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The effect of preoperative anemia on perioperative outcomes among patients undergoing emergency surgery: A multicenter prospective cohort study

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Preoperative anemia is a common finding among surgical patients. It is associated with an increased risk of perioperative morbidity and mortality. Outcomes among emergency surgical patients are not established. This study aimed to assess the effect of preoperative anemia on perioperative outcomes among patients undergoing emergency surgery in selected Southern Ethiopia governmental teaching hospitals, Southern Ethiopia, 2022.
Method: A multicenter prospective cohort study was conducted. Data were collected at selected hospitals, after obtaining ethical approval from the institutional review board. Descriptive statistics, cross-tabulation, and multivariable binary logistic regression analysis were performed. A *P*-value less than 0.05 were taken as statistically significant.
Result: A total of 200 patients who underwent emergency surgery were grouped into the anemia group (100 patients) while the rest were in the non-anemia group. There was no statistically significant difference between the groups regarding socio-demographic and intraoperative patient characteristics. Based on multivariate logistic regression, anemia group had a significant risk of perioperative transfusion requirement (Relative Risk (RR) = 4.030, $p < 0.001$), developing postoperative complications (RR = 1.868, $p = 0.017$), occurring in-hospital mortality (RR = 5.763, $p = 0.045$), prolong the length of hospital stay (RR = 4.028, $p < 0.001$), and requiring postoperative intensive care unit admission (RR = 6.332, $p = 0.003$) compared with non-anemia groups.
Conclusion: Preoperative anemia was associated with a higher rate of perioperative transfusion requirements, along with increased postoperative complication, increased in-hospital mortality, increased Intensive Critical Care Unit admission rate, and prolonged length of hospital stay. We recommend adequate preoperative assessment and correction of hemoglobin concentrations to normal values to improve surgical outcomes and reduce complications.

1. Introduction

According to the Global Surgery Report, approximately 313 million surgeries are performed worldwide each year. At least 4.2

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Abbreviations and acronyms

ASA	American Society of Anesthesiologist
BMI	Body Mass Index
CBC	Cell Blood Count
DURH	Dilla University Referral Hospital
HCT	Hematocrit
HGB/Hb	Hemoglobin
HUCSH	Hawassa University Comprehensive Specialized Hospital
ICU	Intensive Care Unit
IQR	Inter Quartile Range
LOS	Length Of Hospital Stays
OR/AOR	Odds Ratio/Adjusted Odds Ratio
PACU	Post Anesthesia Care Unit
RBC	Red Blood Cell
RR	Relative Risk
SNNPR	South Nation Nationality and People Regional
WHO	World Health Organization
WSUCSH	Wolaita Sodo University Comprehensive Specialized Hospital

million (1%) people die within 30 days of surgery each year, and it accounts for (8%) of all deaths globally. Half of these deaths occur in low-income and middle-income countries (LMICs). The mechanism underlying morbidity and mortality after surgery is still not fully understood, but patients with anemia and co-morbidities are at greater risk [1,2].

Anemia is defined either as a reduced number of circulating red blood cells as a percentage of blood volume (hematocrit) or as a decreased concentration of circulating hemoglobin in the blood. World Health Organization (WHO) defined anemia as hemoglobin (<12 g/dl) and (<13 g/dl) for females and males, respectively. Preoperative anemia has multiple etiologies including iron deficiency, blood loss, chronic disease, malignancy, or an inflammatory state [3,4].

Anemia has a significant effect on the physiology of oxygen delivery to the tissue. Oxygen delivery depends on cardiac output and arterial oxygen content. Anemia reduces arterial oxygen content and oxygen delivery for a given cardiac output. The insufficient supply to meet the body's physiologic requirements results in tissue hypoxia, a change to anaerobic metabolism, and the production of lactic acid [5,6]. In the perioperative period, the tissue oxygen supplies are further impaired due to blood loss during surgery, physiologic stress, and pharmacologic factors; resulting in severe tissue hypoxia, cellular failure, and finally organ dysfunction and failure. Especially, ischemic damage to the heart and brain is the most serious clinical risk [7].

It is a global major public health problem. It affects approximately 1.7 billion people worldwide. The prevalence of anemia is varied among geographical areas, age, and sex patterns, and between industrialized and non-industrialized countries. The prevalence of anemia in the general population accounts for 22.8% worldwide in 2019 [8]. In the surgical patient population, the prevalence of preoperative anemia varies between (8% to 64%) depending on comorbidity, gender, age, and underlying pathology needing surgery [4,9]. In Ethiopia, the prevalence of anemia reported by Gilgel Gibe Field Research Center is about (40.9%) in the general population [10] and a study done at the University of Gondar Hospital reported about (36.8%) in elective surgical patients [11].

Therefore, the prevalence of anemia is high and it is associated with adverse perioperative outcomes in surgical patients [12]. It increases the risk of perioperative red blood cell (RBC) transfusion by about (30.7%) [13], postoperative complications by about (33.2%) [14], in-hospital mortality by about (4.9%) [15], prolonged the length of hospital stay by about (46.2%) [16], and unplanned readmission rate by around (11.4%) [16]; in non-cardiac major surgical patients. This increases health care costs, and economic burden, and impacts functional recovery after surgery [17]. Blumberg et al. reported that anemia is indirectly associated with incremental hospital costs of about $1,000 to $1,500 [18]. In another report by G Amponsah et al., anemia increases health costs by approximately 38.0 USD compared with non-anemic patients [13]. Therefore, early diagnosis and appropriate optimization of anemic surgical patients are very important [9,19,20].

Several studies in different countries have tried to assess whether anemia is independently associated with harmful effects on patient perioperative outcomes [13,21–26]; however, there are different risk profiles and confounding variables in the surgical patient population, which needs appropriate controlling of the variables [27]. Most of the studies were from high-income countries. To date, no large study has investigated this association in Ethiopia; which is a developing country. The patient's socio-demographics and the level of the perioperative care of Ethiopia surgical patients differ from those of surgical patients in the other settings from which the preoperative anemia data were derived. These associations between preoperative anemia and perioperative outcomes are therefore not necessarily transferable to Ethiopian surgical patients. Therefore, this study aimed to assess the effect of preoperative anemia on perioperative outcomes among patients undergoing emergency surgery.

2. Methods and materials

2.1. Study design and area

A multicenter prospective cohort study was conducted from January 2022 to June 2022 at selected Southern Ethiopia governmental teaching hospitals such as Dilla university referral hospital, Hawassa University Comprehensive Specialized Hospital, and Woliata Sodo University Comprehensive Specialized Hospital. The Hospitals are located in South Nation Nationality and People Regional State (SNNPR) and Sidama regional state, Southern Ethiopia.

2.2. Population

The source population was all patients who underwent emergency surgery in Southern Ethiopia and the study population was all adult (age 15 and above) patients who underwent emergency surgery at selected referral hospitals during the study period. Obstetric procedures, pregnant women who come for non-obstetric emergency surgery, patients with active bleeding, patients who do not have CBC obtained within 28 days before surgery, and patients transfused in the preoperative period who do not have CBC obtained after transfusion were excluded from this study.

2.3. Study variables

The primary outcome of the study was perioperative transfusion requirement (Yes/No) and secondary outcomes were the length of hospital stay (Prolonged/Normal), postoperative ICU admission (Yes/No), hospital mortality (Yes/No), and postoperative complications (Yes/No). The independent variables were socio-demographic variables (age, sex, BMI), anemia, comorbidities (Coronary artery disease, Heart failure, Diabetes mellitus, Cirrhosis, Metastatic cancer, Stroke, COPD/asthma, others), ASA physical status, hemodynamic status, type of anesthesia, surgery status (type, grade, and duration), and intraoperative blood loss.

2.4. Operational definition

Perioperative outcomes: defined as intraoperative and postoperative clinical outcomes classified into perioperative transfusion requirement, in-hospital mortality, postoperative complications, ICU admission, and length of hospital stay [28].

Postoperative complications: defined as having one or more of the cardiac and/or non-cardiac complications during the postoperative period until discharge day [28].

Preoperative hemoglobin (Hb): defined as the last Hb value measured before surgery, with all Hb measurements obtained within 28 days before surgery [25].

Anemia: defined according to World Health Organization (WHO) criteria (Hb $<$ 12.0 g/dl) and (Hb $<$ 13.0 g/dl) for females and males (age 15 years and above) respectively [3].

Emergency surgery: it is defined as a surgical condition that should be done immediately as soon as possible, with no delay to plan care, ideally within 24 h, to prevent potential harm to the patient [29].

Perioperative transfusion: defined as patients who received at least 1 unit of whole or packed red blood cells at any time from the start of surgery until discharge from the hospital [30].

Prolonged hospital length of stay: defined as the proportion of patients with hospital stay greater than the 75th percentile [31].

In-hospital mortality: is defined as the death that occurred in the hospital during the same hospital stay [32].

Postoperative ICU admission: defined as postoperative ICU admission for critical care for any reason [28].

2.5. Sample size determination and sampling techniques

The sample size was determined by using a double population proportion formula. A study conducted in Ghana (2017) by G Amponsah et al. reported that postoperative red blood cell transfusions were more required for patients with anemia compared to non-anemia (16.7% versus 4.2%) [13]. By assuming an equal sample size for the two groups:

$N_1 = N_2 = \frac{P_1(1-P_1)+P_2(1-P_2)}{(P_1-P_2)^2} \times C$; Where N_1 = number of patients with anemia, N_2 = number of patients without anemia, P_1 = proportion of patients with transfusion in anemia = 16.7% = 0.167, P_2 = proportion of patients with transfusion in non-anemia = 4.2% = 0.042, C = standard value at 95% CI and 80% study power = 7.85

$$= \frac{0.167(1-0.167)+0.042(1-0.042)}{(0.167-0.042)^2} \times 7.85$$

$= \frac{0.179347}{(0.125)^2} \times 7.85 = 91$ and 10% of the additional sample was included by assuming a loss to follow up from the study and the total sample become 100 for each group.

A situational analysis was done based on a recorded logbook of adult general emergency surgery for the last three months in each hospital and a total of 600 patients have undergone emergency surgery on average at these hospitals. According to this, the sample size was allocated proportionally (Hawassa comprehensive specialized hospital (HUCSH) = 365/3 = 122, Dilla referral hospital (DURH) = 95/3 = 32, and Wolaita Sodo comprehensive specialized hospital (WSUCSH) = 140/3 = 46).

A systematic random sampling technique was used to select study participants and the first patients were recruited by a lottery method from daily emergency surgery that fulfills the inclusion criteria. The participants were categorized into two groups (anemia and non-anemia) based on preoperative hemoglobin level (WHO criteria, Female< 12.0 g/dl and Male< 13.0 g/dl) with a 1:1 allocation ratio (Fig. 1). The patients with preoperative anemia were exposed group and non-anemic were a non-exposed group.

2.6. Data procedure and analysis

After ethical approval (**Reference number: duchm/irb/053/2022**) was obtained from the Institutional review board (IRB) of Dilla University College of Medicine and Health Science and informed consent from each participant, data were collected by using a pretested structured questionnaire (the pre-test was conducted among 10 (5%) patients whose data were not included in the main results). Training for data collectors and supervisors was provided by the principal investigator. The data were collected by chart review and interview-based questionnaires. Data collection began with pre-anesthetic assessment and all patients were followed up until discharge from the hospital. After the completion of data collection, the variables were coded and cleaned.

The data was entered and analyzed by IBM SPSS statistical package version 26. The data were tested for normality using a histogram and Shapiro–Wilk normality test. Pearson's chi-square test was used to compare the categorical variable proportions between groups. Continuous data were presented as mean ± SD for normally distributed, and median ± IQR for non-normally distributed. Categorical data were presented as the number and percentage of individuals in each category. Binary logistic regression analyses were performed. Univariate analysis was done to identify each risk factor and only factors ($p < 0.2$) were used in the final model as covariates. The adjusted odds ratio (AOR) with 95% confidence intervals (CIs) was obtained for each risk factor. The AOR was converted to a relative risk ratio (RR) to compare the relative risk of perioperative outcomes occurring in the anemia group to the non-anemia group. A *P*-value less than 0.05 were taken as statistically significant.

3. Result

3.1. Socio-demographic status

A total of 200 patients who underwent emergency surgery were included in this study with 100% follow-up completion. The patients were grouped into the anemia group (100 patients) while the rest were in the non-anemia group (Fig. 1). The majority of the participants 105 (52.5%) were males and 95 (47.5%) were females. The median age of the study population was 33.0 (22.25–50) years. There was no statistically significant difference between the groups regarding age, sex, BMI, residence status, ASA status, and co-existing disease as shown in (Table 1).

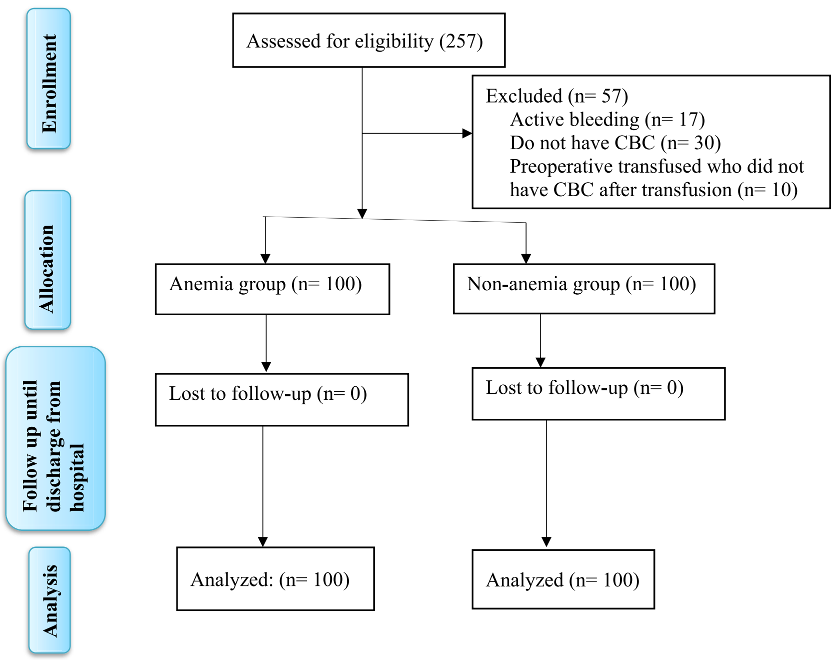

Fig. 1. Patient enrolment flow diagram.

Table 1
Patient baseline characteristics.

Parameter	Total frequency (n = 200)	Anemia group (n = 100)	Non-anemia group (n = 100)	P value
Age n (%)				
15-50	160 (80.0)	79 (79.0)	81 (81.0)	0.724
>50	40 (20.0)	21 (21.0)	20 (19.0)	,
Sex n (%)				
Male	105 (52.5)	49 (55.0)	56 (49.0)	0.322
Female	95 (47.5)	51 (51.0)	44 (44.0)	,
BMI n (%)				
<18.5	66 (33.0)	35 (35.0)	31 (31.0)	0.455
18.5-24.9	122 (61.0)	61 (61.0)	61 (61.0)	,
>25	12 (6)	4 (4.0)	8 (8.8)	,
Residence n (%)				
Urban	65 (32.5)	32 (32.0)	33 (33.0)	0.880
Rural	135 (67.5)	68 (68.0)	67 (67.0)	,
ASA PS n (%)				
I	121 (60.5)	56 (56.0)	65 (65.0)	0.420
II	64 (32.0)	36 (36.0)	28 (28.0)	,
III and above	15 (7.5)	8 (8.0)	7 (7.0)	,
Co-exiting diseases n (%)				
Hypertension	24 (12.0)	14 (14.0)	10 (10.0)	0.884
Diabetes mellitus	12 (6.0)	5 (5.0)	7 (7.0)	,
Heart disease	1 (0.5)	0 (0.0)	1 (1.0)	,
Asthma/COPD	4 (2.0)	2 (2.0)	2 (2.0)	,
HIV/AIDS	2 (1.0)	1 (1.0)	1 (1.0)	,
Metastatic cancer	3 (1.5)	2 (2.0)	1 (1.0)	,

Abbreviations: ASA PS- American Society of Anesthesiology Physical Status, BMI- Body Mass Index, CPOD- Chronic Pulmonary Obstructive Diseases, HIV/AIDS- Human Immunodeficiency Virus/Acquired Immunodeficiency Diseases.

3.2. Intraoperative factors

There was no statistically significant difference between the groups related to type of anesthesia, type of surgery, grade of surgery, duration of surgery, and intraoperative estimated blood loss (as shown in Table 2).

3.3. Perioperative outcomes

3.3.1. Perioperative transfusion rate

The total perioperative transfusion rate was (37.0%). Anemic patients had a significantly higher transfusion rate at (53%) compared to (21%) in non-anemic patients ($p < 0.00001$), with an RR of 4.030 (95% CI 2.918–4.526, $p < 0.001$) (Table 4). There were no statistically significant differences in terms of the number of RBCs transfused across groups ($p = 0.420$) (Table 3). Intraoperative blood loss independently predicted perioperative RBC transfusion with AOR = 1.012 (95% CI 1.008–1.016, $p < 0.001$).

Table 2
Intraoperative factors.

Variable	Total frequency n (%)	Anemia group n (%)	Non-anemia group n (%)	*P*
Type of surgery				
General surgery	59 (29.5)	27 (27.0)	32 (32.0)	0.546
Gynecology	36 (18.0)	21 (21.0)	15 (15.0)	,
Orthopedics	53 (26.5)	28 (28.0)	25 (25.0)	,
Neurosurgery	45 (22.5)	22 (22.0)	23 (23.0)	,
ENT/maxillofacial	3 (1.5)	0 (0.0)	3 (3.0)	,
Cardiothoracic	1 (0.5)	1 (1.0)	0 (0.0)	,
Urology	3 (1.5)	1 (1.0)	2 (2.0)	,
Grade of surgery				
Minor	17 (8.5)	9 (9.0)	8 (8.0)	0.968
Intermediate	139 (69.5)	69 (69.0)	70 (70.0)	,
Major	44 (22.0)	22 (22.0)	22 (22.0)	,
Type of anesthesia				
General anesthesia	142 (71.0)	70 (70.0)	72 (72.0)	0.432
Spinal anesthesia	50 (25.0)	24 (24.0)	26 (26.0)	,
Sedation/local anesthesia	8 (4.0)	6 (6.0)	2 (2.0)	,
Duration of surgery (*mean (min))*	115 (±42.0)	114.7 (±42.8)	115.3 (±41.4)	0.803
Intraoperative estimated blood loss (Median (IQR) *ml)*	519.1	550.0 (±487.5)	500.0 (±337.5)	0.324

ENT-Ear Nose Throat, ml-mill litter, min-minute, IQR-Interquartile Range, *P*-statically significance.

Table 3
Effects of preoperative anemia on perioperative outcomes.

Outcome Variables	Anemia group n (%)	Non-anemia group n (%)	Total frequency n (%)	*P*
Perioperative transfusion rate	53 (53.0)	21 (21.0)	74 (37.0)	**<0.001***
Intraoperative transfusion rate	34 (34.0)	9 (9.0)	43 (21.5)	**<0.001***
Postoperative transfusion rate	37 (37.0)	17 (17.0)	54 (27.0)	**0.007***
Transfusion amount				
1–2 unit	41 (55.4)	18 (24.3)	59 (79.7)	0.420
3 and more unit	12 (16.2)	3 (4.1)	15 (20.3)	,
ICU admission rate	20 (20.0)	3 (3.0)	23 (11.5)	**<0.001***
In-hospital mortality rate	9 (9.0)	2 (2.0)	11 (5.5)	**0.030***
Postoperative complication rate	36 (36.0)	22 (22.0)	58 (29.0)	**0.002***
Cardiac				
Myocardial ischemia	9 (9.0)	3 (3.0)	12 (6.0)	0.111
Arrhythmia/cardiac arrest	1 (1.0)	1 (1.0)	2 (1.0)	,
Hypotension	16 (16.0)	9 (9.0)	25 (12.5)	,
Renal				
Acute renal injury	5 (5.0)	2 (3.0)	7 (3.5)	0.248
Pulmonary				
Pneumonia	4 (4.0)	6 (6.0)	10 (5.0)	0.213
ARDS	5 (5.0)	1 (1.0)	6 (3.0)	,
GIT				
Paralytic ileus	6 (6.0)	5 (5.0)	11 (5.5)	0.953
Nausea/vomiting	5 (5.0)	5 (5.0)	10 (5.0)	,
CNS				
Stroke	4 (4.0)	0 (0.0)	4 (2.0)	0.106
Delirium	8 (8.0)	6 (6.0)	14 (7.0)	,
Surgical site infection	14 (14.0)	10 (10.0)	24 (12.0)	0.384
Prolonged hospital stay	35 (35.0)	11 (11.0)	46 (23.0)	**<0.001***

*Statically significant; **Abbreviations:** ARDS- Acute Respiratory Distress Syndrome, CNS- Central Nerve System, GIT- Gastrointestinal Tract, ICU-Intensive Critical Care Unit.

Table 4
The relative risk of perioperative outcomes between anemia and non-anemia.

Variables	RR (95% CI)	*P*
Perioperative transfusion		
Non-anemia	Reference	
Anemia	4.030 (2.918–4.526)	<0.001*
Postoperative complications		
Non-anemia	Reference	
Anemia	1.868 (1.134–2.697)	0.017*
Postoperative ICU admission		
Non-anemia	Reference	
Anemia	6.322 (1.940–15.662)	0.003*
Length of hospital stay		
Non-anemia	Reference	
Anemia	4.028 (2.215–6.025)	<0.001*
Hospital mortality		
Non-anemia	Reference	
Anemia	5.763 (1.040–22.201)	0.045*

*Statistically significant; CI-Confidence Interval; ICU- Intensive Critical Care Unit; RR-Relative Risk.

3.3.2. Postoperative complication

The overall postoperative complication rate was (29%). The anemic patients had the highest postoperative complication rate than non-anemic patients (36% versus 22%, $p = 0.002$, respectively), with RR of 1.868 (95% CI 1.134–2.697, $p = 0.017$) (Table 4). There was no significant difference in specific postoperative complication rates between the groups (in detail shown in Table 3). Age greater than 50 years (AOR = 3.058; 95% CI 1.119–8.355, $p = 0.029$), and duration of surgery (>100 min) (AOR = 1.010; 95% CI 1.000–1.020. $p = 0.048$) are independent predictors of postoperative complications.

3.3.3. In-hospital mortality

The total in-hospital mortality rate was (5.5%). There was a statistically significant difference in in-hospital mortality among anemic patients (9.0% versus non-anemic 2.0%, $p = 0.030$, respectively), with RR of 5.763 (95% CI 1.040–22.201, $p = 0.045$) (Table 4). Having co-existing diseases independently predicted in-hospital mortality with AOR = 12.712 (95% CI 1.588–101.762, $p = 0.017$).

3.3.4. Length of hospital stay

Forty-six patients (23%) had LOS for more than 10 days (prolonged LOS). The anemia group had a higher rate of prolonged LOS than the non-anemia group (36% versus 11%; respectively, $p < 0.0001$), with an RR of 4.028 (95% CI 2.215–6.025, $p < 0.001$) as shown in (Table 4). Intraoperative blood loss (AOR = 1.003; 95% CI 1.001–1.004, $p < 0.001$), and age (>50 years) (AOR = 5.173; 95% CI 1.661–16.113, $p = 0.005$) are independent predictors of prolonged length of hospital stay.

3.3.5. Postoperative ICU admission rate

The overall postoperative ICU admission rate was (11.5%). The patients from the anemia group were more frequently admitted to ICUs compared with those from the non-anemia group (20% versus 3%, $p < 0.0001$; respectively), with a relative risk (RR) of 6.322 (95% CI 1.940–15.662, $p = 0.003$) shown in (Table 4). ASA II (AOR = 5.336, $p = 0.010$), and ASA III (AOR = 7.041, $p = 0.035$) are predictors of postoperative ICU admission.

4. Discussion

This study revealed that preoperative anemia is related to an increased risk of postoperative complications, perioperative transfusion requirement, in-hospital mortality, length of hospital stay, and postoperative ICU admission when compared with non-anemia groups.

This study found that the anemia group required more perioperative transfusion rate (53%) compared to the non-anemia group (21%), with an RR of 4.030 (95% CI 2.918–4.526, $p < 0.001$), showing that the patients with anemia are 4.030 times more at risk of requiring perioperative transfusion than patients with non-anemia. This finding is consistent with previous studies [13,16,24,27,33–35]. This is in line with a study by G Amponsah et al. on patients undergoing emergency and elective major non-cardiac surgery that found a 30.7% transfusion rate in anemic and a 5.6% transfusion rate in non-anemic patients, with an RR of 7.42 (95% CI 4.67–11.79) [13].

A single-center observational cohort study done in Canada by Beattie et al. reported an RBC transfusion rate in 30.4% of anemic and 10.6% of non-anemic non-cardiac adult surgical patients [24]. Another retrospective study by J. Kielty et al. revealed more anemic patients receiving RBC transfusion than non-anemic patients (27.0% vs. 7.8%, respectively), with RR of 4.35 (95% CI 3.0–6.2) [36]. As compared with our study findings, this slightly lower rate might be due to a difference in the study design (retrospective), elective patient population, and large sample size (1074 adult patients) in the previous study.

In contrast to our study findings, Richards T et al. reported perioperative transfusion requirement rates are more in the anemia group than non-anemia group (9.2% vs. 1.5%) [35], and similarly, a study by Sarhane et al. showed blood transfusion requirement in anemic patients are higher than non-anemic patients (2.9% vs. 1.7%; respectively) [34], compared with our study the findings of these studies are low, this discrepancy might be due to study population (elective), sample sizes, and transfusion practices across different centers explain this finding.

There were no statistically significant differences in terms of the median number of RBCs transfused across groups ($p = 0.420$). The majority of transfused patients (79.7%) received 1–2 unit RBCs. This is in line with J. Kielty et al. report that there was no difference in the median number of units transfused between groups ($p = 0.094$) [36]. Logically a patient with lower starting hemoglobin would need a higher number of red cell units than patients with normal hemoglobin concentration. This is possible may be due to the common practice of routinely administering two units of red cells, nevertheless the patient's hemoglobin level.

The transfusion requirement rate increases with the severity of anemia. The study by Abdullah HR et al. reported that patients with mild anemia are 4.13 times, while patients with moderate/severe anemia are 9.13 times more at risk of requiring perioperative transfusion than patients with non-anemia [17]. However, in our study, the sample size of patients with severe anemia was very small; the effect size was not adjusted for anemia severity status.

Furthermore, this study found intraoperative blood loss is an independent predictor of perioperative RBC transfusion with (AOR = 1.012). Abdullah HR et al. reported other independent risk factors increased perioperative transfusions such as ASA-PS score of 3 (AOR = 4.00), and duration of operation (>100 min) (AOR = 1.89) [17], however, our study failed to confirm these variables as risk factors of perioperative transfusion. The possible reasons for the discrepancies are the differences in patient populations and study design.

Anemic patients experience an increased risk of postoperative complications. In our study findings, the overall composite postoperative complication rate before discharge was 29%. The complication rate was significantly greater in preoperatively anemic patients than in non-anemic patients (36% versus 22%, $p = 0.002$; respectively), with an RR of 1.868 (95% CI 1.134–2.697, $p = 0.017$). However, there was no significant difference in specific postoperative complication rates between the groups.

Our study is in agreement with other studies having found anemia to be an independent predictor of postoperative complications [23,24,26,34]. Proposed mechanisms driving this direct relation may be due to the reduction of oxygen-carrying capability of blood leading to reduced delivery of oxygen to end organs that may cause hypoxia, and the lower tolerance to bleeding that may occur during or after surgery, explaining the higher complication rates in anemic patients [37].

The study by Lasocki et al. showed comparable findings, postoperative complications were more frequent in preoperatively anemic than non-anemic patients (36.9% vs. 22.2%) among orthopedic surgical patients [33]. Another consistent finding reported by Viola et al. among joint arthroplasty (JTA), the incidence of all complications was significantly higher in anemic patients compared to the non-anemic patients (33.2% vs. 15.4%, respectively) with a higher rate of cardiovascular complications compared to the non-anemic patients (26.5% vs. 11.8%; respectively) [14]. The study by Phan et al. is also in line with our study findings, which reported a significantly higher overall complication rate in the anemic patient group than in non-anemic (19.8% vs. 6.3%; $P < 0.0001$), with (AOR) = 3.14; 95% CI 1.61–6.12; $P = 0.001$) [16].

So far, there are inconsistent reports in the literature as to whether preoperative anemia is an independent risk factor for postoperative complications. It has been suggested that anemia only impacts postoperative outcomes indirectly through other factors such as perioperative blood transfusions. Nevertheless, several studies have identified statistically significant correlations between anemia and complications even when accounting for such confounding factors [23,24,27,34].

Surprisingly, the study by Kim et al. revealed that preoperative anemia alone had no association with overall complications (OR = 1.10; 95% CI 0.77–1.58; P = 0.601) after single-level lumbar fusion. By controlling for confounding factors (transfusions), they found no direct association between anemia and postoperative complications [21]. This study finding contradicts our results which demonstrated the direct association between anemia and postoperative complications with controlled confounding factors. The possible reasons might be a specific patient population (single-level lumbar fusion), and well-controlled potential confounders in previous studies.

The increase in the age of patients also is attributed to postoperative complications. This study determined age greater than 50 years (AOR = 3.058; 95% CI 1.119–8.355, p = 0.029), and duration of surgery (>100 min) (AOR = 1.010; 95% CI 1.000–1.020. p = 0.048) were associated with independent predictors of postoperative complications. In contrast to our study, Phan et al. reported ASA scores of 3 and more (AOR = 3.849; 95% CI 1.556–9.52, p = 0.0035) are independent predictors of postoperative complications [16]; this finding was failed by our study may be due to small sample of patients with ASA score of 3. However, this is explained as older patients are more likely to suffer from chronic diseases and co-morbidities and are classified under higher ASA scores; both studies indicate old age and high ASA scores that can unfavorably affect postoperative outcomes.

Preoperative anemia is also associated with a prolonged length of hospital stay. This study found the overall mean hospital stay duration was 8.04 days (±2.821) and the 75th percentile of 10 days. The outcome was measured using an indicator variable for patients with a length of stay greater than 10 days. The prolonged length of stay is a significant postoperative outcome; it is directly associated with increased financial costs and a higher burden on healthcare resource consumption [17].

The patients with preoperative anemia had a higher rate of prolonged LOS than non-anemic (35% versus 11%; respectively, p < 0.0001), with an RR of 4.028 (95% CI 2.215–6.025, p < 0.001). This study finding is consistent with the study by Phan et al. reporting that anemic patients were associated with a prolonged length of hospital stay (46.2% vs. 19.0%; respectively), with an RR of 2.863; the study was done among elective posterior cervical fusion [16]. Another study by J. Kielty et al. showed that the length of postoperative stay was 31% longer in anemic patients than in non-anemic [36]. The study by Abdullah HR et al. also reported comparable findings with our study and showed the effect of severity of anemia on prolonged LOS, the patients with mild anemia are 1.71 times, while patients with moderate/severe anemia are 2.29 times more at risk of prolonged LOS than the patients with non-anemia [17].

The study done on colorectal surgery by Pierre-Yves Hardy et al. contradicts our study findings showing that anemia did not affect LOS (p = 0.27) [22]. The possible reason might be that adherence to the enhanced recovery protocol (ERP) in the previous study may lead to a discrepancy in the postoperative length of hospital stay.

One of the aims of our study was to determine in-hospital mortality. This study showed that patients with preoperative anemia had a greater risk of in-hospital mortality when compared with those with normal preoperative Hb concentrations (9.0% versus 2.0%, p = 0.030; respectively), with RR of 5.763, p = 0.045). This agrees with the findings of Baron et al. which showed that preoperative anemia was associated with an increased risk of hospital mortality (11.3%) when compared with non-anemic (2.2%) [25]. Another study by D Marsicano et al. consistent with our study, reported anemia was independently associated with in-hospital mortality compared with non-anemic (4.9% vs. 1.9%) [15]. In contrast to our findings, other studies showed preoperative anemia had no significant association with in-hospital mortality [13]. The possible reason may be the differences in sample size, study population, study design, and follow-up duration.

Additionally, this study revealed that preoperative anemia is associated with a greater risk of postoperative ICU admission than non-anemia (20% versus 3%, p < 0.0001; respectively). Our study findings are similar to a previous study by D Marsicano et al. among non-cardiac and non-obstetric surgery [15]. It is also consistent with the study by Baron et al. showing postoperative admission to ICUs was greatest in patients with anemia than in non-anemic (25.6% versus 5.4%, p < 0.001 respectively) among non-cardiac surgery [25].

In contrast to our study results, Luo et al. reported that there was no statistical difference in the Intensive Care Unit (ICU) admission rate among different anemia groups within 30 days after non-cardiac surgery [23]. The possible reasons for the discrepancies are the differences in sample size, follow-up duration, patient populations, and probably institutionally guided practices across different centers that may explain this finding.

The data reported in this study suggest that preoperative anemia is associated with a high risk of perioperative outcomes, but factors such as regional differences in patient care and center policies have to be considered when interpreting these data. Our findings should lead to the careful attention of appropriate interventions to correct preoperative anemia in patients undergoing emergency surgery. It is easy to detect and, in many conditions, inexpensive to treat. Preemptive treatment may improve patient outcomes and decrease LOS, reducing health care costs, a growing national health care concern.

5. Strengths and limitations of the study

The study's strength was that the first multicenter setting prospective cohort study in our country Ethiopia showed the relation of preoperative anemia with perioperative outcomes. The limitations of this study include that the hemoglobin concentrations were determined within 28 days of surgery, and we only used laboratory results than the combination with clinical findings. Therefore, the actual values on the day of surgery might differ from those included in the analysis. The fact that only laboratory results obtained within 28 days of surgery were included in the study may account for some missing Hb values.

Second, healthcare provider preferences and other factors may affect the decision of whether or not to transfuse, as well as how many RBC units will be transfused in cases when a transfusion is decided. Furthermore, we were not separated intraoperative and postoperative transfusions from each other; these variables were into one variable. Moreover, we did not report the outcomes after the patients were discharged from the hospital.

Another limitation, the calculated sample size is not considered anemia subclassification, which may limit the regression analysis for anemia subclassification. In addition, the study does not specify the subtype of anemia, duration of anemia before surgery, or the etiology of anemia, which is important for knowing how to treat anemia in each patient before surgery.

6. Conclusions and recommendations

In this study, we have identified the associations between preoperative anemia and perioperative outcomes in emergency surgery. After controlling for potential confounders, we showed that preoperative anemia was associated with a higher rate of perioperative transfusion requirements, along with increased postoperative complications, increased in-hospital mortality, increased ICU admission rate, and prolonged length of hospital stay. We recommend to perioperative care providers adequate preoperative assessment and correction of hemoglobin concentrations to normal values to improve surgical outcomes and reduce complications. Institutions and policymakers should plan reasonable preemptive and therapeutic policies specifically for emergency surgery to decrease the impact of anemia on perioperative outcomes. We recommend conducting other studies with a large sample size with equal allocation for anemia subclassification for a better conclusion of the association between anemia severity and perioperative outcomes of patients undergoing emergency surgery.

Declaration

Ethical approval

Support letter and ethical clearance (Reference number: duchm/irb/053/2022) were received from the institutional review board (IRB) of Dilla University College of medicine and health science before the start of the study. The importance of the study was explained & written informed consent was obtained from each participant. Confidentiality was kept during the study by avoiding identifiers and using codes to identify patients. Participants' involvement in the study was voluntary.

Consent for publication

Not applicable; this article does not include any personal or clinical details of any participant.

Availability of data and material

The [DATA TYPE] data used and materials to support the findings of this study are available from the corresponding author upon request.

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Author contribution

All authors have made substantial contributions to the conception, design, analysis, and interpretation of the study, and editing of the manuscript drafts for scientific quality and depth.

Guarantor

Kanbiro Gedeno Gelebo.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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