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Research Article

Transfusion practices in critical care units in Rwanda: A cross-sectional study reviewing best evidence and current practice

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Abstract

Background: Blood transfusion is a critical intervention in intensive care units, yet adherence to evidence-based guidelines varies globally. In resource-limited settings like Rwanda, the balance between transfusion benefits and risks requires careful evaluation. This study aimed to assess current transfusion practices, guideline adherence, and complications among critically ill patients in Rwandan tertiary hospitals. **Methods:** A prospective observational cross-sectional study was conducted from January 2023 to January 2024 across four tertiary hospitals in Rwanda. We enrolled 301 adult intensive care unit patients who received blood transfusions. Data on patient demographics, transfusion indications, blood product types, pre-transfusion laboratory values, guideline adherence, complications, and outcomes were collected. Data analysis was conducted in Stata version 17. **Results:** The median age was 36 years (IQR: 27-53), with 51.2% male patients. Anemia was the most common transfusion indication (34.6%). The median pre-transfusion hemoglobin was 7.5 g/dL (IQR: 6.7-9.2). Packed red blood cells were transfused in 85.4% of cases. Rwanda transfusion guidelines were followed in 59% of cases, while transfusion reactions occurred in 5.3% of patients. **Conclusions:** Transfusion practices in Rwandan intensive care units showed suboptimal adherence to evidence-based guidelines, with significant gaps in documentation and protocol implementation. These findings highlight the need for improved guideline implementation, enhanced monitoring systems, and targeted interventions for high-risk populations in resource-limited critical care settings.

Keywords: Blood transfusion; critical care; intensive care unit; guideline adherence

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1 INTRODUCTION

Blood transfusion is a life-saving intervention and one of the most commonly performed medical procedures worldwide (Hassall and Bates 1975). In intensive care units (ICUs), transfusion therapy is essential for managing severe anemia, acute hemorrhage, and coagulopathy, while maintaining adequate oxygen delivery in critically ill patients (Goodnough 2020; St Vincent's Hospital Melbourne n.d.). Blood components, including packed red blood cells (PRBCs), fresh frozen plasma (FFP), platelet concentrates, and cryoprecipitate, have specific indications and play distinct roles in patient stabilization and supportive care (Lotterman and Sharma 2024).

Over the past two decades, evidence from randomized controlled trials and international guidelines has supported the use of restrictive transfusion strategies in most critically ill patients (Arshall; 1999; Meert et al. 2007). A hemoglobin threshold of 7 g/dL is generally recommended for stable ICU patients, as restrictive approaches have been shown to be safe and associated with comparable or improved survival, fewer cardiac events, reduced infections, and more efficient utilization of blood resources compared to liberal strategies (Chacko and Brar 2019; Chaitman et al. 2011; Trentino et al. 2020; Vlaar et al. 2020). The 2023 the Association for the Advancement of Blood & Biotherapies (AABB) International Guidelines reaffirm these recommendations while emphasizing that transfusion decisions should be individualized for specific populations, including patients with acute coronary syndromes, active bleeding, or refractory septic shock (Carson JL, Stanworth SJ, Guyatt G 2023; Shailaja J., Hayden; Tyler J. Albert; Timothy R., Watkins; Erik R. 2012).

Despite advances in transfusion medicine, substantial disparities remain, particularly in low- and middle-income countries (LMICs). Blood donation rates average 6.6 per 1,000 population in low-income countries compared to 33.5 per 1,000 in high-income countries (World Health Organization (WHO) 2021). In sub-Saharan Africa, donation rates are approximately 4.7 units per 1,000 population annually (Weimer et al. 2019). Limited access to safe and sufficient blood supplies contributes to an estimated 6.4% of direct and indirect deaths globally (World Health Organization (WHO) 2021). Although serious acute transfusion reactions occur in fewer than 1 per 1,000 transfusions in high-income settings, the burden may be higher in resource-limited environments due to challenges in screening, storage, and hemovigilance systems (Frca et al. 2006).

In Rwanda, the national blood transfusion system has improved markedly, with delivery success rates approaching 100% (Rwanda Biomedical Center 2024). National guidelines recommend PRBC transfusion at hemoglobin levels below 7 g/dL in hemodynamically unstable ICU patients, below 8 g/dL for selected surgical patients, and below 6 g/dL in severe chronic anemia (Rwanda Biomedical Center 2018). However, adherence to these recommendations in routine ICU practice has not been systematically evaluated. Understanding current transfusion practices in Rwandan ICUs is critical to optimizing resource use and improving patient outcomes. This study aimed to assess transfusion practices, evaluate adherence to evidence-based guidelines, and describe associated complications in tertiary critical care units in Rwanda.

2 MATERIALS AND METHODS

2.1 Ethical considerations

Ethical approval was obtained from the Institutional Review Board of the College of Medicine and Health Sciences, University of Rwanda (Approval No. 079/CMHS IRB/2023), and from participating hospitals. Written informed consent was obtained from competent patients or their legal representatives. Confidentiality was ensured through coded identifiers and secure, password-protected data storage. No personal identifiers were included in the final dataset or analysis.

2.2 Study Design and Setting

This prospective observational cross-sectional study was conducted from January 2023 to January 2024 in the four public tertiary hospitals in Rwanda: Centre Hospitalier Universitaire de Kigali (CHUK), Centre Hospitalier Universitaire de Butare (CHUB), Rwanda Military Hospital (RMH), and King Faisal Hospital Rwanda (KFH). These national referral centers provide the highest level of care and collectively operate approximately 40 ICU beds serving a population exceeding 13 million people.

2.3 Study Population and Sampling

The study population comprised all adult patients (≥16 years) admitted to ICUs who received blood transfusions during the study period. We employed consecutive sampling, a non-probability sampling method, to recruit participants. Patients or their caretakers who refused blood transfusion for religious or personal reasons, or who declined study participation, were excluded. Given the observational nature of the study and the aim to capture real-world practices, we did not exclude patients based on diagnosis, severity of illness, or type of blood product received. A total of 301 patients were enrolled in the study through consecutive sampling of all eligible patients during the one-year study period across the four participating hospitals.

2.4 Data Collection

A structured data collection tool, developed from existing literature and Rwandan national guidelines, was piloted on 16 patients, demonstrating good reliability (Cronbach's alpha = 0.79) with minor revisions for clarity. Data extracted from medical records included sociodemographic characteristics, admission diagnosis, interventions, transfusion indications, pre-transfusion laboratory values, type and quantity of blood products, protocol adherence, transfusion reactions, and ICU and hospital length of stay. Data were collected by the principal investigator and four trained ICU-based research assistants. A one-day training preceded data collection, and regular supervision and quality checks were conducted throughout the study period.

2.5 Statistical data analysis

Data were entered into Microsoft Excel and analyzed using Stata version 17. Data quality was ensured through double entry of 10% of records with discrepancies resolved by review of source documents. Categorical variables were presented as frequencies and percentages. Continuous variables were assessed for normality using the Shapiro-Wilk test and presented as medians with interquartile ranges (IQR) due to non-normal distributions. Logistic regression analysis was performed to identify independent predictors of ICU mortality among the transfused critically-ill patients.

3 RESULTS

3.1 Participant Characteristics and Recruitment

During the 12-month study period, a total of 318 patients met the initial inclusion criteria. Of these, 8 patients or their families refused to participate in the study (2.5% refusal rate), and 9 had incomplete data due to transfer to other facilities or early discharge, leaving 301 patients in the final analysis (94.7% of eligible patients). The

distribution across hospitals was: CHUK (n=112, 37.2%), CHUB (n=78, 25.9%), RMH (n=64, 21.3%), and KFH (n=47, 15.6%). The median age was 36 years (IQR: 27-53; range: 16-97 years), with a slight male predominance (51.2%). The vast majority (96.0%) had an available next of kin. Age distribution showed 10.0% of patients were <21 years, 38.5% were 21-35 years, 25.2% were 36-50 years, and 26.2% were >50 years (Table 1).

Table 1. Sociodemographic characteristics of study participants (N=301)

Characteristics	n (%) or Median (IQR)
Age (years)	36 (27-53)
Age categories	
<21 years	30 (10.0%)
21-35 years	116 (38.5%)
36-50 years	76 (25.2%)
>50 years	79 (26.2%)
Sex	
Male	154 (51.2%)
Female	147 (48.8%)
Next of kin available	
Yes	289 (96.0%)
No	12 (4.0%)
Hospital distribution	
CHUK	112 (37.2%)
CHUB	78 (25.9%)
RMH	64 (21.3%)
KFH	47 (15.6%)

3.2 Diagnosis among the participants

Primary diagnoses were categorized into five major groups for analysis. Infectious diseases were most common (n=98, 32.6%), predominantly septic shock (n=42, 14.0%), pneumonia (n=13, 4.3%), and severe malaria (n=11, 3.7%). Surgical and trauma conditions accounted for 95 cases (31.6%), including peritonitis (n=30, 10.0%), traumatic brain injury (n=26, 8.6%), and polytrauma (n=24, 8.0%). Obstetric complications comprised 45 cases (15.0%), primarily postpartum hemorrhage (n=22, 7.3%), HELLP syndrome (n=12, 4.0%), and eclampsia (n=11, 3.7%). Hematologic and oncologic conditions represented 38 cases (12.6%), including acute kidney injury (n=19, 6.3%), leukemia (n=8, 2.7%), and multiple myeloma (n=6, 2.0%). The remaining 25 cases (8.3%) included chronic kidney disease, upper gastrointestinal bleeding, and other conditions (Figure 1).

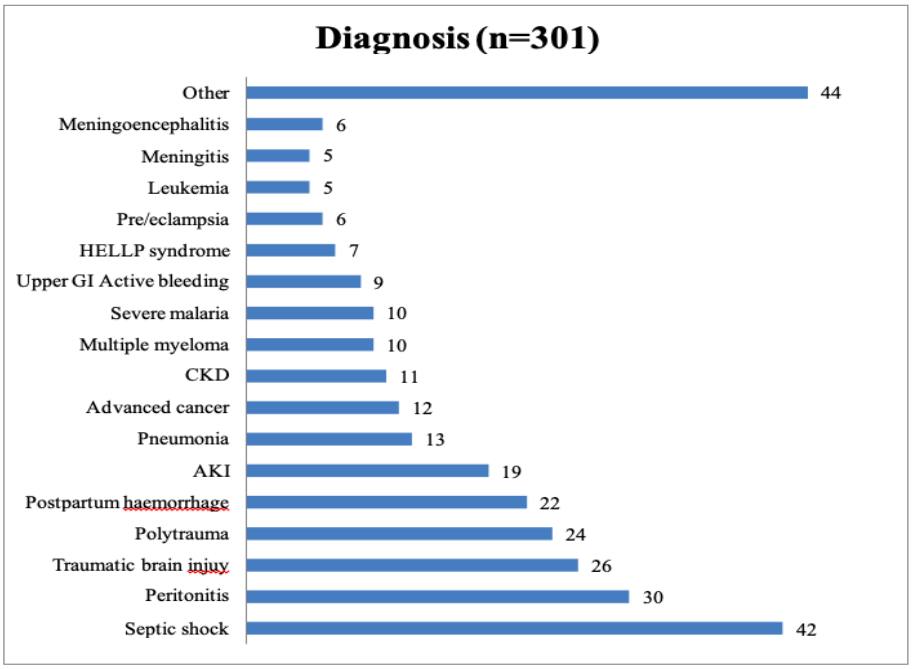


Figure 1: Dianosis among the participants
CKD: Chronic Kidney Disease, AKI: Acute Kidney Injury

3.3 Transfusion indications and blood products utilization

Anemia was the most common documented indication for transfusion (34.6%), followed by preoperative optimization (15.3%), active bleeding (9.0%), thrombocytopenia (8.0%), and hemodialysis optimization (7.3%). However, 21.6% of cases lacked documented transfusion indications in the medical records. The median pre-transfusion hemoglobin level was 7.5 g/dL (IQR: 6.7-9.2; range: 2.1-15.0 g/dL), with 31.6% of patients having hemoglobin <7 g/dL, 57.1% having hemoglobin 7-12.9 g/dL, and 2.7% having hemoglobin ≥13 g/dL. Among patients receiving platelet transfusions, the median platelet count was 56,500/μL (IQR: 36,500-76,500; range: 20,000-335,000/μL). For those receiving FFP, the median INR was 2.0 (IQR: 1.2-2.03; range: 0-2.12). PRBCs were the most frequently transfused product, administered to 257 patients (85.4% of all transfusion episodes). Platelets were transfused in 60 cases (19.9%), FFP in 19 cases (6.3%), and cryoprecipitate in 11 cases (3.7%). Multiple blood products were administered to 68 patients (22.6%). The median number of PRBC units transfused per patient was 2 (IQR: 2-3; range: 1-8 units), with 89% of patients receiving ≤4 units. The median time from ICU admission to first transfusion was 2 days (IQR: 1-5 days) (Table 2)

Table 2: Transfusion parameters and biochemical measurements among study participants

Transfusion information	n (%) or Median (IQR)
Time to first transfusion (days)	2 (1-5)
Transfusion indication	
Anemia	104 (34.6%)
Preoperative optimization	46 (15.3%)
Active bleeding	27 (9.0%)
Thrombocytopenia	24 (8.0%)
Hemodialysis optimization	22 (7.3%)
Anemia and thrombocytopenia	13 (4.3%)
Not documented	65 (21.6%)
Pre-transfusion hemoglobin (g/dL) (n=275)	**7.5 (6.7-9.2)**
Hb Category (n=275)	
<7 g/dL	95 (31.6%)
7-12.9 g/dL	172 (57.1%)
≥13 g/dL	8 (2.7%)
Pre-transfusion INR	**2.0 (1.2-2.03)**
Range (min-max)	0-2.12
Pre-transfusion platelet count (×10³/µL)	**56.5 (36.5-76.5)**
Range (min-max)	20-335
Blood products transfused	
Packed red blood cells (n=301)	257 (85.4%)
Platelets (n=301)	60 (19.9%)
Fresh frozen plasma (n=301)	19 (6.3%)
Cryoprecipitate (n=301)	11 (3.7%)
PRBC units transfused per patient	**2 (2-3)**
Range (min-max)	1 to 8

IQR, interquartile range; INR, international normalized ratio; PRBC, packed red blood cells

3.4 Transfusion Protocol Adherence and Documentation

Rwanda transfusion guidelines were followed in 178 cases (59%), while 123 transfusions (41%) did not adhere to established protocols. Among guideline-discordant transfusions, the most common deviation was PRBC administration at hemoglobin levels >8 g/dL in hemodynamically stable patients without acute coronary syndrome (n=67, 54.5% of non-adherent cases). Other deviations included platelet transfusion for counts >50,000/µL without bleeding (n=31, 25.2%), FFP administration without documented coagulopathy (n=18, 14.6%), and transfusion without documented indication (n=7, 5.7%). Written informed consent for blood transfusion was documented in 260 cases (86.3%), representing a gap in consent documentation for 41 patients (13.6%) (Figure 2).

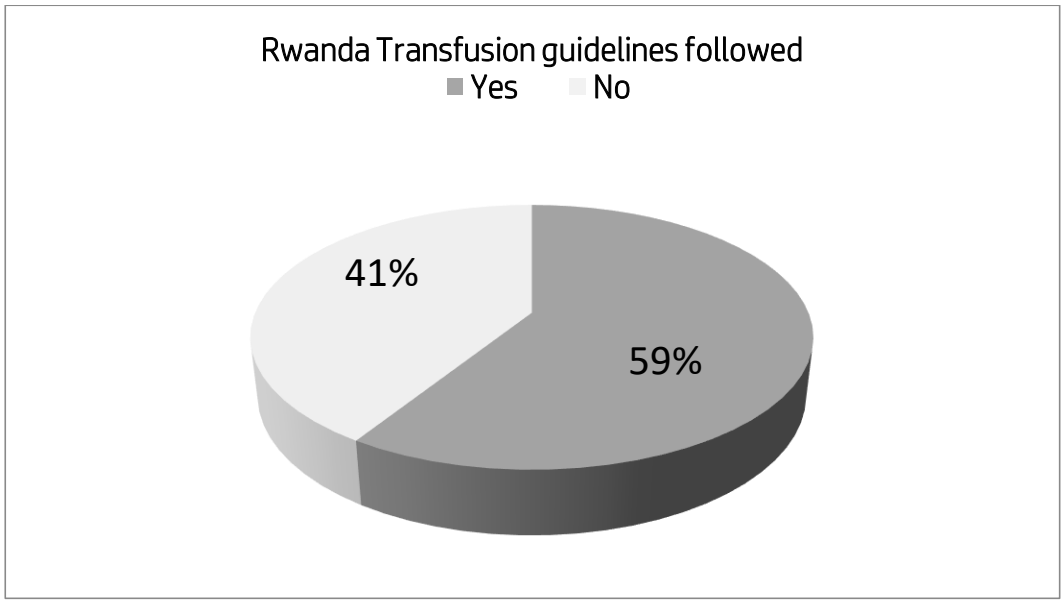


Figure 2: Adherence to Rwanda transfusion guidelines

3.5 Transfusion reactions and complications

Documented transfusion reactions occurred in 16 patients (5.3%). Among those experiencing reactions, fever was most common (n=8, 50% of reactions), followed by allergic rash (n=4, 25%), transfusion-associated circulatory overload (TACO) (n=3, 18.8%), and transfusion-related acute lung injury (TRALI) (n=1, 6.3%). The cause of reactions was identified in only 4 cases (25%): laboratory error in sample handling or cross-matching in 3 cases (18.8% of reactions) and ABO incompatibility in 1 case (6.3%). The majority of reaction causes (n=12, 75%) remained unknown or undocumented despite investigation. All patients with documented reactions received appropriate management, including antihistamines for allergic reactions, diuretics for volume overload, and supportive care. No deaths were directly attributed to transfusion reactions, though the single TRALI case required prolonged mechanical ventilation. The median ICU length of stay was 8 days (IQR: 5-14; range: 1-67 days), and the median total hospital stay was 13 days (IQR: 7-21; range: 1-120 days). Of the total patients, 145 (48.2%) died during their ICU stay. Beyond transfusion, patients received various concurrent interventions reflecting the complexity of critical illness. Vasopressors were administered to 40 patients (13.3%). Hemodialysis was performed in 33 patients (11.0%), laparotomy in 30 patients (10.0%), and other surgical procedures in 27 patients (9.0%). Mechanical ventilation was utilized in 156 patients (51.8%), and vasopressor support was required in 142 patients (47.2%). Palliative care was provided to 27 patients (9.0%) with advanced malignancies or multi-organ failure deemed irreversible (Table 3).

Table 3. Transfusion complications and outcomes (N=301)

Variable	n (%) or Median (IQR)
Documented transfusion reaction	
Yes	16 (5.3%)
No	285 (94.7%)
Type of reaction (n=16)	
Fever	8 (50.0%)
Allergic rash	4 (25.0%)
Transfusion-associated circulatory overload	3 (18.8%)
Transfusion-related acute lung injury	1 (6.3%)
Cause of reaction (n=16)	
Laboratory error	3 (18.8%)
ABO incompatibility	1 (6.3%)
Unknown/not documented	12 (75.0%)
Supportive interventions	
Mechanical ventilation	156 (51.8%)
Vasopressor support	142 (47.2%)
ICU length of stay (days)	8 (5-14)
Range (min-max)	1 to 67
Total hospital stay (days)	13 (7-21)
Range (min-max)	1-120
30 days ICU outcome	
Improved/discharged	156 (51.8%)
Died	145 (48.2%)

IQR, interquartile range; ICU, intensive care unit

3.6 Factors associated with mortality among transfused critically ill patients

The analysis of the factors associated with mortality among critically ill patients who were transfused showed that age was the only predictor of mortality among these patients where patients aged above 50 years were 4.7 times more likely to die than those who were below 20 years of age (Table 4).

Table 1: Factors associated with mortality among transfused critically ill patients

Predictors	Discharge outcome		OR (95%CI)	P value
	Improved	Died		
Age of participant in years (n=301)				
<21	21 (70%)	9 (30%)	ref	
21-35	66 (56.9%)	50 (43.1%)	1.76 (0.74-4.19)	0.196
36-50	43 (56.6%)	33 (43.4%)	1.79 (0.73-4.42)	0.206
>50	26 (32.9%)	53 (67.1%)	4.75 (1.91-11.83)	0.001
Sex (n=301)				
Male	81 (52.6%)	73 (47.4%)	ref	
Female	75 (51.0%)	72 (49.0%)	1.06 (0.67-1.67)	0.784
Hemoglobin level (n=283)				
Normal	2 (25%)	6 (75%)	ref	
Moderate anemia	94 (52.2%)	86 (47.8%)	0.30 (0.06-1.55)	0.152
Severe anemia	53 (55.8%)	42 (44.2%)	0.26 (0.05-1.37)	0.114
Available transfusion guidelines followed (n=301)				
Yes	97 (54.8%)	80 (45.2%)	ref	
No	59 (48.0%)	64 (52.0%)	1.30 (81-2.06)	0.266
Any documented reaction from transfusion (n=301)				
Yes	5 (31.2%)	11 (68.75%)	2.47 (0.83-7.32)	0.100
No	151 (53.2%)	133 (46.8%)	ref	
Hospital stay (n=301)				
<7 days	39 (46.4%)	45 (53.6%)	1.41 (0.53-3.76)	0.492
7-30 days	106 (53.8%)	91 (46.2%)	1.05 (0.42-2.64)	0.919
>30 days	11 (55.0%)	9 (45.0%)	ref	

Ref: reference category; OR: Odds ratio; CI: Confidence Interval

4 DISCUSSION

The median age of 36 years in our study population is considerably younger than that reported in high-income countries, where mean ages of 60–70 years are typical among transfused ICU patients (Giora, Netzer; Xinggang, Liu; Anthony D., Harris; Bennett B., Edelman; John R., Hess; Carl Shanholtz; David J. 2011; Taylor et al. 2006). This age difference reflects broader epidemiological patterns in sub-Saharan Africa, where communicable diseases such as sepsis, malaria, and HIV-related illnesses, as well as maternal complications and trauma, disproportionately affect younger populations (Bhutta et al. 2014; Razzak and Kellermann 2002). The predominance of infectious diseases (32.6%) and surgical/trauma conditions (31.6%) as primary diagnoses in our cohort corroborates this pattern and contrasts with ICUs in high-income countries, where cardiovascular and chronic diseases predominate (Vincent et al. 2014). The high proportion of obstetric cases (15.0%) requiring ICU admission and transfusion

is particularly noteworthy and reflects ongoing maternal health challenges in the region. Rwanda has made substantial progress in reducing maternal mortality from 1,071 per 100,000 live births in 2000 to 248 per 100,000 in 2020 (National Institute of Statistics of Rwanda (NISR) 2021); however, postpartum hemorrhage remains a leading cause of maternal death and ICU admission. Anemia was the most common indication for transfusion (34.6%), consistent with international literature documenting anemia as the primary reason for red blood cell transfusion in ICUs, with reported prevalence ranging from 22% to 50% (Kinnear 2011; Miquilino et al. 2020; Napolitano et al. 2009).

The 41% non-adherence rate to Rwanda transfusion guidelines represents a substantial gap in optimal care delivery. This finding is comparable to non-adherence rates reported in other low- and middle-income countries (30–60%) (Kassebaum et al. 2016; Sadana et al. 2021), but higher than rates typically observed in high-income settings with established clinical decision support systems and routine audits (Wintermeyer et al. 2017). Multiple factors likely contribute to this discrepancy, including variations in provider knowledge and training amid staff rotation and limited continuing medical education opportunities; emergency situations requiring rapid decision-making without time for guideline consultation; patient-specific circumstances and clinical judgment that may justify deviation from standardized thresholds; and institutional practice variations with limited protocol harmonization across facilities (Sada, Husain, and Misbah 2023). The 21.6% rate of undocumented transfusion indications is particularly concerning, as it suggests deficiencies in documentation and possibly in the decision-making process itself. Adequate documentation ensures appropriate clinical rationale, facilitates communication among healthcare providers, enables quality improvement and audit, and provides medico-legal protection.

The rate of transfusion reactions observed in our study falls within the expected range for documented acute complications, which generally occur in 1–6% of transfusions (Frca et al. 2006; Rawal et al. 2016). Fever was the most common reaction (50% of all reactions), consistent with febrile non-hemolytic transfusion reactions being among the most frequently reported adverse events globally (Donaldson, Seaman, and Park 1992). Transfusion-associated circulatory overload (TACO) was reported in 3 patients (1%), lower than the pooled incidence of 5.3% reported by Cloedt et al. in their scoping review among adult ICU patients (Cloedt, Savy, and Gauvin 2019). Our rate is also lower than the 2% reported by Rana et al. (2006) (Rana et al. 2006), the 6% described by Li et al. (2011) (Guangxi Li; Sonal Rachmale; Marija Kojicic; Khurram Shahjehan; Michael Malinchoc; Daryl J Kor; and Ognjen Gajic 2012), and the 5.98% reported by Bosboom et al. (2018) (Bosboom et al. 2017). This comparatively lower incidence may reflect differences in patient characteristics, including a younger study population and variations in pre-existing comorbidities. Notably, preventable causes, laboratory errors (18.8%) and ABO incompatibility (6.3%), accounted for 25% of identified reactions, highlighting critical safety gaps that could be addressed through strengthened laboratory quality control, barcode scanning systems, strict adherence to administration protocols, and regular staff training.

The 48% ICU mortality rate among transfused patients is substantially higher than rates reported in recent studies from high-income countries (15–30%) (Cable et al. 2021; Taylor et al. 2006; Xiao et al. 2023), but comparable to mortality rates reported in other African ICUs (30–60%) (Baelani et al. 2011; Kwizera, Dünser, and Nakibuuka 2012). We had initially hoped to investigate blood transfusion as an independent predictor of mortality among ICU patients. However, the current study was not specifically powered or designed to establish a causal association between transfusion practices and mortality outcomes. Future studies should more

rigorously examine whether patients managed under more liberal transfusion strategies experience higher rates of mortality and transfusion-related complications compared to those managed under restrictive approaches, thereby generating context-specific evidence to guide ICU transfusion practice.

Several limitations warrant consideration. Most importantly, the absence of standardized illness severity scores limits our ability to adjust adequately for disease severity in mortality analyses. Additionally, the absence of a non-transfused comparator group limits the ability to determine the independent effect of transfusion on clinical outcomes. Consequently, future studies employing comparative designs are warranted to evaluate the impact of transfusion on mortality and other outcomes among ICU patients by directly comparing transfused and non-transfused populations.

5 CONCLUSION

This multi-center study provides the first comprehensive evaluation of transfusion practices in tertiary critical care units in Rwanda. Transfusion was predominantly administered to a young, critically ill population with infectious, trauma-related, and obstetric conditions. Our findings shows that adherence to evidence-based guidelines was suboptimal, with 41% of transfusions not aligned with recommended thresholds and guidelines and notable gaps in documentation of indications and consent. Although the overall rate of transfusion reactions was within expected ranges and no deaths were directly attributed to transfusion, preventable laboratory errors and ABO incompatibility highlight important safety concerns. Our results underscore the need for strengthened protocol implementation, documentation practices, and transfusion safety systems to optimize resource utilization and improve patient outcomes in Rwandan ICUs.

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Institutional review board statement

The study was approved by the Institutional Review Board of College of Medicine and Health Sciences, University of Rwanda (Approval No. 079/CMHS IRB/2023) and was conducted following the guidelines of the Declaration of Helsinki.

Data availability

The data presented in this study are available on request from the corresponding author on reasonable request. The data are not publicly available due to ethical and participants' privacy reasons

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