Scientific Research Publishing

Open Journal of Blood Diseases, 2023, 13, 102-120
https://www.scirp.org/journal/ojbd
ISSN Online: 2164-3199
ISSN Print: 2164-3180

Blood Safety in the Democratic Republic of the Congo: Literature Review

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How to cite this paper: Ilunga, A.K.K., Inkale, C.B., Kilara, T., Woto, I., Kabengele, G.K., Bongenya, B.I., Buassa, B.B.T., Nyembue, D.T., Kabengele, B.O. and Kamangu, E.N. (2023) Blood Safety in the Democratic Republic of the Congo: Literature Review. *Open Journal of Blood Diseases*, **13**, 102-120.
https://doi.org/10.4236/ojbd.2023.133013

Received: July 5, 2023
Accepted: September 18, 2023
Published: September 21, 2023

Abstract

Background: The Democratic Republic of the Congo (DRC) faces severe malaria, postpartum haemorrhage, malnutrition and sickle cell disease that require transfusion. The latter poses immunological, infectious, metabolic and hemodynamic risks to recipients. **Objective:** To present transfusion safety in the DRC through data from the literature. **Methods:** This review consists of listing the various articles and abstracts published online and presented in scientific conferences having as a subject of interest transfusion safety in the DRC. **Results:** The review is dominated by articles from eastern DRC and blood mobilization is around 0.5% of the general population. All screening tests are serological with a proven residual risk. The prevalence of HIV, HBV, HCV and syphilis infections is documented at more than 80% and represents respectively 1.9%, 2.96%, 1.89% and 1.21%. The prevalence of other pathogens, the immunological and haemodynamic risk are very poorly documented (12.5% to 25%). The prevalence of Parvovirus B19 infection is 5.3% and that of bacterial contamination at 1.4%, that of malaria infestations between 0.3% and 28.3%, that of trypanosomiasis at 1.3%, that of babebiosis at 0.17% in blood donors. Allo-immunization represents 47.8%, adverse reactions 3.4%, iron deficiency 63.2, iron deficiency anemia 25.9% and anemia

36.5%. Pediatrics is the biggest user of this blood. **Conclusion:** The prevalence of HIV, HBV, HCV and Syphilis infections is within the range of sub-Saharan African countries. The serological test is systematic and involves the residual risk, it is necessary to introduce the molecular tests. The prevalence of other pathogens (emerging viruses, bacteria and hemoparasites), the immunological and metabolic risk is poorly documented. The search for these pathogens, irregular antibodies and the determination of ferritin in blood donations is not systematic.

Keywords

Prevalence, Pathogens, Transfusion, Democratic Republic of the Congo

1. Introduction

The Democratic Republic of the Congo (DRC) is a resource-limited country in sub-Saharan Africa. She is confronted with severe malaria, postpartum haemorrhage, malnutrition and sickle cell disease which are the real indications for Transfusion [1].

The latter saves several people all over the world each year. However, each transfused patient runs immunological, infectious, metabolic and hemodynamic risks [2] [3]. Transfusion safety therefore consists in reducing and or eliminating these risks. The World Health Organization defines 3 components of this transfusion safety, namely the availability of blood, the harmlessness of blood products and the judicious use of blood products [4].

The world mobilizes 118.5 million blood donations each year, 40% of which are in high-income countries where 16% of the world's population lives.

In low-income countries, up to 54% of blood transfusions are given to children under 5 years of age, while in high-income countries the most common patient group transfused is those over 60 years of age, which accounts for up to 76% of transfusions [5].

In low-income countries, among blood donors, the prevalence of human immunodeficiency virus (HIV) infection is between 1% and 12%, that of hepatitis C between 0.5% and 12%, and that of hepatitis B between 3% and 22%; curable parasitic infections such as malaria are not systematically sought [3] [6].

In the DRC, between 2010 and 2020 the availability of collected blood was less than 0.5% and that of voluntary donors at 34%. The infectious risk was 1.78% for HIV, 2.42% for HBV, 1.48% for HCV and 1.21% for syphilis. The Pediatrics department was the major user of this blood [7].

Among the causes of the non-safety of blood transfusion in Sub-Saharan Africa, we cite the lack of material resources to test and store blood and the lack of human resources sufficiently trained to properly carry out biological analyzes [6]. Several studies on blood transfusion show a significant residual infectious risk characterized by the use of tests incapable of detecting virus antibodies dur-

ing the seroconversion period [3] [6] [8] [9].

The DRC suffers from the causes of the non-safety of blood transfusion mentioned above but also from the non-systematic search for emerging viruses (HTLV-1/2, CMV, ParvovirusB19, etc.), bacteria and certain Hemoparasites (Plasmodium, Trypanosome, Loa Loa, Toxoplasma circulating in its provinces [2] [10].

These pathogens are transmissible by blood and likely to give leukemia, tropical spastic paraparesis, serious fatal malaria, sleeping sickness, serious vision disorders.

In addition, measures aimed at preventing the transmission of unknown viruses by transfusion can be implemented, such as the exclusion of donors at risk, leukodepletion of plasmas, the physico-chemical treatment of the various blood components aimed at inactivating these pathogens (use of detergents, solvents, ultraviolet rays and riboflavin, filtering) and techniques for amplification of virus nucleic acids but they are not yet topical [10] [11] [12] [13].

Due to the genetic variability of individuals, homologous erythrocyte transfusion necessarily brings red blood cells carrying antigens of blood groups unknown to the recipient. These antigens will be likely to trigger immunization with the appearance of "irregular" antibodies, itself likely to lead to delayed haemolysis. If immunization is pre-existing in the recipient, whether "natural" antibodies from the ABO system or "irregular" antibodies from other blood groups, the transfusion will give rise to a hemolysis reaction. To avoid this immunological risk, compatibility tests or extended phenotyping should be done.

This study aims to present the studies carried out in the DRC on transfusion safety from 2000 to the present day.

2. Methods

2.1. Literature Search

This study consists in listing the various articles and summaries published and presented in scientific conferences having as subjects of interest transfusion safety in the Democratic Republic of the Congo.

This published work on transfusion safety is carried out using the following elements from internet search engines: Google scholar, PubMed, Cochrane Library, Scientific Reports published on the internet, public access data on conference documents.

This online search is based on the following keywords: Viruses, parasites, bacteria, infections, transfusion, immunology, Provinces and Cities of the Democratic Republic of the Congo.

2.2. Inclusion and Non-Inclusion Criteria

The search was limited to published works and abstracts submitted within the last 23 years (2000 to 2022). The works are selected according to their relevance, methodology, results and representativeness of the samples.

The socio-demographic elements of the sample, the measurement methods and the objectives were taken into account in the evaluation of the articles.

Unpublished or published articles and summaries not directly concerning blood safety in the provinces and cities of the Democratic Republic of the Congo were not included in this review.

3. Results and Discussion

The objective of this study was to present the literature review on transfusion safety in the DRC from 2000 to 2022.

According to the regulatory framework and the epidemiological context in the DRC, screening for infectious diseases involves screening for anti-HIV1/2 and anti-HCV antibodies, hepatitis B antigen (AgHbs) and screening for syphilis. The techniques used are generally rapid tests, except at the level of the CNTS and the CPTS, where the detection of these markers is enhanced by standardized procedures such as Elisa tests, with the passage of internal and external quality controls. In some provinces in the center of the country (the two Kasai and Maniema), trypanosomiasis screening is also carried out [4].

The results will be presented taking into account the central level and the 8 geographical areas that are in the West the greater Equateur, the greater Bandundu, the Kongo-Central and the city province of Kinshasa; in the East, Grand Oriental, Grand Kivu and Grand Katanga and in the Center, Grand Kasaï.

This third part will be presented and discussed in terms of 3 components of transfusion safety according to the WHO: availability of blood, safety of blood and use of this blood.

3.1. Availability of Blood

At the central level, at the National Blood Transfusion Center

Mobilization, blood quality and types of donors

The mobilization of blood was on average 300,000 per year between 2000 and 2012 and 400,000 donations per year for a population estimated at 60 or 80 million inhabitants (0.5% of the general population). The proportion of blood tested within the standards was 71% between 2000 and 2012 and fell to 64% between 2010 and 2020 and risky blood donations varied between 29% and 36%. The data presented above are included in **Table 1** [4] [7].

The average prevalence of volunteer donors is 34% and replacement donors 66%. The data presented above are included in **Table 2** [4] [7].

Table 1. Average prevalence of the proportions of donations tested within the norms and donations at risk between 2000 and 2020 in the DRC.

Study	Publication Year	Donations mobilized per year	Gifts tested within standards	Donations at risk
Kabinda M. J. *et al.* [4]	2015	300.000	71%	29%
Ilunga K. K. A. *et al.* [7]	2022	400.000	64%	36%

Table 2. Average prevalence of the proportions of donations made and donations from voluntary donors between 2000 and 2020 in the DRC.

Study	Publication Year	Volunteer donors (VD)	Replacement donors
Kabinda M. J. *et al.* [4]	2015	34%	66%
Ilunga K. K. A. *et al.* [7]	2022	34%	66%

The average annual mobilization of blood does not reach the WHO objectives in terms of need of 1% to 2% of the total population nor its own objectives of 0.75%. The proportion of blood tested within the standards is lower than the WHO target of 100% and that of CNTS of 80% of blood tested within the standards. We must put the financial means and ensure awareness of voluntary and secure donations to achieve this objective.

At the local or provincial level

Age, Sex and Types of Donors

This review noted the publication of 5 geographical areas out of 8 (62.5%). These are Grand Oriental, Grand Kivu (3 publications), Grand Katanga, the city-province of Kinshasa and the province of Kongo-Central.

The age of donors in general is from 10 to 79 years old, male donors are predominant (from 57.2% to 85.8%) except in Kinshasa in a study carried out in churches (24.7%) and in Kisangani (45.6%), family donors are the predominant type (64.21% to 89.5%) The data presented above are included in **Table 3** [9] [14]-[23].

The age of donors is linked to the selection criteria

The predominance of male donors is commonly reported in low- and middle-income countries [24] in different countries in sub-Saharan Africa, including Angola (73.4%) [11], Gabon (83%), in Burkina Faso (75.6%), Cameroon (78.3%), Sierra Leone (80%), Tanzania (83.7%), Mali (88.8%), Ghana (92.2%), Mauritania (95%) and Nigeria (98.7%) [25]-[33]. It can be explained by the presence of criteria for blood donation limiting female contributions, such as menstruation, pregnancy, breastfeeding and cultural social factors in Africa, which bring women back to second place in related requests. With this type of intervention [34] [35] without forgetting the insecurity due to the war, which limits the displacement of populations and particularly that of women in the DRC.

Transfusion is urgent in the DRC. Male donors are commonly available to supply blood immediately to family, friends or neighbors who need a blood transfusion. Family donors are predominant because not only is the culture of donations not ingrained in us, but also the financial means to raise awareness and educate the population in the culture of voluntary blood donation are insufficient.

The WHO recommends having at least 80% voluntary donors because replacement donations (family and paid) carry a greater risk of infection [16].

Table 3. Breakdown by age, gender and type of publication donations since 2000 by province.

Provinces	Study	Publication Year	Age (years)	M	F	DV	FD	RD
Sud Kivu	Chirimbiza J. P. *et al.* [14]	2018	14 - 62	63.8%	36.2%	56%	44%	-
Sud Kivu	Kabinda M. J. *et al.* [9]	2014	18 - 64	70.3%	29.7%	-	-	-
Tanganyika (Kalemie)	Kabemba B. A. *et al.* [15]	2017	-	57.2%	42.8%	2.3%	89.5%	8.2%
Haut Uélé (Kisangani)	Batina A. *et al.* [16]	2007	18 - 60	45.64%	54.36%	29.2%	69.2%	1.6%
Kinshasa	Tshinguta L. C. *et al.* [17]	2016	18 - 65	24.71%	75.29%	100%	-	-
Kinshasa	Kamangu N. E. *et al.* [18]	2016	-	85.8%	14.2%	-	-	-
Kinshasa	Longo M. B *et al.* [19]	2020	18 - 65	80.5	19.5	32%	68%	-
Maniema (kindu)	Abdala K. A. *et al.* [20]	2016	-	-		13.8%	79.8%	6.4%
Tanganyika (kamina)	Kabamba N. M. *et al.* [21]	2013	-	95%	5%	51.4%	48.6%	-
Kinshasa	Mbendi N. C. *et al.* [22]	2001	10 - 79	77.9%	22.1%	-	-	-
Kongo-Central (Matadi)	Situakibanza N. H. *et al.* [23]	2017	37.43 + 9.6	80%	20%	16.84%	64.21%	18.94%

3.2. Blood Safety

Prevalence of pathogens according to WHO (HIV, HBV, HCV and syphilis)

At the central level, at the National Blood Transfusion Center

The proportion of contaminated donations between 2000 and 2012 with HIV, HBV, HCV and Syphilis is respectively 2.1%, 3.5%, 2.3% and 1.21%. The proportion of contaminated donations between 2010 and 2020 with HIV, HBV, HCV and Syphilis is respectively 1.78%, 2.42%, 1.48% and 1.21%. The average proportion of contaminated blood during the period from 2000 to 2020 for HIV, HBV, HCV and syphilis is respectively 1.9%, 2.96%, 1.89% and 1.21%. The data presented above are included in **Table 4** [4] [7].

At the local or provincial level

This review noted the publication of 5 geographical areas out of the 8, *i.e.* 62.5%. These are Grand Oriental, Grand Kivu, Grand Katanga, the city-province of Kinshasa and the province of Kongo-Central.

Studies carried out in the provinces show that the proportion of blood contaminated with HIV varies from 0.97% to 5.7%, HBV from 1.5% to 5.4%, HCV from 0.2% to 5.8% and Syphilis 0.0% to 3.7% except in the port city of Matadi in Kongo Central where the proportions of blood contaminated with HIV go up to 22.2%, with HBV at 61.1% and HCV at 31.3%. Serodiagnosis of infectious markers on each donation is carried out by the Determine™ HIV-1/2 tests for HIV, Determine™ HBsAg Abbott for HBV, HCV SCAN for hepatitis C and Rapid Plasma Reagin test (RPR 100) for syphilis. The data presented above are included in **Table 5** [3] [9] [14]-[19] [22] [22] [23].

Table 4. Average prevalence of the proportions of infectious markers between 2000 and 2020.

Provinces	Publication Year	HIV	HBV	HCV	Syphilis
Kabinda M. J. *et al.* [4]	2015	2.1%	3.5%	2.3%	-
Ilunga K. K. A. *et al.* [7]	2022	1.78%	2.42%	1.48%	1.21%

Table 5. Prevalence of the proportions of infectious markers between 2000 and 2020 in the different provinces.

Provinces	Study	Publication Year	HIV	HBV	HCV	Syphilis
Sud Kivu	Chirimbiza J. P. *et al.* [14]	2018	1.1%	3.8%	0.7%	0.0
Sud Kivu	Kabinda M. J. *et al.* [9]	2014	1.6%	4.8%	3.9%	-
Tanganyika (Kalemie)	Kabemba B. A. *et al.* [15]	2017	2.2%	1.5%	1%	-
Haut Uélé (Kisangani)	Batina A. *et al.* [16]	2007	4.7%	5.4%	-	3.7%
Kinshasa	Tshinguta L. C. *et al.* [17]	2016	5.7%	-	-	-
Kinshasa	Kamangu N. E. *et al.* [18]	2016	2.1% - 2.3%	-	5.2% - 5.8%	-
Kinshasa	Longo M. B. *et al.* [19]	2020	2.2%	4.0%	1.3%	-
Sud kivu(Bukavu)	Kashosi T. M. *et al.* [3]	2018	0.97%	2.93%	0.97%	-
Tanganyika (kamina)	Kabamba N. M. *et al.* [21]	2013	2.9%	1.6%	0.2%	0.2%
Kinshasa	Mbendi N. C. *et al.* [22]	2001	6.4%	9.2%	-	-
Kongo-Central (Matadi)	Situakibanza N. H. *et al.* [23]	2017	6.3% - 22.2%	5.0% - 61.1%	26.2% - 31.3%	-

The prevalence of HIV, HBV, HCV and syphilis infections at the central level as well as at the local level remained in the range or even lower than that of Sub-Saharan Africa which are respectively 0.4% to 28.3%; 6.1%; 1.6% and 4% - 5% and French-speaking Africa which are respectively 1.06%, 6.7%, 1.3% and 1.3% [32].

This result can be attributed to the fact that the DRC is a conflict zone in its eastern part and the high rate of replacement donors (66%) who are at risk. It is also biased by the fact of reagent shortages and the gradual introduction of screening tests for these pathogens [4].

The very high proportions of contamination in the port city of Matadi can be explained either by the seroprevalence of these viruses in the community or by the poor selection of blood donors or by both factors [23].

Residual risk for HIV, HBV and HCV testing

This review noted the publication of only 1 geographical space out of 8 (12.5%). This is the province of South Kivu. The residual risk for HIV infection varies between 0.6 and 9.7 per 1000 person years, for HBV infection between 7.9 and 29.1 per 1000 person years and for HBV infection, between 3.1 to 9.7 per 1000 person years. The RDTs commonly used in the regulations were compared to the ELISA. The data presented above are included in **Table 6** [3] [6] [9].

Table 6. Residual risk of viral infections (HIV, HBV and HCV).

Provinces	Study	Publication Year	HIV	HBV	VHC
Sud Kivu (Bukavu)	Namululi *et al.* [6]	2009	3.57/1000	25.4/1000	-
Sud Kivu (Bukavu)	Kabinda *et al.* [9]	2014	0.6/1000	7.9/1000	3.1/1000
Sud Kivu (Bukavu)	Kashosi *et al.* [3]	2018	9.7/1000	29.1/1000	9.7/1000

All tests performed on donor blood are serological

These tests are less expensive and their intrinsic test qualities remain limited with low diagnostic sensitivity in the early stages of infection. Since these tests are based solely on the detection of viral antibodies, donors in the seroconversion period or those with an undetectable antibody level cannot therefore be detected by this type of test [3] [6]. The ELISA confirmed some positive cases with rapid diagnostic tests and ruled out others [3].

Thus it is recommended in such circumstances for HIV screening, diagnostic tests detecting at the same time the p24 antigen, other HIV antigens as well as existing anti-HIV antibodies [3] [34] [36]. These data illustrate the infectious risk run by polytransfused patients in a disadvantaged socio-economic context. Given that no diagnostic test is 100% reliable, blood transfusion is always marred by residual infectious risks; but measures aimed at reducing this risk as much as possible should be recommended, such as viral nucleic acid amplification technology including PCR, sequencing or pathogen inactivation techniques using blood, detergents, solvents , ultraviolet rays and riboflavin or even deleukocytation by filtering.

Emerging viruses

The current review has only found one publication from one geographical area out of 8 (12.5%) and only for one virus (PVB19). No space systematically tests for emerging viruses. 48.6% of donors are positive only for IgG antibodies while 40.8% are positive for both IgG and IgM antibodies. 5.3% are positive only for IgM antibodies against PVB19. The data presented above are included in **Table 7** [37]. The pathologies associated with PVB19 are often benign, but transfusion contamination can have serious consequences in three types of recipients [38]:

1) Those with chronic hemolysis and not yet immunized in whom PVB 19 may be responsible for deep central anemia;

2) Immunocompromised patients, in whom viremia can become chronic and be accompanied by profound anemia or even bone marrow aplasia;

3) Non-immune pregnant women in whom the fetus is at risk for anasarca.

For these 3 categories of recipients, it can therefore be proposed to reserve selected labile blood products as donations collected outside the acute primary infection phase.

The identification of such donations could certainly be carried out by viral genomic screening (VGD) for B19, but another possibility, simpler and less

Table 7. Prevalence of parvovirus B19 infections in blood donors.

Provinces	Study	Publication Year	IgG	IgG et IgM	IgM	Laboratory
Kinshasa	CHABO BYAENE ALAIN [37]	**2018**	48.6%	40.8%	5.3%	Elisa

expensive, would be to select immunized donors and located at a distance from their own primary infection. In other words immunized subjects, positive for the specific IgG antibody and negative for the IgM antibody or positive for the IgG twice with a follow-up of a few months [38].

Parvovirus B19 is not the only emerging blood-borne virus circulating in the DRC. There are also HTLV-I, cytomegalovirus. HTLV-I is the basis of leukemia and tropical spastic paraparesis. CMV infection is asymptomatic in the majority of cases, this virus is responsible for seasonal infection of possible transmission by blood. The most vulnerable are transplant recipients, HIV-infected people, cancer patients, pregnant women, premature babies and newborns [39] [40].

After initial contact with the human body, CMV remains latent there and could be reactivated in the event of immunosuppression. It is the cause of many infections: pneumonia, neurological damage, retinitis, ulceration, digestion and others [41]. Cytomegalovirus screening should be either mandatory or indicated for more vulnerable people.

Bacterial Contamination

The current review has only found one publication from one geographical area out of 8 (12.5%). No space tests for bacterial infections. The prevalence of bacterial contamination is 1.4%. The data presented above are included in **Table 8** [42]. The prevalence is lower compared to other countries in sub-Saharan Africa [43] [44] [45] [46] [47] but seems similar to cross-sectional studies of contamination of red blood cells or whole blood in high-income countries (0.18% - 2.2%) and South Africa [43] [48] [49] [50] [51] [52].

The real problem is the fight against the factors that influence bacterial contamination. These factors are the degree of exposure, the ability to reduce this exposure, the prevention of the introduction of bacteria into the blood bag and the limitation of the species of bacteria introduced into the blood bag [44] [45].

Hemoparasites

This review noted the publication of 3 geographical areas out of 8. These are Grand Oriental, Grand Bandundu and the city-province of Kinshasa. The prevalence of malaria infestations is 28.3%, trypanosomiasis 1.3% and babesiosis 0.17%. The data presented above are included in **Table 9** [46] [47] [53] [54]. Malaria, trypanosomiasis, toxoplasmosis, filariasis, leishmaniasis and babesiosis are parasitic diseases transmitted by blood transfusion. The majority of blood banks do not systematically screen for these pathogens. These samples containing these parasites pose a great risk to blood recipients, particularly immunocompromised patients and those who need regular care and frequent and multiple transfusions.

Table 8. Prevalence of bacterial contamination.

Country	Study	Publication Year	Prevalence (%)	Culture résultats (%) gramme + Gram −
RDC	Anne-Sophie Heroes *et al.* [25]	2020	1.4%	85%, 10%, 5% non identifié

Table 9. Prevalence of Malaria, Trypanosomiasis and Babebsiosis infections.

Provinces	Study	Publication Year	Parasites	Prevalence (%)	Laboratory
Haut Uélé (Kisangani)	Jacques Ossinga Bassandja [51]	2014	Malaria	28.3%	G. E
Bandundu (Kikwit)	Lefils Kasiama Ndilu [52]	2016	Trypanosomiasis	1.3%	CATT
Kinshasa	Sokolua E [53]	2014	Babebsiosis	0.17%	G. E
Kinshasa	Mwama Nshimba [54]	2018	Malaria	0.3%	G. E

Parasitic infections depend on several asymptomatic factors, parasitaemia levels, the ability of the parasite to survive in donated stored blood, and infected blood is transfused in a sufficient dose to a susceptible patient.

***Immunological Risks* (*Haemovigilance*)**

ABOD positive blood group

This review noted the publication of only 1 geographical space out of 8 (12.5%). This is the city province of Kinshasa. The profile of GS ABO and Rh D positive was O+: 49.4%, GS A+: 22.2%, GS B+: 20.5% and GS AB+: 4.6%. The data presented above are included in **Table 10** [54].

ABOD negative blood group

This review noted the publication of only 1 geographical space out of 8. This is the city-province of Kinshasa. The profile of GS ABO and Rh D was O−: 1.1%, GS A−: 0.3%, GS B−: 1.4% and GS AB−: 0.3%. The data presented above are included in **Table 11** [54]. This observation is consistent with the work of Lawson in Togo in 2015(14). However, no blood typing errors among donors or recipients were found whereas Mulumba *et al.* (10) working in 6 blood transfusion centers in Kinshasa found 3.4% (2 out of 58 cases).

Alloimmunization

This review noted the publication of 2 geographical areas out of 8 (25%). This is the province of Haut Uélé and Haut Katanga. No space systematically searches for irregular antibodies in donors and recipients. These studies are carried out on very small samples and in sickle cell recipients.

The two studies published in 2010 by Batina Agasa *et al.* and in 2017 Boma Muteb *et al.* (Boma Muteb refer to alloimmunization. The first is a cross-sectional study on 144 sickle cell patients 17 presented an alloimmunization including:

Table 10. Distribution of ABO and Rh-positive blood groups of donors.

Provinces	Study	Publication Year	A+	B+	AB+	O+
Kinshasa	Mwama *et al.* [54]	2018	22.2%	20.5%	4.6%	49.4%

Table 11. Distribution of ABO and Rh-negative blood groups of donors.

Provinces	Study	Publication Year	A−	B−	AB−	O−
Kinshasa	Mwama *et al.* [54]	2018	0.3%	1.4%	0.3%	1.1%

3D, 3C, 2E, 9UI. The second is a retrospective study on 39 sickle cell patients 1 presented an alloimmunization of which 1K. The data presented above are included in **Table 12** [55] [56].

Studies on alloimmunization are fragmented and no systematic research is done in the DRC. The latter is the 3rd country in the world affected by sickle cell disease and the 2nd in Africa after Nigeria [55] [57] and alloimmunization is a frequent complication in sickle cell patients with a frequency of up to 76% [58].

The results of the study by Batina Agasa *et al.* show that antibodies directed against antigens of the Rhesus system are involved (8/17 = 47.05%). They are similar to those of Kabore [59] and Ben Amor *et al.* [60], who had shown in their studies that the alloantibodies found were essentially anti-Rhesus specific. This high frequency reflects the strong immunogenicity of its antigens. On the other hand, Vichinsky *et al.* [61], had reported greater immunization in other erythrocyte systems such as the Kidd, Duffy and MNS systems. This is the case of the study by Muteb *et al.*, which had only one case of the Kidd system in 39 cases. Akre *et al.* [62], for their part, reported that the antibodies directed against the antigens of the Rhesus and Kell systems represented almost 70% of the specificities identified. Unlike our study, Akre *et al.* found anti-KEL antibodies.

Immunization with E antigen (11.76%), C antigen (17.63%) and D antigen (17.63%) is common in this review. This observation had also been made, but rather with the E antigen and the C antigen by Kabore [59], Aguiah Vianou [63] and by Kintomonho [64], also by Adebo and Hounkponou [65]. Our results are in agreement with the literature data.

Allo-immunization leads to great difficulty in transfusing. As Antibodies appear in a recipient and to the extent that they correspond to antibodies of relatively high frequencies, the number of compatible donors becomes smaller and smaller. Anti-erythrocyte alloantibodies can induce severe post-transfusion haemolysis. The clinical consequences range from transfusion inefficiency to patient death [66]. Thus, it is necessary to detect "the subject at risk" of such conflicts during potential or iterative blood transfusion, post-transfusion monitoring and pregnancy.

Reactive Adverse Effects

The current review has only found one publication from one geographic space out of 8 (12.5%) in two different periods (2004 and 2016). This is the city province

Table 12. Prevalence of alloimmunization and irregular antibody types.

Provinces	Study	Publication Year	Techniques	Frequencies	Irregular Antibody types.
Haut Uélé (Kisangani)	Batina Agasa [55]	2010	CGA-USS	17/127 (13.38%)	3D, 3C, 2E et 9UI
Haut Katanga (Lubumbashi)	Boma Muteb [56]	2017	NR	1/39 (2.56%)	1K

of Kinshasa. Haemovigilance remains poorly documented. Mulumba *et al.* reported a frequency of transfusion reactions of 1.8% in Kinshasa in 2004 and Nzengu *et al.* reported a frequency of 3.4% in 2018. The data presented above are included in **Table 13** [54] [67].

Homologous erythrocyte transfusion necessarily brings red blood cells carrying antigens of blood groups unknown to the recipient. These antigens will be likely to trigger immunization with the appearance of "irregular" antibodies, itself likely to lead to delayed haemolysis. If immunization is pre-existing in the recipient, whether "natural" antibodies from the ABO system or "irregular" antibodies from other blood groups, the transfusion will give rise to a hemolysis reaction.

Furthermore, erythrocyte transfusion can bring, in the residual plasma of the RCC, "natural" or "irregular" antibodies present in the donor and directed against blood group antigens which may be found in the recipient. We will then speak of hemolysis linked to passive antibodies. The onset of fever during or following a blood transfusion may be linked to factors including the presence of anti-white blood cell antibodies in the recipient's blood, extra vascular destruction of incompatible red blood cells, presence of incompatible platelets, cytokines, pyrogens endogenous etc.

Metabolic risk

This review noted the publication of only 1 geographical space out of 8 (12.5%). This is the city-province of Kinshasa and only concerned voluntary donors of CNTS. No space systematically measures ferritin.

The prevalence of anemia, iron deficiency anemia and iron deficiency is 36.5%, 25.9% and 63.2% respectively. The data presented above are included in **Table 14** [68]. This result can be explained by the fact that the DRC has a high prevalence of anemia in the donor population (53% women and 20% men) [69]. It shows that the hemoglobin and hematocrit levels used as biological parameters for the recruitment of DS in the transfusion policy remain insufficient to detect iron deficiency in DS [70].

Indeed, a blood donation of 450 ml can cause a loss of 213 to 236 mg of iron, which corresponds to at least one hundred days of dietary iron intake [71] [72]. To prevent these complications in SDs, it is recommended to limit the number of blood donations to 4 per year, whether or not associated with iron supplementation in regular SDs in certain regions [72]. If this standard is not respected,

Table 13. Prevalence of Reactive Adverse Effects (RAE).

Provinces	Study	Publication Year	RAE
Kinshasa	Mulumba *et al.* [67]	2004	1.8%
Kinshasa	Mwama *et al.* [54]	2018	3.4%

Table 14. Prevalence of anemia, iron deficiency anemia and iron deficiency.

Provinces	Study	Publication Year	Échantillons	Iron deficiency	Iron deficiency anemia	Anémia
Kinshasa	Nzengu *et al.* [68]	2016	386	63.2%	25.9%	36.5%

Table 15. Proportions of transfusions used in consumer services.

Study	Publication Year	Pediatrics	Obstetrics gynecology	Other services
Kabinda M. J. *et al.* [4]	2015	75%	15%	10%
Ilunga K. K. A. *et al.* [7]	2022	58.94%	9.70%	31.36%

a regular DS is exposed to iron deficiency which can progress to iron deficiency anemia [72] [73]. This develops in three phases: first a decrease in serum ferritin, then serum iron, then a decrease in the hemoglobin level and finally cytological changes reflected in a decrease in hematimetric constants [72] [74].

Finally, routine ferritin dosage in regular SDs is essential in order to reduce iron deficiency, which represents the most frequent nutritional deficit in the world, particularly in developing countries.

Use of Blood

75% to 59% of donations made between 2000 and 2020 went to the Pediatrics department, 15% to 10% to the obstetrics and gynecology department and 10% to 31% for all other departments. The data presented above are included in **Table 15**. This confirms WHO data on pediatrics [5] as the primary user of donations, but it should be noted in the DRC that this trend has declined over the past 10 years. It could be explained by the use of mosquito nets impregnated with insecticide which would limit the prevalence of severe anemic form of malaria (2014 PNLP report) for pediatrics and the use of utero tonics, misoprostol during childbirth, caesarean section and myomectomy which would prevent heavy bleeding.

4. Conclusion

The prevalence of HIV, HBV, HCV and Syphilis infections is within the range of sub-Saharan African countries. The serological test is systematic and involves the residual risk, it is necessary to introduce the molecular tests. The prevalence of other pathogens (emerging viruses, bacteria and hemoparasites), the immu-

nological and metabolic risk is poorly documented. The search for these pathogens, irregular antibodies and the determination of ferritin in blood donations is not systematic.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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