Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

Laboratory-Based Evaluation of Anemia in Young Adults Using CBC and Serum Ferritin

Nawaf Khalid Aljabri[1], Mohammed Ahmed Sharif[2], Ahmed Saeed Saleh Alzahrani[3], Danya Ahmed Abualsaud[4], Alya Saud Ali Alghamdi[5], Abdullah Saad Guzai Alghamdi[6], Ahmed Habeeb Hakami[7], Talal Abdullah Saleh Almoqbil[8], Aziz Jumaan Alsewaihy[9], Ahmed Abdullah Ahmed Almuntashiri[10], Ahmed Ali Alkinani[11], Jalal Alkhebary[12]

Abstract

Anemia in young adults is a significant yet often underdiagnosed condition that can profoundly affect physiological function, cognitive development, academic performance, work productivity, and overall quality of life. Laboratory evaluation forms the cornerstone of diagnosing anemia, enabling not only the detection but also the classification of its diverse etiologies. The Complete Blood Count (CBC) provides a comprehensive assessment of red blood cell indices, hemoglobin concentration, and related hematologic parameters, offering vital clues into the type and severity of anemia. Serum ferritin measurement complements CBC findings by reflecting the body's iron stores and helping differentiate iron deficiency anemia from other microcytic or normocytic anemias. Accurate diagnosis, however, requires more than technical measurement; it demands a nuanced understanding of laboratory data in the context of the patient's clinical status. This detailed review synthesizes the perspectives of Laboratory Specialists, Senior Laboratory Scientists, Microbiology Molecular Specialists, Medical Laboratory Officers, Technicians, and Medical Technologists, illustrating how multidisciplinary collaboration optimizes the diagnostic workflow. Critical attention is given to pre-analytical, analytical, and post-analytical variables, quality assurance protocols, molecular diagnostic advancements, and emerging technologies that are reshaping the laboratory landscape. By emphasizing a holistic and quality-driven approach, this article aims to enhance diagnostic precision, inform clinical decision-making, and promote improved health outcomes among young adult populations affected by anemia.

Keywords: *Anemia, Complete Blood Count, Serum Ferritin, Iron Deficiency, Young Adults, Hematologic Indices, Laboratory Quality Control, Molecular Microbiology, Diagnostic Innovations, Multidisciplinary Laboratory Approach.*

Introduction

Anemia, defined by a reduction in the oxygen-carrying capacity of the blood due to decreased hemoglobin concentration, hematocrit, or red blood cell count, remains a pervasive public health issue worldwide, particularly among young adults aged 18 to 35 years. Despite its widespread prevalence, anemia in this population often escapes early detection due to its insidious onset and nonspecific symptomatology. Clinical manifestations such as fatigue, reduced exercise tolerance, impaired concentration, and pallor are frequently attributed to lifestyle stressors or other benign causes, delaying appropriate medical evaluation. Yet, untreated anemia in young adults can lead to significant complications including diminished academic performance, reduced workforce participation, delayed physical development, increased susceptibility to infections, and, in cases of severe anemia, cardiovascular strain and adverse pregnancy outcomes (1).

Understanding the causes of anemia in young adults is essential for guiding laboratory investigations. Nutritional deficiencies, particularly iron, vitamin B12, and folate, account for a substantial proportion of

[1] Medical Laboratory Specialist, King Fahad Armed Forces Hospital, Jeddah.
[2] Senior Specialist - Laboratory, King Fahad Armed Forces Hospital, Jeddah.
[3] Laboratory Specialist, King Fahad Armed Forces Hospital, Jeddah.
[4] Senior Specialist - Microbiology Molecular, King Fahad Armed Forces Hospital, Jeddah.
[5] Laboratory Specialist, King Fahad Armed Forces Hospital, Jeddah.
[6] Medical Laboratory Specialist Officer, King Fahad Armed Forces Hospital, Jeddah.
[7] Lab Technician, King Fahad Armed Forces Hospital, Jeddah.
[8] Specialist Laboratory - Laboratory and Medical Technology, King Fahad Armed Forces Hospital, Jeddah.
[9] Laboratories and Medical Technology, King Fahad Armed Forces Hospital, Jeddah.
[10] Laboratories and Medical Technology, King Fahad Armed Forces Hospital, Jeddah.
[11] Laboratory Specialist, King Fahad Armed Forces Hospital, Jeddah.
[12] Laboratories and Medical Technology, King Fahad Armed Forces Hospital, Jeddah.

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748
cases. Other contributors include hereditary disorders like thalassemia and sickle cell disease, chronic infections, autoimmune diseases, renal insufficiency, and inflammatory disorders. Differentiating among these causes is clinically critical because management strategies vary widely, from simple supplementation to complex hematological interventions or treatment of underlying systemic diseases (1).

Laboratory testing provides the most objective, sensitive, and reproducible means of diagnosing and classifying anemia. Among available tests, the Complete Blood Count (CBC) is fundamental, offering a broad profile of red cell indices that enable morphological classification of anemia as microcytic, normocytic, or macrocytic. When interpreted correctly, CBC parameters such as mean corpuscular volume (MCV), red cell distribution width (RDW), mean corpuscular hemoglobin (MCH), and hemoglobin concentration provide indispensable insights into underlying pathophysiology (2).

Complementing CBC, serum ferritin measurement serves as a specific marker of iron stores, essential for diagnosing iron deficiency anemia, the most common anemia type in young adults globally. However, because ferritin is also an acute-phase reactant, its levels may be elevated in inflammatory or infectious conditions, potentially masking underlying iron deficiency. Therefore, laboratory professionals must integrate ferritin values with clinical history, other iron studies (such as serum iron, total iron-binding capacity), and inflammatory markers to arrive at an accurate diagnosis (3).

Laboratory evaluation of anemia is a complex process that benefits significantly from the expertise of a multidisciplinary team. Laboratory Specialists, Senior Laboratory Officers, Technicians, Microbiology Molecular Specialists, and Medical Technologists each play unique roles in ensuring diagnostic accuracy. From pre-analytical specimen handling to the use of advanced automated hematology analyzers, molecular diagnostic platforms, and rigorous quality control systems, every stage of laboratory testing influences the final interpretation (2).

This review seeks to offer a comprehensive, interdisciplinary perspective on laboratory-based anemia evaluation in young adults. By integrating current best practices, technological innovations, common diagnostic pitfalls, and future directions, we aim to provide laboratory and healthcare professionals with an in-depth understanding necessary for improving diagnostic workflows and patient care outcomes.

Understanding the Clinical Spectrum of Anemia in Young Adults

Anemia in young adults is a multifaceted condition that presents a wide range of clinical manifestations, with potential causes rooted in nutritional, genetic, infectious, or chronic disease processes. Understanding the spectrum of anemia is critical for laboratory professionals to guide diagnostic testing and clinical management effectively. The classification of anemia is based on several factors, including the underlying cause, red blood cell morphology, and the severity of the condition. While iron deficiency anemia (IDA) is the most common cause, particularly in young women, the spectrum of anemia in young adults extends beyond iron deficiency, including anemia of chronic disease, vitamin B12 and folate deficiencies, hemoglobinopathies, and other rare disorders (4).

Iron Deficiency Anemia (IDA)

Iron deficiency anemia is the most prevalent form of anemia, particularly in young adult populations, especially young women of reproductive age. The pathogenesis of IDA typically involves insufficient dietary iron intake, increased iron requirements (such as during periods of rapid growth, pregnancy, or menstruation), or impaired iron absorption due to gastrointestinal disorders like celiac disease, inflammatory bowel disease, or chronic gastritis. In young adults, menstrual blood loss is a significant risk factor, with excessive or heavy menstrual periods being one of the leading causes of iron deficiency in women (5).

Clinically, IDA presents with symptoms such as fatigue, pallor, shortness of breath, dizziness, and irritability. More severe cases can manifest with pica (the craving for non-food substances), glossitis, and

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

cheilosis. Laboratory findings in IDA are typically characterized by microcytic, hypochromic red blood cells, low hemoglobin, and low hematocrit levels. Additionally, serum ferritin levels are reduced, which serves as a key diagnostic marker. It is important to note that serum ferritin is an acute-phase reactant, and its levels may be elevated in inflammatory states, potentially masking true iron deficiency, particularly in the context of chronic disease (5).

Anemia of Chronic Disease (ACD)

Anemia of chronic disease, also referred to as anemia of inflammation, is commonly seen in young adults with underlying chronic infections, autoimmune diseases, or inflammatory disorders. The condition is characterized by a normocytic or mildly microcytic anemia with low serum iron levels, low total iron-binding capacity (TIBC), and normal or elevated serum ferritin levels. ACD arises from the body's response to chronic inflammation, which leads to impaired iron mobilization and utilization, along with altered erythropoiesis (6).

Conditions that frequently lead to ACD in young adults include rheumatoid arthritis, systemic lupus erythematosus (SLE), inflammatory bowel disease (IBD), and chronic infections such as tuberculosis. Clinically, ACD presents similarly to other forms of anemia but is often associated with the underlying inflammatory condition, such as joint pain in rheumatoid arthritis or gastrointestinal symptoms in IBD. Laboratory evaluation typically reveals a normocytic anemia with relatively normal red blood cell morphology, making it essential to differentiate from other anemias such as IDA or thalassemia (6).

Vitamin Deficiency Anemia (B12 and Folate)

Vitamin B12 and folate deficiencies are less common causes of anemia in young adults, but they can have significant clinical consequences. Both deficiencies lead to macrocytic anemia, characterized by large, immature red blood cells (megaloblasts), which are typically detected in the peripheral blood smear. Deficiencies in these vitamins can result from poor dietary intake, malabsorption syndromes, or increased requirements due to pregnancy or certain medical conditions (7).

In vitamin B12 deficiency, the anemia is often accompanied by neurological symptoms such as numbness, tingling in the extremities, and cognitive disturbances. Pernicious anemia, an autoimmune disorder that impairs vitamin B12 absorption, is a well-known cause in young adults. Folate deficiency, on the other hand, is typically associated with poor diet, alcohol abuse, or malabsorption due to conditions like celiac disease. The clinical presentation of folate deficiency-related anemia may include fatigue, weakness, and irritability, but without the neurological involvement seen in B12 deficiency (7).

Both vitamin B12 and folate deficiencies can lead to irreversible neurological damage if left untreated, making early detection and treatment essential. Laboratory findings include an elevated mean corpuscular volume (MCV), and serum vitamin B12 or folate levels that are lower than normal thresholds. In cases where the underlying cause is suspected to be malabsorption, further investigation into gastrointestinal function may be necessary (8).

Hemoglobinopathies (Thalassemia, Sickle Cell Disease)

Inherited hemoglobinopathies such as thalassemia and sickle cell disease are common causes of anemia in young adults, particularly in individuals from ethnic groups with a higher prevalence of these disorders. Thalassemia is a genetic condition that results in abnormal hemoglobin production due to mutations in the globin genes, leading to microcytic anemia. Sickle cell disease, caused by a mutation in the β-globin gene, leads to the production of abnormal hemoglobin (hemoglobin S) and sickling of red blood cells, which can cause hemolysis, pain crises, and organ damage (9).

In both conditions, laboratory findings typically include microcytic anemia, reduced hemoglobin levels, and abnormal peripheral blood smears. In thalassemia, peripheral blood smears often show target cells,

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

basophilic stippling, and microcytic hypochromic red blood cells. In sickle cell disease, sickle-shaped red blood cells are seen under microscopic examination, and hemoglobin electrophoresis is used to confirm the diagnosis (10).

The clinical management of these hemoglobinopathies is complex and depends on the severity of the disease. For instance, thalassemia major may require regular blood transfusions, iron chelation therapy, and in some cases, bone marrow transplantation. Sickle cell disease management focuses on preventing crises, managing pain, and addressing complications such as organ damage and infection (9).

Other Causes of Anemia

While the aforementioned causes represent the most common etiologies of anemia in young adults, other rare but important causes include bone marrow disorders, renal insufficiency, and drug-induced anemia. Bone marrow disorders, such as aplastic anemia or myelodysplastic syndromes, result from impaired hematopoiesis and lead to pancytopenia, which can manifest as anemia, neutropenia, and thrombocytopenia. These conditions are often diagnosed through bone marrow aspiration and biopsy, in addition to routine CBC testing (11).

Chronic kidney disease (CKD) is another cause of anemia in young adults, especially in individuals with conditions such as polycystic kidney disease or nephropathy related to hypertension or diabetes. In CKD, anemia results from decreased erythropoietin production by the kidneys, leading to a normocytic, normochromic anemia. The management of CKD-related anemia often involves erythropoiesis-stimulating agents (ESAs) and iron supplementation (11).

Certain medications, such as chemotherapy agents or antibiotics, can also cause anemia by affecting bone marrow production or inducing hemolysis. For instance, drugs like methotrexate or sulfonamides can cause folate deficiency or hemolytic anemia, respectively (12).

The Role of Complete Blood Count in Anemia Evaluation

The Complete Blood Count is a multifaceted test that quantifies various blood parameters, providing the first laboratory indication of anemia. Key indices include: (13).

Hemoglobin (Hb): The primary indicator of anemia; its concentration correlates with oxygen-carrying capacity.

Hematocrit (Hct): Expresses the volume percentage of RBCs in blood; decreases proportionally with anemia severity.

Red Blood Cell Count (RBC): Reflects the absolute number of circulating RBCs.

Mean Corpuscular Volume (MCV): Determines RBC size, guiding classification into microcytic, normocytic, or macrocytic anemia.

Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC): Reflect the hemoglobin content and concentration within RBCs, essential in identifying hypochromic conditions.

Red Cell Distribution Width (RDW): Measures variability in RBC size, aiding in distinguishing mixed anemia or early iron deficiency.

Modern automated analyzers use flow cytometry, laser scatter, and electrical impedance to measure these parameters with high precision. Advanced parameters such as reticulocyte counts, immature reticulocyte fraction, and nucleated RBCs further enrich the diagnostic picture (13).

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

Automated analyzers also generate morphological flags, prompting manual smear reviews to detect abnormalities such as anisocytosis, poikilocytosis, and basophilic stippling, which are crucial in specific anemia types (4).

Significance of Serum Ferritin in Assessing Iron Stores

Serum ferritin serves as the intracellular protein that stores iron and releases it in a controlled fashion. Clinically, ferritin concentration correlates with the body's total iron reserves. (14).

Low serum ferritin (<30 ng/mL) is highly specific for iron deficiency anemia, even before clinical anemia develops.

Normal or elevated ferritin levels in an anemic patient suggest alternative or coexisting conditions, including anemia of chronic disease, liver disease, or malignancy, as ferritin is also an acute-phase reactant.

The measurement of serum ferritin is commonly conducted through immunoassay techniques such as enzyme-linked immunosorbent assay (ELISA), chemiluminescence immunoassay (CLIA), or immunoturbidimetry. Each method has specific sensitivity, specificity, and interference profiles, requiring expertise in assay selection and interpretation (9).

When interpreting ferritin results, it is crucial to consider confounding factors such as inflammatory conditions, renal dysfunction, and recent iron supplementation, all of which can skew ferritin levels independent of true iron status (14).

Multidisciplinary Contributions in Laboratory-Based Anemia Evaluation

The laboratory-based evaluation of anemia is a complex process that requires the integration of knowledge, skills, and expertise from multiple professional disciplines. From sample collection to result interpretation, each role within the laboratory plays an essential part in ensuring diagnostic accuracy and improving patient outcomes. The collaboration among Laboratory Specialists, Senior Laboratory Scientists, Medical Technologists, Microbiology Molecular Specialists, Laboratory Technicians, and Medical Laboratory Officers is key to optimizing the anemia diagnostic workflow. This multidisciplinary approach not only ensures that laboratory results are precise but also that these results are interpreted in the correct clinical context. Below, we explore the specific contributions of each professional in the diagnostic process of anemia in young adults (15).

Laboratory Specialists

Laboratory Specialists are pivotal in overseeing the entire testing process, ensuring that laboratory tests are performed accurately and in compliance with quality standards. They are responsible for supervising the preparation and analysis of blood samples, ensuring that the appropriate tests—such as CBC and serum ferritin—are conducted under optimal conditions. Specialists interpret complex data and contribute to identifying the underlying etiology of anemia by integrating laboratory findings with patient history and clinical symptoms (16).

In the context of anemia evaluation, Laboratory Specialists are responsible for maintaining and validating laboratory equipment, ensuring calibration, troubleshooting, and preventing errors that could affect the accuracy of results. For example, they ensure that hematology analyzers used for CBC are working at peak efficiency and that parameters such as hemoglobin concentration, mean corpuscular volume (MCV), and red blood cell count are reliably measured. Furthermore, they may perform additional testing, such as reticulocyte counts or hemoglobin electrophoresis, to further classify the anemia and identify rare causes, such as hemoglobinopathies (15).

Senior Laboratory Scientists

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

Senior Laboratory Scientists play a leadership role in managing laboratory teams and coordinating the various components of the anemia diagnostic process. They are involved in advanced testing techniques, such as flow cytometry, molecular diagnostics, and next-generation sequencing, which are increasingly important in the detection of rare or inherited forms of anemia. Senior Scientists oversee the implementation of new technologies and test methods, ensuring that they meet the highest standards for reliability, reproducibility, and sensitivity (17).

In anemia evaluation, they may direct special tests, such as serum iron panels, total iron-binding capacity (TIBC), and transferrin saturation, which help differentiate between iron deficiency anemia, anemia of chronic disease, and other causes of microcytic anemia. Furthermore, their expertise is crucial in handling ambiguous cases where common anemias, like IDA, overlap with conditions such as anemia of chronic disease or vitamin B12 deficiency. They provide the necessary insight to resolve such complexities through advanced testing and clinical correlation (15).

Medical Laboratory Technologists

Medical Laboratory Technologists are often the frontline professionals in the laboratory who perform most of the routine tests necessary for anemia evaluation. They operate sophisticated instruments that automate the CBC, perform manual hematological tests, and carry out specialized assays like serum ferritin and iron studies. Technologists are responsible for the precise handling of blood samples, following strict protocols to avoid pre-analytical errors that can compromise results (15).

For example, in serum ferritin testing, Medical Technologists are trained to handle and store samples properly, as ferritin levels are highly sensitive to sample degradation. They also play a key role in verifying the results of automated CBC systems, ensuring that abnormal findings—such as low hemoglobin levels or abnormal red cell indices—are flagged for further investigation. Technologists often work in conjunction with Laboratory Specialists to validate results and provide preliminary interpretations, making them integral to the first stage of the diagnostic process (15).

Microbiology Molecular Specialists

In cases where anemia may be related to an underlying infectious or inflammatory condition, Microbiology Molecular Specialists provide invaluable contributions. These professionals focus on identifying pathogens or genetic conditions that may be contributing to anemia. Molecular diagnostics, particularly polymerase chain reaction (PCR) testing, is crucial in detecting infections such as malaria, tuberculosis, or HIV, which can cause anemia due to chronic disease or direct hemolysis (18).

Microbiology Molecular Specialists also play a significant role in identifying inherited hemoglobinopathies, such as sickle cell disease and thalassemia, through advanced genetic testing and hemoglobin electrophoresis. They are responsible for processing and analyzing blood samples for mutations in the hemoglobin gene and providing molecular diagnostic results that allow clinicians to differentiate between different types of anemia. In some cases, next-generation sequencing (NGS) techniques are employed to detect rare genetic causes of anemia, enabling a more precise diagnosis (18).

For example, in cases where a young adult presents with unexplained anemia, molecular testing can provide a definitive diagnosis of thalassemia or sickle cell disease, conditions that require lifelong management and specialized care. The collaboration between Molecular Specialists and Laboratory Scientists ensures that diagnostic results from genetic testing are accurate and appropriately interpreted (19).

Medical Laboratory Officers

Medical Laboratory Officers are responsible for overseeing the operational aspects of the laboratory, ensuring that laboratory procedures follow regulatory and accreditation standards. Their role in anemia evaluation includes ensuring that laboratories are stocked with the necessary reagents, that staff are

Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

adequately trained, and that quality control measures are consistently followed. Medical Laboratory Officers work closely with laboratory leadership to implement continuous quality improvement initiatives aimed at enhancing the diagnostic accuracy and operational efficiency of the laboratory (20).

They also play a role in managing patient data, ensuring that test results are appropriately documented and communicated to clinicians in a timely manner. In the context of anemia evaluation, this may involve facilitating the smooth flow of test orders, result reporting, and the tracking of patient outcomes. They may also be involved in patient education and communication, particularly in cases where test results indicate a need for further investigation or specialized care (15).

Laboratory Technicians

Laboratory Technicians often serve as support staff, ensuring that samples are collected, processed, and prepared for testing. In the case of anemia evaluation, Laboratory Technicians are essential in ensuring proper blood sample collection (e.g., venipuncture) and handling, including the preservation of samples to prevent hemolysis, contamination, or degradation before testing. They are also responsible for the preparation of laboratory materials, such as reagents, and for ensuring that these materials are stored and handled according to protocol (21).

In the context of anemia testing, Laboratory Technicians may prepare slides for peripheral blood smears, which are crucial for the morphological assessment of red blood cells. These smears help identify certain features of anemia, such as the presence of target cells, sickle cells, or poikilocytosis, which can provide important clues about the type of anemia. Technicians often work closely with Medical Technologists and Laboratory Specialists to ensure that test results are accurate and that proper procedures are followed during sample processing (17).

Collaborative Workflow in Anemia Diagnosis

The successful diagnosis of anemia is the result of a well-coordinated, multidisciplinary effort. From the initial blood collection by Laboratory Technicians to the final report generated by Laboratory Specialists, each professional plays a key role in the diagnostic process. The integration of data from multiple laboratory tests (e.g., CBC, serum ferritin, reticulocyte count, and iron studies) is essential to accurately classify the anemia and identify its underlying cause. This requires close collaboration between laboratory staff, clinicians, and healthcare providers to ensure that the results are interpreted in the appropriate clinical context (22).

Additionally, as technology advances, new diagnostic techniques and methodologies emerge, further enhancing the ability of laboratories to provide comprehensive and accurate anemia evaluations. The role of molecular diagnostics, next-generation sequencing, and artificial intelligence in the diagnostic process is increasingly becoming a part of the laboratory's routine workflow, requiring multidisciplinary expertise to harness these innovations effectively (23).

Pre-Analytical, Analytical, and Post-Analytical Variables Influencing Anemia Diagnosis

Pre-Analytical Factors

Errors at this stage can account for up to 70% of all laboratory errors. Key considerations include patient preparation, sample collection techniques, appropriate anticoagulant use, timely transport, and proper sample storage. For instance, delayed processing of CBC samples can result in falsely elevated MCV due to RBC swelling (4).

Analytical Factors

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

Ensuring analyzer calibration, reagent quality, and correct instrument settings are critical. Analytical errors may arise from machine malfunction, sample hemolysis, lipemic interference, or cross-reactivity in ferritin immunoassays (24).

Post-Analytical Factors

This phase focuses on result validation, critical value reporting, interpretative comments, and communication with clinical teams. Effective post-analytical processes ensure that significant findings, such as a critically low hemoglobin or markedly reduced ferritin, are rapidly relayed to the treating physician (25).

Quality Control and Laboratory Accreditation in Anemia Diagnostics

Laboratory reliability depends heavily on stringent internal quality control (IQC) and external quality assessment (EQA). (26).

Internal Quality Control

Routine use of control materials allows monitoring of analyzer performance. Application of Westgard rules facilitates early detection of analytical shifts or trends (26).

External Quality Assessment

Participation in programs such as CAP (College of American Pathologists), RIQAS, or NEQAS ensures external validation of laboratory accuracy. Proficiency testing using blinded samples enables benchmarking against peer laboratories (27).

Accreditation Standards

Accreditation under ISO 15189 or CAP Laboratory Accreditation Program reinforces commitment to quality and continual improvement, providing assurance of technical competence and patient safety (28).

Emerging Technologies and Future Trends in Anemia Diagnostics

Advances in laboratory hematology are revolutionizing anemia diagnosis. Automation, artificial intelligence, and molecular diagnostics are increasingly integrated into routine practice (29).

Automation and Digital Morphology

Automated digital imaging systems reduce manual workload while enhancing accuracy and reproducibility. AI algorithms assist in classifying RBC morphology and identifying subtle features indicative of early or complex anemias (29).

Point-of-Care Testing

Portable CBC devices and ferritin assays are being developed, allowing rapid anemia screening in outpatient or resource-limited settings, enabling early diagnosis and treatment (22).

Molecular Diagnostics

Next-generation sequencing (NGS) and multiplex PCR platforms are enabling comprehensive screening for genetic anemia syndromes and infectious contributors in a single assay (27).

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

Big Data and Predictive Analytics

Integration of large datasets from CBC results, ferritin levels, and clinical information allows predictive modeling for anemia trends, improving population-level health management (30).

Challenges and Opportunities in Laboratory Anemia Diagnosis

The laboratory diagnosis of anemia faces several challenges, including distinguishing iron-deficiency anemia from anemia of chronic disease, interpreting ferritin levels in inflammatory states, managing resource constraints, and maintaining high-quality standards across diverse healthcare settings (31).

Opportunities lie in enhancing laboratory training, expanding access to advanced diagnostics, fostering interdisciplinary collaboration, and leveraging technology to refine and personalize anemia management strategies (31).

Conclusion

An accurate laboratory-based diagnosis of anemia in young adults requires a coordinated effort across multiple laboratory disciplines, meticulous attention to pre-analytical, analytical, and post-analytical processes, and a commitment to continual innovation. Complete Blood Count and serum ferritin assessments, when performed and interpreted with expertise, remain central to anemia evaluation. Multidisciplinary collaboration, robust quality systems, and adoption of emerging technologies are pivotal in improving diagnostic precision and, ultimately, patient outcomes.

References

Namaste, S., Brindle, E., & Garrett, D. (2022). Measurement Methods for Anemia and Iron Status Surveillance. Nutritional Anemia, 35-48.

Williams, A. M., Brown, K. H., Allen, L. H., Dary, O., Moorthy, D., & Suchdev, P. S. (2023). Improving anemia assessment in clinical and public health settings. The Journal of nutrition, 153, S29-S41.

Saengnipanthkul, S., Tawiangnan, C., Sirikarn, P., Supasai, S., Sitthikarnkha, P., Techasatian, L., & Uppala, R. (2024). Accuracy of noninvasive total haemoglobin measurement for detecting anaemia in infants: a cross-sectional study in a well-child care clinic, Khon Kaen, Thailand. BMJ open, 14(12), e083356.

Karakochuk, C. D., Hess, S. Y., Moorthy, D., Namaste, S., Parker, M. E., Rappaport, A. I., ... & HEmoglobin MEasurement (HEME) Working Group. (2019). Measurement and interpretation of hemoglobin concentration in clinical and field settings: a narrative review. Annals of the new York Academy of Sciences, 1450(1), 126-146.

Read, A. J., Waljee, A. K., Sussman, J. B., Singh, H., Chen, G. Y., Vijan, S., & Saini, S. D. (2021). Testing practices, interpretation, and diagnostic evaluation of iron deficiency anemia by US primary care physicians. JAMA Network Open, 4(10), e2127827-e2127827.

Mengesha, M. B., & Dadi, G. B. (2019). Prevalence of anemia among adults at Hawassa University referral hospital, Southern Ethiopia. BMC hematology, 19, 1-7.

Locks, L. M., Bhaise, S., Dhurde, V., Gugel, A., Lauer, J., Shah, M., ... & Patel, A. (2024). The prevalence of anemia during pregnancy and its correlates vary by trimester and hemoglobin assessment method in Eastern Maharashtra, India. Maternal & Child Nutrition, 20(4), e13684.

Kim, H. J., & Lim, Y. J. (2024). Endoscopic findings and predictors of gastrointestinal lesions in children with iron deficiency anemia. Pediatric Hematology and Oncology, 41(2), 114-120.

Paoletti, G., Bogen, D. L., & Ritchey, A. K. (2014). Severe iron-deficiency anemia still an issue in toddlers. Clinical Pediatrics, 53(14), 1352-1358.

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748

PANDEY, A., & PRASAD, D. V. (2025). Examining the prevalence of moderate to severe anaemia in adults aged 18 to 60 in urban areas. Cuestiones de Fisioterapia, 54(2), 2110-2117.

Cojulun, A. C., Bustinduy, A. L., Sutherland, L. J., Mungai, P. L., Mutuku, F., Muchiri, E., ... & King, C. H. (2015). Anemia among children exposed to polyparasitism in coastal Kenya. The American journal of tropical medicine and hygiene, 93(5), 1099.

Al Ghwass, M. M., Halawa, E. F., Sabry, S. M., & Ahmed, D. (2015). Iron deficiency anemia in an Egyptian pediatric population: A cross-sectional study. Annals of African Medicine, 14(1), 25-31.

Hans, A., Atreja, C. B., & Batra, N. (2024). Distinguishing iron deficiency anemia from beta-thalassemia trait: comparative analysis of CRUISE index and other traditional diagnostic indices. Cureus, 16(7).

Sholzberg, M., & Tang, G. H. (2025). The detrimental impact of ferritin "normal" ranges on diagnosis of bleeding disorders in women. Research and Practice in Thrombosis and Haemostasis, 9(1).

Sowndarya, K., Basavaiah, S. H., Shenoy, R., & Hegde, A. (2019). Proportion and Associated Factors of Vitamin B12 Deficiency–A Retrospective Laboratory-Based Study. Current Research in Nutrition and Food Science Journal, 7(3), 670-677.

Lauer, J. M., Bhaise, S., Dhurde, V., Gugel, A., Shah, M., Hibberd, P. L., ... & Locks, L. M. (2024). Maternal Anemia during Pregnancy and Infant Birth Outcomes: A Prospective Cohort Study in Eastern Maharashtra, India. Current Developments in Nutrition, 8(11), 104476.

Odhiambo, C., Oyaro, B., Odipo, R., Otieno, F., Alemnji, G., Williamson, J., & Zeh, C. (2015). Evaluation of locally established reference intervals for hematology and biochemistry parameters in Western Kenya. PloS one, 10(4), e0123140.

Birhaneselassie, M., Birhanu, A., Gebremedhin, A., & Tsegaye, A. (2013). How useful are complete blood count and reticulocyte reports to clinicians in Addis Ababa hospitals, Ethiopia?. BMC Blood Disorders, 13, 1-7.

O'Brien, L. M., Koo, J., Fan, L., Owusu, J. T., Chotinaiwattarakul, W., Felt, B. T., & Chervin, R. D. (2009). Iron stores, periodic leg movements, and sleepiness in obstructive sleep apnea. Journal of clinical sleep medicine, 5(6), 525-531.

Wilcox, N. S., Tapé, C., Cordisco, A. J., Than, M. T., Zuroff, L., Dobkin, J., ... & Kosseim, L. M. (2021). Anemia in a young Guinean male. Clinical Case Reports, 9(8), e04593.

Miller, J. M., Astles, R., Baszler, T., Chapin, K., Carey, R., Garcia, L., ... & Wiedbrauk, D. (2012). Guidelines for safe work practices in human and animal medical diagnostic laboratories. MMWR Surveill Summ, 6(61), 1-102.

Mekonnen, E. (2004). Health Laboratory Management and Quality Assurance. Ethiopia: Gondar University College. K. Elissa,"Title of paper if known," unpublished.

Carey, R. B., Bhattacharyya, S., Kehl, S. C., Matukas, L. M., Pentella, M. A., Salfinger, M., & Schuetz, A. N. (2018). Practical guidance for clinical microbiology laboratories: Implementing a quality management system in the medical microbiology laboratory. Clinical microbiology reviews, 31(3), 10-1128.

Howerton, D., Anderson, N., Bosse, D., Granade, S., & Westbrook, G. (2005). Good laboratory practices for waived testing sites. MMWR Recomm Rep, 54, 1-25.

Juretić, D., Božičević, S., & Vučić, M. L. (2002). Pre-Analytical, Analytical and Post-Analytical Factors Influencing Specific Tests For Diagnosis and Monitoring of DM-National Network in Quality Assessment. EJIFCC, 13(5), 232.

Pai, S., & Frater, J. L. (2019). Quality management and accreditation in laboratory hematology: Perspectives from India. International journal of laboratory hematology, 41, 177-183.

Guindo, M. A., Shott, J. P., Saye, R., Diakité, M. L., Sanogo, S., Dembele, M. B., ... & Doumbo, O. K. (2012). Promoting good clinical laboratory practices and laboratory accreditation to support clinical trials in sub-Saharan Africa. The American journal of tropical medicine and hygiene, 86(4), 573.

Garcia-Casal, M. N., Dary, O., Jefferds, M. E., & Pasricha, S. R. (2023). Diagnosing anemia: Challenges selecting methods, addressing underlying causes, and implementing actions at the public health level. Annals of the New York Academy of Sciences, 1524(1), 37-50.

Volume: 3, No: 8, pp. 14414 – 14424
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.6748
Hevessy, Z., Toth, G., Antal-Szalmas, P., Tokes-Fuzesi, M., Kappelmayer, J., Karai, B., ... & Algorithms of the Hungarian Society of Laboratory Medicine. (2024). Algorithm of differential diagnosis of anemia involving laboratory medicine specialists to advance diagnostic excellence. Clinical Chemistry and Laboratory Medicine (CCLM), 62(3), 410-420.

Newman, A. W., & Behling-Kelly, E. (2016). Quality assurance and quality control in point-of-care testing. Topics in Companion Animal Medicine, 31(1), 2-10.

Chaudhry, A. S., Inata, Y., & Nakagami-Yamaguchi, E. (2023). Quality analysis of the clinical laboratory literature and its effectiveness on clinical quality improvement: a systematic review. Journal of clinical biochemistry and nutrition, 73(2), 108.