Characteristics of blood donors and donated blood in sub-Saharan Francophone Africa

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BACKGROUND: The importance of blood safety in public health was recognized long ago, and data are essential to plan strategies to improve the status. This study aims to obtain data on blood donor and blood donation characteristics that would complement blood safety data from national and international organizations.

MATERIALS AND METHODS: A questionnaire was sent to seven Francophone countries (Burkina Faso, Cameroon, Congo, Ivory Coast, Mali, Niger, and Rwanda) and was structured to obtain objective data on blood donors and donated blood and in administrative and technical organization.

RESULTS: The results reflect a poor level of organization of blood transfusion centers in large regions of the African continent, insufficient supply of blood products, high prevalence of transfusion-transmitted infections, limited financial resources, a lack of well-trained personnel, and cultural obstacles. Six countries had less than 50% of their personnel trained in transfusion medicine. Only one country had the entire standard operating procedure written. Female donors represented less than 30% of the donors and the range of percentage of hepatitis B found in donors was 2.76% to 18.96%.

CONCLUSION: The inclusion of these regions in future blood safety surveys and in the development of national blood transfusion programs is essential and will undoubtedly require the assistance of international organizations.

Blood safety in Africa is one of the priorities of the World Health Organization (WHO) since the adoption of a strategy for Africa in 2001.[1] This strategy aims to implement a national policy for each African country by 2012 to assure a safe and sufficient blood supply. The principal roles of national programs are blood collection from low-risk donors, systematic and efficient infectious disease screening, production of sufficient and safe blood products, and the rational clinical use of these products.

Sub-Saharan African blood donors live in a multicultural environment but have many biologic characteristics in common. Genetic disorders pertaining to red blood cells (RBCs), malnutrition, anemia, and infectious diseases are widespread in the region. In many African countries the prevalence of sickle cell disease and some enzymopathies is high;[2-4] the phenotype Fy(a–b–) of the

ABBREVIATIONS: SOP(s) = standard operating procedure(s); VNR = voluntary nonremunerated (donor).

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Duffy erythrocytic system is frequent;[5] and the prevalences of HIV infection, malaria, and of other transfusion-transmissible infections are also elevated compared to other parts of the world.[6-8] A better understanding of the current characteristics of the African blood transfusion system and its donors is essential for optimal management of the blood supply, developing a strategy for biologic qualification, improving infectious and immunologic blood safety, and optimal clinical use of blood products.[9]

We report results from a multicenter survey of the characteristics of blood donors and blood donations conducted in seven blood transfusion centers in sub-Saharan African countries. We believe these results will provide a useful complement to, and improve interpretation of, official data published by national and international organizations.

MATERIALS AND METHODS

Blood transfusion centers from seven sub-Saharan African countries participated in the study: two from Central Africa (Cameroon, Congo), four from West Africa (Niger, Mali, Ivory Coast, Burkina Faso), and one from East Africa (Rwanda; Fig. 1). The questionnaire used for the survey was structured to obtain objective data for years 2006 or 2007 in five specific domains:

1. The administrative, technical, and financial organization of the centers: whether or not a national blood transfusion program was in place and the date of its implementation; different services provided by the institution (administration, donor program, blood collection, infectious disease screening, preparation and distribution of blood products); percentage of personnel trained specifically in transfusion; existence of standard operating procedures (SOPs) for transfusion activities; and the existence of a technical/financial assistance by a foreign or an international organization.
2. The characteristics of the blood donors and the management of the blood supply: proportion of mobile collection sites; existence of a donor questionnaire and a medical predonation interview; existence of a permanent blood donor database; the numbers of blood donors per year; the frequency of donation—distribution of sex, age, new versus regular (two or more donations) donor, type of donor (voluntary, familiar/replacement, remunerated, autologous), and type of donation (total blood, blood from aphaeresis); and median amount of blood collected per donor.
3. Hematologic testing: proportion of donors tested for hemoglobin (Hb) level or hematocrit (Hct) before blood donation; prevalence of anemia among prospective donors; existence of a national strategy for the blood grouping in ABO and Rh system; existence of written SOP and blood typing methods; the percentage of units of blood tested for blood grouping; the frequency of erythrocytic phenotypes in ABO and Rh system; and screening protocol for and prevalence of sickle cell disease and G6PD deficiency.
4. Infectious disease screening: existence of a national strategy for the screening of transfusion-transmitted diseases; the pathogens screened (HIV, hepatitis B virus [HBV], hepatitis C virus [HCV], human T-lymphotropic virus of type I [HTLV-I], human herpes virus 8 [HHV-8], plasmodium species, *Treponema pallidium*); techniques used and percentage of units tested for each transmissible pathogen; prevalence of transfusion-transmissible infections based on screening (not confirmatory) test results; and percentage of units contaminated by one or more types of pathogens.
5. The preparation of the labile blood products: percentage of total blood units delivered; and percentage and type of labile blood products prepared.

Fig. 1. The seven participating centers. 1 = Daloa, Ivory Coast; 2 = Bamako, Mali; 3 = Ouagadougou, Burkina Faso; 4 = Niamey, Niger; 5 = Kigali, Rwanda; 6 = Kinshasa, Democratic Republic of Congo; 7 = Yaoundé, Cameroon.

RESULTS

Organization of the participating centers

Three centers had the status of national blood transfusion center: Ouagadougou (Burkina Faso), Kigali (Rwanda), and Bamako (Mali). Two had the status of regional blood transfusion center: Niamey (Niger) and Daloa (Ivory

Coast). Two centers were hospital-based blood banks: University Teaching Hospital of Yaoundé (Cameroon) and University Clinic of Kinshasa (Congo). Table 1 shows the characteristics of each center for the administrative, technical, medical, and financial organization.

Blood donors and types of donations

Table 2 shows the epidemiologic characteristics of the blood donors and donations for the seven countries. In all centers, a questionnaire and a medical interview were done to select safe blood donors before donation. Officially, no center had recruited remunerated blood donors or autologous donors. No center collected blood from donors younger than 18 years. All the centers collected only whole blood from their donors, except one (2% from apheresis in the center from Mali).

Hematologic characteristics of blood donors and donations

Table 3 shows the hematologic characteristics of blood donors and donation in the seven countries. In four centers donors were screened for anemia before the donation but in only two of them was it done systematically.

All the centers had a national strategy for blood grouping in ABO and Rh system, but SOPs existed only in three centers (Burkina Faso, Niger, and Ivory Coast). All countries used Beth-Vincent and Simonin techniques for blood grouping in ABO system but only four of them used a dual determination. All centers screened 100% of their donors for the D antigen; only two of them (Mali and Niger) looked for other Rh antigens (C, c, E, e) but in no more than 10% of their blood donors. The frequencies of ABO phenotypes and D antigen are detailed for each country in Table 3. No center has done a systematic screening for sickle cell or G6PD deficiency; therefore, the prevalences of these diseases are not known.

Infectious characteristics of blood donors and donation

A national strategy of infectious disease screening of donated blood exists in all seven centers including testing for HIV, HBV, HCV, and *T. pallidium*. Screening for malaria was not done. No center screened donors for HTLV-I or HHV-8 infections. Table 4 details for each center the techniques used, the percentage of tested units, and the prevalence for each marker of the four transfusion-transmitted infections, based on screening, not confirmatory, test results.

Total blood and labile blood products

The proportions of total blood delivered by the centers and the types of blood products prepared are detailed in

TABLE 1. Organization of the seven participating centers

Characteristics of organization	Yaoundé (Cameroon)	Bamako (Mali)	Niamey (Niger)	Kigali (Rwanda)	Daloa (Ivory Coast)	Kinshasa (Congo)	Ouagadougou (Burkina Faso)
National Blood Transfusion Program (date of implementation)	–	–	+ (2005)	+ (2005)	+ (1998)	+ (2001)	+ (2000)
Functions included within the center							
Administration	+	+	+	+	+	+	+
Donor recruitment	+	+	+	+	+	+	+
Blood collections	+	+	+	+	+	+	+
Infectious disease screening	+	+	+	+	+	+	+
Component preparation	+	+	+	+	+	–	+
Distribution of blood products	+	+	+	+	+	+	+
Personnel trained in blood transfusion (%)	25	42	64	30	8.7	40	50
Written SOPs	Partially	Partially	100%	Partially	Partially	Partially	Partially
Technical assistance by foreign or international organizations	+ (WHO, INTS)	+ (EFS)	–	+ (CDC, PEPFAR)	+ (PEPFAR)	–	+ (Luxembourg)
Financial assistance by foreign or international organizations	–	–	–	+ (CDC, PEPFAR)	+ (PEPFAR)	–	+ (Luxembourg)

CDC = Center for Disease Control, United States; EFS = Etablissement Français du Sang, France; INTS = Institut National de la Transfusion Sanguine, France; PEPFAR = President Bush's Emergency Plan for AIDS Relief, United States.

TABLE 2. Characteristics of the blood donors and donations in the seven participating centers

Characteristics	Cameroon	Mali	Niger	Rwanda	Ivory Coast	Congo	Burkina Faso
Proportion of mobile collections (%)	10	13	45	55	23.8	60	70
Permanent data on donations and donors	No or partial	Yes	No or partial	No or partial	No or partial	Yes	No or partial
Total number of blood donors	2,887	25,543	2,962	37,000	14,257	480	30,364
Donor status							
First-time donor* (%)	75.6	68.3	52.7	45	33.3	30	73.8
Regular donor† (%)	24.4	31.7	47.3	55	66.7	70	26.2
% Female	28.3	12.7	20	12	30	9.4	20
Age (years)							
18-30	63.7	45	73.6	75	80	51	90.1
30-40	19	39	13.5	15	15	28	6.6
>40	17.3	16	12.9	5	5	21	3.3
Type of donors (%)							
Volunteer	25.5	30	86.8	100	100	70	92
Familial	74.5	70	13.2	0	0	30	8
Type of donations (%)							
Whole blood	100	98	100	100	100	100	100
Apheresis	0	2	0	0	0	0	0
Mean amount of collected blood (mL)	400	350	450	450	400	350	400

* One donation per year or less.
† At least two donations per year.

Table 5. Whole blood was predominantly collected in all the centers except two of them (Burkina Faso, Rwanda), where RBCs represented the majority of blood products delivered. Standard platelet (PLT) concentrates were produced in three centers of seven and represented 2.5% or less of all blood products. Four centers of seven prepared fresh-frozen plasma (FFP) but in variable proportion (between 0.5 and 40% of the total blood components).

DISCUSSION

This survey gives a cross-section of current blood collection practice in sub-Saharan Africa. Among the seven participating centers, five had a national blood transfusion program promulgated by their country's public health ministry, usually following active collaboration between national and international organizations. In our two centers and other sub-Saharan African countries without a national program, it is an utmost priority to implement such a national program.

At the national level, the implementation of such a program must be done progressively, with prioritization of the different phases. An important priority is that all personnel of a blood transfusion service must be trained in transfusion medicine and have access to an SOP for blood transfusion. Our study shows that no center had personnel exclusively trained in transfusion medicine and that only one center had an SOP at any level of the transfusion chain. African countries need additional help from industrialized countries and international organizations with respect to technical assistance and professional training.

This study suggests that sub-Saharan African blood donors have unique characteristics. First, the mean age of donors is 10 to 15 years younger than European donors.[10] Many reasons for this age difference have been proposed. Because familial and replacement blood donation is frequent, many blood donors are students and/or young workers, solicited by their family to donate blood because of their apparent "good health."[11,12] Furthermore, fear of illness after donation may limit the participation of donors over 40 years. Finally, the African population is younger than the European one, with a life expectancy averaging 50 years across sub-Saharan African countries. Similarly to other studies we also found that in this multicenter donor population a much higher proportion of men than women donated blood,[12,13] while in western countries the sex distribution among donors is even.[10] One explanation for this sex difference among African donors is that men are usually perceived as being healthier than women.[11,12] Cultural beliefs and deep-rooted traditions may also explain the sex difference like the belief that HIV may be transmitted through blood donation. The belief that among women menstrual bleeding represents a repeated loss of blood, and that further loss through donation may put women at risk for anemia, is also prominent in Africa. Finally, pregnancy and immediate postpartum period constitute important obstacles to blood donation in this continent with a high birth rate.

Another major issue with respect to blood transfusion in Africa is the chronic shortage of donors, especially voluntary nonremunerated (VNR) donors. Preconceived ideas stemming from rumors, cultural beliefs, and lack of information exacerbate this situation. While they represent the majority of blood donors in most western countries,[10,13] VNR blood donors still represent the minority in many African countries.[14] Because VNR donors

TABLE 3. Hematologic characteristics of blood donors and blood donation in the seven countries

Characteristics	Cameroon	Mali	Niger	Rwanda	Ivory Coast	Congo	Burkina Faso
Predonation screening of anemia (%)							
New donors	15	0	0	0	100	100	28.4
Regular donors	3	0	0	0	100	100	13.4
Anemia in blood donors (%)							
Males*	11.6				7.14	3.5	3
Females†	20.3				5.71	0	10
ABO determination (Beth-Vincent and Simonin methods)	Double	Double	Single	Single	Single	Double	Double
Technique	Tube/Slide	Gel/microplaque	Tube	Tube	Slide	Tube/microplaque	Slide
ABO system frequencies (%)							
A	28	24	22.1	25	15	18.3	22.3
B	22	28	23	20	10	14.8	28.6
O	47	41	50	50	70	63.7	43.2
AB	3	6	4.8	5	5	3.2	5.9
D frequency	91	92	93.1	94	85	95.4	92.6

* Hb level <12 g/dL or Hct <38%.
† Hb level <11 g/dL or Hct <36%.

TABLE 4. Infectious marker prevalence of blood donations at the seven centers

Infectious agents	Testing	Cameroon	Mali	Niger	Rwanda	Ivory Coast	Congo	Burkina Faso
HIV	Technique	RIT + ELISA Ab	ELISA Ab+Ag	ELISA Ab+Ag	ELISA Ab	ELISA Ab	RIT	RIT, ELISA Ab+Ag
	Tested units (%)	100	100	100	100	100	100	100
	Prevalence (%)	2.9	2.58	1.4	1.0	3.48	0.8	2.1
HBV	Technique	RIT	RIT, Ag HBs	ELISA AgHBs	Ag HBs	Ag HBs	RIT	RIT, Ag HBs
	Tested units (%)	100	100	100	100	100	100	100
	Prevalence (%)	10.3	13.89	18.96	2.76	5.85	6	11.2
HCV	Technique	RIT, ELISA Ab	ELISA Ab	ELISA Ab	ELISA Ab	ELISA Ab	RIT	RIT, ELISA Ab
	Tested units (%)	100	70	100	100	100	100	100
	Prevalence (%)	3.9	3.25	1.42	3.13	6.98	2	3.2
Syphilis	Technique	VDRL+TPHA*	VDRL	VDRL	VDRL	VDRL+TPHA*		VDRL+TPHA*
	Tested units (%)	100	100	100	100	100	0	100
	Prevalence (%)	9.5	0.3	1.88	0.6	4.54	ND	1.2
Units discarded for at least one positive marker (%)		15.7	22.42	20.65	2.4	20.85	8.8	20

* With decision algorithm.
Ab = antibody; Ag = antigen; ELISA = enzyme-linked immunosorbent assay; HBs = hepatitis B surface; ND = not determined; RIT = rapid immunochromatographic test; VDRL = Venereal Disease Research Laboratory; TPHA = *T. pallidum* hemagglutination assay.

TABLE 5. Component production at the seven centers (%)

Component	Cameroon	Mali	Niger	Rwanda	Ivory Coast	Congo	Burkina Faso
Whole blood	85.1	87.5	60	2	>50	100	14.5
RBCs (mean volume, mL)	14.9 (220)	10.7 (200)	40 (200)	98 (220)	<50 (200)	0	75.8 (232)
Standard PLT concentrates	2.4	1.3*	0	0	0	0	1.5
FFP	3.1	0.5	40	0	0	0	8.3

* PLT-rich plasma.

generally have the lowest prevalence of transfusion-transmissible infections, dependence on blood supplied by familial or remunerated blood donors has a negative impact on blood safety. In the countries that still collect blood from familial or replacement blood donors (five of seven in our study), programs to recruit VNR blood donors must be a priority, but they are unfortunately expensive and depend frequently on international financial assistance.[15] Ideally, these programs must be based on national resources to ensure sustained funding. Another problem is the insufficient proportion of regular donors, who are still uncommon even among VNR donors. In 2002, 61% of the global blood supply was donated in developed countries. Only 10% was donated in Africa region and 39% in developing countries, where 82% of the world's population lives.[13] Among possible solutions, the development of mobile collections and the implementation of reliable data to ensure regular donation are important. (In our study, only one country had complete data for all their donors.)

Data on hematologic testing qualification of blood donations in Africa have heretofore been scarce. The majority of our centers did not screen all donors for anemia (Hb concentration or Hct). However, anemia is frequent in African blood donors, and it is a major public health problem.[16,17] The causes are genetic abnormalities of the RBC (sickle cell disease and G6PD deficiency), iron deficiency, nutritional causes, and diseases caused by parasites (malaria, helminthiasis). This lack of screening for anemia could have a negative impact on the donor (hemodynamic risk in an anemic blood donor) and also on the recipient who received an anemic nonefficient blood.

With respect to immunohematology, ABO and Rh blood groups were determined at all seven centers. Frequently using the glass slide technique could increase the risk of errors with serious consequence to the blood recipient. Moreover, for financial reasons, dual typing was not done for every blood group determination. Blood typing for other RBC antigen systems was not systematically done, despite the likelihood of incompatibility in those systems.

The frequency of erythrocytic phenotype in the ABO system was similar in the participating centers, with the O phenotype being the most common. This similarity is not surprising because the donors of the centers are from the same race and same environment. In all seven centers except one, more than 90% of blood donors had the phenotype D+. Some authors think that this frequency might be even higher if the detection of the antigen D was more efficient, particularly by the detection of the weaker D.[18] This frequency is higher than in Caucasian blood donors,[10,19] but declines toward North Africa.

One of the major issues of transfusion medicine in Africa is blood safety with respect to infection, because the residual risk of transfusion-associated contamination is still very high compared to western countries. Many reasons could explain this situation: 1) Transfusion-transmitted infections are highly endemic in sub-Saharan Africa: in our study, the percentage of infected blood units for at least one type of pathogen was more than 20% in three centers. 2) Familial or replacement blood donors probably have a higher prevalence and incidence of transfusion-transmitted infections than VNR donors, but they remain indispensable due to blood shortages. 3) Even if the majority of the participating centers had a policy of screening all the blood units for the three major transfusion-transmitted viruses, two of them pointed out that blood units were sometimes released without testing because test kits were unavailable or too expensive. This lack of testing, which included HIV, significantly increases the risk of transfusion-transmitted infection in this high prevalence setting.

The reduction of the infectious transfusion risk is a priority for all national policies. The paradox is that transfusion systems in western countries, where the prevalence of transfusion-transmissible pathogens is lower in blood donors, have the most powerful screening system while those of African countries where this prevalence is the highest in the world have the least powerful screening system. In fact, infectious disease screening in sub-Saharan Africa relies on serologic tests and rapid immunochromatographic tests. Nucleic acid testing (NAT), which reduces the risk due to window-period infections, is prohibitively expensive for most African countries. Screening is frequently based on rapid tests, because they are affordable in resource-limited countries.[20] But the results of those tests are not always confirmed by specific tests in reference laboratories. Finally, genetic variability of viruses like HIV[21,22] could be an obstacle to the reliability of some serologic tests.[23,24] For these reasons, the seven

centers have initiated a program of external quality control by periodically testing a panel of serum provided by the Institut National de Transfusion Sanguine of Paris, France.

In the general population as well as in the blood donor population, sub-Saharan Africa has the highest prevalence of HBV infection; HBV high infection rates in sub-Saharan Africa are related to vertical (i.e., mother to child) transmission and sexual contact. HBV via transfusion route can be significantly reduced by proper donor screening. This high infection rate is partly explained by the way of life in Africa, where communal life and promiscuity are frequently observed and favor the transmission of the virus. Because of very high HBV prevalence, the use of anti-HBc testing to detect donors with low-level surface antigenemia is impractical. Also, inadequate infection control in hospitals and clinics as well as culturally related blood contact contribute to the high prevalence of HCV infection. Despite the serious complications of HCV infection including chronic hepatitis, cirrhosis, and hepatocellular carcinoma, screening for this virus is not systematic in all African blood transfusion programs,[14] even though it was performed in each of the seven centers participating in our study.

As almost 40 million sub-Saharan Africans are living with HIV, the prevalence of this virus is high in blood donors of the continent, but varies from one center to another in our study. Considering that NAT is not affordable for the majority of countries, combined antigen and antibody testing (the HIV combitest) is theoretically the best serological test to reduce the transfusion-transmitted HIV infection. However because of its expense, only three centers of seven in the study use the HIV combitest. Finally, none of the seven centers screened for other infections such as HTLV-I and HHV-8.

Endemic in sub-Saharan Africa (almost 1 million deaths per year), malaria is at high risk of transmission during transfusion, because 30% of blood donors are infected, according to some studies.[8,25] No participating centers in our survey screened systematically for the disease: the explanation provided by the centers for this lack of malaria screening was that it would exclude too many donors and reduce the blood supply, which is already seriously deficient. Other strategies to reduce this transfusion risk must be developed, such as pathogen inactivation or the prevention of the disease in the blood recipient with drug prophylaxis.

On the other hand, the screening of syphilis was performed in all of the seven participating centers. The prevalence of *T. pallidium* is high in African blood donors, the test is not expensive, and the techniques are easy. Moreover, a specific treponemic test was used by some centers to distinguish syphilis from other treponematoses (pian, béjel, pinta), also frequent in the continent. The transfusion transmission of syphilis does not seem to constitute a public health problem anywhere in the world, but its screening is useful for the purpose of diagnosis in the general population. In such setting of high prevalence of transfusion-transmitted infections, pathogen inactivation could probably be a way to increase the safety of the blood products but the real impact of this emerging technology on the safety as well as on the budget of the blood banks needs to be evaluated.

In our study, only two centers produced significant quantities of blood components, with the rest producing only whole blood. However, an important supply to blood banks of RBCs is useful in a continent where anemia is frequent, due to obstetrical hemorrhage, malaria, sickle cell disease, or bleeding associated to trauma. RBCs were the most frequent type of components produced by the participating centers.

Strengths of this study include the use of a standardized survey instrument to collect data directly from a network of collaborating blood centers as opposed to the ministries of health of the seven countries. We hope that these data are important as a baseline against which efforts to improve the adequacy and safety of blood supplies can be measured. A weakness of the study that limits its generalization is its inclusion of mostly large centers, frequently located in the capitals of the countries. This reflects the current poor level of organization of blood transfusion in large regions of the continent. The inclusion of these regions in future data collection and in the development of a national blood transfusion program is essential and will certainly require the assistance of international organizations.

The realization of these objectives will be difficult because of poor physical infrastructure, limited financial resources, a lack of well-trained managers, and cultural obstacles. In spite of the difficulties inherent to the implementation of the WHO blood safety program, some efforts have been made and some goals achieved after collaborative action of local governments and international organizations. Still, there remain many obstacles to reducing disparity between the blood transfusion systems in Africa and in western countries. Considering that humans and pathogens increasingly cross borders, increased collaboration between developing countries and industrialized countries seems to be essential for all.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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