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Effect of Season on Blood Transfusion Patterns: A Retrospective Study

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Abstract

Background: Different seasons present varied environmental factors that influence the occurrence of transfusion-driven diseases. Therefore, this study determined the patterns of blood transfusion among hospitalized patients and the effect of season on ABO/Rh phenotypes. *Methods*: A single-center retrospective cross-sectional study was conducted on 5089 hospitalized patients that were transfused with blood at Sunyani Municipal Hospital. Archived blood transfusion records were retrieved and analyzed using GraphPad Prism, and SPSS. The association, effect size, and yearly trends of transfusion patterns were determined. *Results*: The majority of the participants were females (63.0% [3208]), 36-49 years old (20.4% [1039]), O phenotype (48.1% [2447]), Rh-positive (93.1% [4737]), and transfused in the rainy season (61.0% [3103]). Patients' ABO was weakly associated with age ($r = 0.07$, $p \leq 0.001$) and season ($r = 0.05$, $p = 0.008$). Eighty percent (4053/5089) of the transfusions were ABO group-specific, and 28.3% (1146/4053) of this occurred at the emergency ward. The source of transfusion request was weakly associated with season ($r = 0.1$, $p \leq 0.001$) and type of transfusion ($r = 0.1$, $p = 0.002$). The rainy season (slope: 142.9, $p \leq 0.001$) and ABO-specific transfusions (slope: 219.5, $p \leq 0.001$) showed consistent increasing trends over the years. *Conclusion*: Blood transfusion was frequent among females, adults, Rh-positive and O phenotypes, and in the rainy season. Age and season were significantly associated with ABO, but not Rh. A transfusion request was associated with the season and type of transfusion, with the majority of transfusions occurring in the rainy season and emergency ward. There was an increasing yearly trend in blood transfusions.

Keywords: Blood Transfusion; Inpatient; Rainfall; Season; Transfusion Pattern.

1. Introduction

Blood transfusion involves the safe transfer of whole blood or blood components into the systemic circulation of another person [1]. A blood transfusion may be required to replenish blood volume in clinical conditions that culminate in severely reduced circulatory blood or to treat anaemia-associated sequelae. Such clinical conditions requiring blood transfusions include pregnancy-induced anaemia, severe haemorrhage during and after childbirth [2],

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sickle cell disease (SCD) [3], malaria, malignancy [4], coagulopathy [5], surgery, and exsanguination caused by trauma [6].

Globally, more than one hundred million transfusions are performed each year [7]. Although there is an increased demand for blood and blood products worldwide, the number of blood units donated is not sufficient. Moreover, out of about eighty-million whole blood units collected annually worldwide, only two million are collected from the Sub-Saharan African region [8]. Despite this huge global deficit in donated blood, prescribers often request more blood transfusions than are required [9, 10], which may result in wastage and further exacerbate the insufficiency.

A significant number of Ghanaian hospitals involved in the provision of blood transfusion services face challenges with blood supply. The most frequently reported are shortages, most of which result from the unavailability of the requested blood type or the absence of an appropriate blood donor. The frequency of the clinical conditions for which blood transfusion may be requested varies for different sociodemographic variables, including season. Furthermore, different seasons present diverse environmental factors that influence the occurrence of diseases. For instance, Fall et al. [11] suggest a nexus between rainfall and increased cases of malaria and, subsequently, malaria-induced anaemia in the rainy season that may require a blood transfusion. However, it may be difficult to obtain blood from donors in the rainy season because rainfall aggravates the existing obstacles of inaccessibility to many health facilities, the absence of a well-organized means of transportation, and poor road networks [12] in Ghana. Therefore, access to this therapeutic commodity remains a challenge [13] in many parts of Ghana.

Blood transfusion centers in Ghana must maintain a functional inventory for the different seasons to help them stock the required blood group phenotypes to prevent blood shortages and avoidable deaths. However, the few studies [14, 15] that reported the distribution of different blood group phenotypes in Ghana only highlighted the ethnic variations of the ABO and Rh blood group phenotypes, while they failed to report the association between these phenotypes and season. Therefore, this study determined the patterns of blood transfusion and the effect of season on ABO/Rh blood group phenotypes among hospitalized patients. The findings of the current study would help health authorities reduce shortages in blood supply and waste from the expiration of blood and consumables used for blood transfusion. Furthermore, this study would help the National Blood Service and hospital managers effectively plan blood donor recruitment campaigns to increase access to blood and blood products even in the rainy season.

1. Materials and methods

1.1. Study Design/Study Site

This study was a retrospective cross-sectional study conducted at a single hospital from January to May 2022. In the present study, we retrieved archived primary data on hospitalized patients who were transfused with whole blood and or blood products at the Sunyani Municipal Hospital between January 2018 and December 2021. Sunyani Municipal Hospital is among a few government-owned health facilities in Sunyani regulated by the Ghana Health Service. The hospital has about 105 inpatient beds and provides services like medical laboratory, imaging, gynaecologic and obstetric care, surgery, ophthalmic care, and internal medicine. Furthermore, the hospital operates special clinics for patients seeking treatment for chronic diseases like diabetes, hypertension, the human immunodeficiency virus (HIV), and tuberculosis.

1.2. Study Population

Figure 1 shows the exclusion and inclusion criteria used for selecting the participants. In the present study, we retrieved archived data on hospitalized patients who were transfused with whole blood and or blood products between January 2018 and December 2021 at the Sunyani Municipal Hospital. Overall, records of 5120 patients were screened, out of which 31 (0.6%) were excluded. The remaining 5089 eligible patients who received blood transfusions were conveniently sampled from the archived registers of the blood center. The study included records of all paediatric and adult patients who received a blood transfusion (Figure 1).

1.3. Data Collection

Each of the patients' records was validated for the accuracy and completeness of the information. Records of patients with legible and complete information were included in the study, while those with either incomplete or incorrect information and/or ineligible handwriting were excluded. Some of the patients' information collected was: the source of the transfusion request, month and year of blood transfusion, age of the patient in years, gender, and ABO/Rh blood types of both the patients and transfused blood units.

1.4. ABO and Rh Blood Typing by Spun Tube

Whole blood from patients, donors, and control cells was subjected to qualitative in-vitro haemagglutination testing. The blood specimens from both the patients and donors were centrifuged at 1000×g for 5 minutes, and the plasma was separated from the red blood cell (RBC) sediment. The RBCs were washed three times with physiological saline solution, and cell suspensions of the washed cells were prepared by adding 20 drops of physiological saline to a drop of the washed cells. In separate tubes, cell suspensions of each blood specimen and control cells were mixed with approximately equal volumes of antisera containing monoclonal anti-A, anti-B, and anti-D antibodies (Fortress Diagnostics, United Kingdom). Monoclonal antibodies are used to detect respective antigens on the surface of the RBCs. The mixture was incubated at room temperature and centrifuged at 200×g for a minute. The observation of haemagglutination in the test tubes indicated the presence of the respective antigens.

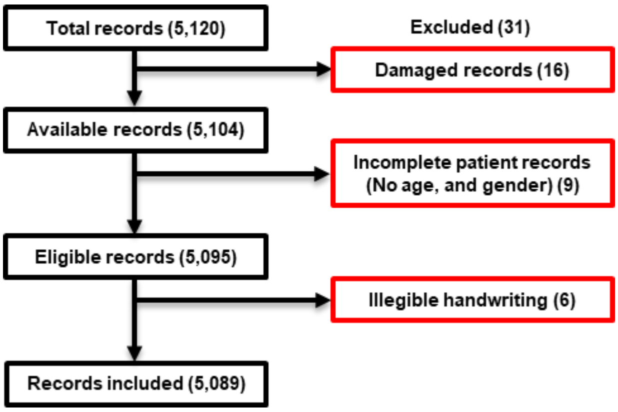


Figure 1. Flow diagram of the inclusion and exclusion criteria for recruiting patient records.

1.5. Statistical Data Analysis

All statistical analyses were executed using IBM SPSS Statistics, Version 25.0 (Armonk, NY: IBM Corp.). The data were graphically presented using GraphPad Prism for Windows, Version 8.4.3 (GraphPad Software, San Diego, California USA) and Microsoft Excel 2016 (Microsoft Corp., United States). Descriptive statistics for nominal variables were estimated and presented as frequencies, with respective percentages placed in parentheses. The age of patients was presented as percentiles (50^{th} [25^{th}-75^{th}]) and further recoded into nominal groups. The month was transformed into a binary variable, season with rainy- and dry seasons as outcomes as reported by Osei-Boakye et al. [16]. The test of association between two-by-two matrix and larger nominal categories was determined using the Fisher's Exact and Chi-Square tests, respectively. The strength of the association (effect size) was determined using the Cramer's V test. The yearly trend of blood transfusion was determined by linear regression. Statistical significance was set at $p \leq 0.05$ for all analyses in this study.

2. Results

2.1. Sociodemographic and Immunohaematologic Characteristics of the Blood Recipients

Table 1 presents the sociodemographic and immunohaematologic characteristics of patients transfused with whole blood and/or its products. The median age of the patients was 30 years, with an interquartile range of 17 to 45 years. Out of 5089 records of hospitalized patients that received a blood transfusion at the Sunyani Municipal Hospital, 63.0% (3208) were females, 20.4% (1039) were 36-49 years of age, 61.0% (3103) were transfused in the rainy season, 48.1% (2447) and 93.1% (4737) were blood type O and Rh-positive, respectively (Table 1).

Table 1. Sociodemographic and immunohaematologic characteristics of blood recipients at Sunyani Municipal Hospital, Ghana (2018-2021)

Variable	Frequency (*n*)	Proportion (%)
Gender		
Male	1881	37.0
Female	3208	63.0
Median (IQR)	30 (17, 45)	
Age (years)		
≤11	1033	20.3
12-25	1010	19.8
26-35	1022	20.1
36-49	1039	20.4
≥50	985	19.4

Season		
Rainy season	3103	61.0
Dry season	1986	39.0
ABO blood group		
O	2447	48.1
A	1170	23.0
B	1269	24.9
AB	203	4.0
Rh blood group		
Positive	4737	93.1
Negative	352	6.9
Total	5089	100.0

Data are presented as frequencies and proportions. Age is presented as median with interquartile range (IQR) in parenthesis; *n*: Sample size.

2.2. Patterns of Immunohaematologic Characteristics of the Blood Recipients

Figure 2 shows the patterns of immunohaematologic characteristics of blood recipients, stratified by gender, age, and season. Out of the 1881 male patients, 46.6% (876) had the O blood type, followed by 25.8% (485) B, 23.7% (446) A, and 3.9% (74) AB blood type. Similarly, out of the 3208 females, 49.0% (1571) had O, 24.4% (784) had B, 22.6% (724) had A, and 4.0% (129) had AB blood type. Also, the Rh-positive blood type was predominant in both males and females (93.0% [1749] vs. 93.1% [2988]). However, gender had no significant associations with either ABO or Rh blood types.

Out of the 1033 patients that were ≤11 years, 40.6% (419) were blood group O, followed by blood group B (29.3% [303]), A (23.6% [244]), and AB (6.5% [67]). A similar pattern was observed in patients 12-25 years and ≥ 50 years, while in the 26-35-year and 36-49-year groups blood group O was the highest recorded, followed by A, B, and AB. The predominant Rh type across the age groups was Rh-positive.

Of the 3103 patients transfused in the rainy season, the majority (48.0% [1499]) were of the O blood type, followed by B (26.4% [818]), A (21.9% [681]) and AB (3.7% [115]). However, out of 1986 patients transfused in the dry season, the majority were of the O blood type and followed rather by A (24.6% [958]), B (22.7% [451]), and AB (4.4% [88]). The majority of patients transfused during either rainy or dry season expressed the Rh-positive phenotype (93.3% [2896/3103] vs. 92.7% [1841/1986], respectively). The ABO blood phenotypes showed a significant and weak association with age and season (r=0.07, p≤0.001 vs. r=0.05, p=0.008) (Figure 2).

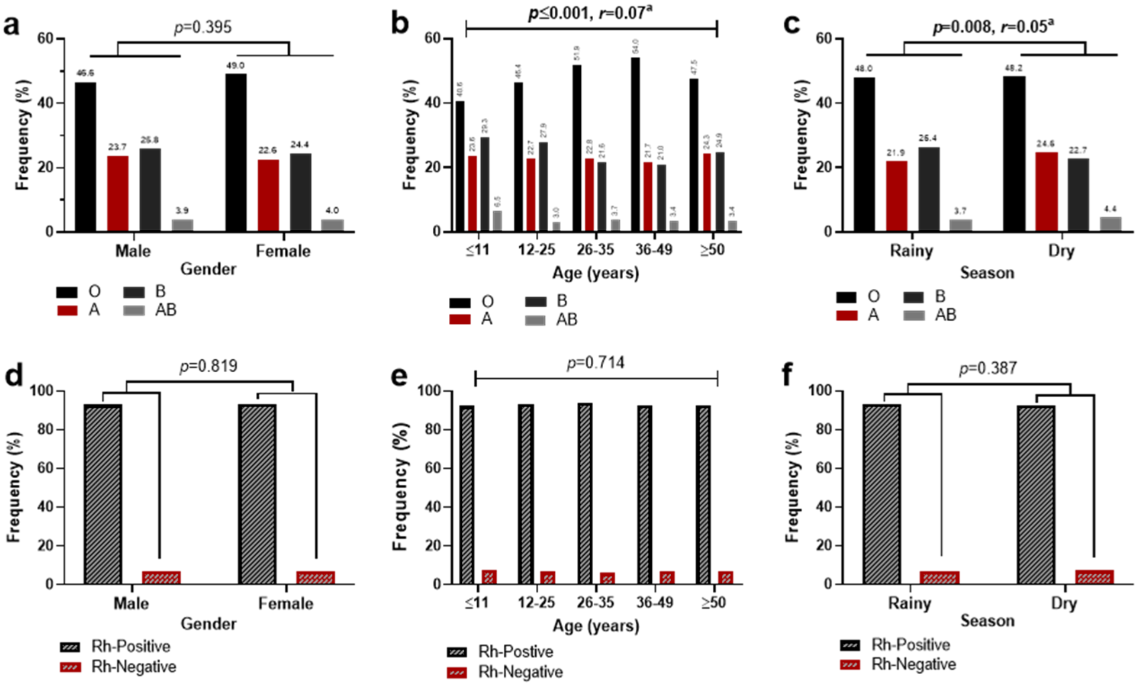


Figure 2. Patterns of immunohaematologic characteristics of blood recipients, stratified by gender, age, and season. *r*: strength of association (effect size); a: Cramer's V; statistical significance was set at *p*≤0.05

2.3. The association of Source of Blood Request with Season and Type of Blood Transfusion

Of the 5089 blood transfusions performed during the four years, 80.0% (4053) were ABO group-specific. Of this, the majority (28.3% [1146]) was recorded in the emergency ward, followed by adult females' ward (23.2% [940]), adult males' ward (18.6% [752]), maternity ward (16.1% [652]), paediatric ward (13.5% [546]), and the surgical theatre (0.4% [17]). Conversely, out of 1036 non-ABO group-specific transfusions, the majority (27.9% [289]) was performed for patients in the emergency ward, followed by adult females' ward (21.5% [223]), adult males' ward (19.2% [199]), paediatric ward (18.1% [187]), maternity ward (13.1% [136]), and surgical theatre (0.2% [2]). The source of transfusion request showed a significant and weak association with the season and type of transfusion (r=0.1, p≤0.001 vs r=0.1, p=0.002) (Table 2).

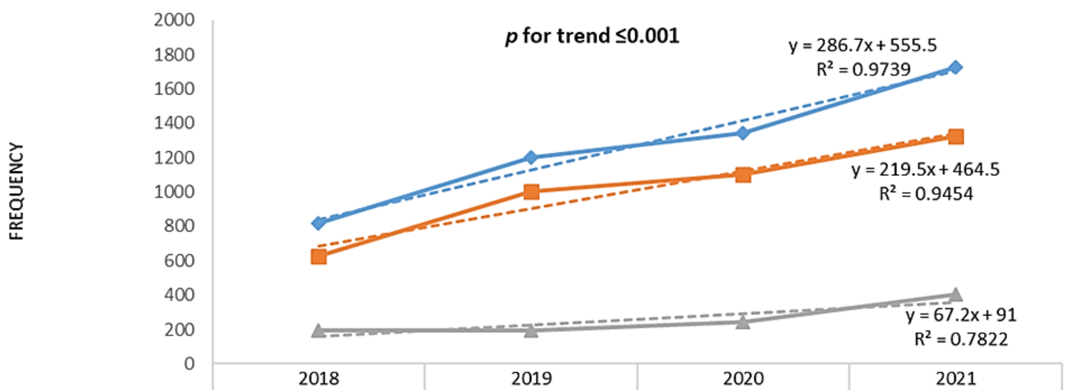
Table 2. Association of source of blood request with season and type of blood transfusion at the Sunyani Municipal Hospital (2018-2021)

Variables	Total transfused *n* (%)	Season			Type of transfusion		
		Rainy *n* (%)	Dry *n* (%)	Effect size	ABO group-specific *n* (%)	Non-ABO group-specific *n* (%)	Effect size
Source of blood request		***p*≤0.001**		0.1[a]	***p*=0.002**		0.1[a]
Emergency ward	1435 (28.2)	906 (29.2)	529 (26.6)		1146 (28.3)	289 (27.9)	
Adult males' ward	951 (18.7)	547 (17.6)	404 (20.3)		752 (18.6)	199 (19.2)	
Adult females' ward	1163 (22.9)	695 (22.4)	468 (23.6)		940 (23.2)	223 (21.5)	
Maternity ward	788 (15.5)	456 (14.7)	332 (16.7)		652 (16.1)	136 (13.1)	
Paediatric ward	733 (14.4)	490 (15.8)	243 (12.2)		546 (13.5)	187 (18.1)	
Theatre	19 (0.4)	9 (0.3)	10 (0.5)		17 (0.4)	2 (0.2)	
Total	5089 (100.0)	3103 (61.0)	1986 (39.0)		4053 (80.0)	1036 (20.0)	

The data are presented as frequencies, with proportions in brackets; the Chi-Square test was used to compare differences in proportions; *n*: Sample size; a: Cramer's V; *p*≤0.05 was considered significant.

2.4. Year-on-year Trend of Blood Transfusion among Hospitalized Patients Over Four Years (2018-2021)

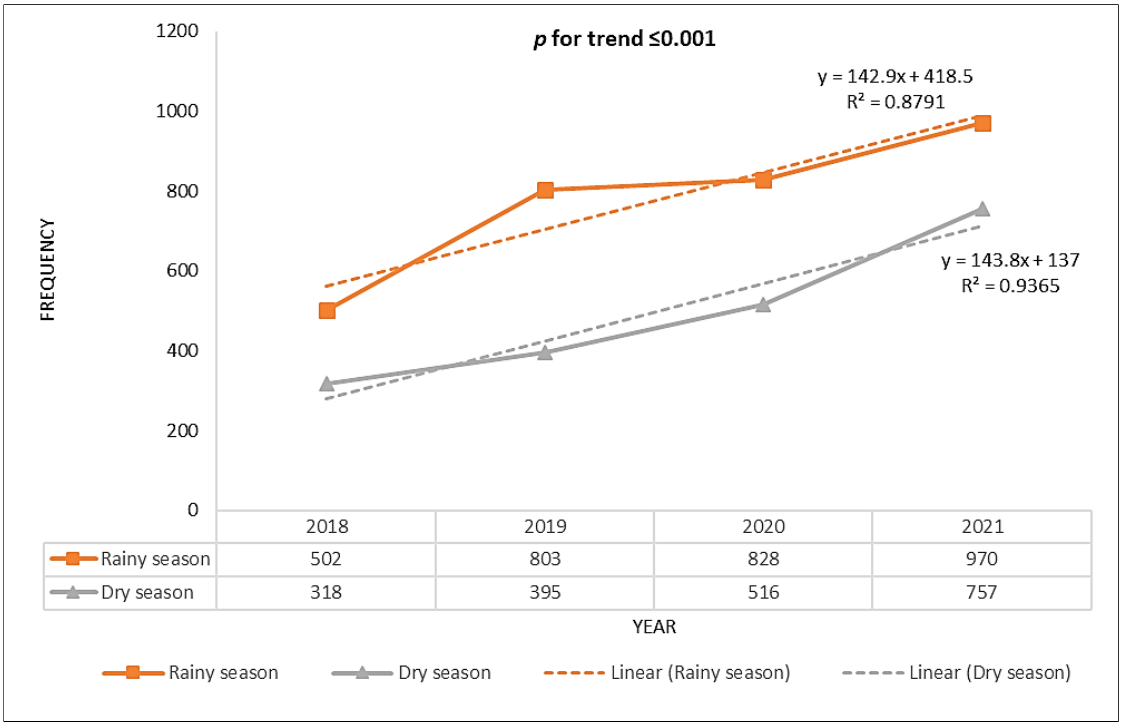
Figure 3 shows a 4-year trend of blood and or blood product transfusions among hospitalized patients. Both the total transfused and ABO-specific blood transfusions showed progressive increasing trends from 2018 through to 2021 with gradients of 286.7 and 219.5, respectively. However, non-ABO-specific transfusions remained steady from 2018 to 2019 and subsequently rose from 2020 to 2021, yielding a gradient of 67.2. The trends observed over the four years were statistically significant (p≤0.001) (Figure 3).



	2018	2019	2020	2021
ABO-specific	626	1002	1100	1325
non-ABO-specific	194	196	244	402
Total transfused	820	1198	1344	1727

Figure 3. Year-on-year trend of ABO-specific- and non-ABO-specific transfusions among hospitalized patients at the Sunyani Municipal Hospital (2018-2021)

Figure 4 shows a 4-year trend of blood and or blood product transfusions among hospitalized patients in different seasons. Blood transfusions performed in the rainy season showed a sharp increase from 2018 to 2019 and transiently remained steady between 2019 and 2021. Subsequently, there was a sharp increase from 2020 to 2021 with a gradient of 142.9. Conversely, although transfusions performed in the dry season showed an increasing trend, there was a moderate rise in transfusions from 2018 to 2019. This was followed by a sharp rise from 2020 to 2021, yielding a gradient of 143.8. The trends observed over the 4 years were statistically significant ($p \leq 0.001$) (Figure 4).



	2018	2019	2020	2021
Rainy season	502	803	828	970
Dry season	318	395	516	757

Figure 4. Year-on-year trend of blood transfusion stratified by season among hospitalized patients at the Sunyani Municipal Hospital (2018-2021)

3. Discussion

Blood transfusion plays a significant therapeutic role in the administration of modern medicine and surgical interventions. In Ghana, blood transfusions are mostly requested for the management of life-threatening conditions that require urgent medical attention or elective surgeries. The urgency associated with blood transfusion requires health authorities to sustain the blood supply chain, as shortages of blood could result in preventable mortalities. This study, therefore, determined the patterns of blood transfusion and the effect of season on ABO/Rh blood group phenotypes.

In this study, females were the highest (63.0%) recipients of blood transfusions, which corroborates the findings of Feyisa et al. [6] in Ethiopia. The plausible explanation is that the female hormone oestrogen inhibits the blood production capacity of the bone marrow which results in reduced haemoglobin levels in females [17]. This may further be compounded by the loss of blood through periodic menstruation [18], and childbirth associated haemorrhaging in females.

The frequency of blood transfusion was increased (61.0%) in the rainy season. In Ghana, malaria due to *P. falciparum* infestation, sickle cell anaemia (SCA), and exsanguination due to motor accidents are among the major determinants of blood loss, and consequently, blood transfusion. The incidence of these three events is notably associated with changes in season. According to Fall et al. [11], rainfall enables the creation of suitable habitats that support the breeding of mosquitoes. Furthermore, rainfall influences the spread of malaria via alterations in the lifecycles of the vector (mosquito) and the disease-causing plasmodium [19]. Ramifications of these may result in increased cases of malaria-induced anaemia requiring blood transfusions. Conversely, patients with sickle cell disease (SCD) present with frequent haemolysis and vaso-occlusive crisis which are indications for blood transfusion. Risk factors for the occurrence of this SCD-induced haemolysis include extreme weather, including those with cold temperatures as observed during the rainy season. Furthermore, the rainy season is generally characterized by poor visibility and slippery roads, and in Ghana, these may further be exacerbated by the masking of potholes by pools of water on the roads which mostly result in motor accidents. Since most conditions requiring blood transfusions are clinical emergencies, it is imperative for blood centres to stock refrigerators with the required ABO and Rh blood phenotypes instead of relying on on-the-spot replacement donations which may be challenging in the rainy season and could delay healthcare.

This study showed a predominance of both blood group O and Rh-positive phenotypes among the patients when stratified by gender, age, and season. However, only age and season showed significant associations with the ABO blood group ($p \leq 0.001$, and $p = 0.008$, respectively). This corroborates similar patterns reported in other parts of Ghana [14, 15]. In the rainy season, blood type B was the second most frequent phenotype after blood type O, whereas in the dry season, blood type A was second after the O phenotype. It is known that different seasons present varied environmental conditions, which affect disease-causing microorganisms differently. Worldwide, the association between blood group systems and disease states has been established and reported in several studies [20–24]. It is worthy of note that this study presents data on patients presenting with a myriad of diseases; therefore, it is plausible that these blood group phenotypes may have revolutionized as a result of natural selection due to adaptations to some diseases persistent in either the rainy or dry season.

Although not significant, the small number of Rh-negative patients presented in each sociodemographic stratification of gender, age, and season and the overall low frequency (6.9%) suggest a scarcity of the Rh-negative phenotype in the general population. This finding corroborates similar studies conducted in the Volta [14] and Greater Accra Regions of Ghana [15]. This may culminate in shortages of Rh-negative blood types and could lead to mortalities in patients in need of such blood types. Consequently, blood center managers should be cognizant of this to effectively plan for emergencies requiring Rh-negative blood types.

Patients admitted to the emergency ward were frequently transfused, and this may be because patients requiring intensive care are initially admitted to the emergency unit [5]. There was an increased frequency of blood transfusions in paediatric- than in pregnant patients in the rainy season. In limited-resource settings like Ghana, where stem cell transplants and access to medications like hydroxyurea remain a challenge for the majority of inhabitants, most patients suffering from SCD are not likely to survive beyond childhood. Therefore, the majority of SCD patients are children, who may suffer a frequent haemolytic crisis in the rainy season, requiring transfusions. Also, there were more transfusions among pregnant than paediatric patients in the dry season, which is not well understood. Furthermore, there was a significantly increased frequency of ABO group-specific blood transfusions in pregnant- than paediatric patients, while non-ABO group-specific blood transfusions were rather increased in paediatric- than pregnant patients ($p = 0.002$).

The ABO blood antigens are the most immunogenic, and capable of causing immediate blood transfusion reactions following the transfusion of incompatible blood. However, the majority of blood centers in Ghana do not perform either qualitative antibody panel screening or a quantitative antibody titre determination before transfusing blood, due to the increased costs associated with the laboratory screening procedure. This may have necessitated the increased transfusion of ABO group-specific blood to pregnant women who are more prone to mother-foetus ABO incompatibility and associated adverse health outcomes. However, the high incidence of non-ABO group-specific transfusions in paediatric patients is not well understood. Furthermore, our findings showed an overall progressive and increasing trend in blood transfusions in the four years, with ABO group-specific transfusions significantly higher than non-ABO group-specific transfusions ($p \leq 0.001$). This could be due to improved referral systems and the increased capacity of the hospital to manage complex cases, including referred patients, especially those requiring surgeries.

This study was not without limitations: the retrospective design of the study did not favor the identification of the ethnicity and or country of origin of participants. Meanwhile, some studies [20, 25] suggest an association between the frequency of ABO/Rh blood antigens and the descent of the population. Therefore, knowledge of the ethnicity and or country of origin could explain some of the varied patterns observed in the present study.

4. Conclusion

Blood transfusion was frequent among females, adults in the 36–49-year range, O and Rh-positive blood group phenotypes, and in the rainy season. Blood transfusion requests were significantly associated with season and type of transfusion, with the majority of the blood transfusions occurring in the emergency ward. Furthermore, age and season were both significantly associated with patients' ABO but not Rh blood type. Also, the yearly trend showed a significant increase in blood transfusions, with an increased frequency of ABO group-specific transfusions. We recommend that managers of blood centers encourage the donation of Rh-negative blood phenotypes since their low frequencies in the general population are likely to cause shortages and even deaths. Also, we implore clinical laboratory and health services managers to invest in the establishment of a blood bank inventory system using the data presented in this research as a baseline.

5. Declarations

5.1. Author Contributions

Conceptualization, F.O-B.; methodology, F.O-B., and A-R.S.; software, F.O-B.; validation, F.O-B., N.A., and D.S.; formal analysis, F.O-B.; investigation, F.O-B. and M.D.; resources, F.O-B.; data curation, M.D., K.K., M.K., F.S., and A.O.A.; writing—original draft preparation, F.O-B., N.A., C.N., and D.S.; writing—review and editing, F.O-B. and C.N.; visualization, F.O-B.; supervision, F.O-B.; project administration, F.O-B., and A-R.S.; funding acquisition, F.O-B. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are openly available in the Harvard Dataverse repository at doi:10.7910/DVN/S1OWZ7.

5.3. Funding

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5.4. Acknowledgements

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5.5. Ethical Approval

This study was approved by the Committee on Human Research, Publication and Ethics (CHRPE) of the School of Medicine and Dentistry, Kwame Nkrumah University of Science and Technology (Reference: CHRPE/AP/023/23). Also, permission was obtained from the Administration of the Sunyani Municipal Hospital before conducting the study. However, due to the retrospective design of the study, consent from the subjects was not required.

5.6. Informed Consent Statement

Not applicable.

5.7. Declaration of Competing Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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