, involving laboratory access, financing, supply chains, workforce training, surveillance, policy enforcement, and integration of nutrition programs with clinical care. Therefore, the synthesis indicates that improving anemia outcomes in Pakistan depends on both clinical modernization and health-system strengthening, rather than supplementation alone.

Figure 1 summarizes the evidence-to-implementation gradient identified across four major anemia management domains: diagnostic precision, therapeutic individualization, clinical-system integration, and public-health execution. The synthesis was derived from five searched databases covering 2015–2025 and approximately 80 initially screened records. Developed healthcare systems demonstrate a more integrated model based on hemoglobin assessment plus ferritin, transferrin saturation, inflammatory markers, intravenous iron, erythropoiesis-stimulating agents, Patient Blood Management, perioperative screening, transfusion stewardship, surveillance, and fortification monitoring. In contrast, Pakistan shows implementation gaps across the same domains, including hemoglobin-centered diagnosis, limited ferritin/TSAT/CRP access, predominant oral iron use, restricted access to intravenous iron and ESA therapy, fragmented clinical pathways, minimal institutional PBM implementation, and inconsistent public-health monitoring despite anemia affecting more than 40% of women of reproductive age and more than 50% of children under five.

DISCUSSION

This structured narrative review found a substantial disparity between advanced anemia management practices in developed healthcare systems and the current diagnostic, therapeutic, and policy-related approaches available in Pakistan. The principal finding was that developed countries increasingly manage anemia through integrated, evidence-informed systems that combine accurate etiological diagnosis, biomarker-based iron assessment, individualized treatment, intravenous iron therapy, erythropoiesis-stimulating agents, Patient Blood Management programs, and preventive public health surveillance. In contrast, anemia care in Pakistan remains constrained by hemoglobin-centered diagnosis, limited access to ferritin and transferrin saturation testing, predominant reliance on oral iron supplementation, restricted use of modern therapies, fragmented care pathways, and inconsistent implementation of national nutrition and screening policies. These findings indicate that anemia in Pakistan should not be viewed only as a nutritional deficiency or isolated hematological disorder, but as a multidimensional clinical and health-system challenge requiring coordinated diagnostic, therapeutic, and public health responses.

The diagnostic findings are consistent with contemporary evidence showing that hemoglobin concentration alone is insufficient to define the cause of anemia or guide optimal treatment. Established evidence demonstrates that iron deficiency anemia, anemia of inflammation, chronic kidney disease-related anemia, and mixed anemia states require different diagnostic interpretations and treatment strategies (15). In developed healthcare systems, serum ferritin, transferrin saturation, inflammatory markers, and selected advanced indices such as reticulocyte hemoglobin content are increasingly incorporated into diagnostic algorithms to distinguish absolute iron deficiency from functional iron restriction and inflammation-mediated anemia (16). The present synthesis suggests that Pakistan's continued reliance on basic hemoglobin estimation limits etiological classification and increases the likelihood of empirical treatment. This interpretation is particularly important in settings where infection, malnutrition, pregnancy, chronic inflammation, and chronic disease may coexist, producing anemia patterns that cannot be adequately managed through routine oral iron therapy alone.

Therapeutic findings from this review also align with the evolving evidence base supporting individualized anemia treatment. Oral iron remains effective for many uncomplicated cases of iron deficiency, but established clinical evidence indicates that intravenous iron provides faster iron repletion and may be more appropriate in patients with moderate-to-severe iron deficiency, poor oral tolerance,

malabsorption, chronic kidney disease, heart failure, inflammatory disorders, or perioperative anemia (17). Similarly, erythropoiesis-stimulating agents have a defined role in selected chronic kidney disease populations when used with careful iron assessment, hemoglobin monitoring, and cardiovascular risk consideration (18). The expert interpretation emerging from this review is that Pakistan's treatment gap is not simply the limited availability of individual therapies, but the absence of structured decision pathways that identify which patients require oral iron, intravenous iron, ESA therapy, transfusion, or further diagnostic evaluation. Without such pathways, anemia management may remain symptom-driven rather than mechanism-based.

A major systems-level finding was the contrast between institutionalized Patient Blood Management in developed countries and its limited implementation in Pakistan. Patient Blood Management represents a shift from reactive transfusion-based care toward proactive anemia identification, preoperative optimization, blood conservation, restrictive transfusion thresholds, and multidisciplinary clinical governance (19). Evidence from high-income hospital systems suggests that PBM can reduce unnecessary transfusions, improve perioperative outcomes, shorten hospital stay, and lower healthcare costs when implemented as a coordinated program rather than as an isolated clinical recommendation (20). In Pakistan, the absence of broadly adopted PBM frameworks contributes to fragmented responsibility for anemia correction, particularly in surgical, obstetric, nephrology, and inpatient settings. This gap has practical consequences because patients may enter surgery or childbirth with untreated anemia, while hospitals may lack standardized pathways for correction, transfusion stewardship, and post-treatment follow-up.

The public health findings reinforce the need to connect clinical anemia care with prevention strategies. Developed countries have generally achieved better anemia control through the combined use of screening, food fortification, prenatal supplementation, nutritional surveillance, and health-system monitoring. In Pakistan, national data continue to show a high burden of anemia among women of reproductive age and children under five, despite the presence of nutrition and maternal-child health initiatives (21). This suggests that the problem is not merely the absence of policy but inconsistent execution, weak monitoring, uneven geographic coverage, and insufficient linkage between public health programs and clinical diagnostic services. Established evidence supports the value of iron and micronutrient interventions, but expert interpretation indicates that supplementation alone is unlikely to achieve sustained improvement unless combined with screening, infection control, dietary diversification, fortification quality monitoring, reproductive health services, and accessible laboratory confirmation.

The findings of this review extend prior anemia literature by emphasizing the implementation gap between global evidence and Pakistan's healthcare reality. Much of the international literature focuses on clinical efficacy of iron therapy, anemia in chronic kidney disease, or PBM in hospital systems. By contrast, the Pakistan-specific challenge lies in adapting these approaches within a resource-constrained system characterized by variable laboratory infrastructure, high out-of-pocket expenditure, uneven rural access, inconsistent primary care continuity, and limited specialist referral networks. Therefore, the most clinically relevant implication is that Pakistan requires a tiered anemia management model. At the primary care level, standardized screening, nutritional assessment, pregnancy-focused anemia prevention, and rational oral iron use should be strengthened. At secondary and tertiary levels, ferritin and transferrin saturation testing, intravenous iron protocols, CKD-related anemia pathways, preoperative anemia clinics, and transfusion stewardship should be progressively introduced.

The review has limitations that arise from its narrative design and the heterogeneity of the evidence base. Because the synthesis included clinical guidelines, national surveys, interventional studies, observational reports, and policy literature, the strength of evidence varied across domains. Developed-country practices were often supported by guideline-based and trial-derived evidence, whereas Pakistan-specific findings were more commonly derived from national surveys, regional studies, and health-

system observations. This limits direct comparison between settings and reduces the ability to quantify the magnitude of each diagnostic or therapeutic gap. In addition, the review did not perform formal risk-of-bias assessment or meta-analysis, which means that the conclusions should be interpreted as a structured interpretive synthesis rather than pooled quantitative evidence. Nevertheless, the consistency of findings across diagnostic, therapeutic, institutional, and policy domains supports the central conclusion that anemia control in Pakistan requires both clinical modernization and health-system strengthening.

The policy implications are substantial. First, Pakistan would benefit from national anemia management guidelines that move beyond hemoglobin thresholds and include diagnostic algorithms for ferritin, transferrin saturation, inflammatory markers, pregnancy-related anemia, pediatric anemia, CKD-associated anemia, and perioperative anemia. Second, public-sector laboratory capacity should be strengthened so that iron studies become available in district and tertiary hospitals rather than remaining limited to selected private or specialist settings. Third, intravenous iron and ESA use should be governed by standardized protocols to improve access while preventing inappropriate use. Fourth, PBM programs should be piloted in high-volume surgical, obstetric, and nephrology centers before wider scale-up. Finally, national nutrition and fortification programs require stronger monitoring systems linked to measurable anemia indicators in women, children, and high-risk clinical groups.

Future research should focus on generating Pakistan-specific evidence capable of guiding implementation. Priority areas include facility-based studies measuring access to ferritin and transferrin saturation testing, prospective studies comparing oral and intravenous iron outcomes in pregnant women and patients with chronic disease, cost-effectiveness analyses of intravenous iron and PBM implementation, and regional evaluations of food fortification quality and anemia surveillance. Pragmatic implementation studies are also needed to assess whether tiered anemia algorithms can be integrated into primary care, maternal-child health services, and district hospital systems. Such research would help move anemia control in Pakistan from broad policy recognition toward measurable improvements in diagnosis, treatment, and population-level outcomes.

CONCLUSION

This structured narrative review concludes that anemia management in developed healthcare systems has progressed toward a biomarker-guided, evidence-based, and system-integrated model that combines accurate etiological diagnosis, individualized treatment, intravenous iron therapy, erythropoiesis-stimulating agents, Patient Blood Management, and preventive public health surveillance. In contrast, Pakistan continues to face a substantial anemia burden because routine care remains largely dependent on hemoglobin-based diagnosis, oral iron supplementation, limited access to advanced laboratory testing, restricted availability of modern therapies, fragmented clinical pathways, and inconsistent implementation of nutrition and screening policies. The most important implication is that reducing anemia in Pakistan requires more than supplementation alone; it requires a coordinated national framework that strengthens diagnostic capacity, expands appropriate treatment access, integrates anemia care into maternal-child health, nephrology, perioperative, and primary care services, and supports policy implementation through surveillance, monitoring, and locally relevant research.

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