



Serological profile of blood donors from the hemonucleus of a triple border region

Perfil sorológico de doadores de sangue do hemonúcleo de uma região de tríplice fronteira

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ABSTRACT

To identify reactive seroprevalence and the characteristics (age and sex) of blood donors in a municipality on the triple border, Foz do Iguaçu. Cross-sectional, quantitative study carried out in 2022 at the blood center in Foz do Iguaçu, Paraná, Brazil. The information was obtained from the Blood Bank System and analyzed using the Chi-square and G tests ($p < 0.05$). Among the 16,372 candidates, 14,192 donated blood and 471 were unsuitable due to reactive serology. The analysis showed 3.3% of positive serologies for an infectious agent. The majority were male ($p = 0.3792$) aged over 29 years ($p = 0.0001$), representing 51.6% and 48.4%. Tests for hepatitis B were the most prevalent (54.2%), followed by syphilis (34.0%), human immunodeficiency virus (3.9%) and hepatitis C (3.8%), with a predominance of linked or replacement donors. The reactive seroprevalence detected was higher than that found in different national and international regions.

Descriptors: Border areas. Blood Donors. Seroprevalence. Sexually transmitted infections.

RESUMO

Identificar a soroprevalência reagente e as características (idade e sexo) em doadores de sangue de um município de tríplice fronteira, Foz do Iguaçu. Estudo transversal, quantitativo, no período de 2022, no hemonúcleo de Foz do Iguaçu, Paraná, Brasil. As informações foram obtidas do Sistema do Banco de Sangue e analisadas com os testes de Qui-quadrado e G ($p < 0,05$). Dentre os 16.372 candidatos, 14.192 doaram sangue e 471 foram inaptos por sorologia reagente. A análise mostrou 3,3% de sorologias reagentes para algum agente infeccioso. A maioria do sexo masculino ($p = 0,3792$) com idade acima de 29 anos ($p = 0,0001$), representando 51,6% e 48,4%. Testes para hepatite B foram os mais prevalentes (54,2%), seguidos de sífilis (34,0%), vírus da imunodeficiência humana (3,9%) e hepatite C (3,8%), com predomínio em doadores de vinculação ou reposição. A soroprevalência reagente detectada foi superior a encontrada em diferentes regiões nacionais e internacionais.

Descritores: Doadores de Sangue. Infecções sexualmente transmissíveis. Áreas de fronteira. Soroprevalência.

INTRODUCTION

Blood transfusion is still an irreplaceable and widely used therapeutic process in healthcare.¹ In the United States alone, 13.6 million units of whole blood and red blood cells are collected and approximately 16 million blood components are transfused every year.² In Europe, 17,407,743 units of red blood cells were donated and 22,863,118 transfusions took place in 2019.³

In Brazil, 3,999,937 blood donation candidates were registered and 3,329,713 transfusions were carried out in 2020. Of the collections carried out in the same year, 59,565 bags were discarded because they tested positive for some type of blood-borne agent.⁴

Blood donor screening consists of a standardized interview covering clinical and behavioral aspects, as well as laboratory tests for hepatitis B and C, syphilis, Human Immunodeficiency Virus (HIV), Human T-cell Lymphotropic Virus (HTLV), Chagas' disease and malaria.⁵ Sexually transmitted infections (STIs) are a public health problem due to their complications and are generally related to sexual contact with infected people without the use of condoms.⁶⁻⁸

The transmission of diseases through blood or blood product transfusions can occur, but it has become rare, as the tests used in blood centers in recent years have been highly sensitive. However, if the person is in the immune window, the tests may not detect the infectious agent and could harm the recipients of the contaminated blood.⁸ Therefore, preventing transfusion-transmitted infections among recipients is a fundamental issue in the blood transfusion scenario.

The blood bank in the city of Foz do Iguaçu is located in a triple border region, Brazil-Paraguay-Argentina. It is considered South America's main border in terms of population, movement of people and international relations.⁹

Likewise, this region is recognized as one of the main tourist destinations. In Foz do Iguaçu, the most popular tourist attractions are the Iguaçu Falls and the Itaipu Binacional Hydroelectric Power Plant.¹⁰ In 2022, the Iguaçu Falls received 1.4 million visitors from 148 countries and the Hydroelectric Power Plant 418,819 people.¹⁰ This raises the question: what is the serological profile of blood donors at the hemonucleus in the triple border region of Foz do Iguaçu?

Research on the profile of blood donors at national¹¹⁻¹³ and international^{6,8,14-16} level is available. However, although some studies have been carried out in border regions, such as research in the Netherlands⁶ (bordering Belgium and Germany) and in Nairobi, Kenya¹⁴ (surrounded by the Indian Ocean), studies on this subject in a hemonucleus, located in a triple border region with specific characteristics, have not been found.

Therefore, this study sought to identify reactive seroprevalence and the characteristics (age and gender) of blood donors in a municipality on the triple border, Foz do Iguaçu, Paraná, Brazil, and thus provide support for future interventions that could contribute to health promotion and the prevention of blood-borne disease transmission.

MATERIALS AND METHODS

A cross-sectional, analytical, documental study with a quantitative approach guided by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) instrument.

The study was carried out with data from blood donors from the hemonucleus of the triple international border region, Foz do Iguaçu, considering the period from January to December 2022. The municipality of Foz do Iguaçu is located in the western region of the state of Paraná-Brazil and borders Paraguay and Argentina. The municipality currently has 285,415 inhabitants.¹⁷

The data was obtained through the Blood Bank System (Sistema de Bancos de Sangue, SBS) of the hemonucleus in February 2023, and the following inclusion criteria were considered: data from blood donors (by law, over 18 years old), from anywhere and who passed the clinical screening. Data from candidates who had any hematological complications or had their samples taken were excluded from the study.

Data on the number of donors and unsuitable individuals, the number of donors by gender and age were considered. In addition, data on reactive serologies and whether candidates in the period were first-time or repeat donors.

The data was organized in Excel® spreadsheets (Microsoft Office 2016, Microsoft Corporation, USA), transferred to the Minitab v. 18 program and analyzed using descriptive statistical methods (frequencies and percentages) and analytical statistics (statistical tests - p-value). The Chi-square test and the G-test were used to verify the association between the dependent and independent variables, statistical significance, $p \leq 0.05$.

The research was approved by the research coordination of the Teaching and Research Institute of the Ministro Costa Cavalcanti Hospital, of the Quality, Biosafety and Research Division of the HEMEPAR network, by process no. 407.155 of 30/09/2022 and by the Human Research Ethics Committee, according to the Certificate of Presentation for Ethical Appreciation (CAAE) 67378023.7.0000.0107 and opinion no. 5.975.391 of 30/03/2023. All ethical and legal aspects were respected, in accordance with Resolution 466/2012 of the National Health Council.

RESULTS

The analysis carried out at the Foz do Iguaçu blood center between January and

December 2022 identified 16,372 candidates for blood donation. Of these, the number of people who actually donated blood in the year analyzed was 14,192, 86.7% of whom were considered suitable and 13.3% unsuitable for various reasons. Of all the applicants for blood donation, 6,022 (36.8%) were first-time donors and 10,350 (63.2%) had donated once in their lives, which is considered a repeat donation (Table 1).

Table 1. Blood test results of blood donors from the hemonucleus of Foz do Iguaçu, Paraná, Brazil, in 2022.

Characteristics	Frequency	
	N	%
Donor profile		
Suitable donors	14,192	86.7%
Unsuitable donors	2,180	13.3%
Total	16,372	100.0
Type of donation		
First donation	6,022	36.8%
Repeat donation	10,350	63.2%
Total	16,372	100.0

Source: Prepared by the authors based on data from the Foz do Iguaçu hemonucleus, 2022.

Of the candidates who came to the blood center and were suitable to donate blood, 6,323 (44.5%) were spontaneous/voluntary donors, 7,865 (55.4%) were replacement/connection donors and four people were suitable for autologous donation. Of the unsuitable candidates, 840 (38.5%) were spontaneous/voluntary donations and 1,340 (61.4%) were tied/replacement.

In relation to gender, the most frequent donors were male (53.8%) compared to female (46.2%), while the donors who were unsuitable for different reasons were female (52.2%) and male (47.8%), with a statistical difference between the suitable and unsuitable when these

data were categorized by gender ($p=0.0001$) (Table 2). The most frequent age observed in suitable candidates, as well as in those unsuitable

for different reasons, was over 29 (65.9%) and (55.1%), then between 18-29 (33.1%) and (42.8%) ($p=0.0001$) (Table 2).

Table 2. Sociodemographic characteristics of blood donors, suitable and unsuitable for different causes at the hemonucleus of Foz do Iguaçu, Paraná, Brazil, in 2022.

Variables	Suitable for blood donation	Unsuitable for various reasons	p-value
	n (%)	n (%)	
Gender			
Male	7629 (53.8%)	1043 (47.8%)	0.0001*
Female	6563 (46.2%)	1137 (52.2%)	
Total	14192 (100.0%)	2180 (100.0%)	
Age			
Under 18 years of age	146 (1.0%)	45 (2.1%)	0.0001*
18-29 years old	4698 (33.1%)	933 (42.8%)	
29+ years old	9348 (65.9%)	1202 (55.1%)	
Total	14192 (100.0%)	2180 (100.0%)	

*Chi-square test. Source: Prepared by the authors based on data from the Foz do Iguaçu hemonucleus, 2022.

Among the unsuitable donors by serology, (51.6%) were men and (48.4%) women ($p=0.3792$). Most unsuitable donors were over the age of 29 (81.3%), followed by donors aged 18-29 (18.5%) and only (0.2%) donors under the age of 18 ($p=0.0001$) (Table 3).

In relation to the gender of donors who were unsuitable due to inconclusive results, both had the same number of people, as shown in Table 3. In terms of age, there was a predominance of people aged over 29 (65.9%), 18-29 (33.1%) and under 18 (1.0%) ($p=0.0001$) (Table 3).

Of the 14,192 candidates who passed the clinical and hematological screening and

underwent blood collection for serological tests, 471 (100.0%) donors were unsuitable due to a reactive serology result and eight donors had inconclusive results (Table 3).

It was also observed that four people had inconclusive results for one transmitting agent, as well as having a reactive result for a second agent, thus being on the list of people with positive serology. Furthermore, three samples were inconclusive for the detection of Hepatitis B Virus (HBV) capsid antibodies and one for HTLV, and all were reactive for syphilis.

Table 3. List of blood donors, suitable, unsuitable by serology and unsuitable inconclusive, according to gender and age at the blood center in Foz do Iguacu, Paraná, Brazil, in 2022.

Variables	Suitable for blood donation	Unsuitable by serology	p-value	Unsuitable inconclusive
	n (%)	n (%)		
Gender				
Male	7629 (53.8%)	243 (51.6%)	0.3792 ^a	4 (50%)
Female	6563 (46.2%)	228 (48.4%)		4 (50%)
Total	14192 (100.0%)	471 (100.0%)		8 (100.0)
Age				
Under 18 years of age	146 (1.0%)	1 (0.2%)	0.0001 ^b	1 (12.5%)
18-29 years old	4698 (33.1%)	87 (18.5%)		5 (62.5%)
29+ years old	9348 (65.9%)	383 (81.3%)		2 (25.0%)
Total	14192 (100.0%)	471 (100.0%)		8 (100.0%)

^aTeste do Qui-quadrado; ^bG test. Source: Prepared by the authors based on data from the Foz do Iguacu hemonucleus, 2022.

Among the 471 donors who were unsuitable due to serology, 278 had serology for hepatitis B, which was the main cause of unsuitability detected during the period investigated. Of the three tests carried out, anti-HBc detected the highest number of hepatitis B cases (48.4%), followed by the Hepatitis B Surface Antigen (HBsAg) test (4.4%) and the Hepatitis B Virus (HBV) Nucleic Acid Test (NAT) (1.4%). However, among these reactive results for hepatitis B, 269 donors were identified as positive for the disease, as nine people had more than one positive result in the same sample, two people

had two positive samples and seven had a reactive result in all three tests for hepatitis B (Table 4).

The second cause of serological unsuitability was syphilis, with 34.0% of the samples positive. The third was HIV, with 2.4% of cases testing positive for HIV I/II and 1.5% for HIV NAT. Hepatitis C was then detected, with 3.4% of cases for the detection of antibodies against the Hepatitis C Virus (anti-HCV) and 0.4% for the Hepatitis C Virus (HCV) Nucleic Acid Test (NAT), two of which were positive. Tests for anti-HTLV showed 2.1% of cases, and for Chagas' disease 2.0% of positive samples (Table 4).

Table 4. List of diseases and reactive serologies, number and percentage of samples from blood donors at the hemonucleus in Foz do Iguacu, Paraná, Brazil, in 2022.

(Continued)

Disease	Reactive	Reactive samples	% in reactive samples (n=471)
Hepatitis B	Anti-HBc	249	48.4%
	HBsAg	22	4.4%
	NAT HBV	7	1.4%
Subtotal		278	54.2%
Syphilis	IgG anti <i>T. pallidum</i>	176	34.0%

(Conclusion)

Disease	Reactive	Reactive sam- ples	% in reactive samples (n=471)
Subtotal		176	34.0%
Human Immunodeficiency Virus	Anti-HIV I/II	12	2.4%
	NAT HIV	8	1.5%
Subtotal		20	3.9%
Hepatitis C	Anti-HCV	17	3.4%
	NAT HCV	2	0.4%
Subtotal		19	3.8%
Human T-cell Lymphotropic Virus	Anti-HTLV I/II	11	2.1%
Subtotal		11	2.1%
Chagas' disease	IgG anti <i>T. cruzi</i>	10	2.0%
Subtotal		10	2.0%
Total		514	100.0

Abbreviations: Anti-HBc = Hepatitis C Virus Antibody; HBsAg = Hepatitis B Surface Antigen; NAT = Nucleic Acid Test; HBV = Hepatitis B Virus; IgG anti *T. pallidum* = detection of immunoglobulin G against the *T. pallidum* bacterium. pallidum; Anti-HIV I/II = detection of antibody against Human Immunodeficiency Virus I/II; NAT = Nucleic Acid Test; HIV = Human Immunodeficiency Virus; Anti-HCV = detection of antibody against Hepatitis C Virus; NAT = Nucleic Acid Test; HCV = Hepatitis C Virus; Anti-HTLV = detection of antibody against Human T-cell Lymphotropic Virus I/II; IgG anti *T. cruzi* = detection of immunoglobulin G against the protozoan *T. cruzi*. Source: Prepared by the authors based on data from the Foz do Iguacu hemonucleus, 2022.

Of the donors who tested positive, 16 reacted to more than one potential infection-transmitting agent: hepatitis B and syphilis (13 donors), hepatitis B and Chagas' disease (1 donor), syphilis and HIV (1 donor) and syphilis and HTLV (1 donor).

Of the 471 donors who were unsuitable due to reactive serology, 39 (8.2%) had previously donated blood between six months and one year ago and had seroconverted. Of these, 16 (41.0%) tested positive for syphilis, 12 (30.7%) for hepatitis B, five (13.0%) for hepatitis C and two (5.1%) for HIV, HTLV and Chagas' disease, respectively. Of the donors who returned to the hemonucleus and had their tests repeated, 21 samples confirmed the previous results, 10 were negative and one sample showed an inconclusive result, while seven people did not show up at the hemonucleus.

DISCUSSION

The use of blood components and blood derivatives in countless health conditions and

services, especially in Foz do Iguacu, a triple border region, is extremely important. The region encompasses the cities of Foz do Iguacu (Brazil), Ciudad Del Este (Paraguay) and Puerto Iguazu (Argentina), which have a combined population of over 500,000, making it possible for people who live in the border area to commute daily between home and work, study, shopping and health services without permanently changing their place of residence.^{18,19}

In addition, approximately 20,000 foreigners study at universities in Foz do Iguacu and the region, 98.0% of whom are Brazilian and complement commuter migration at the border.²⁰ The region also receives visitors from different parts of the world (148 countries) with specific cultures.¹⁰ Given the daily movement of residents and the circulation of people from different countries, with the possible spread of STIs, ensuring blood quality is essential.

In this study, the percentage of unsuitable donors for various reasons is related to personal

data, clinical, laboratory and epidemiological conditions that do not comply with the current acceptance criteria for blood donation. Depending on the person's history, they can be a first-time, repeat or sporadic donor.⁵

In relation to the serology of blood donors, the percentage found was similar to that observed at national level in 2020, which corresponds to 3.1% of serologically unsuitable people.⁴ Another study also carried out in the southern region of Brazil reported a lower seroprevalence than this study, with 0.4% in the state of Paraná, between 2018 and 2019.¹²

In other regions of the country, in the Southeast, in the state of São Paulo, the percentage was 2.1% between 2015 and 2019¹¹ and in the North, in the state of Pará, an investigation also carried out between 2015 and 2019, reported 0.3% of serological inaptitudes.²¹ According to the National Health Surveillance Agency (Agência Nacional de Vigilância Sanitária, Anvisa), the higher serological prevalence shown in the current study is related to risk behavior for STIs.⁴ This highlights the need to develop and implement public policies aimed at preventing STIs, with subsequent changes in the sexual behavior of the population in the Triple Frontier region.

A study carried out at the Specialized Care Centre in Foz do Iguaçu investigated the prevalence of syphilis and other STIs and sexual risk behaviour in individuals with human immunodeficiency virus and found a prevalence of syphilis and other STIs of 9.5% and 5.2%. The majority of participants were aged between 18 and 44, single/not dating, with one to five male sexual partners and low condom use ($p < 0.05$). In addition, they were residents of Foz do Iguaçu and medical students in Ciudad Del Este ($p < 0.05$), indicating that the degree of awareness about STI transmission should be relatively uniform, but the findings indicated that the participants were not concerned about STI transmission.⁷

In Nanjing, China, during 2019, a seroprevalence of 7.0% was identified in blood donors⁸, in India, in 2017, (4.7%)²², in Nairobi, Kenya, in 2019 (2.3%)¹⁴, in the Netherlands, 2020 (0.7%)⁶ and in Switzerland, during the year 2017 to 2018 (0.9% - 1.6%).¹⁵ It is worth pointing out that there is a great deal of variation between international data, as countries have different forms of clinical and serological screening, and as a result of the great local influence of infections.

In relation to the pattern of donation in the unsuitable candidates in this study, the higher prevalence of tied/replacement donation explains the serological percentage of unsuitability shown in this study, i.e. tied or replacement donation is aimed at supporting sick friends or family members. The voluntary donor is likely to become a loyal donor, with greater awareness of the donation process and a lower risk of blood-borne infections.²³

In relation to gender, in the current study, the similar percentage between men and women, when comparing suitable and unsuitable donors, corroborates a study carried out in the state of Paraná, Brazil, when comparing the variable, gender, among unsuitable candidates, the affected people had similar percentages.¹²

In relation to age, the statistically significant difference in the comparison between suitable and unsuitable donors, with a prevalence of over 29 years, is similar to that shown at national level by the 9th Annual Blood Production Bulletin.⁴ In the state of Pará, Brazil, the mean age of blood donors was 40 years, with a peak in the 36 to 46 age group²¹ and in the state of Bahia, Brazil, 30 years or more.¹³ In Canada, the mean age was 47.²⁴ Although this study was carried out on the general donor population, and did not consider only unsuitable donors, it could solidify the findings in relation to the age peak with the highest occurrence.

As for the infections found in this study, the predominance of hepatitis B, followed respectively by syphilis, HIV I and II, hepatitis C,

HTLV I and II and Chagas' disease, differs from the data issued by Anvisa's Hemotherapy production bulletin for 2020, with a higher prevalence of reactive serologies for syphilis and hepatitis B at the national and regional level, in the Midwest, Northeast and Southeast.⁴ However, there was a coincidence in the same serology pattern between the general results of this survey and what happened in the North and South of Brazil, as presented by Anvisa.⁴

In the state of Paraná, the main disqualifications found between 2018 and 2019 were hepatitis B, followed by hepatitis C and HIV. This result is in line with the findings of this study regarding hepatitis B and HIV, but differs from the finding of hepatitis C reactive as the second cause.¹² Conversely, in southern Ethiopia, the predominance of positive serology was for hepatitis B, HIV, hepatitis C, followed by syphilis.¹⁶

Hepatitis B is investigated in hemotherapy services by testing for anti-HBc, HBsAg and NAT-HBV, with anti-HBc reacting most frequently. The higher rate of total anti-HBc reactivity is explained by the association between anti-HBc IgM and anti-HBc IgG, due to the persistence of reactivity after the end of the infection, identifying the donor as a risk group.²⁵ In the present study, the 48.4% anti-HBc percentage indicates concern.

According to the Viral Hepatitis Epidemiological Bulletin, a significant proportion of confirmed hepatitis B cases in Brazil are concentrated in the Southeast, followed by the South, North, Northeast and Midwest regions.²⁶ HBV is still considered the virus with the highest risk of transfusion transmission, compared to HIV and HCV.⁴

As for syphilis, the second cause of serological unsuitability in this study, unlike the global scenario, in Brazil the number of cases has been increasing. In 2022, the detection rate for acquired syphilis was 99.2 cases/100,000 inhabitants, syphilis in pregnant women 32.3 cases/1,000 live births and congenital syphilis

10.3/1,000 live births.²⁷ In some Brazilian international border regions, depending on their specificities, this reality is even more worrying, especially in congenital infection, as evidenced in the state of Rio Grande do Sul and the city of Uruguaiana, from 2011 to 2020, where the mean annual incidence rates were 13.2 and 12.3 cases/1,000 live births,²⁸ and in the state of Paraná, from 2017 to 2021, with a mean annual rate of 85.2 cases/100,000 live births.²⁹

HIV was the third cause of serological unsuitability, a fact that is justified by the reduction in the number of notifications identified throughout Brazil. However, from 2007 to June 2022, 434,803 cases of HIV infection were reported in the country, the majority of which were in males (70.2%).²⁶

It should be noted that in this study, four people tested positive for a second infectious agent. In addition, three samples were inconclusive for HBV and one for HTLV, and all three were reactive for syphilis. These findings reinforce the hypothesis of behavioral risks, especially unprotected sex, since these diseases are transmitted mainly through sexual intercourse, the use of injectable illicit drugs and other routes of exposure to blood and blood products.^{4,12}

In this context, Foz do Iguaçu has phenomena that provide conditions for exposure to behavioral risks, including the proximity between the countries that make up the triple border, Brazil-Paraguay-Argentina. In addition, access is free, with no bureaucratic procedures at the customs office linking Brazil and Paraguay. Nevertheless, the number of people looking for tourism, education, culture and leisure on the triple border is increasing day by day.⁹ This dynamic allows for contact between people from different regions of the world, with the possible spread of STIs.³⁰ This set of phenomena shows the importance of building trinational border policies, especially between Brazil, Paraguay and Argentina, aimed at preventing STIs.

The use of condoms in sexual relations is important, the contraceptive method of prevention is provided free of charge by public health services, however, the search for these services to obtain condoms in all Brazilian regions is low (10.7%).³¹ Thus, the expansion of combined prevention, whose basic premise is the specificities of the subjects and their contexts, the individual characteristics and the moment of life of each person, with the simultaneous use of different prevention approaches, biomedical, behavioral and structural, becomes necessary.³²

The limitations of this study refer to the fact that other sociodemographic variables were not identified, as well as a longer period to compare them. However, it is considered that there was no interference in the results obtained. We suggest expanding the time frame and comparing them on an annual basis, as well as studies that reveal the reasons why these donors are not loyal.

CONCLUSION

It was observed that in the hemonucleus of Foz do Iguaçu, the rate of unsuitable donors in serological screening was higher than that found in different national and international regions. There was a prevalence of hepatitis B, followed by syphilis, HIV, hepatitis C, HTLV and Chagas' disease, with a predominance in linked or replacement donors, in males and in the 29+ age group.

It is inferred that the seroprevalence of reactive serologies found is a reflection of phenomena existing in the triple border region, with subsequent favoring of exposure to behavioral risks.

Therefore, it is hoped that this study will contribute to the design and implementation of border programs involving combined prevention, considering Brazil, Paraguay and Argentina, with a view to raising awareness among the population

about safe sexual behavior and STI prevention.

Finally, future research in the area of hemotherapy and hematology services could help identify weaknesses and analyze operational issues that reflect on the performance of services and the management of actions, with a view to strategies to increase the number of donors at the Foz do Iguaçu hemonucleus.

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