

Original article

Transfusion, mortality and hemoglobin level: Associations among emergency department patients in Kigali, Rwanda



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ABSTRACT

Background: Studies from high-income countries (HIC) support restrictive blood transfusion thresholds in medical patients. In low- and middle-income countries (LMIC), the etiologies of anemia and baseline health states differ greatly; optimal transfusion thresholds are unknown. This study evaluated the association of packed red blood cell (PRBC) transfusion with mortality outcomes across hemoglobin levels amongst emergency center (EC) patients presenting with medical pathology in Kigali, Rwanda.

Methods: This retrospective cohort study was performed using a random sample of patients presenting to the EC at the University Teaching Hospital of Kigali. Patients ≥ 15 years of age, treated for medical emergencies during 2013–16, with EC hemoglobin measurements were included. The relationship between EC PRBC transfusion and patient mortality was evaluated using logistic regression, with stratified analyses performed at hemoglobin levels of 7 mg/dL and 5 mg/dL.

Results: Of 3609 cases sampled, 1116 met inclusion. The median age was 42 years (IQR 29, 60) and 45.2% were female. Transfusion occurred in 12.1% of patients. Hematologic (24.4%) and gastrointestinal pathologies (20.7%) were the primary diagnoses of those transfused. Proportional mortality was higher amongst those receiving transfusions, although not statistically significant (23.7% vs 17.0%, $p = 0.06$). No significant difference in adjusted odds of overall mortality by PRBC transfusion was found. In stratified analysis, patients receiving EC transfusions with a hemoglobin > 5.0 mg/dL, had 2.21 times the odds of mortality (95% CI 1.51–3.21) as compared to those ≤ 5.0 mg/dL.

Conclusions: No association between PRBC transfusion and odds of mortality was observed amongst EC patients in this LMIC setting. An increased mortality association was found for patients receiving PRBC transfusions with an initial hemoglobin > 5 mg/dL. Results suggest benefits from PRBC transfusion are limited as compared to HIC. Further research evaluating emergent transfusion thresholds for medical pathologies should be performed in LMICs to guide practice.

African relevance

- Blood products are a valuable resource across Africa
- Transfusion threshold studies have occurred only in high income countries.
- This study evaluates associations between transfusions and haemoglobin levels in Kigali, Rwanda.
- Higher associated mortality was found for those receiving

transfusions with initial haemoglobin levels > 5 mg/dL.

Introduction

Across Africa, 4.9 million people suffer from severe anemia [1,2]. While worldwide there has been a movement towards more restrictive blood transfusion thresholds, the studies leading to these guidelines have all occurred in high income countries (HIC) [3,4]. Comparable

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transfusion threshold investigations in low and middle income countries (LMICs), and specifically throughout Africa, have not been performed. As the primary etiologies of anemia differ between Africa and HIC, the appropriateness of current blood transfusion guidelines is not clear. Thus, there is a potential for worse patient outcomes [5]. Differing effects of treatment between HIC and LMIC populations have been demonstrated in recent literature. In children from Uganda and Malawi, a benefit from higher volume whole blood transfusions was found for afebrile patients only. These findings that have not been previously demonstrated in HIC [6]. In addition, interventional trials of fluid resuscitation strategies in Africa have demonstrated that current guidelines developed in HICs do not transfer the same benefits in the African population and may, in fact, lead to increased mortality [7–9].

Blood products are a valuable and limited resource with unmet needs across Africa [10,11]. In Rwanda, a national blood transfusion program has been developed and blood donation is increasing, but there remains a gap between supply and demand [12]. In addition, transfusions do not come without risk. Given the increased burden of infectious disease as well as gaps in universal screening, Africa has the highest rates of transfusion related infections worldwide [13,14]. Rates of infections for sub-Saharan Africa are estimated at 1 case per 1000 transfusions for HIV and 2.5 cases per 1000 transfusions for HCV [15].

Given these multiple factors, studies of medical blood transfusion for patients in Africa are imperative to understand clear indications and guide local practices. This study evaluated the association of packed red blood cell (PRBC) transfusion with mortality outcomes based on presenting hemoglobin levels amongst emergency center (EC) patients with medical pathology in Kigali, Rwanda.

Methods

Study design, setting and population

This retrospective cohort study was performed using a previously established database from the University Teaching Hospital of Kigali (UTH-K) in Kigali, Rwanda [16]. This hospital is the primary national public referral center of Rwanda and is an urban, tertiary-care institution with 40 emergency beds and 500 inpatient beds. Patients 15 years of age or older, presenting to the EC from November 2012–October 2013 and then August 2015–July 2016, with a primary medical complaint, and an initial hemoglobin measurement were eligible for inclusion. Medical patients were defined as those diagnosed with a non-traumatic pathology, including obstetrical complications. The time-interrupted random sample database was initially developed to evaluate the effects of implementation of a new emergency medicine residency program at the study site [16]. Based on previous strategies of restrictive blood transfusion practices performed in HICs [3,4,17,18], we hypothesized that the mortality benefits of medical PRBC transfusions would only be observed amongst patients presenting with severe anemia as defined by the World Health Organization (WHO) as a hemoglobin level <7.0 g/dL [19].

Data management

The primary exposure was PRBC transfusion received during EC care. Presenting hemoglobin levels were subdivided into categories of ≤ 7 mg/dL, 7.1–9.9 mg/dL and > 10 mg/dL based on previously described stringent versus liberal transfusion thresholds performed in HICs [4,18,20,21].

The World Health Organization (WHO) defines severe anemia as a hemoglobin level <7.0 g/dL [19] while current 2018 Rwandan guidelines advise medical transfusions for patients with hemoglobin levels 5.0 mg/dL or lower, when hemodynamically stable [22]. Consequently, hemoglobin levels were additionally stratified for analysis at: > 7.0 mg/dL and ≤ 7.0 mg/dL as well as > 5.0 mg/dL and ≤ 5.0 mg/dL [22].

To access blood products at UTH-K, physicians must complete a paper requisition form which is provided to nursing staff for blood requests. Limited supplies of emergent blood are stocked in the hospital. If not available, it is requested from the National Center for Blood Transfusion located next to the hospital. Given the highly regulated use of blood products at the UTH-K and therefore unlikely utilization without documentation, cases without documentation of receiving blood were coded as non-treated.

All-cause mortality aggregated inpatient and emergency department deaths. Patients who eloped or were transferred were analyzed as survivals. Case characteristics evaluated included demographics, time of arrival, clinical characteristics, EC and inpatient interventions, EC and inpatient outcomes and final diagnoses. Time of arrival was divided into day (6 am to 7 pm) and night (7 pm to 6 am) to control for staffing differences in the EC. Time period was binary and included before (December 2012 – October 2013) and after (August 2015 - July 2016) the implementation of the emergency medicine residency.

Clinical characteristics included initial EC triage vital signs and mobility upon arrival which was coded as walking, wheelchair/with help, or stretcher/immobile. EC triage vital signs including systolic blood pressure, respiratory rate and oxygen saturation and were dichotomized based on cut-offs in the triage early warning system, a resource validated in Africa [23]. Systolic blood pressure was categorized as ≤ 100 mmHg or > 100 mmHg corresponding to hypotensive versus normotensive patients. Respiratory rate was categorized as ≤ 20 or > 20 breaths per minute, and oxygen saturation was divided in categories of $\leq 92\%$ or $> 92\%$ on room air. Heart rate was analyzed based on the triage early warning score categorization without dichotomization.

Emergency center interventions of interest included: IV crystalloid administration, antibiotic administration, vasopressor administration, use of supplemental oxygen, intubation and cardiopulmonary resuscitation (CPR). IV crystalloids included lactated ringer and normal saline administration. Vasopressor administration, supplemental oxygen, intubation and CPR were coded as binary as received in the EC or not. All forms of vasopressors were aggregated for analysis. Inpatient interventions evaluated included: inpatient blood transfusion, endoscopy, operative intervention, and dialysis. All were coded as binary. Final diagnoses at time of discharge from either the EC or inpatient care were recorded and the most common diagnoses were reported. For all data, ambiguous elements were coded as missing within the database.

Data analysis

Data analysis was performed using STATA version 15.0 (StataCorp; College Station, USA). Descriptive analysis was performed for the study cohort stratified by the intervention of PRBC transfusion while in the emergency department. Variables were described using frequencies with percentages. Chi-Squared analysis was performed for covariates by exposure: PRBC transfusion.

Bivariate regression was performed for patient characteristics to assess for differences between those receiving emergent blood versus those not receiving blood. A multivariable logistic regression analysis was performed to assess the relationship between mortality and PRBC transfusion. Age, gender, hemoglobin level and time period of treatment were included in the multivariable model a priori. In addition, covariates resulting in a $> 10\%$ change in odds of all-cause mortality by the exposure, blood transfusion were included in multivariate analysis to calculate adjusted odds ratios (aOR) with associated 95% confidence intervals (CI). These included patient characteristics: systolic blood pressure, oxygen saturation, time of arrival, and mobility upon arrival as well as hospital interventions: EC blood transfusion, crystalloid fluid administration, inpatient blood transfusion, and surgical intervention [24].

Additionally, two separate stratified analyses of unadjusted and adjusted odds of mortality by emergent transfusion were performed

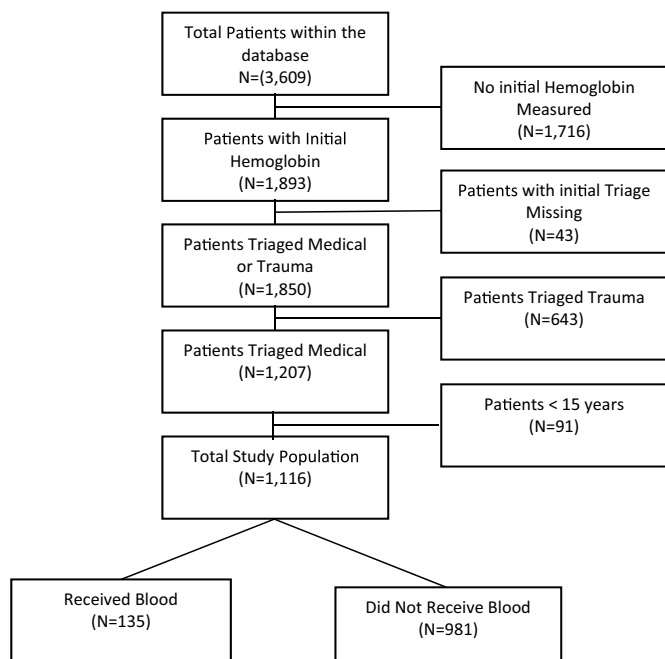


Fig. 1. Study sample.

based on hemoglobin concentration: hemoglobin >7.0 mg/dL and ≤7.0 mg/dL as well >5.0 mg/dL and ≤5.0 mg/dL. In the 7.0 mg/dL stratified analysis model, odds of mortality by emergent transfusion was adjusted by age, gender, time period, triage systolic blood pressure and oxygen saturation. In the 5.0 mg/dL stratified model, odds of mortality by emergent transfusion was adjusted by time period, age and gender only due to the limited numbers (N = 43) in the hemoglobin less than or equal to 5.0 mg/dL cohort.

Results

During the study time period, 1116 medical patients of ages 15 years or older, with initial hemoglobin measurements, were identified. Forty-three patients (3.85%) were excluded for missing triage data. Twenty-two cases (1.97%) were excluded due to missing all-cause mortality data. Of this cohort, 135 patients (12.10%) received emergent PRBC transfusions (Fig. 1).

There was no difference in gender and age distributions. Heart rates and respiratory rates were not statistically significant between cohorts. However, amongst those receiving EC PRBC transfusions, patients were more likely to be hypotensive with a systolic blood pressure ≤ 100 mmHg (10.37% vs. 5.61%, p = 0.014). Those receiving transfusions had lower hemoglobin levels as compared to those not receiving emergent transfusions (Table 1).

The most common primary diagnoses in those receiving PRBC transfusions were hematologic problem (24.44%) with a mean hemoglobin level = 5.9 mg/dL followed by gastrointestinal disease (20.74%, mean hemoglobin level = 8.3 mg/dL) and infectious disease (13.33%, mean hemoglobin level = 6.9 mg/dL). For patients not receiving PRBCs, gastrointestinal pathology was most common (27.22%, mean hemoglobin level = 13.4 mg/dL) while hematologic pathology was least common (0.71%, mean hemoglobin level = 7.3 mg/dL) (Supplemental Table 2).

Mortality proportions were not statistically different between those receiving and those not receiving blood transfusions (23.7% vs. 17.02%, p = 0.06). Patient characteristic covariates associated with a significant increase in unadjusted odds of mortality included: increased age, a final diagnosis of malignancy, triage oxygen saturation < 92% and mobility upon arrival (Table 2). The unadjusted odds of mortality

Table 1
Patient characteristics by blood transfusion exposure.

	Received blood N = 135 (%)	No blood N = 981 (%)	p Value
Hgb level (mg/dL)			
Hgb ≥ 10	17 (12.59)	779 (79.41)	<0.0001
Hgb 7.1–9.9	40 (29.63)	165 (16.82)	
Hgb ≤ 7.0	78 (57.78)	37 (3.77)	
Age			
16–44	84 (62.22)	528 (53.82)	0.16
45–64	32 (23.70)	264 (26.91)	
≥ 65	19 (14.07)	188 (19.16)	
Missing	0 (0)	1 (0.10)	
Gender			
Male	70 (51.85)	542 (55.25)	0.46
Female	65 (48.15)	439 (44.75)	
Final diagnosis			
Hematologic problem	33 (24.44)	7 (0.71)	<0.0001
Gastrointestinal problem	28 (20.74)	267 (27.22)	
Infectious disease	18 (13.33)	143 (14.58)	
Cancer	18 (13.33)	70 (7.14)	
Cardiac	6 (4.44)	64 (6.52)	
Time period			
Pre residency	79 (58.52)	513 (52.29)	0.17
During residency	56 (41.48)	468 (47.71)	

Triage vital signs			
	Received blood N = 135 (%)	No blood N = 981 (%)	p value
Heart rate (beats per minute)			
≤ 100	25 (18.54)	209 (21.30)	0.56
101–110	6 (4.44)	50 (5.10)	
111–129	14 (10.37)	76 (7.75)	
> 129	4 (2.96)	43 (4.38)	
Missing	86 (63.70)	603 (61.47)	
Systolic blood pressure (mmHg)			
≤ 100	14 (10.37)	55 (5.61)	0.01
> 100	36 (26.67)	325 (33.13)	
Missing	85 (62.96)	601 (61.26)	
Respiratory rate			
≤ 20	44 (32.59)	317 (32.31)	0.37
> 20	6 (4.44)	65 (6.63)	
Missing	85 (62.96)	599 (61.06)	
Oxygen saturation			
≤ 92%	6 (4.44)	59 (6.01)	0.59
> 92%	39 (28.89)	299 (30.48)	
Missing	90 (66.67)	623 (63.51)	
Time of arrival			
Day hours 6 am to 7 pm	30 (22.22)	222 (22.63)	0.49
Night hours 7 pm to 6 am.	17 (12.59)	157 (16.00)	
Missing	88 (65.19)	602 (61.37)	
Mobility upon arrival			
Walking	9 (6.67)	48 (4.89)	0.48
Wheelchair, with help	24 (17.78)	177 (18.04)	
Stretcher, immobile	17 (12.59)	154 (15.70)	
Missing	85 (62.96)	602 (61.37)	
Mortality			
Lived (Discharged or transferred)	101 (74.81)	794 (80.94)	0.06
Died (ED or inpatient)	32 (23.70)	167 (17.02)	
ED Mortality	12 (8.89)	36 (3.67)	
Inpatient mortality	20 (14.81)	131 (13.35)	
Missing	2 (1.48)	20 (2.04)	
ED interventions			
Received crystalloid	102 (75.56)	595 (60.65)	0.001
Received antibiotics	83 (61.48)	447 (45.57)	
Received vasopressors	4 (2.96)	7 (0.71)	0.098
Received CPR	5 (3.70)	4 (0.41)	0.002
Intubated	6 (4.44)	19 (1.94)	0.12
Received supplemental O2	30 (22.22)	176 (17.94)	0.19

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Table 1 (continued)

Triage vital signs	Received blood N = 135 (%)	No blood N = 981 (%)	p value
Hospitalization characteristics			
Inpatient blood transfusion	55 (40.74)	109 (11.11)	<0.0001
Endoscopy	17 (12.59)	57 (5.81)	0.003
Operation	16 (11.85)	302 (30.78)	<0.0001
Dialysis	1 (0.74)	13 (1.33)	0.57

was not statistically significant between those receiving versus not receiving EC transfusions (Table 2).

Emergency center medical intervention covariates associated with a significant increase in unadjusted odds of mortality included: crystalloid fluids, antibiotics, vasopressors, supplemental oxygen, intubation and CPR (Table 3). Inpatient medical interventions associated with a significant increase in unadjusted odds of mortality included inpatient PRBC transfusions (1.87, 95% CI 1.27–2.75) while those receiving an operation had a significant decrease in unadjusted odds of mortality (0.46, 95% CI 0.31–0.69) (Table 3).

When adjusting for presenting patient characteristics and medical interventions, the adjusted odds of mortality remained not statistically different between those receiving versus not receiving an EC transfusion. While receiving crystalloid fluid significantly increased the odds of mortality in the unadjusted model, when adjusting for patient characteristics and medical interventions the association decreased and was no longer significant (aOR 1.58, 95% CI 0.80–3.09). However, those with a low oxygen saturation had 3 times the odds of mortality (95% CI 1.62–6.00), and those receiving inpatient blood had 3.25 times the odds of mortality (95% CI 1.43–7.41) (Table 2). When stratifying the study sample by a hemoglobin level of 7.0 mg/dL, ED transfusions were not associated with a change in adjusted odds of mortality (Table 4). However, those receiving inpatient PRBCs with an initial hemoglobin >7 mg/dL had 2.69 times the adjusted odds of mortality (95% CI 1.32–5.51).

When stratified at a hemoglobin level of 5.0 mg/dL concurrent with Rwandan transfusion guidelines, those receiving EC PRBC transfusions with hemoglobin levels >5.0 mg/dL were found to have an increased adjusted odds of mortality (2.21, 95% CI 1.51–3.21, Table 4). For those receiving PRBCs in the inpatient setting with an initial hemoglobin >5 mg/dL, the odds of mortality was 1.72 times greater (95% CI: 1.26–2.36).

Of those receiving emergent PRBC transfusions, 57% had a hemoglobin >7 mg/dL and 75% had a hemoglobin >5 mg/dL. A sub-analysis of final diagnoses subtypes concerning for active hemorrhage (upper and lower gastrointestinal bleeding, uterine bleeding) was performed to estimate the percentage of transfusions in the setting of active bleeding. Of the 15 cases identified with active hemorrhage, only 3 cases receiving emergent blood had hemoglobin levels >7.0 mg/dL (2.2% of the overall cohort).

Discussion

This study identified no association between emergent PRBC transfusion in patients with medical conditions and all-cause mortality outcomes when controlling for patient characteristics and medical interventions. Blood represents a valuable and scarce resource in LMICs and the lack of mortality benefit amongst medical patients receiving emergent PRBCs identifies the potential need for improved understanding of this high-cost therapy. While the population receiving blood may be sicker, thus limiting the apparent mortality benefit of blood transfusion, an attempt to minimize this bias was made by controlling for multiple cofounders.

Table 2

Unadjusted and adjusted odds of mortality by patient characteristics and medical interventions.

Patient characteristics	Unadjusted odds ratio (95% CI)	Adjusted odds ratio (95% CI)
Triage vital signs		
Hgb Level (mg/dL)		
Hgb ≥ 10	1.00 (ref)	
Hgb 7.1–9.9	1.41 (0.96–2.06)	0.85 (0.40–1.81)
Hgb ≤ 7.0	1.20 (0.73–1.98)	0.68 (0.18–2.60)
Age (years)		
16–44	1.00 (ref)	
45–64	1.48 (1.03–2.13) ^a	1.93 (1.00–3.74)
≥ 65	1.77 (1.20–2.63) ^a	1.18 (0.56–2.54)
Gender		
Male	1.00 (ref)	
Female	0.87 (0.64–1.19)	0.62 (0.34–1.14)
Final diagnosis		
Hematologic problem	0.38 (0.11–1.24)	
Infectious disease	1.18 (0.77–1.80)	
Gastrointestinal problem	0.59 (0.40–0.87)	
Cancer	2.82 (1.76–4.51) ^a	
Cardiac	1.05 (0.56–1.95)	
Triage vital signs		
	Unadjusted odds ratio (95% CI)	Adjusted odds ratio (95% CI)
HR (beats per minute)		
≤ 100	1.00 (ref)	
101–110	1.60 (0.77–3.34)	
111–129	1.71 (0.92–3.18)	
> 129	1.55 (0.71–3.41)	
SBP (mmHg)		
> 100	1.00 (ref)	
≤ 100	1.39 (0.73–2.62)	1.39 (0.66–2.94)
Respiratory rate (breaths per minute)		
≤ 20	1.00 (ref)	
> 20	1.15 (0.60–2.19)	
Oxygen saturation		
> 92%	1.00 (ref)	
≤ 92%	2.94 (1.60–5.38) ^a	3.16 (1.61–6.17) ^a
Time of arrival		
Day time: 6 am to 7 pm	1.00 (ref)	
Night Time: 7 pm to 6 am.	1.22 (0.74–2.01)	1.14 (0.64–2.05)
Mobility upon arrival		
Walking	1.00 (ref)	
Wheelchair, with help	2.09 (0.70–6.22)	1.53 (0.47–4.93)
Stretcher, Immobile	3.86 (1.31–11.34) ^a	2.20 (0.68–7.09)
Medical interventions		
	Unadjusted odds ratio (95% CI)	Adjusted odds ratio (95% CI)
ED interventions		
Received blood	1.51 (0.97–2.32)	0.44 (0.14–1.37)
Crystalloid fluids	2.25 (1.58–3.21) ^a	1.58 (0.80–3.09)
Antibiotics	1.60 (1.18–2.19) ^a	
Received vasopressors	8.12 (2.35–28.02) ^a	
CPR	360.51 (49.51–2625.04)	
Intubation	10.36 (4.40–24.36) ^a	
Supplemental O2	5.06 (3.60–7.12) ^a	
Inpatient interventions		
Inpatient blood transfusion	1.87 (1.27–2.75) ^a	3.25 (1.43–7.41) ^a
Endoscopy	1.16 (0.64–2.08)	
Operation	0.46 (0.31–0.69) ^a	0.59 (0.29–1.20)

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Table 2 (continued)

Medical interventions	Unadjusted odds ratio (95% CI)	Adjusted odds ratio (95% CI)
	Dialysis	1.82 (0.56–5.85)
Time period	0.97 (0.91–1.04)	089 (0.69–1.14)

^a Denotes statistical significance.

In HICs, practices have moved towards restrictive thresholds with no mortality increase [3,17,18,20,21,25]. Stratified analysis, based on these restrictive thresholds and the WHO severe anemia threshold of 7 mg/dL [1], failed to demonstrate a benefit from emergent blood transfusion. Results suggest that this treatment, even for those with WHO defined severe anemia, may not be associated with improved outcomes amongst the medical patients studied in Rwanda.

Current Rwandan guidelines employ a more restrictive transfusion threshold, recommending blood at a hemoglobin level of 5 mg/dL or for unstable patients [22]. In analysis stratified by these local guidelines, an increased odds of mortality was found for those receiving blood with a hemoglobin level > 5 mg/dL. However, given limited number of patients with hemoglobin levels ≤ 5.0 mg/dL, there were limitations in adjustments for confounders including patient stability; unmeasured factors could account for the observed outcomes.

Literature has demonstrated that the adoption of HIC treatment paradigms to LMIC can result in patient harm. In the FEAST trial, mortality was increased for children receiving fluid boluses vs. no bolus for severe febrile illnesses across Kenya, Tanzania and Uganda [7]. Similarly, aggressive fluid resuscitation amongst the adult septic population in Zambia resulted in harm despite HIC literature demonstrating benefit from this treatment strategy [8,26]. Results from this study challenge the current treatment strategy of medical transfusion, especially for those patients with a hemoglobin ≥ 5 mg/dL. While no mortality benefit was found within any population, there was not a mortality increase amongst patients with a hemoglobin < 5 mg/dL. Further multicenter studies from LMICs are needed to assess the benefits or harms of blood transfusion in these patient populations which have different etiologies and baseline burdens of anemia as compared to populations in HICs.

High rates of blood transfusion utilization amongst patients with hemoglobin levels > 5 mg/dL document discordances between current practice and current Rwandan guideline recommendations with the majority of emergent transfusions administered for medical patients with only mild or moderate anemia. At UTH-K, hemoglobin levels are

not available for approximately 8–10 h leading to empiric treatment of blood for unstable patients. Rapid hemoglobin measurements as well as further prospective research to identify physicians' perceived indications leading to transfusions outside of current guidelines would help to conserve and appropriate this scarce resource.

While patient characteristics and hospital interventions were controlled for in regression analyses, it is possible that this bias persists from unmeasured cofounders such as comorbid conditions or baseline nutritional status. Additionally, given smaller sample sizes, adjustment for confounders was limited in stratified analyses increasing the risk of bias especially from patient acuity.

Given the retrospective nature of the chart review, a proportion of cases were deemed ineligible due to missing data which may introduce bias. However, given the random case sampling used, the missing records are likely to be missing at random and should therefore represent limited bias. In addition, the retrospective nature of the dataset does not allow for analysis of causality, limiting the ability to determine the effects of blood transfusion. There was not sufficient data to sub-analyze by disease specific states which may confer differing benefits to blood transfusion receipt; future studies looking at specific pathologies would be informative for settings in Africa.

While hospital interventions were analyzed, changes in patient acuity during hospitalization were not captured limiting inferences from results. Specifically, while inpatient blood transfusions were associated with increased odds of mortality, it may be that these patients decompensated once admitted, warranting blood transfusions. Specific studies analyzing inpatient blood transfusion practices are needed to further explore this association.

Of the original study sample, only a small proportion were excluded (2%) for missing outcome data. However, the study sample required an initial hemoglobin level for inclusion. This may introduce survival bias as more critically ill patients may have received interventions based solely on clinical evaluation, bypassing hemoglobin measurements. In addition, patients may have died prior to receiving testing. Conversely, less sick patients may have been less likely to receive testing or interventions due to rationing of limited resources. Although these aspects may have resulted in some bias, the study is representative of clinical practice and provides pragmatic data to inform care. Finally, data was collected from a single tertiary care hospital which may limit generalizability to the country and region.

Conclusions

Understanding the pathologies driving the need for blood transfusion as well as local transfusion practices and outcomes, will allow

Table 3
Odds of mortality stratified by hemoglobin threshold 7.0 mg/dL.

	Hemoglobin > 7.0 mg/dL (N = 1001)		Hemoglobin ≤ 7.0 mg/dL (N = 115)	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI) ^a	Unadjusted OR (95% CI)	Adjusted OR (95% CI) ^a
ED PRBC transfusion	1.90 (1.03–3.48)	0.75 (0.24–2.40)	1.28 (0.45–3.58)	0.87 (0.04–18.73)
Inpatient blood	2.30 (1.48–3.56)	2.69 (1.32–5.51)	0.87 (0.34–2.23)	0.77 (0.05–13.12)

^a Multivariable modeling adjusted for age, gender, time period, triage systolic blood pressure and oxygen saturation.

Table 4
Odds of mortality stratified by hemoglobin threshold of 5.0 mg/dL.

	Hemoglobin > 5.0 mg/dL (N = 1073)		Hemoglobin ≤ 5.0 mg/dL (N = 43)	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI) ^a	Unadjusted OR (95% CI)	Adjusted OR (95% CI) ^a
ED PRBC transfusion	2.31 (1.62–3.32)	2.21 (1.51–3.21)	0.71 (0.11–4.43)	0.46 (0.06–3.72)
Inpatient PRBC transfusion	1.74 (1.29–2.35)	1.72 (1.26–2.36)	1.33 (0.24–7.39)	5.23 (0.47–58.83)

^a Multivariable modeling adjusted for age, time period and gender.

providers to target the appropriate use of this valuable resource [11]. The present data outlines transfusions over a wide range of hemoglobin levels with no mortality benefit and possible increased mortality amongst those with hemoglobin levels ≥ 5.0 mg/dL. This supports the need for prospective analysis of emergency department blood transfusions to further inform current transfusion practice.

Dissemination of results

Findings were disseminated through the emergency medicine residency program at the University Teaching Hospital of Kigali, Rwanda as well as through the Department of Emergency Medicine, Brown University. In addition, results will be shared with the Rwanda Emergency Care Association.

Authors' contributions

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: KM contributed 50%; CGM, SG, GM, CU, FB, SA and AG 5% each; and AA 15%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

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Conflicts of interest

The authors have no competing interests to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.afjem.2020.01.004>.

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