



Acute Transfusion Reaction and Associated Factors among Blood Transfused Adult Patients at Debre Markos Comprehensive Specialized Hospital, Ethiopia: A Cross Sectional Study

Yalew Muche^{1*}, Yemataw Gelaw², Aytene Atnaf¹, Zegeye Getaneh²

¹Department of Medical Laboratory Sciences, Debre Markos University, Debre Markos, Ethiopia; ²Department of Hematology and Immunohematology, University of Gondar, Gondar, Ethiopia

ABSTRACT

Background: Blood transfusion is the infusion of whole blood or its components into the veins of the patient to improve tissue oxygenation and maintain hemostasis. Besides its clinical use, it can pose a risk of transfusion complication with different factors.

Purpose: The aim of this study was to assess blood transfusion complications, and associated factors among transfused adult patients at Debre Markos comprehensive specialized hospital, North West Ethiopia, 2022.

Materials and methods: An institution based cross-sectional study design was conducted on a total of 182 patients from March 20, 2022 to June 15, 2022. Patients were enrolled in the study using consecutive sampling method. The socio-demographic and clinical data were collected using a structured questionnaire and data extraction sheet, respectively. About three milliliters of anti-coagulated blood and 30 milliliters of urine samples were collected to assess transfusion complications. CBC and coombs test were performed from the blood and urinalysis from the urine, respectively. *Chi-square*, Fisher's exact test, and binary logistic regression were done using SPSS version 25. P-values less than 0.05 declared as statistically significant.

Results: An Acute Transfusion Reaction (ATR) was encountered on 12 (6.6%) patients. It was 4.13, 7.78, and 3.96 times more likely to occur among patients with a previous history of transfusion, abortion, and transfused blood stored for more than 20 days compared to their counterparts, respectively. In addition, the odds of developing ATR increase by 2.07 as the number of transfused blood units increases by 1 unit.

Conclusion: The incidence of acute transfusion reactions was high. During transfusion the clinicians should closely monitor patients who had history of transfusion, abortion, transfused old blood and more than 1 unit.

Keywords: Acute transfusion reactions; Adults; Transfusion outcome; Platelets; Gynecological/obstetrics

INTRODUCTION

Blood transfusion is a common lifesaving therapy in modern medicine for a variety of diseases to improve tissue oxygenation and maintain hemostasis [1,2]. Blood transfusion can be whole blood, Packed Red Blood Cells (PRBCs), Platelets (PLT), plasma, or plasma derivatives [3].

Blood transfused patient may develop a Transfusion Reaction (TR), defined as unintended patient outcomes due to blood product transfusion [4]. The two types of Transfusion Reactions (TR) are Acute Transfusion Reactions (ATR) and Delayed Transfusion Reactions (DTR). Acute transfusion reactions occur during the transfusion and for up to 24 hours after the transfusion is stopped [5,6]. It includes Acute Hemolytic Transfusion Reaction (AHTR), Febrile Non-Hemolytic

Correspondence to: Yalew Muche, Department of Medical Laboratory Sciences, Debre Markos University, Debre Markos, Ethiopia; E-mail: enathager08@gmail.com

Received: 10-Mar-2023, Manuscript No. JBBDT-23-20107; **Editor assigned:** 13-Mar-2023, PreQC No. JBBDT-23-20107 (PQ); **Reviewed:** 27-Mar-2023, QC No. JBBDT-23-20107; **Revised:** 18-Aug-2023, Manuscript No. JBBDT-23-20107 (R); **Published:** 25-Aug-2023, DOI: 10.4172/2155-9864.23.S2.009

Citation: Muche Y, Gelaw Y, Atnaf A, Getaneh Z (2023) Acute Transfusion Reaction and Associated Factors among Blood Transfused Adult Patients at Debre Markos Comprehensive Specialized Hospital, Ethiopia: A Cross Sectional Study. J Blood Disord Transfus. S2.009.

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Transfusion Reaction (FNHTR), anaphylactic, simple allergic. Transfusion Related Acute Lung Injury (TRALI), and Transfusion Associated Circulatory Overload (TACO) are another ATR. An ATR is assessed using clinical findings (physical examinations, and vital signs), and laboratory investigation includes ABO and RhD group, re-cross match, Complete Blood Count (CBC), Direct Anti-Globulin Test (DAT), and hemoglobinuria [7].

In sub-Saharan Africa, whole blood is widely used for treatment, transfusions beyond their indications, and there is lack of different pre-transfusion testing reagents that trigger TR [8]. Whole blood transfusion is also widely used in Ethiopia, with a component preparation rate of 16.5%. Moreover, in high income countries, the most frequently transfused patient group is over 65 years of age and accounts for up to 76% of all transfusions [9]. In low and middle income countries, pregnancy related complications, childhood malaria, and trauma related injuries are common indications [10].

The burden of ATR also varies in different countries. In some Europe and other continents, the prevalence is between 0.23% and 3.6%. The lowest prevalence is reported in the United States of America (USA) (0.23%), while the highest is found in Bangladesh (3.6%). However, the prevalence of ATR ranges from 2.6% to 5.2% in some African countries whereas, in Ethiopia it is not well studied [11].

Transfusion reaction prevalence is affected by different factors including gender and age, pre-hematological abnormalities in CBC results, clinical severity of disease, storage time of transfused blood, and history of transfusion [12]. Furthermore, factors influencing blood transfusion outcome or complications include abortion history, vital signs, transfused blood component, and the number of transfused units [13]. To summarize, there was variation in blood component transfusion and ATR across the world. In Ethiopia, there is no hemovigilance system, and whole blood is the most commonly transfused blood [14].

Despite the fact that Ethiopia had a transfusion service for many years, there is still an unfilled gap in the evidence on major indications for blood transfusion complication and associated factors of patient outcomes information. As a result, the purpose of this study was to assess blood transfusion complications and associated factors of ATR in adult transfused patients at Debre Markos Comprehensive Specialized Hospital, Ethiopia (DMCSH) in North West Ethiopia.

MATERIALS AND METHODS

Study design, setting and period

An institutional based cross-sectional study was conducted from March 20 to June 15, 2022. The study was conducted at DMCSH, Debre Markos, East Gojjam zone, Amhara regional state, Ethiopia [15]. Debre Markos is located 299 km far from Addis Ababa, the capital city of Ethiopia, in the North West direction and 265 km away from Bahir Dar, the Amhara regional city. The city is longitude of 37.734398, latitude of 10.3296345, elevation of 2411 m/7910 feet. According

to 2012 censuses the population of the city 262,497. The hospital gives services to an estimation of 5 million people from the catchment area and as a referral from other general and primary hospitals. The hospital has one mini blood bank to distribute blood products to different wards [16]. In this hospital, blood is transfused in surgical, gynecological/obstetrics, emergency, and inpatient (medical) wards. The hospital gets the blood for transfusion from Debre Markos blood bank. All blood transfused adult patients at DMCSH were the source population [17].

Population

Blood Transfused adult patients who fulfill the eligibility criteria at DMCSH during the study period were the study populations. In this study patients who took anesthetic drug were excluded from the study [18].

Sample size and sampling technique

The total sample size was calculated using single population proportion formula with a 95% confidence interval, margin of error (d), and previous prevalence of ATR (5.2%).

$$\left(\frac{Z_{\alpha/2}}{d}\right)^2 \left(\frac{p^*(1-P)}{d^2}\right) = \left(\frac{(1.96)^2(0.052*0.948)}{(0.035)^2}\right) = 182$$

Therefore, the total sample size calculated was 182.

All of the adult participants who received blood transfusions and met the eligibility requirements were enrolled in the study by consecutive manner.

Data collection methods

Socio-demographic and clinical data collection: Socio-demographic data were collected from voluntary participants using a pretested, structured questionnaire. Clinical data were collected through interviews and patient card reviews, and extracted onto a data extraction sheet [19]. General physical and clinical examinations like body temperature, blood pressure, pulse rate, respiratory rate, and oxygen saturation percentage were measured as baseline data after taking a rest of at least 5 minutes.

During the transfusion, vital signs were initially recorded at intervals of 15 minutes, 30 minutes, and 1 hour during the transfusion. They were then recorded again at 4 hours after the transfusion had ended. Patients were physically evaluated, and their vital signs were monitored at the same time to look for indicators of a TR. The following symptoms were recorded: Headache, palpitations, mild dyspnea, urticarial, nausea, tachycardia, restlessness, vomiting, and dyspnea.

After the transfusion, the monitoring was kept up for 24 hours at 4 hours intervals. Data from the patient chart and/or the laboratory registration logbook were also used to record the blood donation date, the blood group of the transfused blood, and the quantity of units transfused. The patients were suspected of having ATR, and laboratory tests were performed when one or more vital signs deviated from the baseline values and when signs and symptoms were noticed [20].

Sample collection and laboratory analysis

Sample collection: Blood and urine samples were collected from each volunteer patient before and after transfusion. Those samples were used to investigate the post transfusion outcome and ATR for suspected cases. Seventy percent alcohol was used to clean the skin, and waited until it dried. About 3 here Milliliters (ML) of blood specimens were collected from every patient and added to Tri-Potassium Ethylene Di-Amine Tetra Acetic acid (K₃-EDTA) test tube. The collected blood sample was checked for proper labeling, hemolysis, and clotting pre-analytically. Then it was mixed properly to prevent clotting, and it was used for CBC testing, ABO and Rh regrouping, rechecking crosses matching, and DAT testing. About 30 ml of urine was collected in a clean urine cup container for the Urine Analysis (UA), which is typically used to determine hemoglobinuria levels.

Laboratory analysis: For each laboratory test, standard operating procedures were strictly followed. Pre-transfusion CBC (Hb, RBC, WBC, and PLT), and UA results were used as a baseline. These data were obtained from either on a patient chart or requested for those who lack on their chart. The baseline CBC was performed from a specimen collected for cross-match for those who didn't have it on their chart and CBC was analyzed before performing cross-match. The pre and post-transfusion samples were performed with a similar instrument to avoid instrumental variation. For patients suspected of ATR either clinically or using the screening of urine samples, firstly the labels of transfused blood units and the patients' identity were checked. Additionally, the pre-transfusion of patients' samples was regrouped for ABO and Rh blood types. Then donor blood samples were rechecked for blood groups, cross-match, on the other side, the recipient's post-transfusion blood sample was tested for CBC, blood grouping, and screened for *in vivo* sensitization of RBCs (DAT).

The CBC analysis of the K₃-EDTA anti-coagulated blood was carried out automatically by a mind ray BC-3000 plus (mind ray, China) three differential hematological analyzer machines at DMCSH. The tests were performed within 2 hours of sample collection. The remaining sample was kept for blood type regrouping, cross match rechecking, and DAT when TRs were suspected. Patient blood ABO, and Rh type were re-grouped by using commercially prepared antisera (anti-A, anti-B, and anti-D). The slide method was applied to determine ABO and Rh blood groups. If a transfusion reaction was suspected, patient plasma and donor red cells were mixed for compatibility test under saline and anti-globulin conditions. The DAT was performed for all study participants who were suspected of ATR. It was tested by mixing washed patient RBCs directly with the anti-globulin serum for the detection of *in vivo* sensitization of patient RBCs. Urine dipstick was performed for screening of transfusion reaction followed by microscopic examination to rule out hematuria.

Data analysis and interpretation: Data were entered, cleaned using Epidata version 3.1, and exported to Statistical Package for the Social Sciences (SPSS) version 25 software for analysis. The result was presented in texts, tables, and figures as numbers and percentages. To determine the average distribution of data, the median with interquartile range and mean with standard deviation were calculated for the participants' age and Hb. The strength of the association was assessed by binary logistic regression. Variables with p-values less than or equal to 0.25 from the output of bi-variable were transferred to multivariable binary logistic regression. Finally, the odd ratio, 95% confidence interval, and p-value were used to express the strength of the association. P-value of <0.05 declared statistically significant.

RESULTS

Demographic characteristics of study participants

A total of 182 participants were enrolled in the study. 99 (54.4%) of the total participants were male. Majority of the study participants 110 (60.4%) were in the age range of 18-35 years, while aged 36-45 years were 29 (15.9%) participants. Females had a median (interquartile range) age of 32 (11) years, while males had a median (interquartile range) age of 30 (23) years. Most of (81.9%) of the study participants were rural residents.

Clinical characteristics of the participants

Of the total study participants, 95 (52.3%) were transfused in the emergency department, followed by surgical department 33 (18.1%), medical ward 30 (16.5%), gynecology/obstetrics 15 (8.2%), and the least transfusion was done intensive care unit 9 (4.9%). Out of the total number of transfused patients, 95 (52.2%) were stable based on pre-transfusion clinical assessment. Forty-six (25.3%) participants had previous transfusion histories. Of the total female participants, 66 (79.5%) had a history of pregnancy; among females who had pregnancy history, 13 (19.7%) had abortion history.

One hundred five and 55 patients were transfused by the orders of general practitioners and specialist doctors, respectively. In this study, 350 ml Citrate Phosphate Dextrose Adenine-1 (CPDA-1) preserved whole blood was the only blood transfused during the study period. The mean (standard deviation) of the blood storage time was 17.36 (7.74) days. One hundred twenty five (68.7%) participants were transfused with blood that had a storage time of up to 20 days, and 141 (77.5%) were transfused more than 1 unit of blood (Table 1).

Table 1: Clinical characteristics of blood transfused adult patients at DMCSH from March 20, 2022 to June 15, 2022.

Clinical variables		Frequency	
		N	%
Transfusion ward	Emergency	95	52.2
	Gynecology/obstetrics	15	8.2
	Medical in patient	30	16.5
	Intensive care unit	9	4.9
	Surgical	33	18.1
Pre transfusion clinical status	Stable	95	52.2
	Not stable	87	47.8
Age of blood (days)	≤ 20	125	68.7
	>20	57	31.3
Amount of blood transfused (units)	1	41	22.5
	>1	141	77.5

Primary diagnosis of transfusion

In the current study, acute anemia (57), chronic anemia

(95), and hematological abnormalities (17) are the common reasons for whole blood transfusion (Table 2).

Table 2: Indications of blood transfusion for adult patients at DMCSH from March 20, 2022 to June 15, 2022.

Indication=182	Underline disease	Frequency	
		N	%
Chronic anemia	GI bleeding	9	4.9
	Infection	40	22
	Metabolic disorder	8	4.4
	Organ associated	28	15.4
	Others	10	5.5
Acute anemia	Gynecological and obstetrics cases	13	7.1
	Trauma, other surgical cases	44	24.2
Hematological	Malignancy	8	4.4
	Bi and pan cytopenia	9	4.9

Anemia	Undefined	10	5.5
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Note: Infection: HIV, HBV, malaria, and tuberculosis. Metabolic disorder: Diabetic mellitus, hypertension, and malnutrition; Maternal and gynecological related: Retained placenta, uterine atony, myoma, GTD: Gestational Thromboplastin Disease, vaginal bleeding, eclampsia, and abortion; Other surgical-related diseases: PUD: Peptic Ulcer Disease, hyperthyroidism and ascites; Organ-related: Chronic kidney disease, chronic liver disease, and acute kidney disease; Hematological malignancy: ALL: Acute Lymphoid Leukemia; CML: Chronic Myeloid Leukemia; AML: Acute Myeloid Leukemia; Hematological Cy-topenia: Bicytopenia, and pancytopenia. Others include: Asthma, epistaxis and gangrene.

Acute transfusion reaction

One hundred eighty-two patients were assessed for ATR. Fifty four patients who took anesthetic drugs were excluded because it may mask the ATR. The overall incidence of ATR was 12 (6.6%) with 95% confidence interval (95% CI: 3.3%-10.7%). Among

this ATR, allergic reactions were the highest proportion followed by FNHTR with a proportion of 50%, and 33.33%, respectively. In addition, allo-immunization, and TRALI were encountered with equal proportion of 8.33% (Table 3).

Table 3: Acute transfusion reaction proportion among blood transfused adult patients at DMCSH from March 20 to June 15, 2022.

Transfusion reaction (n=182)	No=170	Incidence of ATR		Proportion of ATR%
		Yes=12	N %	
ATR=12 (6.6%)	Allo-immunization	1	0.55	8.34
	Allergic	6	3.3	50
	FNHTR	4	2.2	33.33
	TRALI	1	0.55	8.33
	Total	12	6.6	100

Note : FNHTR; febrile non hemolytic transfusion reaction, TRALI; transfusion related acute lung injury.

Factors associated with the development of ATR

The proportion of ATR was higher in females (8.6%), patients who lived in an urban area (18.2%). In the bivariable binary logistic regression analysis, ATR was associated with urban residence (COR=5.26, 95% CI: 1.58-17.53), transfusion history (COR=4.67, 95% CI: 1.4-15.52), abortion history (COR=9.11, 95% CI: 2.31-40.75), storage time (COR=4.89, 95% CI: 1.41-17.01), and transfused whole blood increased by 1 unit (COR=2.42, 95% CI: (1.44-4.06).

Transfusion history (AOR=4.13, 95% CI: 1.07-15.99), abortion history (AOR=7.78, 95% CI: 1.75-18.68), storage time of transfused blood for more than 20 days (AOR=3.96, 95% CI: 1.03-15.2), and transfused blood increased by 1 unit (AOR 2.07, 95% CI: 1.21-3.55) were significantly associated with ATR in multivariable logistic regression analysis (Table 4).

Table 4: Bivariable and multivariable binary logistic regression analysis of associated factors of ATRs among adult transfused patients at DMCSH from March 20, 2022 to June 15, 2022.

Variables	ATR no. (%)		COR	AOR (95% CI)	p-value
	Yes	No			
Gender (n=182)	Male	5 (5.1)	94 (94.9)	Ref	
	Female	7 (8.4)	76 (91.6)	1.71 (0.52-5.61)	0.374

Residence (n=182)	Urban	6 (18.2)	27 (81.8)	5.29 (1.58-17.53)	3.87 (1.00-14.88)	0.051
	Rural	6 (4.0)	143 (96.0)	Ref	Ref	
Age years (n=182)	18-35	4 (3.6)	106 (96.4)	Ref	Ref	
	36-45	2 (6.9)	27 (93.1)	1.94 (0.34-11.81)	2.18 (0.33-14.49)	0.42
	≥ 46	6 (13.9)	37 (86.1)	4.26 (1.14-15.93)	3.62 (0.80-16.37)	0.095
Transfusion history (n=182)	Yes	7 (15.2)	39 (84.8)	4.67 (1.40-15.52)	4.13 (1.07-15.99)	0.040*
	No	5 (3.7)	131 (94.3)	Ref	Ref	
Pregnancy (83)	Yes	5 (7.6)	61 (92.4)	0.62 (0.11-3.44)		0.582
	No	2 (11.8)	15 (88.2)	Ref		
Abortion history (n=66)	Yes	4 (30.8)	9 (69.2)	9.11 (2.31-11.75)	7.78 (1.75-18.68)	0.015*
	No	1 (1.9)	52 (98.1)	Ref	Ref	
Storage time (days) (n=182)	>20	4 (3.2)	121(96.8)	Ref	Ref	
	≤ 20	8 (14.0)	49 (86.0)	4.89 (1.41-17.01)	3.96 (1.03-15.2)	0.045*
Transfused units (=182)				2.42 (1.44-4.06)	2.07 (1.21-3.55)	0.008*
Qualifications (n=182)	Specialist	3 (5.5)	52 (94.5)	1.21 (0.12-12.32)		0.871
	General practitioner	8 (7.6)	97 (92.4)	1.73 (0.21-14.60)		0.614
	Nurses/midwifery	1 (4.6)	21 (95.4)	Ref		

Note: REF=Reference categorical variables, COR=Crud Odd Ratio, AOR=Adjusted Odd Ratio, CI=Confidence Interval, ATR=Acute Transfusion Reaction, No=Number, *=significantly associated factors.

DISCUSSION

In the current study we have evaluated acute transfusion complications and associated factors among 182 adult patients who were transfused blood.

An ATR is an unintended outcome related to blood product transfusion that happens during transfusion and 24 hours after cessation of transfusion. In this study, the incidence of ATR was encountered in 12 patients (6.6%) (95% CI: 3.3%-10.7%). This result was in line with the previous studies conducted in Bahir Dar, Ethiopia (5.2%), Bangladesh (3.6%), Sweden (7.9%), Tzu-Chi

hospital, Taiwan (3.5%), Belgaum (4.4), Kano, and North-Western Nigeria (3.6%). The result of this study was higher than studies conducted in Iran (0.95), India (0.96%), Namibia (0.2%), Bangalore, India (0.5%), and Democratic Republic of Congo 2.6. one of the reasons may be that component transfusion was practiced in the areas mentioned later, especially in Iran, where leukocyte filtration was practiced. In contrast, only whole blood is used in the current study, which has triggering factors for TR.

In our study allergic reactions (50%) and FNHTR (33.33%) were the two most common types of ATRs, which is consistent with studies conducted in Bahir Dar, Ethiopia (65% and 30%), Iran (49.2%, 37.2%), and Bangladesh (40.5%, 36.4%), respectively. This study's proportion of FNHTR was higher than in India (22.8%), and the Democratic Republic of the Congo (19.2%), but lower than in Kano, North-Western Nigeria (90%).

Recipient immunoglobulin E or non-IgE antibodies to proteins or other allergenic soluble substances in the donor plasma cause the allergic reaction. Due to the infused antigens, such as WBC, which increase the recipient's *in vivo* cytokine production, a febrile non-hemolytic transfusion reaction developed. The infusion of donor cytokines generated in storage may also affect the start of allergic responses and FNHTR in transfusion recipients. Histamine, lipids, complement fragments, and cytokines are examples of potential biological response modifiers. These substances rise during storage in RBC or PLT products or both are linked to TR. There is no clinical proof that cytokines cause ATR since their levels are low in the products made from preserved erythrocytes.

In this study, AHTR was encountered on one patient with a proportion of (8.6%) from the total of ATR. This is comparable to the study conducted in Iran 6.8% 18, and Bangladesh (9.4%). This patient's cross-match result was compatible in the saline technique but incompatible in IAT, suggesting that AHTR is caused by incompatible blood transfusion. Furthermore, TRALI was observed only in one patient, accounting for 8.6% of the total ATR. This patient was presented with respiratory distress, bilateral infiltration in x-ray result. This might be due to the infusion of plasma containing antibodies against the patient's WBCs. Lung edema and neutrophil buildup are brought on by complement activation and cytokine stimulation.

In the current study, patients who had previous transfusion histories were 4.13 times more likely to develop ATR than its counterpart. The reason may be due to the immune system's sensitization and production of antibodies to certain blood cell antigens (RBC, WBC, and PLT) after the previous transfusion. This sensitized immune system may cause the development of HTR or FNHTR in a subsequent blood transfusion. According to the American society of hematology, alloimmunization to sickle cell disease and thalassemia causes hyper hemolysis in subsequent transfusions. It also causes immune modulation and leads to immune suppression, which increases the risk of pneumonia and sepsis. The formation of alloantibodies can directly increase the morbidity and mortality of transfusion dependent patients by increasing the probability of HTR. Previous transfusion was found to be significantly associated with TR similar to studies done in Bahir Dar, Ethiopia and Kano, North West, Nigeria.

Additionally, as transfused blood increased by 1 unit, the odds of developing ATR increased by 2.07, which was similar to the study conducted in Bahirdar, Ethiopia. Repeated or multi-unit blood transfusions can result in the production of alloantibodies against one or more red cell antigens, which complicates the subsequent transfusions. In multiple (many

units transfusion) biochemical, cytokines, and antibodies complexity happened leads to TR. Endothelial vasculature may induce recipient neutrophil priming and production of Reactive Oxygen Species (ROS). These changes may produce depletion of available nitric oxide, with subsequent endothelial dysfunction predisposing to morbidity and mortality in the transfused patients. In addition, there might be an incompatibility between the previously transfused blood and the new blood, which leads to the patient developing ATR. Multiple units of transfusion are associated with FNHTR and allergic reactions.

Moreover, in pre-transfusion Hb, as Hb increased by 1 g/dl the odds of patient improvement increased by 69%. When Hb is low, the patient is more likely to receive many units, resulting in complex formation and decreased patient compliance. Studies indicate a negative correlation between pre-transfusion Hb and transfusion complications in Thailand. Patients' low pre-transfusion hematocrit and the dose of PRBCs administered were risk factors, but not factors in survival.

Patients who had a history of abortion were 7.78 times more likely to develop ATR. During an abortion, the fetal antigens may enter the maternal circulation, leading to sensitization. When transfusion takes place, the immune system produces antibodies, which cause AHTR or FNHTR. The finding is similar to the study in Bahirdar, Ethiopia.

In this study, patients who had received blood stored for more than 20 days had a risk of developing ATR by 3.96 times than its counter. It is similar with study conducted Kano, North-Western Nigeria. The effect of young versus old blood on patient outcomes is still controversial. Red blood cell storage induces progressive biochemical, biomechanical, and immunological changes that affect RBC viability, survival, oxygen delivery capacity, and the recipient's response to transfusion. In ICU patients, cardiac surgery patients, and trauma patients with prolonged storage of transfused blood may have a higher mortality rate. In contrast, the age of transfused PRBC units was not identified as a risk factor for TR. Despite this, in the United States, mortality after massive blood transfusion was no worse in patients transfused with PRBC stored for long periods of time.

CONCLUSION

We concluded that the incidence of ATR was higher than the 2014 WHO report in African countries. Patients with a history of transfusion, abortion, blood transfusion older than 20 days, or more than 1 transfusion were associated with developing ATR.

We recommended that, clinicians should closely monitor and consider transfused patients who have a history of previous transfusions, abortions. Regardless of these factors, they should strictly adhere to transfused patients who have old blood transfused, or more than 1 unit transfused. The laboratory

personnel should implement the crossmatch of at least saline and IAT to handle TRs due to incompatibility. Additionally, for those suspected of having TRs, antibody screening and identification should be performed. We recommend that researchers look into multi-center cohort studies to see if there are any explanatory factors, outcomes, or ATR subtypes.

LIMITATIONS OF THE STUDY

Because of whole blood is the only blood transfused in the study area, this study used only whole blood transfusion which may overestimate the prevalence transfusion reactions. Antibody screening, identification, and organ function tests were not assessed for those who develop AHTR.

ETHICAL APPROVAL AND INFORMED CONSENT

This research was carried out in accordance with the Helsinki declaration. Ethical approval was obtained from the school of biomedical and laboratory sciences, research ethical review committee, college of medicine and health sciences, university of Gondar. Before recruitment, the aim, potential benefits, and risks of the study were explained to participants or their attendants. The written informed consent or assent was taken from volunteer participants or attendants, respectively. Furthermore, whenever a TRs or abnormal laboratory results occurred, the patient was linked the responsible health professionals to manage the problem.

FUNDING

No funded organization.

COMPETING INTERESTS

Authors declare no conflict of interest.

AUTHOR CONTRIBUTION STATEMENT

Yalew conceptualized the study protocol, study design, collected analyzed and data, and drafted the manuscript. Yemataw, Zegeye supervised the data collection and analysis, edited the manuscript. Aytenuw edited, and finalized the manuscript write-up.

All authors listed have significantly contributed to the development and the writing of this article.

ACKNOWLEDGMENTS

We want to acknowledge DMCSH staff that helped during data collection. We also thank the study participants for their voluntary participation in the study.

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