



Hemoglobin Levels and Anemia Patterns in Hospitalized Patients with Culture-Confirmed Bacterial Infections

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Abstract

Background: Anemia is a common hematological abnormality among hospitalized patients and is frequently associated with bacterial infections and systemic inflammation. Reduced hemoglobin levels may reflect disease severity and negatively affect clinical outcomes. This study aimed to evaluate hemoglobin levels and the prevalence, severity, and morphological patterns of anemia among hospitalized patients with culture-confirmed bacterial infections.

Methods: This retrospective cross-sectional study was conducted at Al Hada Military Hospital. A total of 212 hospitalized patients with culture-confirmed bacterial infections were included. Demographic and laboratory data were obtained from medical records. Complete blood count parameters were analyzed using Sysmex XN-9000 analyzer. Anemia was classified according to World Health Organization criteria based on severity and morphology. Statistical analysis was performed using descriptive statistics, chi-square test, and independent t-test.

Results: Among the 212 patients, 80.2% were anemic, while 19.8% had normal hemoglobin levels. The mean age of anemic patients was 70.9 ± 18.5 years, with the majority aged ≥ 65 years. Normocytic normochromic anemia was the most common morphological type (61.2%), followed by microcytic hypochromic anemia (28.2%). Moderate anemia was the predominant severity category (67.6%). Gram-positive bacteria accounted for 68.8% of isolates. No significant association was found between Gram stain type and anemia severity or hemoglobin levels ($p > 0.05$).

Conclusion: Anemia was highly prevalent among hospitalized patients with culture-confirmed bacterial infections, particularly among elderly patients. Normocytic normochromic and moderate anemia were the most common patterns, supporting the role of inflammation in anemia development. Hemoglobin assessment may serve as an important clinical indicator in hospitalized patients with bacterial infections.

Keywords: Hemoglobin; Anemia; Bacterial Infections; Blood Culture; Hospitalized Patients

Introduction

Anaemia is a worldwide health concern that affects individuals regardless of age or gender. Anaemia may result from multiple reasons, including acute and chronic infections, in addition to haematological problems. Nutritional and inflammatory diseases may also serve as causative factors [1,2]. Chronic disorders can also induce anaemia. Chronic illnesses can elicit an inflammatory response or disrupt iron metabolism, leading to the sequestration and immobilisation of iron within storage sites. Furthermore, anaemia resulting from chronic illnesses may result in diminished haemoglobin (Hb) production [3,4].

Anaemia can be classified in various ways. Anaemia can be categorised based on the morphology of red blood cells (RBC) utilizing characteristics such as mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC). Anaemia can be categorised as macrocytic, normocytic, or microcytic based on these criteria. Each group corresponds to distinct disease mechanisms [5]. Anaemia may also be categorised based on haemoglobin concentration. The World Health Organization (WHO) has set guidelines to categorise anaemia by severity as mild, moderate, or severe [6].

Anaemia is a prevalent clinical observation among hospitalised patients. Anaemia is prevalent among both medical and surgical patients, particularly those with chronic conditions and severe illnesses. Individuals with inflammation and anaemia exhibit elevated morbidity and mortality rates. Moreover, these individuals frequently experience prolonged hospitalisations and necessitate blood transfusions [7]. Numerous factors contribute to the development of anaemia in hospitalised patients. A contributing factor to the development of anaemia is inflammation, which inhibits erythropoiesis and the generation of red blood cells.

Materials and Methods

Study design

This retrospective cross-sectional study was conducted from December 2025 to May 2026 at Al Hada Military Hospital, Taif, Saudi Arabia.

Participants and data collection

The study included hospitalized male and female patients of all ages with culture-confirmed bacterial infections and available hemoglobin measurements at admission. Patients with incomplete

data, known hematological disorders, active major bleeding, or prior transfusion were excluded. Data were extracted from medical records using Microsoft Excel and included demographic variables (age and gender) and laboratory results. Only baseline complete blood count (CBC) values at admission were analyzed. Hematological data were obtained from the Hematology Laboratory, and microbiological results from the Microbiology Laboratory.

Laboratory investigations

Hematological and microbiological analysis

Complete blood count parameters were analyzed using an automated hematology analyzer (Sysmex XN-9000 series). Hemoglobin (g/dL) served as the primary indicator for defining anemia. Additional red cell indices, including RBC count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW), were assessed to classify anemia and evaluate erythrocyte morphology. Bacterial infections were confirmed through blood culture, and the isolated organisms were categorized as Gram-positive or Gram-negative.

Statistical analysis

Descriptive statistics were used to summarize demographic and laboratory results. Continuous variables were expressed as mean $\pm$ standard deviation (SD). Chi-square tests were applied for categorical variables, and independent t-tests were used to compare hemoglobin levels. A p-value <0.05 was considered statistically significant.

Ethical approval

Ethical approval was obtained from the Ethics Committee of the College of Applied Medical Sciences, Taif University. In addition, the Research Committee at Al Hada Military Hospital approved the study (IRB No. H-02-T-078). Patient confidentiality was ensured by anonymizing all collected data.

Results

Demographic characteristics of the study population

A total of 212 participants were included in this study, comprising 115 males (54.2%) and 97 females (45.8%), indicating a slight predominance of male participants. All participants were Saudi nationals and hospitalized patients from various age groups with bacterial infections confirmed by microbiological blood culture

results. The study was conducted over a five-month period, from December 2025 to May 2026, at Al Hada Military Hospital in Taif, Western region of Saudi Arabia. The age distribution of the participants demonstrated a clear predominance of older adults. Infants aged less than 1 year accounted for 2 participants (0.9%), while 4 participants (1.9%) were in the 1–17 years age group, indicating minimal pediatric representation. Among adult participants, 27 individuals (12.7%) were aged 18–44 years, and 33 participants (15.6%) were aged 45–64 years. A substantial proportion of the study population belonged to older age groups, with 48 participants (22.6%) aged 65–74 years. The largest group was observed among participants aged 75 years and above, comprising 98 individuals (46.2%). Overall, these findings indicate that the study population was predominantly elderly, with the majority of participants aged 65 years and older, which may reflect the increased susceptibility of older individuals to bacterial infections requiring hospitalization.

Prevalence and demographic distribution of anemia among hospitalized patients

Out of the total study population, 170 patients (80.2%) were identified as anemic, while 42 patients (19.8%) had normal hemoglobin levels, indicating a high prevalence of anemia among hospitalized patients with bacterial infections. Among the anemic patients, 96 (56.5%) were males and 74 (43.5%) were females. The mean age of the anemic patients was 70.9 ± 18.5 years, further supporting the predominance of anemia among elderly patients. The distribution of anemia across age groups showed that it was predominantly observed in older adults, with 66 patients (38.8%) aged ≥ 75 years and 42 patients (24.7%) aged 65–74 years. In comparison, 32 patients (18.8%) were aged 45–64 years, and 23 patients (13.5%) were aged 18–44 years, while only 7 patients (4.1%) were below 18 years. No cases were identified among infants (<1 year) (Table 1).

Clinical presentation of anemic patients with bacterial infections

The clinical presentation of anemic patients with culture-confirmed bacterial infections was variable, with fever being the most common symptom (48.2%), followed by respiratory manifestations such as cough, shortness of breath, and pneumonia (44.7%). Gastrointestinal symptoms, including vomiting, diarrhea, and abdominal pain, were reported in 34.1% of patients. Neurological manifestations such as confusion, decreased level of consciousness,

and seizures were observed in 24.1%, while 21.2% of patients presented with general symptoms including fatigue, weakness, and anorexia. Urinary symptoms were noted in 18.8%, and cardiovascular manifestations, including chest pain and shock, were present in 17.1% of cases. Additionally, 15.9% of patients presented with severe conditions such as septic shock or multiorgan dysfunction.

Comparison of hemoglobin levels between anemic and non-anemic patients

The mean hemoglobin (Hb) level among anemic patients was 9.57 ± 1.48 g/dL, compared to 13.99 ± 1.96 g/dL in non-anemic patients. An independent samples t-test demonstrated that this difference was highly statistically significant ($p < 0.001$). This finding confirms a marked reduction in hemoglobin levels among anemic patients compared to those with normal hemoglobin levels. The observed difference is consistent with the diagnostic criteria for anemia and highlights the clinical significance of hemoglobin measurement in hospitalized patients (Table 2).

Classification of anemia based on red blood cell morphology (WHO Criteria)

The morphological classification of anemia based on red blood cell indices demonstrated that normocytic normochromic anemia was the most prevalent type, accounting for 104 patients (61.2%). This was followed by microcytic hypochromic anemia in 48 patients (28.2%), while macrocytic normochromic anemia was observed in 18 patients (10.6%). The predominance of normocytic normochromic anemia indicates that most patients had red blood cells of normal size and hemoglobin content, which is commonly associated with acute or chronic inflammatory conditions, including infections. Given that all patients in this study had culture-confirmed bacterial infections, this pattern is consistent with anemia of inflammation (anemia of chronic disease), where iron utilization is impaired despite adequate iron stores.

In contrast, the presence of microcytic hypochromic anemia suggests that a proportion of patients may have underlying iron deficiency or later stages of inflammatory conditions, while the relatively smaller proportion of macrocytic anemia may be related to nutritional deficiencies (e.g., vitamin B12 or folate), chronic illness, or medication effects. Overall, these findings highlight the heterogeneous nature of anemia in hospitalized patients and emphasize the importance of red blood cell indices in guiding further diagnostic evaluation (Table 3).

Classification of anemia based on severity (WHO Criteria)

The classification of anemia based on severity revealed that moderate anemia was the most common form, observed in 115 patients (67.6%). This was followed by mild anemia in 32 patients (18.8%), while severe anemia was identified in 23 patients (13.5%) (Table 3). The predominance of moderate anemia indicates that a substantial proportion of patients experienced a clinically meaningful reduction in hemoglobin (Hb) levels, which may adversely affect tissue oxygenation and overall clinical outcomes. Although mild anemia was present in nearly one quarter of patients, the combined proportion of moderate and severe anemia (75.3%) demonstrates that the majority of patients had clinically significant anemia, rather than mild or incidental findings.

Furthermore, the presence of severe anemia in a notable proportion of patients highlights the potential impact of acute illness, systemic inflammation, and underlying comorbidities on hemoglobin levels. This distribution underscores the importance of routine assessment of anemia severity in hospitalized patients, as it may guide clinical decision-making, including closer monitoring, supportive care, and targeted therapeutic interventions.

Distribution of bacterial isolates among anemic patients

Among the 170 anemic patients with culture-confirmed bacterial infections, Gram-positive bacteria predominated, accounting for 117 cases (68.8%), while Gram-negative bacteria were identified in 53 cases (31.2%). This indicates that Gram-positive organisms were the most frequently isolated pathogens in this cohort of hospitalized anemic patients.

Association between gram stain type and anemia severity

The distribution of anemia severity according to Gram stain type showed a similar pattern across both groups. Among patients with Gram-positive infections (n = 117), moderate anemia was the most prevalent, observed in 81 patients (69.2%), followed by mild anemia in 19 patients (16.2%) and severe anemia in 17 patients (14.5%). Similarly, among patients with Gram-negative infections (n = 53), moderate anemia predominated, affecting 34 patients (64.2%), followed by mild anemia in 13 patients (24.5%) and severe anemia in 6 patients (11.3%). The Chi-square test was used to compare the distribution of anemia severity between Gram-positive and Gram-negative infections and demonstrated no statisti-

cally significant difference (χ^2 test, $p = 0.49$), indicating that anemia severity was similarly distributed across both groups (Table 4).

Comparison of hemoglobin levels by gram stain type

The mean hemoglobin level among patients with Gram-positive infections was 9.61 ± 1.47 g/dL, compared to 9.84 ± 1.59 g/dL among those with Gram-negative infections. An independent samples t-test demonstrated that this difference was not statistically significant ($p = 0.374$), indicating that hemoglobin levels were comparable between the two groups. These findings suggest that anemia severity and hemoglobin levels are not significantly influenced by the type of bacterial organism (Gram-positive vs Gram-negative). Instead, the consistent predominance of moderate anemia across both groups supports the notion that infection-related mechanisms particularly systemic inflammation and impaired erythropoiesis play a central role in the development of anemia in hospitalized patients, regardless of bacterial classification.

Age Group (years)	Number (n)	Percentage (%)
<1 year	0	0.0%
1–17	7	4.1%
18–44	23	13.5%
45–64	32	18.8%
65–74	42	24.7%
≥75	66	38.8%
Total	170	100%

Table 1: Age distribution of anemic patients (n = 170).

Group	Number	Mean Hb (g/dL) ± SD	t-value	p-value
Anemic	170	9.57 ± 1.48	15.2	<0.001
Non-anemic	42	13.99 ± 1.96		

Table 2: Comparison of hemoglobin levels between anemic and non-anemic patients.

Category	Subtype	Number (n)	Percentage (%)
Morphological Classification (WHO Criteria)	Microcytic hypochromic	48	28.2
	Normocytic normochromic	104	61.2
	Macrocytic normochromic	18	10.6
Severity (WHO Criteria)	Mild	32	18.8
	Moderate	115	67.6
	Severe	23	13.5

Table 3: Morphological classification and severity of anemia among patients (n = 170).

Severity of Anemia	Gram-Positive (n = 117) n (%)	Gram-negative (n = 53) n (%)	Total (n = 170) n (%)
Mild	19 (16.2%)	13 (24.5%)	32 (18.8%)
Moderate	81 (69.2%)	34 (64.2%)	115 (67.6%)
Severe	17 (14.5%)	6 (11.3%)	23 (13.5%)
Total	117 (100%)	53 (100%)	170 (100%)

Table 4: Distribution of anemia severity according to gram stain type. Chi-square test showed no statistically significant association (p = 0.49).

Discussion

Bacterial infections are usually linked with haematological abnormalities, especially anaemia, which might be a marker of the severity of systemic inflammation and the underlying disease burden. Haemoglobin levels could have useful clinical and prognostic implications in the association with bacterial infections in hospitalised patients [7]. This study assessed 212 hospitalised Saudi patients with culture-confirmed bacterial infections and showed a substantial incidence of anaemia, particularly in older persons. The data demonstrated a significant prevalence of anaemia with the most common patterns being moderate severity and normocytic normochromic morphology. No significant association was found between type of bacterial infection and haemoglobin levels or severity of anaemia. The high incidence underscores the clinical necessity of routinely measuring haemoglobin in hospitalised patients with infections, since anaemia may be a marker of illness severity and adverse clinical outcomes. The study population exhibited a marginal male majority, with males constituting 54.2% of the participants. This disparity seems improbable to be clinically relevant, as prior hospital-based research in Saudi Arabia have indicated that gender does not significantly influence susceptibility to bacterial infections. Conversely, age emerged as a more signifi-

cant determinant, with a distinct preponderance of senior individuals. Approximately two-thirds of participants were aged 65 years or older, with nearly half exceeding 75 years. This pattern aligns with regional and national statistics demonstrating that older persons are more susceptible to serious infections necessitating hospitalisation, possibly due to immunosenescence and the existence of several comorbidities [12,13].

This study reveals a very high prevalence of anaemia (80.2%) among hospitalised patients with bacterial illnesses. A recent hospital-based study indicated that 52.17% of hospitalised patients demonstrated anaemia [14]. This discrepancy can be attributed to differences in the study group, including the inclusion of patients with culture-confirmed bacterial infections, who are predisposed to systemic inflammation, increased disease severity, and a heavier load of comorbidities. These findings indicate a high prevalence of anemia among hospitalized patients with culture-confirmed bacterial infections.

From a clinical standpoint, fever and respiratory symptoms were the most often reported presentations, succeeded by gastrointestinal and neurological signs. The occurrence of neurological symptoms, such as disorientation, underscores the unusual mani-

festation of infections in aged individuals. Additionally, a significant percentage of patients experienced serious sequelae, such as septic shock and multiorgan dysfunction, indicating the severity of illness within this cohort. These findings align with prior research indicating poorer clinical outcomes in older patients with infections [15,16].

The comparison of haemoglobin levels between anaemic and non-anemic patients revealed a statistically significant difference, affirming the considerable decrease in haemoglobin among those affected. This discovery corresponds with prior research indicating that diminished haemoglobin levels are frequently noted in hospitalised and high-risk groups, especially in the context of infection and systemic inflammation. Furthermore, numerous studies indicate that diminished haemoglobin levels correlate with heightened illness severity in bacterial infections, hence reinforcing the clinical significance of haemoglobin as a prognostic marker [11,16].

Regarding morphological classification, normocytic normochromic anaemia was the most commonly observed form, succeeded by microcytic hypochromic and macrocytic anaemia. Normocytic anaemia predominantly characterises anaemia of inflammation, frequently observed in individuals with acute or chronic infections. This trend aligns with hospital-based research in Saudi Arabia, where normocytic anaemia frequently occurs in patients with inflammatory and viral diseases [17]. This further substantiates the notion that inflammation significantly contributes to the development of anaemia in this study population. The occurrence of microcytic anaemia in certain people indicates potential iron shortage, although the reduced incidence of macrocytic anaemia may signify rarer dietary inadequacies or alternative contributing variables.

In terms of severity, moderate anaemia was the predominant category, succeeded by mild and severe types. The elevated prevalence of moderate to severe anaemia signifies that the majority of patients saw clinically meaningful declines in haemoglobin levels. Severe anaemia, however less common, is clinically significant as it may signify more advanced disease or a greater level of systemic inflammation. The findings can be elucidated by infection-related mechanisms, such as elevated hepcidin synthesis, limited iron availability, and inhibition of erythropoiesis, as documented in a study conducted in Saudi Arabia [18].

Microbiological examination indicated that Gram-positive bacteria were isolated more frequently than Gram-negative species.

This pattern aligns with other observations from Saudi Arabia, where Gram-positive bacteria are often detected in hospitalised patients [19]. Nonetheless, Gram-negative bacteria are therapeutically important due to their link to severe infections, antibiotic resistance, and adverse clinical consequences. Notwithstanding these disparities in bacterial distribution, no substantial correlation was identified between Gram stain type and the severity of anaemia. Likewise, haemoglobin levels showed no significant differences between Gram-positive and Gram-negative infections. The data indicate that the onset and severity of anaemia are predominantly influenced by host inflammatory responses rather than the particular bacterial infection involved. This aligns with the prevailing comprehension of anaemia of inflammation, wherein systemic immune activity significantly influences iron metabolism and erythropoiesis [18].

Limitations

Several limitations should be considered when interpreting the findings of this study. First, not all patients had complete follow-up complete blood count (CBC) results beyond the initial 24 hours of admission, which limited the ability to assess temporal changes in hemoglobin levels during hospitalization. Second, some medical records lacked detailed clinical information, including comprehensive documentation of symptoms and indications for admission, which may have affected the accuracy of clinical correlations. Additionally, the relatively short study duration of five months may not fully capture seasonal variations in infection patterns or anemia prevalence. Finally, as this was a single-center study conducted at Armed Forces Hospital–Alhada in Taif, the generalizability of the findings to other regions or healthcare settings may be limited.

Conclusion

In conclusion, anemia was highly prevalent among hospitalized patients with culture-confirmed bacterial infections, particularly among elderly individuals. Normocytic normochromic anemia and moderate anemia severity were the predominant patterns. These findings suggest that inflammation may contribute to the observed anemia pattern, although inflammatory markers were not assessed. Routine hemoglobin assessment may provide valuable clinical and prognostic information in hospitalized patients with bacterial infections.

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Declaration of Interest

The authors declare that they have no conflicts of interest.

Declaration of Generative AI in Scientific Writing

The authors used ChatGPT (OpenAI, San Francisco, CA, USA) to assist with language editing, grammar correction, and improvement of manuscript readability. The authors carefully reviewed and approved the final version of the manuscript and take full responsibility for the content.

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