

The Association Between Neutrophil-to-Lymphocyte and Platelet-to-Lymphocyte Ratios and Anemia in Adults with Hypertension in Southwestern Uganda: A Cross-Sectional Study

Enoch Muwanguzi^{1,*}, Jazira Tumusiime¹, Rogers Kalyetsi¹, Charles Nkubi Bagenda^{1,*}, Elizabeth A John², Benson Okongo^{1,*}

¹Department of Medical Laboratory Science, Mbarara University of Science and Technology, Mbarara, Uganda; ²Department of Microbiology and Parasitology, University of Dodoma, Dodoma, Tanzania

*These authors contributed equally to this work

Correspondence: Benson Okongo, Department of Medical Laboratory Science, Mbarara University of Science and Technology, P.O. BOX 1410, Mbarara, Uganda, Tel +256-778557867, Email bokongo@must.ac.ug

Purpose:: This study aimed to determine the association of neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) with anemia among hypertensive patients in Southwestern Uganda.

Patients and Methods: We conducted a secondary analysis of a cross-sectional study involving 386 consecutively enrolled hypertensive patients at Bwizibwera Health Centre IV, Mbarara District, Uganda. Anemia was defined as hemoglobin <12.0 g/dL in women and <13.0 g/dL in men. Data were analyzed using STATA. Categorical variables were compared using chi-square or Fisher's exact tests, continuous variables with the Mann-Whitney *U*-test. Logistic regression examined associations of NLR, PLR, and monocyte-to-lymphocyte ratio (MLR) with anemia. Predictive performance was assessed using receiver operating characteristic (ROC) curves.

Results: Overall anemia prevalence was 17.1% (95% CI: 13.7–21.2). Prevalence was significantly higher among participants with uncontrolled versus controlled blood pressure (20.8% vs 12.6%; *p*=0.035). Anemic participants had significantly higher NLR (1.49 vs 1.14; *p*<0.001), PLR (156.06 vs 118.45; *p*<0.001), and MLR (0.23 vs 0.20; *p*=0.006). High NLR and PLR were independently associated with anemia. Participants in the top tertile of NLR had over twice the odds of anemia compared to those in the bottom tertile (aOR=2.29; 95% CI: 1.04–5.07; *p*=0.040). Similarly, those in the top tertile of PLR had higher odds of anemia (aOR=2.28; 95% CI: 1.05–4.97; *p*=0.038). Both ratios showed significant predictive ability to distinguish anemic from non-anemic participants: NLR AUC=0.63 (95% CI: 0.56–0.71); PLR AUC=0.64 (95% CI: 0.56–0.72).

Conclusion: In hypertensive patients, higher NLR and PLR are independently associated with anemia. These inexpensive, readily available inflammatory hematological ratios may help identify individuals at elevated anemia risk.

Keywords: anemia, hypertension, hematological ratios, Uganda

Introduction

Anemia in hypertensive patients is a common disorder that impairs oxygen delivery, increases cardiac workload, and exacerbates cardiovascular strain, leading to worse outcomes.¹ The World Health Organization (WHO) defines anemia as a hemoglobin concentration <13 g/dL in men and <12 g/dL in women.² Hypertension often coexists with metabolic derangements such as hyperuricemia; recent data indicate that hypertensive adults with elevated uric acid have a significantly higher likelihood of anemia.³ Chronic hypertension can also lead to renal impairment and reduced erythropoietin production, further predisposing to anemia.³ Together, these vascular, renal, and metabolic factors make anemia clinically significant in patients with hypertension.

Globally, anemia remains highly prevalent, particularly in resource-limited settings, representing a major public health issue. In sub-Saharan Africa, adult prevalence frequently exceeds 30–40%. Data specifically among hypertensive populations are limited, but some studies suggest substantial burdens: for example, 17.6% of Ethiopian hypertensive adults were found to be anemic.⁴ In Uganda, anemia is endemic; approximately one-third of women aged 15–49 were anemic in 2016,⁵ implying a high baseline risk that likely extends to hypertensive patients. Importantly, undiagnosed anemia in hypertension can have serious consequences. In one cohort of patients with hypertensive emergencies, anemia was associated with more than double the three-year mortality risk.¹ These findings emphasize that missed timely diagnosis and treatment of anemia could intensify end-organ hypoxia and cardiovascular morbidity in hypertensive individuals.

Neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) are simple, readily accessible indices reflecting systemic inflammation. Chronic hypertension is increasingly recognized as a pro-inflammatory condition,^{6,7} and these ratios capture the balance of immune cells that shifts during inflammation. For instance, elevated NLR a marker of neutrophilia and relative lymphopenia has been linked to both the incidence of hypertension and adverse cardiovascular outcomes.⁸ Similarly, PLR tends to increase in patients with more severe hypertension: one study found significantly higher PLR in “non-dipper” hypertensives (who have less nocturnal blood pressure decline) compared to dipper-type patients.^{9,10} Biologically, inflammation in hypertension can raise neutrophil and platelet activity relative to lymphocyte counts, making higher NLR and PLR plausible markers of hypertensive pathology and its systemic effects.

Despite this rationale, few studies have examined how NLR and PLR relate to anemia in hypertensive patients, and to the best of our knowledge, none have done so in Uganda. This knowledge gap is important because both anemia and hypertension are common in Uganda, and markers like NLR and PLR derived from routine blood counts could aid risk stratification. The present study therefore explored the association of NLR and PLR with anemia among hypertensive patients in Southwestern Uganda.

Materials and Methods

Study Design

This was a secondary analysis of data from a hospital-based cross-sectional study conducted from May to August 2025 among hypertensive patients at Bwizibwera Health Centre IV, Southwestern Uganda. The present analysis was performed between January and February 2026 period.

Study Setting

The study was conducted at Bwizibwera Health Centre IV in Mbarara District, Southwestern Uganda. The facility serves as a referral centre for lower-level health units, covering an estimated population of 150,000 people across six sub-districts. It offers comprehensive services including laboratory, outpatient and inpatient care, maternity, diabetes and hypertension management, antiretroviral therapy, surgery, and immunization. The hypertension clinic manages approximately 400 patients monthly, providing a sufficient recruitment pool.

Study Population

The study population comprised hypertensive patients attending care at Bwizibwera Health Centre IV in Southwestern Uganda.

Inclusion Criteria

- Adults aged ≥ 18 years
- Confirmed diagnosis of hypertension
- Currently receiving antihypertensive medication
- Provided written informed consent

Exclusion Criteria

- Acute infection or inflammatory conditions

- Gout or current use of uric acid-lowering drugs
- Pregnancy
- Severe comorbidities (eg, heart failure, liver disease, kidney disease)
- Active malignancy or ongoing chemotherapy
- Recent surgery or trauma

Sample Size Calculation

For this secondary analysis, the sample size calculation was based on an anemia prevalence of 17.6% reported among hypertensive adults in Ethiopia.⁴ Using the Kish Leslie formula (Kish, 1965) with a 5% margin of error and a 95% confidence interval, the minimum required sample size was calculated as follows:

$$n = (1.96)^2 \times 0.176 \times (1-0.176)/(0.05)^2 = 223$$

Since the parent study enrolled 386 participants, the available sample size exceeded the required sample size, making it adequate for the present secondary analysis.

Sampling Procedure

Eligible participants were enrolled using systematic random sampling, with sampling continued consecutively until the predetermined target of 386 participants was reached.

Data Collection

Data were collected using a structured, researcher-administered questionnaire that captured sociodemographic, clinical, and behavioral factors. Anthropometric measurements, including blood pressure, waist circumference, and hip circumference, were taken by a clinician using standardized instruments and protocols. Each measurement was repeated, and the average value was recorded for accuracy.

Following questionnaire administration and anthropometric assessment, a blood sample was drawn from each participant: 4 mL into a plain tube (for serum) and 5 mL into an EDTA tube (for whole blood). Whole blood from EDTA tubes was analyzed using a five part Sysmex XN-550 Hematology Analyzer to obtain complete blood counts. Plain tubes were centrifuged at 1800g for 10 minutes within one hour of collection to separate serum, which was then analyzed for HDL cholesterol and uric acid using a Human 200 Automated Chemistry Analyzer. Quality control samples were run before processing patient specimens. All laboratory measurements were performed in an accredited laboratory at Mbarara Regional Referral Hospital.

Study Variables (Dependent and Independent) in the Secondary Analysis

The primary outcome (dependent variable) was anemia, defined according to World Health Organization (WHO) criteria.² The main independent variables were the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and monocyte-to-lymphocyte ratio (MLR). These ratios were calculated as follows:

- $NLR = (\text{neutrophil count} \times 10^3/\mu\text{L})/(\text{lymphocyte count} \times 10^3/\mu\text{L})$
- $PLR = (\text{platelet count} \times 10^3/\mu\text{L})/(\text{lymphocyte count} \times 10^3/\mu\text{L})$
- $MLR = (\text{monocyte count} \times 10^3/\mu\text{L})/(\text{lymphocyte count} \times 10^3/\mu\text{L})$

No established clinical or epidemiological cut-off values for defining “high” or “low” levels of these hematological inflammatory ratios in relation to anemia prediction were identified in the literature. In the absence of validated thresholds, data-driven approaches are commonly employed in epidemiological analyses to meaningfully categorize continuous variables. Accordingly, NLR, PLR, and MLR were categorized into tertiles based on their distribution within the study population. The use of tertiles provides a balanced stratification method, ensuring adequate sample size within each category while minimizing excessive data fragmentation. Tertile categorization also improves interpretability by enabling comparisons across three distinct groups representing relatively low, intermediate, and high values of the

respective ratios. This approach has been widely applied in observational studies when clinically validated cut-off points are unavailable.

Statistical Analysis

Data were analyzed using Stata version 17 (StataCorp, College Station, TX, USA). Categorical variables were summarized as frequencies and proportions and compared between anemic and non-anemic participants using the chi-square test or Fisher's exact test, as appropriate. Continuous variables, all of which were non-normally distributed (Shapiro–Wilk test $p < 0.05$), were presented as median (interquartile range) and compared using the Mann–Whitney U -test.

Logistic regression was used to examine the associations of neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and monocyte-to-lymphocyte ratio (MLR) with anemia. Variables with a p -value < 0.2 in bivariate analysis, together with biologically plausible confounders, were entered into the multivariable model. Model fit was assessed using the Hosmer–Lemeshow test ($p = 0.7671$), and multicollinearity was excluded (mean variance inflation factor = 1.34). Statistical significance was set at $p < 0.05$.

Predictive performance was evaluated using receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC) was interpreted as follows: excellent (≥ 0.90), good (0.80–0.89), fair (0.70–0.79), poor (0.60–0.69), or failure (0.50–0.59).

Ethical Approval

Ethical approval for the primary study was obtained from the Faculty of Medicine Research Committee of Mbarara University of Science and Technology (reference number: MUST/MLS/25-06M). Administrative permission was secured from the Office of the Chief Administrative Officer and the District Health Officer of Mbarara District. All participants provided written informed consent before enrollment and gave explicit permission for their data to be used in secondary analyses. This study was conducted in accordance with the Declaration of Helsinki (1975, as revised in 2024). Participant confidentiality was maintained by assigning unique study codes that could not be traced back to individuals, and all personal identifiers were removed. Permission to conduct the secondary analysis was obtained from the principal investigator of the primary study.

Results

Socio-Demographic Characteristics of the Study Participants

The study enrolled 386 hypertensive participants. The median age was 61 years (IQR: 50–72). The majority were female (72.5%) and married (61.7%). Nearly half (45.6%) had attained primary education, while 40.9% had no formal education. The vast majority were peasants (85.5%) and resided in rural areas (92.5%). The overall prevalence of anemia was 17.1% (95% CI: 13.7–21.2). Residence was the only socio-demographic factor significantly associated with anemia: urban residents had a markedly higher prevalence (37.9%) compared to rural residents (15.4%; $p = 0.002$). No significant differences in anemia prevalence were observed by age, gender, marital status, education level, or occupation, although marital status ($p = 0.14$) and occupation ($p = 0.088$) showed p -values below 0.2, suggesting potential confounding (Table 1).

Clinical Characteristics of the Study Participants

Among 386 hypertensive participants, 10.4% were HIV-positive, 29.5% had diabetes, and 37.0% had hypertension for > 5 years. Current smoking (3.4%) and alcohol use (9.6%) were uncommon. Uncontrolled blood pressure was present in 54.9%. Most participants slept > 7 hours/night (73.8%), and 84.2% were at high risk for obstructive sleep apnea. Medication adherence was reported by 35.0%. Diuretic use was 23.1%, and 71.2% had stage one hypertension. Over half (58.9%) were overweight/obese, and 79.8% had high waist circumference.

Uncontrolled hypertension was the only clinical factor significantly associated with anemia (20.8% vs 12.6% in controlled; $p = 0.035$). No other clinical variables showed significant associations, though waist circumference ($p = 0.057$),

Table 1 Socio-Demographic Characteristics of the Study Participants by Anemia Status (N=386)

Variable	Total N=386	Anemia Absent (n=320, 82.9%)	Anemia Present (n=66, 17.1%)	p-value
Age (years), median (IQR)	61 (50–72)	61 (51–72)	61 (47–72)	0.60
Gender				0.24
Male	106 (27.5%)	84 (79.2%)	22 (20.8%)	
Female	280 (72.5%)	236 (84.3%)	44 (15.7%)	
Marital status				0.14
Single	11 (2.8%)	7 (63.6%)	4 (36.4%)	
Married	238 (61.7%)	203 (85.3%)	35 (14.7%)	
Separated/divorced	29 (7.5%)	25 (86.2%)	4 (13.8%)	
Widowed	108 (28.0%)	85 (78.7%)	23 (21.3%)	
Education level				0.69
No education	158 (40.9%)	128 (81.0%)	30 (19.0%)	
Primary	176 (45.6%)	150 (85.2%)	26 (14.8%)	
Secondary	35 (9.1%)	28 (80.0%)	7 (20.0%)	
Tertiary	17 (4.4%)	14 (82.4%)	3 (17.6%)	
Occupation				0.088
Peasant	330 (85.5%)	279 (84.5%)	51 (15.5%)	
Self-employed	42 (10.9%)	31 (73.8%)	11 (26.2%)	
Professional	14 (3.6%)	10 (71.4%)	4 (28.6%)	
Residence				0.002*
Rural	357 (92.5%)	302 (84.6%)	55 (15.4%)	
Urban	29 (7.5%)	18 (62.1%)	11 (37.9%)	

Note: *Significant p value.

Abbreviation: IQR, Interquartile range.

family history of hypertension ($p=0.072$), and diuretic use ($p=0.18$) had p -values <0.2 , suggesting potential confounding addressed in multivariable analysis (Table 2).

Biochemical and Hematological Parameters of the Study Participants

Among the 386 hypertensive participants, no statistically significant differences in hyperuricemia prevalence ($p=0.41$), HDL-cholesterol status ($p=0.67$), total white blood cell count ($p=0.38$), monocyte, eosinophil, basophil, platelet, or platelet-related indices (all $p>0.05$) were observed between anemic and non-anemic individuals. However, anemic participants exhibited a significantly lower lymphocyte count ($p=0.044$) and a borderline higher neutrophil count ($p=0.058$) compared to their non-anemic counterparts. The three inflammatory hematological ratios were markedly elevated in the anemic group: NLR (1.49 vs 1.14, $p<0.001$), PLR (156.06 vs 118.45, $p<0.001$), and MLR (0.23 vs 0.20, $p=0.006$). Erythrocyte parameters confirmed the anemic status, with significantly reduced RBC count, MCV, MCH, and MCHC, alongside elevated RDW-SD and RDW-CV among anemic participants (all $p<0.02$). These findings suggest a mixed or microcytic, hypochromic anemia profile accompanied by increased red cell anisocytosis (Table 3).

Association of Neutrophil-to-Lymphocyte Ratio, Platelet-to-Lymphocyte Ratio, and Monocyte-to-Lymphocyte Ratio with Anemia Among Study Participants

In bivariate logistic regression, participants in the highest tertile of NLR had nearly three-fold higher odds of anemia compared to those in the lowest tertile (cOR = 2.75; 95% CI: 1.41–5.35; $p = 0.003$). Similarly, the top PLR tertile was associated with a 2.86-fold increased odds of anemia (95% CI: 1.47–5.56; $p = 0.002$). MLR showed no significant bivariate association. Urban residence (vs rural) and uncontrolled blood pressure (vs controlled) were also significantly associated with higher anemia odds (cOR = 3.36 and 1.81, respectively).

After multivariable adjustment for age, education, residence, hypertension duration, blood pressure control, medication adherence, antihypertensive class, BMI, hyperuricemia, HDL-cholesterol, and eosinophil count, both NLR and PLR remained independently associated with anemia. Participants in the highest NLR tertile had more than double the odds of

Table 2 Clinical Characteristics of the Study Participants by Anemia Status (N=386)

Variable	Total N=386	Anemia Absent (n=320, 82.9%)	Anemia Present (n=66, 17.1%)	p- value
HIV status				0.94
Negative	346 (89.6%)	287 (82.9%)	59 (17.1%)	0.88
Positive	40 (10.4%)	33 (82.5%)	7 (17.5%)	
Diabetes mellitus				0.32
No	272 (70.5%)	225 (82.7%)	47 (17.3%)	0.38
Yes	114 (29.5%)	95 (83.3%)	19 (16.7%)	
Hypertension duration				0.64
≤5 years	243 (63.0%)	205 (84.4%)	38 (15.6%)	0.46
>5 years	143 (37.0%)	115 (80.4%)	28 (19.6%)	
Smoking status				0.035*
Never	294 (76.2%)	244 (83.0%)	50 (17.0%)	0.42
Former	79 (20.5%)	67 (84.8%)	12 (15.2%)	
Current	13 (3.4%)	9 (69.2%)	4 (30.8%)	
Alcohol consumption				0.20
Never	256 (66.3%)	209 (81.6%)	47 (18.4%)	0.55
Former	93 (24.1%)	79 (84.9%)	14 (15.1%)	
Current	37 (9.6%)	32 (86.5%)	5 (13.5%)	
Physical activity (MET-min/week)				0.072
<600	104 (26.9%)	83 (79.8%)	21 (20.2%)	0.67
600–3000	86 (22.3%)	70 (81.4%)	16 (18.6%)	
>3000	196 (50.8%)	167 (85.2%)	29 (14.8%)	
Blood pressure control				0.18
Controlled	174 (45.1%)	152 (87.4%)	22 (12.6%)	0.37
Uncontrolled	212 (54.9%)	168 (79.2%)	44 (20.8%)	
Sleep duration (hours)				0.47
<5	8 (2.1%)	7 (87.5%)	1 (12.5%)	
5–7	93 (24.1%)	73 (78.5%)	20 (21.5%)	
>7	285 (73.8%)	240 (84.2%)	45 (15.8%)	0.20
Obstructive sleep apnea risk				
Low risk	61 (15.8%)	54 (88.5%)	7 (11.5%)	0.55
High risk	325 (84.2%)	266 (81.8%)	59 (18.2%)	
Adherence to antihypertensive medication				0.072
Not adherent	251 (65.0%)	206 (82.1%)	45 (17.9%)	0.67
Adherent	135 (35.0%)	114 (84.4%)	21 (15.6%)	
Family history of hypertension				0.18
No	195 (50.5%)	155 (79.5%)	40 (20.5%)	0.37
Yes	191 (49.5%)	165 (86.4%)	26 (13.6%)	
Family history of kidney disease				0.47
No	339 (87.8%)	280 (82.6%)	59 (17.4%)	0.18
Yes	47 (12.2%)	40 (85.1%)	7 (14.9%)	
Type of antihypertensive medication				0.37
Non-diuretic	297 (76.9%)	242 (81.5%)	55 (18.5%)	0.47
Diuretic	89 (23.1%)	78 (87.6%)	11 (12.4%)	
Hypertension stage				
Stage one	275 (71.2%)	225 (81.8%)	50 (18.2%)	0.47
Stage two	111 (28.8%)	95 (85.6%)	16 (14.4%)	
Body mass index (kg/m²)				
<18.5	15 (3.9%)	13 (86.7%)	2 (13.3%)	0.47
18.5–24.9	144 (37.3%)	117 (81.3%)	27 (18.8%)	

(Continued)

Table 2 (Continued).

Variable	Total N=386	Anemia Absent (n=320, 82.9%)	Anemia Present (n=66, 17.1%)	p-value
25–29.9	111 (28.8%)	97 (87.4%)	14 (12.6%)	0.057
≥30	116 (30.1%)	93 (80.2%)	23 (19.8%)	
Waist circumference				
Normal	78 (20.2%)	59 (75.6%)	19 (24.4%)	
High	308 (79.8%)	261 (84.7%)	47 (15.3%)	

Notes: MET-min/week is a unit that measures your total volume of physical activity. Based on WHO/AHA guidelines: ≥500–600 MET-min/week for substantial health benefits; 1,000–1,500 for optimal benefits. *Significant p value.

Table 3 Biochemical and Hematological Parameters of Study Participants by Anemia Status (N=386)

Variable	Total (N=386)	Anemia Absent (n=320)	Anemia Present (n=66)	p-value
Hyperuricemia				0.41
Absent	279 (72.3%)	234 (83.9%)	45 (16.1%)	
Present	107 (27.7%)	86 (80.4%)	21 (19.6%)	
HDL-cholesterol				0.67
High	103 (26.7%)	84 (81.6%)	19 (18.4%)	
Low	283 (73.3%)	236 (83.4%)	47 (16.6%)	
WBC ($\times 10^3/\mu\text{L}$)	5.645 (4.58–6.99)	5.62 (4.56–6.87)	5.72 (4.65–7.46)	0.38
Neutrophil ($\times 10^3/\mu\text{L}$)	2.60 (1.86–3.53)	2.55 (1.83–3.49)	2.85 (1.89–4.33)	0.058
Lymphocyte ($\times 10^3/\mu\text{L}$)	2.175 (1.75–2.70)	2.23 (1.755–2.74)	2.045 (1.40–2.51)	0.044*
Monocyte ($\times 10^3/\mu\text{L}$)	0.42 (0.34–0.56)	0.42 (0.34–0.55)	0.43 (0.36–0.58)	0.30
Eosinophil ($\times 10^3/\mu\text{L}$)	0.09 (0.05–0.16)	0.09 (0.05–0.17)	0.09 (0.05–0.15)	0.55
Basophil ($\times 10^3/\mu\text{L}$)	0.03 (0.02–0.05)	0.03 (0.02–0.05)	0.03 (0.02–0.05)	0.32
NLR	1.18 (0.85–1.65)	1.14 (0.83–1.61)	1.49 (1.13–2.19)	<0.001*
PLR	126.87 (91.95–163.64)	118.45 (90.19–157.50)	156.06 (111.72–191.48)	<0.001*
MLR	0.20 (0.16–0.26)	0.20 (0.15–0.25)	0.23 (0.16–0.33)	0.006*
RBC ($\times 10^6/\mu\text{L}$)	4.79 (4.35–5.27)	4.92 (4.55–5.32)	3.99 (3.59–4.37)	<0.001*
MCV (fL)	89.35 (84.30–94.10)	89.75 (85.0–94.1)	87.60 (81.0–92.5)	0.015*
MCH (pg)	29.10 (27.60–30.40)	29.20 (27.90–30.40)	27.95 (25.60–30.10)	<0.001*
MCHC (g/dL)	32.60 (31.20–33.60)	32.70 (31.50–33.60)	31.55 (29.90–32.90)	<0.001*
RDW-SD (fL)	42.30 (39.30–46.10)	41.90 (39.20–45.30)	45.10 (40.50–49.00)	0.006*
RDW-CV (%)	13.00 (12.40–14.00)	12.90 (12.30–13.80)	13.80 (12.80–15.60)	<0.001*
PLT ($\times 10^3/\mu\text{L}$)	272 (223–334)	270 (221–329)	280 (238–361)	0.16
PDW (fL)	12.20 (10.90–14.00)	12.30 (11.00–14.20)	12.05 (10.85–13.40)	0.36
MPV (fL)	10.50 (9.90–11.30)	10.50 (9.80–11.30)	10.60 (10.05–11.25)	0.45
P-LCR (%)	28.40 (23.30–35.10)	28.40 (23.10–35.10)	28.70 (24.40–35.05)	0.62
PCT (%)	0.29 (0.24–0.35)	0.29 (0.24–0.35)	0.30 (0.25–0.38)	0.19

Notes: Continuous variables presented as median (IQR); categorical as n (%).

Abbreviations: WBC, white blood cell; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; RBC, red blood cell; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW-SD, red cell distribution width-standard deviation; RDW-CV, red cell distribution width-coefficient of variation; PLT, platelet; PDW, platelet distribution width; MPV, mean platelet volume; P-LCR, platelet-large cell ratio; PCT, Plateletcrit, *Significant p value.

anemia relative to the lowest tertile (aOR = 2.29; 95% CI: 1.04–5.07; $p = 0.040$). Likewise, those in the highest PLR tertile had a 2.28 fold increased odds (95% CI: 1.05–4.97; $p = 0.038$). Urban residence remained a strong independent predictor (aOR = 5.00; 95% CI: 1.66–15.14; $p = 0.004$), while uncontrolled blood pressure was not significant in the final model ($p = 0.091$). MLR showed no independent association. No other variables reached statistical significance in the multivariable analysis (Table 4).

Table 4 Bivariate and Multivariable Logistic Regression Analysis of Factors Associated with Anemia Among Hypertensive Patients (N=386)

Variable	cOR (95% CI)	p-value	aOR (95% CI)	p-value
NLR (tertiles)				
First (lowest)	1.00 (ref)		1.00 (ref)	
Second	1.53 (0.55–2.42)	0.706	1.14 (0.50–2.58)	0.752
Third (highest)	2.75 (1.41–5.35)	0.003	2.29 (1.04–5.07)	0.040*
PLR (tertiles)				
First	1.00 (ref)		1.00 (ref)	
Second	1.09 (0.51–2.30)	0.830	1.11 (0.49–2.49)	0.807
Third	2.86 (1.47–5.56)	0.002	2.28 (1.05–4.97)	0.038*
MLR (tertiles)				
First	1.00 (ref)		1.00 (ref)	
Second	1.00 (0.50–1.99)	1.000	0.71 (0.32–1.55)	0.387
Third	1.62 (0.85–3.08)	0.141	0.94 (0.44–1.99)	0.865
Age (years)	0.99 (0.98–1.02)	0.624	0.99 (0.97–1.02)	0.957
Education level				
No education	1.00 (ref)		1.00 (ref)	
Primary	0.74 (0.42–1.32)	0.304	0.92 (0.47–1.81)	0.815
Secondary	1.07 (0.43–2.67)	0.890	0.66 (0.22–1.97)	0.453
Tertiary	0.91 (0.25–3.38)	0.893	0.36 (0.07–1.90)	0.228
Occupation				
Peasant	1.00 (ref)		–	–
Self-employed	1.94 (0.92–4.11)	0.083	–	–
Professional	2.19 (0.66–7.25)	0.200	–	–
Residence				
Rural	1.00 (ref)		1.00 (ref)	
Urban	3.36 (1.50–7.49)	0.003	5.00 (1.66–15.14)	0.004*
HIV status				
Negative	1.00 (ref)		–	–
Positive	1.03 (0.44–2.44)	0.943	–	–
Diabetes mellitus				
No	1.00 (ref)		–	–
Yes	0.96 (0.53–1.72)	0.884	–	–
Hypertension duration				
≤5 years	1.00 (ref)		1.00 (ref)	
>5 years	1.31 (0.77–2.25)	0.321	1.60 (0.83–3.08)	0.162
Smoking status				
Never	1.00 (ref)		–	–
Former	0.87 (0.44–1.73)	0.700	–	–
Current	2.17 (0.64–7.32)	0.212	–	–
Alcohol consumption				
Never	1.00 (ref)		–	–
Former	0.79 (0.41–1.51)	0.473	–	–
Current	0.69 (0.26–1.88)	0.473	–	–
Physical activity (MET-min/week)				
<600	1.46 (0.78–2.71)	0.234	–	–
600–3000	1.32 (0.67–2.58)	0.422	–	–
>3000	1.00 (ref)		–	–
Blood pressure control				
Controlled	1.00 (ref)		1.00 (ref)	
Uncontrolled	1.81 (1.04–3.16)	0.037	1.69 (0.92–3.12)	0.091

(Continued)

Table 4 (Continued).

Variable	cOR (95% CI)	p-value	aOR (95% CI)	p-value
Red meat intake (days/week)				
≤4 days	0.82 (0.26–2.52)	0.724	–	–
>4 days	1.00 (ref)		–	–
Sleep duration (hours)				
<5	0.76 (0.09–6.34)	0.801	–	–
5–7	1.46 (0.81–2.63)	0.206	–	–
>7	1.00 (ref)		–	–
Obstructive sleep apnea risk				
Low risk	1.00 (ref)		–	–
High risk	1.71 (0.74–3.95)	0.208	–	–
Medication adherence				
Not adherent	1.19 (0.67–2.09)	0.555	1.07 (0.57–2.00)	0.833
Adherent	1.00 (ref)		1.00 (ref)	
Family history of hypertension				
No	1.00 (ref)		–	–
Yes	0.61 (0.36–1.05)	0.074	–	–
Family history of kidney disease				
No	1.00 (ref)		–	–
Yes	0.83 (0.35–1.94)	0.669	–	–
Antihypertensive type				
Non-diuretic	1.00 (ref)		1.00 (ref)	
Diuretic	0.62 (0.31–1.24)	0.179	0.64 (0.28–1.44)	0.275
Hypertension stage				
Stage one	1.00 (ref)		1.00 (ref)	
Stage two	0.76 (0.41–1.40)	0.375	0.71 (0.34–1.51)	0.380
Body mass index (kg/m²)				
<18.5	0.67 (0.14–3.13)	0.607	0.82 (0.16–4.18)	0.812
18.5–24.9	1.00 (ref)		1.00 (ref)	
25–29.9	0.62 (0.31–1.26)	0.188	0.57 (0.27–1.21)	0.143
≥30	1.07 (0.58–1.99)	0.827	0.84 (0.41–1.73)	0.642
Waist circumference				
Normal	1.00 (ref)		–	–
High	0.56 (0.31–1.02)	0.059	–	–
Hyperuricemia				
Absent	1.00 (ref)		1.00 (ref)	
Present	1.27 (0.72–2.25)	0.415	1.28 (0.67–2.43)	0.453
HDL-cholesterol				
High	1.00 (ref)		1.00 (ref)	
Low	0.88 (0.49–1.59)	0.671	1.09 (0.57–2.08)	0.788
WBC (×10³/μL)	1.10 (0.99–1.21)	0.076	–	–
Eosinophil (×10³/μL)	0.33 (0.07–1.65)	0.177	0.38 (0.07–2.01)	0.253
Basophil (×10³/μL)	0.58 (0.01–22.95)	0.771	–	–

Notes: The multivariable model included only variables with $p < 0.2$ in bivariate analysis and biologically plausible confounders (age, education, residence, hypertension duration, blood pressure control, medication adherence, antihypertensive type, BMI, hyperuricemia, HDL-cholesterol, and eosinophil count). Variables marked with “–” were not entered into the final multivariable model. *Significant p value.

Abbreviations: cOR, crude odds ratio; aOR, adjusted odds ratio; CI, confidence interval; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio.

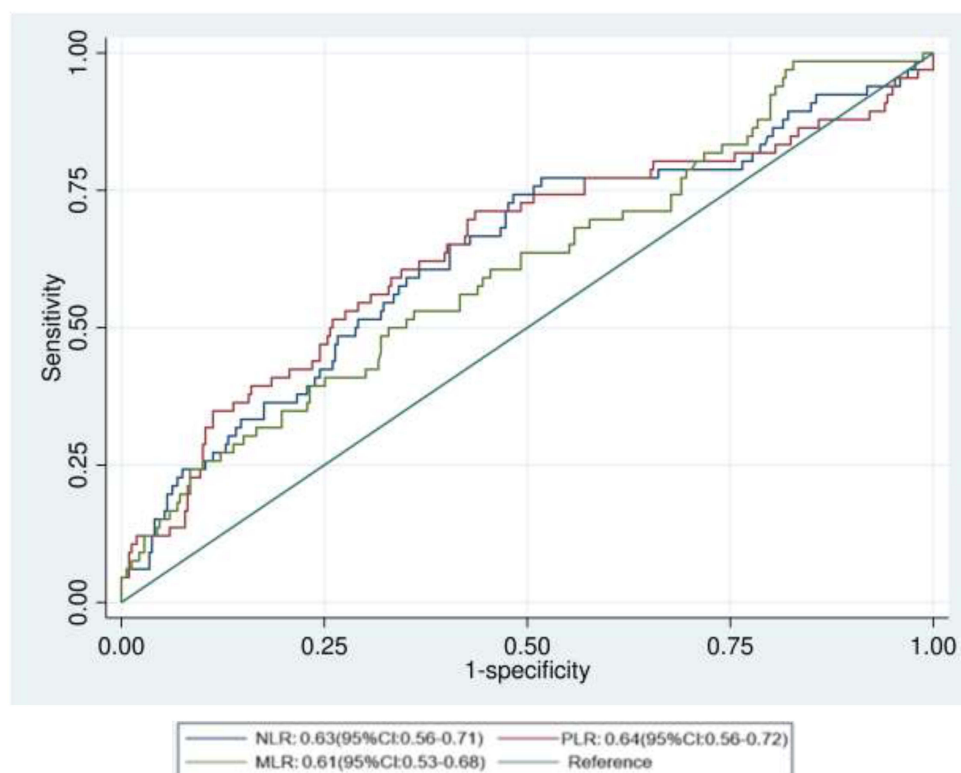


Figure 1 Receiver operating characteristic (ROC) curves showing the area under the curve (AUC) for neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and monocyte-to-lymphocyte ratio (MLR).

Predictive Performance of NLR, PLR, and MLR for Anemia

All three hematological ratios demonstrated significant predictive ability to distinguish participants with anemia from those without anemia: NLR (AUC = 0.63; 95% CI: 0.56–0.71), PLR (AUC = 0.64; 95% CI: 0.56–0.72), and MLR (AUC = 0.61; 95% CI: 0.53–0.68), as shown in (Figure 1).

Discussion

This study of 386 hypertensive patients in Southwestern Uganda found that anemia prevalence was 17.1%, with higher rates among those with uncontrolled blood pressure. Two factors were independently associated with anemia after multivariable adjustment: elevated neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and urban residence.

Participants in the highest tertile of NLR had more than double the odds of anemia compared to the lowest tertile. Similarly, those in the top PLR tertile had increased odds. These findings are consistent with a growing body of evidence linking NLR and PLR to hypertension-related complications. A recent meta-analysis¹¹ confirmed that elevated NLR predicts hypertension risk and associated mortality. Similarly, analysis of the NHANES database^{8,12} demonstrated that elevated PLR independently predicts all-cause and cardiovascular mortality in hypertensive adults. In newly diagnosed hypertensive patients, higher PLR correlates with greater ambulatory blood pressure variability and left ventricular hypertrophy.¹³ The consistency across studies supports NLR and PLR as broad markers of cardiovascular risk in this population.⁸

The significant association that exists between NLR and PLR with anemia in hypertensive participants, converge with evidence from studies. In a large retrospective analysis of individuals in Saudi Arabia, elevated NLR was consistently observed among anemic subjects, who carried nearly double the risk of anemia compared with those with normal NLR.¹⁴ Similarly, in an Indian study of iron-deficiency anemia, both NLR and PLR were significantly higher in moderately and severely anemic patients than in non-anemic controls, with the magnitude of elevation increasing with anemia severity,¹⁵

a pattern consistent with the graded, tertile-based rise in NLR and PLR observed among the anemic participants in the present study. A retrospective analysis from Lebanon similarly reported a negative correlation between hemoglobin and PLR among emergency department patients, reinforcing PLR as a consistent correlate of reduced hemoglobin across clinical settings.¹⁶

MLR was higher in anemic participants in bivariate analysis but was not statistically significant in regression models, possibly due to smaller and more variable monocyte counts, measurement variability, and limited statistical power. Unlike NLR and PLR, MLR may be more susceptible to noise. While some studies found MLR strongly associated with anemia particularly in cancer and acute infection,^{6,16,17} these differences suggest MLR's role in anemia is disease-specific and less prominent in hypertension-related chronic inflammation.

Another significant finding in this study demonstrated an independent association between urban residence and anemia (aOR = 5.00; 95% CI: 1.66–15.14), which increased from bivariate to multivariable analysis, suggesting suppression by confounders. This effect size substantially exceeded that of any clinical or inflammatory marker. Systematic reviews have confirmed that neighbourhood-level factors including urban design, socioeconomic deprivation, and environmental exposures significantly influence hypertension outcomes.^{18–20} The urban-rural dichotomy in this setting likely captures a composite of dietary patterns, physical activity, pollution, psychosocial stress, and healthcare access.

The study also found a significant association between uncontrolled blood pressure and anemia among hypertensive participants. Uncontrolled blood pressure showed nearly doubled odds of anemia in bivariate analysis, aligning with previous findings in Ethiopian hypertensive adults.⁴ However, this association lost significance after adjusting for factors like residence, medication adherence, and duration of hypertension ($p=0.091$). This suggests potential confounding or mediation, indicating that factors like urban residence or medication compliance might explain the relationship rather than blood pressure control itself. Similar findings were noted in a United Arab Emirates cohort where hemoglobin's correlation with blood pressure disappeared after adjusting for age and other covariates.²¹ Despite wide confidence intervals, a modest independent effect of blood pressure control on anemia remains possible, warranting further investigation in larger studies.

These findings suggest that NLR and PLR may serve as accessible markers associated with anemia among hypertensive patients and warrant further evaluation in prospective studies. Particularly in resource-limited settings. The marked urban effect suggests that hypertension control programs should prioritize urban populations and address environmental determinants. Future research should use mixed methods to identify mechanisms underlying the urban-rural disparity, externally validate NLR and PLR cut-offs to establish clinically meaningful thresholds, and test whether inflammation-targeted or urban-specific interventions reduce excess risk.

Study Limitation

This study has several limitations. The cross-sectional design precludes causal inference. Single centre data collection limits generalizability. As a secondary analysis, we lacked data on potential confounders (eg, iron studies, vitamin B12, folate, parasitic infections). Anemia was defined using a single hemoglobin measurement without etiological classification. NLR, PLR, and MLR were categorized using population specific tertiles due to the absence of validated cut-offs, limiting cross study comparability. Blood pressure control was assessed at a single time point. The modest sample size may have underpowered subgroup analyses, reflected in wide confidence intervals. Finally, predictive performance was evaluated without an external validation cohort. Despite these limitations, the study provides novel insights from a resource-limited setting.

Conclusion

Anemia affects one in six hypertensive patients in this setting, with higher prevalence among those with uncontrolled blood pressure. Elevated NLR and PLR are independently associated with anemia, though their modest predictive accuracy (AUC 0.63–0.64) indicates they are best used as adjunctive screening tools rather than standalone diagnostics. These affordable biomarkers can aid early anemia detection in hypertensive individuals, especially where resources are limited. Prospective studies are needed to establish causality and refine predictive models.

Acknowledgments

The authors thank the study participants, the administration and staff of Bwizibwera Health Centre IV (especially the hypertension clinic team), the research assistants and laboratory personnel at Mbarara Regional Referral Hospital, and the principal investigator of the primary study for granting permission for this secondary analysis.

Funding

This study did not receive any external funding.

Disclosure

The authors report no conflicts of interest in this work.

References

- Kim WD, Kim BS, Shin JH. Association of anaemia with long-term mortality among patients with hypertensive crisis in the emergency department. *Ann Med*. 2022;54:2752–2759. doi:10.1080/07853890.2022.2128209
- World Health Organization. Guideline on haemoglobin cutoffs to define anaemia in individuals and populations, *World Health Organization*. 2024.
- Park SM, Gi MY, Cha JA, et al. The relationship between anemia and hyperuricemia and hypertension in Korean adults. *Korea Nat Health Nutri Examinat Survey*. 2023;39:819–825.
- Gela Y, Belay D, Chilot D, Andualem A, Bitew D, Sinamaw D. Prevalence of anemia and associated factors among adult hypertensive patients in referral hospitals, Amhara regional state. *Sci Rep*. 2023;13(1):14329. doi:10.1038/s41598-023-41553-z
- Nankinga O, Aguta D. Determinants of Anemia among women in Uganda: further analysis of the Uganda demographic and health surveys. *BMC Public Health*. 2019;19:1757. doi:10.1186/s12889-019-8114-1
- Guzik TJ, Nosalski R, Maffia P, Drummond GR. Immune and inflammatory mechanisms in hypertension. *Nat Rev Cardiol*. 2024;21:396–416. doi:10.1038/s41569-023-00964-1
- Zhang Z, Zhao L, Zhou X, Meng X, Zhou X. Role of inflammation, immunity, and oxidative stress in hypertension: new insights and potential therapeutic targets. *Front Immunol*. 2023;13:1098725. doi:10.3389/fimmu.2022.1098725
- Zhang X, Wei R, Wang X, et al. The neutrophil-to-lymphocyte ratio is associated with all-cause and cardiovascular mortality among individuals with hypertension. *Cardiovasc Diabetol*. 2024;23:117. doi:10.1186/s12933-024-02191-5
- Özyaşar M, Memioğlu T. Comparative analysis of systemic inflammatory biomarkers on dipper and non-dipper hypertension phenotypes. *Medicine*. 2025;104:42371. doi:10.1097/MD.00000000000042371
- VARİM P, Çakmak AC. Relationship between dipper/non-dipper pattern and neutrophil-lymphocyte ratio and platelet-lymphocyte ratio in geriatric patients with hypertension. *Online Turkish J Health Sci*. 2025;10:76–81.
- Chi X, Bi Q, You L, Zhou Y, Zhao C. Predictive value of NLR for the occurrence and clinical outcomes of hypertension: a systematic review and meta-analysis. *Biomarkers Med*. 2025;19:783–791. doi:10.1080/17520363.2025.2542111
- Xu R, Chen L, Yan C, Xu H, Cao G. Elevated platelet-to-lymphocyte ratio as a predictor of all-cause and cardiovascular mortality in hypertensive individuals. *J Clin Hypertens*. 2025;27:14980. doi:10.1111/jch.14980
- Karaca Y, Karasu M, Gelen MA, et al. Systemic immune inflammatory index as predictor of blood pressure variability in newly diagnosed hypertensive adults aged 18–75. *J Clin Med*. 2024;13:6647. doi:10.3390/jcm13226647
- Alshuweishi Y, Alfaifi M, Almoghrabi Y, Al-Sheikh YA, Alfihili MA. A retrospective analysis of the association of neutrophil–lymphocyte ratio (NLR) with anemia in the Saudi population. *Medicina*. 2023;59:1592. doi:10.3390/medicina59091592
- Hegde A, Puranik N. Assessment of neutrophil-lymphocyte ratio and platelet-lymphocyte ratio in iron deficiency anemia. *Int J Clin Experi Physiol*. 2021;7:146–150.
- Hassan M, Abdayem C, Daouk EL, Matar BF. Correlation of hemoglobin level with new inflammatory markers in the emergency department: a retrospective study exploring neutrophil-to-lymphocyte, monocyte-to-lymphocyte, platelet-to-lymphocyte, and mean platelet volume-to-platelet count ratios. *Cureus*. 2024;16:55401.
- Savencu O, Vulturar CB, Lişcu HD, Verga N, Popescu GC. Association between the monocyte-to-lymphocyte ratio and hemoglobin levels in lung cancer patients. *Vivo*. 2026;40:2066–2074. doi:10.21873/invivo.14359
- Chandrabose M, Rachele J, Gunn L, et al. A9528 urban design and hypertension: a systematic review and meta-analysis. *J Hypertension*. 2018;36:313–314. doi:10.1097/01.hjh.0000549280.84084.9b
- Ranzani OT, Kalra A, Girolamo DI, et al. Urban-rural differences in hypertension prevalence in low-income and middle-income countries, 1990–2020: a systematic review and meta-analysis. *PLoS Med*. 2022;19:1004079. doi:10.1371/journal.pmed.1004079
- Satapathy P, Khatib MN, Gaidhane S, et al. Association of neighborhood deprivation and hypertension: a systematic review and meta-analysis. *Curr Prob Cardiol*. 2024;49:102438. doi:10.1016/j.cpcardiol.2024.102438
- Eldeeb R, Khalil M, Jallo M, Ellao JA, Kamal TF. Association between hemoglobin levels, anemia, and blood pressure in hypertensive adults: a Retrospective Study. *Biomed Pharmacol J*. 2025;18.

Journal of Blood Medicine**Publish your work in this journal**

The Journal of Blood Medicine is an international, peer-reviewed, open access, online journal publishing laboratory, experimental and clinical aspects of all aspect pertaining to blood based medicine including but not limited to: Transfusion Medicine; Blood collection, Donor issues, Transmittable diseases, and Blood banking logistics; Immunohematology; Artificial and alternative blood based therapeutics; Hematology; Biotechnology/nanotechnology of blood related medicine; Legal aspects of blood medicine; Historical perspectives. The manuscript management system is completely online and includes a very quick and fair peer-review system. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <http://www.dovepress.com/journal-of-blood-medicine-journal>

Dovepress
Taylor & Francis Group