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# HEMATOLOGICAL, INFLAMMATORY AND NUTRITIONAL PARAMETER PROFILE IN GERIATRIC ANEMIA: A CROSS-SECTIONAL STUDY

**Dr. Shipra Mathur*** — Third-year Postgraduate Resident, Department of Pathology, Gandhi Medical College, Bhopal, Madhya Pradesh, India*Correspondence Author

**Dr. Rajni Choudhary** — Associate Professor, Department of Pathology, Gandhi Medical College, Bhopal, Madhya Pradesh, India

**Dr. Maneesh Sulya** — Professor and Head, Department of Pathology, Gandhi Medical College, Bhopal, Madhya Pradesh, India

**ABSTRACT** **Background:** Geriatric anemia is common and often multifactorial, with nutritional deficiency and inflammation contributing alongside altered red cell indices. **Objectives:** To assess hospital-based anemia prevalence, severity, morphological patterns, hematological indices, inflammatory markers, and nutritional parameters among adults aged ≥60 years. Materials and **Methods:** This retrospective cross-sectional analytical study used anonymized secondary laboratory data from District Hospital, Sehore, collected from October to December 2025. Of 752 patients aged ≥60 years screened, 278 who met World Health Organization hemoglobin cutoffs for anemia were included. Hemogram parameters, peripheral-smear morphology, neutrophil-to-lymphocyte ratio (NLR), C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), vitamin B12, serum iron, and serum ferritin were analyzed. **Results:** The hospital-based prevalence of anemia was 36.97%; sex-specific prevalence was 37.3% in men and 36.6% in women. Among anemic patients, 144 (51.8%) were men and 134 (48.2%) were women. Mild anemia predominated (46.4%), followed by moderate (36.3%) and severe anemia (17.3%). Microcytic hypochromic anemia was the most common pattern (42.8%). Hemoglobin correlated negatively with RDW-CV ($r = -0.563$, $p < 0.001$) and positively with MCV ($r = 0.291$, $p < 0.001$) and serum iron ($r = 0.135$, $p = 0.024$). NLR correlated weakly with CRP ($r = 0.233$, $p < 0.001$), but neither marker correlated significantly with hemoglobin. **Conclusion:** In this hospital-based geriatric cohort, anemia was common and predominantly microcytic. RDW-CV was associated with anemia severity, whereas the clinical utility of NLR as an adjunct inflammatory marker requires further validation.

**KEYWORDS :** Geriatric anemia; Hemoglobin; Neutrophil-to-lymphocyte ratio; Inflammation; Red cell distribution width

## INTRODUCTION

Anemia is one of the most frequent hematological abnormalities encountered in older adults, and its prevalence rises steadily with advancing age. The United Nations-agreed cut-off for defining the older population is 60 years and above (United Nations, Department of Economic and Social Affairs, Population Division, 2019), and the World Health Organization defines anemia in this group as a hemoglobin concentration below 13 g/dL in men and below 12 g/dL in women (World Health Organization, 2024). Unlike anemia in younger adults, geriatric anemia is frequently multifactorial, arising from an overlap of nutritional deficiency (iron, vitamin B12, folate), chronic kidney disease, anemia of inflammation/chronic disease, and unexplained anemia of the elderly, with the proportion of 'unexplained' cases reported to be as high as one-third in some series (Guralnik et al., 2004).

While the standard peripheral smear and red cell indices remain the first step in classifying anemia into normocytic, microcytic, macrocytic, or dimorphic patterns, they do not by themselves distinguish nutrient deficiency from an inflammatory process. Leukocyte-derived ratios such as the neutrophil-to-lymphocyte ratio (NLR), together with acute-phase markers such as C-reactive protein (CRP) and the erythrocyte sedimentation rate (ESR), have gained attention as low-cost, widely available adjuncts that reflect the systemic inflammatory burden frequently underlying anemia of chronic disease in older patients (Alshuweishi et al., 2023; Zhang et al., 2023). The present study analyzes a panel of hematological, leukocyte-differential, inflammatory, and nutritional parameters in a cohort of anemic geriatric patients to characterize the pattern of anemia and the contribution of inflammation and nutrient status in this population.

Anemia is defined as a reduction in blood hemoglobin concentration below the reference threshold for age, sex, and physiological state. In this study, hemoglobin-based grading was used to classify severity, while MCV, RDW-CV, and peripheral-smear findings were used to characterize morphological patterns, as summarized in Table 1.

**Table 1. Grading of anemia by hemoglobin level**

| Severity of Anemia | Adult Men (Hb, g/dL) | Adult Women (Hb, g/dL) |
|---|---|---|
| Mild anemia | 11.0–12.9 | 11.0–11.9 |
| Moderate anemia | 8.0–10.9 | 8.0–10.9 |
| Severe anemia | <8.0 | <8.0 |

Anemia severity was graded according to the World Health Organization guideline on hemoglobin cutoffs to define anemia in individuals and populations (2024).

Morphological classification was based primarily on peripheral-smear findings, supported by red cell indices: normocytic normochromic anemia (NNA; MCV 80–100 fL), microcytic hypochromic anemia (MHA; MCV <80 fL), macrocytic anemia (MA; MCV >100 fL), and dimorphic anemia (DA; two morphologically distinct red-cell populations on the peripheral smear, often accompanied by an increased RDW-CV) (Bain et al., 2017).

## AIMS AND OBJECTIVES

1. To study the severity and morphological pattern of anemia in geriatric patients of both sexes.
2. To analyze leukocyte-differential indices (WBC, N%, L%, NLR) and their relationship with hemoglobin.
3. To evaluate inflammatory markers (CRP, ESR) and nutritional parameters (vitamin B12, serum iron, serum ferritin) and their correlation with hemoglobin and morphological pattern.

## MATERIALS AND METHODS

This retrospective cross-sectional analytical study used secondary laboratory data collected at District Hospital, Sehore, over 3 months (October–December 2025). During the study period, 752 patients aged ≥60 years were screened; 278 patients who met the World Health Organization hemoglobin criteria for anemia were included. Inclusion criteria were age ≥60 years and hemoglobin below the sex-specific cutoff for anemia. Exclusion criteria were age <60 years, incomplete records, clotted or inadequate samples, missing required hematological or biochemical parameters, and receipt of chemotherapy. Recorded variables included age, sex, hemoglobin, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, red cell distribution width–coefficient of variation, total leukocyte count, differential neutrophil and lymphocyte percentages, neutrophil-to-lymphocyte ratio, C-reactive protein, erythrocyte sedimentation rate, serum vitamin B12, serum iron, and serum ferritin. Peripheral blood smears were reviewed to correlate red-cell morphology and classify anemia as normocytic normochromic, microcytic hypochromic, macrocytic, or dimorphic. Anemia severity was graded using WHO hemoglobin cutoffs; nutritional and inflammatory abnormalities were classified using the reference intervals of the performing laboratory. Formal

ethics committee approval was not required according to institutional policy. Permission to use the anonymized secondary laboratory data was obtained from the Civil Surgeon, District Hospital, Sehore. Data were anonymized before analysis. Data were tabulated in Microsoft Excel and analyzed using Python (SciPy/NumPy). Continuous variables were summarized as mean ± standard deviation and categorical variables as frequency and percentage. Between-group comparisons used Student's t-test or one-way analysis of variance, associations between categorical variables used the chi-square test, and linear associations used Pearson's correlation coefficient, as applicable. Statistical significance was set at $p < 0.05$.

## RESULTS

### 4.1 Prevalence of anemia

**Table 2. Hospital-based prevalence of anemia among screened geriatric patients**

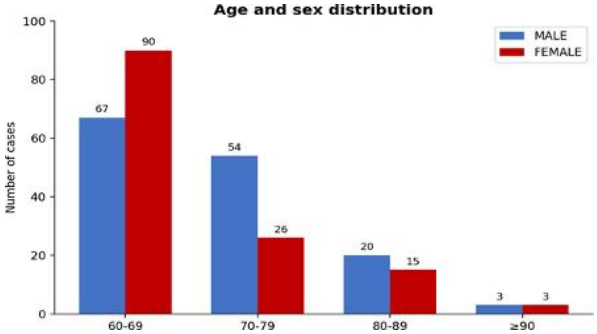
| Group | Screened patient | Anemic patients | Prevalence of anemia |
|---|---|---|---|
| Male | 386 | 144 | 37.3% |
| Female | 366 | 134 | 36.6% |
| Overall | 752 | 278 | 36.97% |

Of the 752 geriatric patients screened during the 3-month study period, 278 were anemic, yielding a hospital-based prevalence of 36.97%. A total of 386 men and 366 women were screened. Among men, 144 were anemic (37.3%); among women, 134 were anemic (36.6%). The sex-specific prevalence was comparable, with a marginally higher value in men.

### 4.2 Age and sex distribution

**Table 3. Age and sex distribution of the study population (n = 278)**

| Age group (years) | Male, n (%) | Female, n (%) | Total, n (%) |
|---|---|---|---|
| 60-69 | 67 (24.1) | 90 (32.4) | 157 (56.5) |
| 70-79 | 54 (19.4) | 26 (9.4) | 80 (28.8) |
| 80-89 | 20 (7.2) | 15 (5.4) | 35 (12.6) |
| ≥90 | 3 (1.1) | 3 (1.1) | 6 (2.2) |
| Total | 144 (51.8) | 134 (48.2) | 278 (100.0) |



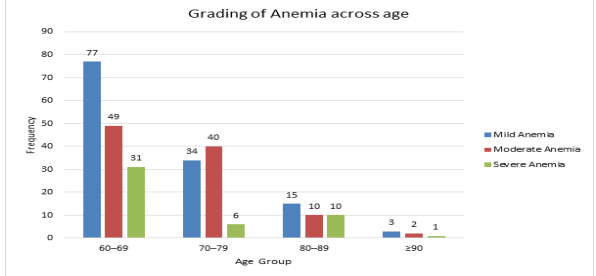

**Graph 1. Age and sex distribution of cases (n = 278)**

### 4.3 Grading of anemia

Mild anemia was the most common severity category (129, 46.4%), followed by moderate anemia (101, 36.3%) and severe anemia (48, 17.3%).

**Table 4. Grading of anemia across age groups**

| Age group | Mild anemia | Moderate anemia | Severe anemia | Total |
|---|---|---|---|---|
| 60–69 | 77 | 49 | 31 | 157 |
| 70–79 | 34 | 40 | 6 | 80 |
| 80–89 | 15 | 10 | 10 | 35 |
| ≥90 | 3 | 2 | 1 | 6 |
| Total | 129 | 101 | 48 | 278 |




**Graph 2. Grading of anemia across age groups**

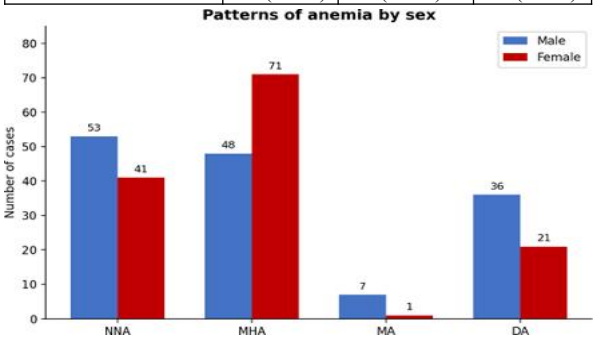
On one-way ANOVA, mean hemoglobin did not differ significantly across the four age groups ($F = 1.69$, $p = 0.169$). The 80–89-year group had the numerically lowest mean hemoglobin (9.39 ± 2.74 g/dL) and the highest proportion of severe anemia (10/35, 28.6%).

### 4.4 Morphological pattern of anemia

Based on peripheral-smear findings supported by MCV and RDW-CV, microcytic hypochromic anemia (MHA) was the most common pattern, occurring in 119 patients (42.8%), followed by normocytic normochromic anemia (NNA) in 94 (33.8%), dimorphic anemia (DA) in 57 (20.5%), and macrocytic anemia (MA) in 8 (2.9%).

**Table 5. Morphological pattern of anemia by sex**

| Pattern | Male, n (%) | Female, n (%) | Total, n (%) |
|---|---|---|---|
| Normocytic normochromic (NNA) | 53 (36.8) | 41 (30.6) | 94 (33.8) |
| Microcytic hypochromic (MHA) | 48 (33.3) | 71 (53.0) | 119 (42.8) |
| Macrocytic (MA) | 7 (4.9) | 1 (0.7) | 8 (2.9) |
| Dimorphic (DA) | 36 (25.0) | 21 (15.7) | 57 (20.5) |
| Total | 144 (100.0) | 134 (100.0) | 278 (100.0) |




**Graph 3. Morphological patterns of anemia by sex**

Microcytic hypochromic anemia was significantly more frequent among women than men (53.0% vs 33.3%), whereas macrocytic and dimorphic patterns were more frequent among men. The association between sex and morphological pattern was statistically significant ($\chi^2 = 14.08$, $df = 3$, $p = 0.003$).

**Table 6. Morphological pattern of anemia by age group**

| Age group (years) | NNA, n | MHA, n | MA, n | DA, n | Total |
|---|---|---|---|---|---|
| 60-69 | 49 | 71 | 5 | 32 | 157 |
| 70-79 | 35 | 28 | 1 | 16 | 80 |
| 80-89 | 7 | 17 | 2 | 9 | 35 |
| ≥90 | 3 | 3 | 0 | 0 | 6 |
| Total | 94 | 119 | 8 | 57 | 278 |

### 4.5 Hematological, inflammatory and nutritional parameters: sex-wise comparison

**Table 7. Sex-wise comparison of hematological, inflammatory and nutritional parameters (mean ± SD)**

| Parameter | Male (n = 144) | Female (n = 134) | t-value | p-value |
|---|---|---|---|---|
| Hb (g/dL) | 10.44 ± 2.23 | 9.64 ± 2.19 | 3.019 | 0.003* |
| MCV (fL) | 83.00 ± 12.63 | 77.65 ± 11.77 | 3.650 | <0.001* |
| MCH (pg) | 26.53 ± 5.09 | 24.46 ± 4.70 | 3.508 | <0.001* |
| MCHC (g/dL) | 31.86 ± 1.96 | 31.20 ± 2.21 | 2.623 | 0.009* |
| RDW-CV (%) | 15.70 ± 3.33 | 16.56 ± 5.41 | -1.601 | 0.111 |
| WBC (cells/mm³) | 8727.71 ± 4057.26 | 9786.87 ± 8350.02 | -1.360 | 0.175 |
| Neutrophil (%) | 64.24 ± 13.98 | 63.55 ± 13.56 | 0.416 | 0.678 |
| Lymphocyte (%) | 22.21 ± 12.60 | 25.21 ± 11.46 | -2.071 | 0.039* |
| NLR | 4.66 ± 4.61 | 3.64 ± 2.93 | 2.195 | 0.029* |
| CRP (mg/L) | 13.60 ± 32.53 | 15.81 ± 41.90 | -0.494 | 0.622 |
| Vitamin B12 (pg/mL) | 622.04 ± 291.01 | 605.01 ± 196.47 | 0.568 | 0.571 |
| Serum iron (µg/dL) | 70.97 ± 11.38 | 68.71 ± 14.20 | 1.474 | 0.142 |
| Serum ferritin (ng/mL) | 101.10 ± 33.47 | 94.04 ± 42.24 | 1.550 | 0.122 |
| ESR (mm/h) | 18.69 ± 8.79 | 20.04 ± 10.18 | -1.192 | 0.234 |

*Statistically significant at $p < 0.05$. Men had significantly higher hemoglobin, MCV, MCH, and MCHC than women, consistent with the higher proportion of microcytic anemia among women (Table 5). NLR was significantly higher in men, whereas lymphocyte percentage was significantly higher in women. CRP, ESR, vitamin B12, serum iron, and serum ferritin did not differ significantly by sex.

### 4.6 Prevalence of nutritional deficiency and inflammatory marker elevation

**Table 8. Prevalence of abnormal nutritional and inflammatory parameters**

| Parameter (cut-off) | n | % of cohort (n = 278) |
|---|---|---|
| Vitamin B12 deficient (<200 pg/mL) | 8 | 2.9 |
| Vitamin B12 borderline (200–300 pg/mL) | 3 | 1.1 |
| Serum ferritin low (<30 ng/mL) | 8 | 2.9 |
| Serum iron low (<60 µg/dl) | 53 | 19.1 |
| CRP elevated (>6 mg/L) | 58 | 20.9 |
| NLR elevated (>3) | 129 | 46.4 |
| ESR elevated (age/sex-adjusted) | 16 | 5.8 |

### 4.7 Correlation of hemoglobin with other parameters

**Table 9. Pearson correlation of hemoglobin with other study .parameters**

| Parameter | r (Pearson) | p-value |
|---|---|---|
| Age | -0.040 | 0.502 |
| MCV | 0.291 | <0.001* |
| RDW-CV | -0.563 | <0.001* |
| WBC | 0.104 | 0.085 |
| NLR | 0.064 | 0.288 |
| CRP | 0.034 | 0.570 |
| Vitamin B12 | -0.054 | 0.370 |
| Serum iron | 0.135 | 0.024* |
| Serum ferritin | 0.018 | 0.759 |
| ESR | -0.028 | 0.648 |

*Statistically significant at $p < 0.05$. Hemoglobin showed a moderate negative correlation with RDW-CV ($r = -0.563$, $p < 0.001$) and weaker positive correlations with MCV ($r = 0.291$, $p < 0.001$) and serum iron ($r = 0.135$, $p = 0.024$).

No significant correlation was observed between hemoglobin and age, WBC count, NLR, CRP, vitamin B12, serum ferritin, or ESR. These findings indicate statistical associations but do not establish the cause of anemia in individual patients.

NLR correlated weakly and positively with CRP ($r = 0.233$, $p < 0.001$). This finding supports further evaluation of NLR as a readily available adjunct marker of systemic inflammation; however, the weak correlation does not justify substituting NLR for CRP (Alshuweishi et al., 2023; Zhang et al., 2023).

## DISCUSSION

Geriatric anemia is associated with adverse health outcomes in older adults (Guralnik et al., 2004). The present study found a hospital-based anemia prevalence of 36.97%, representing more than one-third of the geriatric patients screened. Krishnamurthy et al. (2022), in an Indian hospital-based study, similarly described the frequent and multifactorial nature of geriatric anemia. The relatively high prevalence in the present study may reflect hospital-based sampling, in which patients with symptoms or comorbidities are more likely to be represented than in community surveys.

Among the 278 anemic patients, mild anemia was the most frequent category (46.4%). Sneha and Jigalur (2024) reported Grade 1 anemia in 69.25% of 400 geriatric patients from Karnataka, while Raina et al. (2014) reported mild anemia in 72.6% of a north-west Indian cohort. The lower proportion of mild anemia and higher proportions of moderate (36.3%) and severe anemia (17.3%) in the present study may reflect differences in referral patterns, case mix, and study setting.

The predominant morphological pattern was microcytic hypochromic anemia (42.8%), followed by normocytic normochromic anemia (33.8%). This differs from several Indian and international series in which normocytic normochromic anemia predominated. Sneha and Jigalur (2024) reported normocytic normochromic anemia in approximately 74%–75% of cases and microcytic hypochromic anemia in 17%–18%, while Sharma et al. (2019) found normocytic anemia in 53.3%, microcytic anemia in 40.0%, and macrocytic anemia in 6.6%. In the present cohort, microcytic anemia was more frequent among women (53.0% vs 33.3% in men), and women had lower hemoglobin, MCV, MCH, and MCHC values. These findings suggest an iron-restricted erythropoietic pattern but cannot establish iron deficiency without complete iron studies and clinical correlation (Agravat et al., 2021; Sneha & Jigalur, 2024).

Elevated NLR and CRP were observed in 46.4% and 20.9% of patients, respectively, whereas overt vitamin B12 and ferritin deficiency were each reported in 2.9%. These proportions must be interpreted using the prespecified laboratory cutoffs and the number of patients tested for each parameter. NLR correlated weakly with CRP ($r = 0.233$, $p < 0.001$), but neither NLR nor CRP correlated significantly with hemoglobin. Thus, the findings indicate the presence of inflammatory abnormalities in a subset of patients but do not demonstrate that inflammation caused the anemia. The association between NLR and CRP is consistent with studies describing NLR as a low-cost adjunct inflammatory index (Alshuweishi et al., 2023).

Low serum ferritin was uncommon (2.9%), but ferritin is an acute-phase reactant and may be normal or increased during inflammation despite depleted iron stores. Babaei et al. (2017) reported that conventional ferritin cutoffs may have reduced diagnostic performance in older adults and that interpretation should account for inflammation. This is relevant to the discrepancy between the proportion with low serum iron (19.1%) and the lower proportion classified as ferritin deficient. Similarly, although overt vitamin B12 deficiency was uncommon in this cohort, community-based Indian data indicate that biochemical vitamin B12 deficiency may be more prevalent depending on the cutoff and population studied (Malik & Trilok-Kumar, 2020).

## LIMITATIONS

This study was based on retrospective laboratory records without corresponding clinical history, comorbidity data, renal-function parameters, medication history, transferrin saturation, total iron-binding capacity, folate levels, reticulocyte indices, soluble transferrin receptor measurement, or bone-marrow assessment of iron stores. Consequently, etiological diagnoses such as iron deficiency anemia, anemia of inflammation, chronic kidney disease-related anemia, or mixed anemia could not be assigned reliably. Ferritin and other cutoff-based classifications may be affected by concurrent inflammation. The cross-sectional design precludes causal inference or assessment of longitudinal changes. In addition, the use of parametric tests for variables with markedly dispersed distributions should be supported by assessment of distributional assumptions or sensitivity analyses using nonparametric methods.

## CONCLUSION

Among 278 geriatric patients with anemia, mild-to-moderate anemia predominated, and microcytic hypochromic and normocytic normochromic patterns together accounted for more than three-quarters of cases. Microcytic anemia was more frequent among women. RDW-CV showed the strongest association with hemoglobin, while NLR correlated weakly with CRP but not with hemoglobin. These findings support systematic morphological and laboratory evaluation of geriatric anemia; they do not establish NLR as a diagnostic substitute for CRP or identify the etiology of anemia without clinical correlation and complete iron studies.

## RELEVANCE OF THE STUDY

This study provides hospital-based data on the prevalence, severity, and morphological patterns of geriatric anemia in a district-hospital setting. The findings may help prioritize structured evaluation of red-cell indices, peripheral-smear morphology, iron status, and inflammatory markers in resource-limited practice.

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**Conflicts of Interest**
The authors declare no conflicts of interest.

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