# Demographic profile of blood donors at three major Brazilian blood centers: results from the International REDS-II study, 2007 to 2008

*Anna Bárbara Carneiro-Proietti, Ester C. Sabino, Divaldo Sampaio, Fernando A. Proietti, Thelma T. Gonçalez, Cláudia D.L. Oliveira, João E. Ferreira, Jing Liu, Brian Custer, George B. Schreiber, Edward L. Murphy, and Michael P. Busch*

**BACKGROUND:** The profile of blood donors changed dramatically in Brazil over the past 20 years, from remunerated to nonremunerated and then from replacement to community donors. Donor demographic data from three major blood centers establish current donation profiles in Brazil, serving as baseline for future analyses and tracking longitudinal changes in donor characteristics.

**STUDY DESIGN AND METHODS:** Data were extracted from the blood center, compiled in a data warehouse, and analyzed. Population data were obtained from the Brazilian census.

**RESULTS:** During 2007 to 2008, there were 615,379 blood donations from 410,423 donors. A total of 426,142 (69.2%) were from repeat (Rpt) donors and 189,237 (30.8%) were from first-time (FT) donors. Twenty percent of FT donors returned to donate in the period. FT donors were more likely to be younger, and Rpt donors were more likely to be community donors. All were predominantly male. Replacement donors still represent 50% of FT and 30% of Rpt donors. The mean percentage of the potentially general population who were donors was approximately 1.2% for the three centers (0.7, 1.5, and 3.1%). Adjusting for the catchment's area, the first two were 2.1 and 1.6%.

**CONCLUSIONS:** Donors in the three Brazilian centers tended to be younger with a higher proportion of males than in the general population. Donation rates were lower than desirable. There were substantial differences in sex, age, and community/replacement status by center. Studies on the safety, donation frequencies, and motivations of donors are in progress to orient efforts to enhance the availability of blood.

To ensure an adequate blood supply, it is crucial to recruit suitable blood donors. These are ideally individuals with low risk for infectious diseases, who are in good health, and who are willing to spend their time to help someone out of a sense of solidarity and altruism. Before the late 1970s and early 1980s, blood collections in Brazil were mainly performed by private blood banks. Cash reimbursement for donation was a common practice, and there were few laws regulating blood bank activities. An assessment performed for the Brazilian Ministry of Health Blood by the World Health Organization (WHO) in the early 1970s documented serious problems with the blood banking policies and practices,[1] which led the federal government to define blood safety as a national security problem. Measures were taken to improve the safety and quality of blood and components, especially after the onset of the

**ABBREVIATIONS:** FH-MG = Fundação Hemominas; FH-PE = Fundação Hemope; FPS = Fundação Pró-Sangue; FT = first-time (donor); Rpt = repeat (donor).

From the Hemominas Foundation, the Pró-Sangue Foundation, and the Hemope Foundation, Federal University of Minas Gerais, Belo Horizonte, Brazil; Federal University of São João Del Rei, São João Del Rei, Brazil; University of São Paulo, São Paulo, Brazil; the Blood Systems Research Institute, San Francisco, CA; and Westat, Rockville, Maryland.

*Address reprint requests to:* Anna Bárbara Carneiro-Proietti, Hemominas Foundation, Rua Grão Pará, 882 Belo Horizonte, Minas Gerais, Brazil 30150-241; e-mail: anna.proietti@hemominas.mg.gov.br, annaproietti@gmail.com.

ABCP, ECS, ELM, and MPB contributed equally to the article.

Received for publication September 4, 2009; revision received October 10, 2009, and accepted October 11, 2009.

doi: 10.1111/j.1537-2995.2009.02529.x

**TRANSFUSION** 2010;50:918-925.

AIDS epidemic, when blood transfusion practices became an important political issue.[2,3]

The Brazilian network of public blood centers was created in the late 1970s and early 1980s, as a response to these blood safety concerns. Although the centers were under the state administrations, federal funds were allocated to support these public blood centers, and cooperation with the French government made it possible to train a large number of professionals in blood collection and processing and transfusion practices.

Blood transfusion is now regulated by the Federal Government through Anvisa, the national health surveillance agency, and by the Blood Coordination Office in the Ministry of Health, which is responsible for the policies of the system. Specific methods are defined for donor recruitment, deferral criteria, laboratory tests, proper handling, and related component preparation procedures.[2] The regulations are very similar to those in place in the United States and Europe, and internationally accepted procedures and guidelines are used as reference in the development of Brazilian rules and practice guidelines.[1]

In addition to establishing "sanitary policies" regarding donor selection, blood testing, and handling of blood products, paid blood donations were forbidden.[2] The prohibition from paid donations could have had an enormous impact on the blood supply due to the lack of experience of centers in recruiting voluntary blood donors. General concern that this prohibition would dramatically decrease blood availability led Brazilian blood centers to rapidly develop programs to recruit donors among friends and relatives of hospitalized patients, termed "replacement donors." This procedure had the effect of maintaining the blood supply, after the sudden reduction in collections due to the elimination of paid blood donors, and replacement donors became the major source of blood units in Brazil in the 1980s.

One of the main problems in relying on this type of donor is that most of them are first-time (FT) blood donors, so the prevalence of infectious disease markers is higher,[3-5] leading to an elevated percentage of discarded units and greater risk of a window-period donation. In addition, families and friends of patients were frequently "asked" to donate in a forceful way. Replacement donations, solicited before medical procedures, with numbers determined by the hospitals/procedures, were compulsory before the patient would be treated or undergo surgery. This led to an undesirable situation where, in the quest for blood donors, the patients and/or their families would recruit potential donors at the entrances of blood banks to donate in the name of a specific donor, sometimes offering to pay these unrelated individuals for blood donation. Hence, some donors were still paid, although not by the blood bank.

Recognizing the inherent problem with these practices, concerted efforts were made during the 1990s to change the blood donor supply from replacement FT donors to community voluntary repeat (Rpt) donors. However, still today, replacement donors are responsible for up to 50% of blood donations in many regions of Brazil.[2]

It is estimated that 3 million units of blood are collected per year in Brazil, with approximately 70% of donations in these regions collected through the public system.[1,2] However, national studies on blood donation are scarce in Brazil. Data on blood donation and use are now compiled, in a semimanual way, at the federal level by Anvisa and by the Blood Coordination Office, but these data are usually incomplete and outdated.[1,2] Although blood donor systems in Brazil are required by law to store their donor/and donation data, they have been unable to combine data from multiple centers or systematically analyze these data due to lack of computer database systems with the capacity to create and analyze large data sets.

The NHLBI International REDS-II study in Brazil started in 2007 and is comprised of three major public blood banks. Two of them are in the Southeast region of Brazil,[6] where most of the blood is collected, while the third is in Northeastern coastal Brazil. There are considerable regional differences between the Southeastern and Northeastern parts of Brazil,[7] and differences in blood donor profile and behavior were expected. This work describes the demographic profile of blood donors in the three centers, how it compares with the general population of the cities where each center is located, and discusses strategies to increase the proportion of the general population that donates blood in Brazil.

## MATERIALS AND METHODS

### Participating centers in Brazil

The International REDS-II study in Brazil includes three blood centers: 1) Fundação Pró-Sangue (FPS), in São Paulo; 2) Fundação Hemominas (FH-MG) in Minas Gerais, both in the southeastern part of Brazil; and 3) Fundação Hemope (FH-PE), in the State of Pernambuco, in the Northeastern part of the country. Donor and donation data from each center are centralized in a single data warehouse in São Paulo and then transferred to a coordinating center in the United States. This direct extraction minimizes errors related to the consistency of the data and facilitates the data analysis. This study is part of the international arm of REDS-II that conducts research studies involving safety and adequacy of the blood supply. Standardized demographic and test data on all blood donations are collected, prepared, and electronically sent to the study coordinating center (Westat, Rockville, MD) for compilation and analysis.

FPS is based at a major public hospital (Hospital das Clínicas of the São Paulo University) in São Paulo, Brazil. It is the largest single blood bank in Latin America, collect-

ing, testing, and processing approximately 90,000 units of blood annually, which represents approximately 33% of the blood collected in the public system of the city of São Paulo, a city with approximately 19 million inhabitants, with 12,678,096 ranging from 18 to 65 years old and hence potentially eligible to donate blood.

FH-MG collects blood for the State of Minas Gerais and is responsible for 92% of the blood collected in the state.[7] Donor and donation data from Belo Horizonte, the capital of the state are included in REDS-II International Brazil. Belo Horizonte Blood Center is the main center, collects approximately 50,000 units of blood that are processed and distributed to 76 hospitals, located in 32 cities in the Belo Horizonte metropolitan area, which has 5,195,817 inhabitants, with 3,249,787 in the 18 to 65 years old range.

FH-PE is the blood center of the state of Pernambuco. Donor and donation data from the main center located in Recife, the capital of the state of Pernambuco, is included in REDS-II. This facility collects approximately 75,000 units of blood per year and has coverage estimated in 98% of the blood needs of the area. This unit supplies blood to various hospitals in the metropolitan area, which has 2,681,970 inhabitants, with 2,399,557 in the 18 to 65 years old range.

### REDS-II project structure

This study is part of the international arm of REDS-II that conducts research studies involving safety and adequacy of the blood supply. Standardized demographic and test data on all blood donations are collected, prepared, and electronically sent to the study coordinating center (Westat) for compilation and analysis.

### Data collection and storage

Demographic data from January 2007 to December 2008 were extracted from the computer system of each center and sent to a data warehouse at the University of São Paulo. Data included coded donor identification, age, sex, self-reported skin color (captured as five options but recoded into white, black, mixed, or other), and educational attainment. The number of donations in the year was recorded and donors were classified according to the number of times they donated, as follows:

- FT donors only—those who never donated blood in the center before and gave only once in 2007 to 2008.
- Returning FT donors—those who donated for the first time in 2007 to 2008 and returned again in the period.
- Rpt donors only—those who previously donated in the center and donated at least once in the period.

For the analysis, we have considered FT donors as those originally classified as FT donors only or returning FT donors, and Rpt donors classified as returning FT donors or Rpt donors only. Donor type (replacement, community, autologous, directed) and donation type (whole blood or apheresis) were also evaluated.

### Data warehouse architecture for REDS-II International Brazil

For the REDS-II project we had to address the different operational database structures used by the three centers. The heterogeneous operational databases and distinct data coding practices required the development of specific algorithms for data processing. The central data warehouse architecture has hierarchical levels, as follows:

- Level 1—raw data, that is, transactional database: donations, exams, and clinical data.
- Level 2—transformation into the warehouse database: this Level 2 integrates all primary data belonging to Level 1. Modular inclusion of information in Level 1 is achieved by building, at this level, a data warehouse on top of the operational databases of Level 1.
- Level 3—implements online analytical process queries. Online analytical process is a decision support system that allows for easy querying on the underlying relational databases.

Data were prepared for monthly downloads from the operational databases of each center, other data elements captured included select demographic and personal data (country of birth, ever transfused, zip code), donation data (date of donation, blood unit number, FT/Rpt donation, donation type [whole blood, apheresis], donor type [community/altruistic, replacement, autologous]), and infectious disease data (screening and alternate enzyme immunoassay or other confirmation test data for human immunodeficiency virus [HIV], human T-lymphotropic virus, hepatitis B virus, hepatitis C virus, syphilis, and *Trypanosoma cruzi*). The data were then transferred to Westat quarterly where additional quality assurance and/or quality control procedures were conducted before analyses of the information were performed.

### Statistical analysis

This was a descriptive study, which included all presenting donors. Donors were classified with respect to their first donation made in 2007 to 2008. The information about skin color and educational level was not asked in FH-MG until April 2008 and therefore was not available before this date. The donor profile was compared with the population 18 to 65 years old for the regions studied, available in the official government statistics (Datasus) for each metropolitan area.[7] Frequency distributions were performed by Westat, after data cleaning, using computer software (SAS, Version 9.1.3 for Windows, SAS Institute, Inc., 2003-2004, Cary, NC).

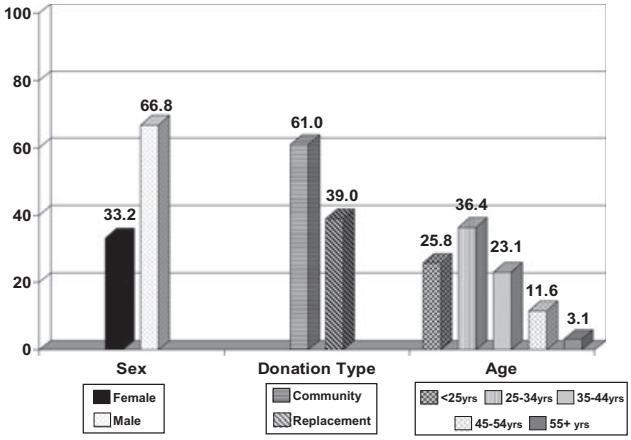


**Fig. 1. Percentage of all donors by sex, donation type, and age in the three centers, Brazil, 2007 to 2008.**

## RESULTS

From January 2007 to December 2008, 410,423 individuals donated blood to the three centers, giving a total of 615,379 units of whole blood or platelets by apheresis donations and including 91 stem cells and five unknown donation types. A total of 44.7% of the donors were from São Paulo (FPS), 31.4% from Recife (FH-PE), and 23.9% from Belo Horizonte (FH-MG). The mean number of donations per donor per year was 1.48 in FPS, 1.58 in FH-PE, and 1.42 in FH-MG in the 2-year period.

Overall, the number of male donors was more than twice as high as that of females (Fig. 1 and Table 1). However, there was a significant regional variation with Recife having the lowest percentage of female donors (20.0%), whereas Belo Horizonte (38.2%) and São Paulo (39.8%) had similar proportions. As for the donation type, community donors were higher than replacement (61.0% vs. 39.0%), but with regional variation, with FPS having the highest proportion of community donors (75.7%) and FH-MG the lowest (46.4%).

When the sex of FT or Rpt status (Fig. 2) was compared, we observed that the proportion of female donors was higher in FT donors (39.6%, Fig. 2A) than Rpt during the period (28.8%, Fig. 2B). Replacement donors were less frequent among Rpt (37%) than FT donors (46.4%). FT donors were younger than Rpt donors.

Donor educational level was uneven across the three centers. With considerable data missing for education in FH-PE and FH-MG (Table 1), data were analyzed after excluding these sites. The findings for education tended to concentrate in donors who completed 11 years of education (essentially equivalent to completing high school in the United States), with few donors on the extremes: elementary education or less and college or higher. There were several differences across centers, with São Paulo showing a higher percentage of donors with 11 years of education and above (76% vs. 68% for Belo Horizonte and 63% for Recife), whereas Recife showed a higher percentage of donors with less than 8 years of education (21.6% vs. 17.8% for Belo Horizonte and 12.5% for São Paulo).

Skin color was evaluated in the three centers (Table 1) and showed that in Recife and Belo Horizonte the self-reported mixed skin color group predominated (60.8% and 47.1%), whereas in São Paulo most of the donors (54.6%) were white. The proportion of black donors in Belo Horizonte (18.1%) was twice as high as in São Paulo (9.7%) and Recife (9.4%). We also found that the demographic distribution between community and replacement donors was similar across centers (not shown).

The proportion of donors compared with the age eligible (18-65 years of age) general population of each corresponding metropolitan area was 1.3% overall. By blood center, the percentages were 0.7% for FPS, 1.5% for FH-MG, and 3.1% for FH-PE. Despite these apparent differences, when we adjust for the percentage of blood each center collects in their catchment area, the proportions of FPS and FH-MG were closer (2.1 and 1.6% of the population). FH-PE, which is virtually the sole blood provider in its region, has the highest proportion of the population donating blood.

## DISCUSSION

For the first time a comprehensive database exists composed of donor and donation data from three geographically dispersed blood centers in Brazil. Although they are not representative of the whole country, which is continental in its extension, the three centers are from regions with diverse socioeconomic and cultural conditions and therefore give a picture of blood donation patterns in the country. The data capture system that was developed for collecting operational and select demographic data of each center and transferring it to a single data warehouse involved considerable work of translating the local operational data elements into common definitions. This recoding of the data element structure was crucial to establish a common language and develop a system based on an information technology that will stay within Brazil and that can be expanded in the future to other blood centers to enable us to monitor blood collections in Brazil.

In the past 10 to 15 years, Brazilian public health policies have sought to change the profile of blood donation from remunerated to nonremunerated blood donors[1-3] and from replacement donors to community volunteer blood donors, because they are thought to be safer.[8] The proportion of "safe donors," based on low infectious disease rates, is considered higher where all donors are volunteer and nonremunerated, conditions that exist in 85% of developed countries, but in only 15% of developing ones and in only 7% of undeveloped countries.[5] For example, in Trinidad and Tobago, 87% of blood donations were

**TABLE 1. Donor demographic characteristics by donation type and blood center, REDS-II, Brazil, 2007 to 2008***

| | FPS-SP | | | FH-MG | | | FHP-PE | | |
|---|---|---|---|---|---|---|---|---|---|
| Demographic | Community | Replacement | Total | Community | Replacement | Total | Community | Replacement | Total |
| Total | 75.7 | 24.3 | 183,306 (100) | 46.4 | 53.6 | 97,983 (100) | 51.3 | 48.7 | 129,134 (100) |
| Sex | | | | | | | | | |
| Males | 59.7 | 61.7 | 110,297 (60.2) | 59.1 | 64.1 | 60,549 (61.8) | 77.1 | 83 | 103,260 (80) |
| Females | 40.3 | 38.3 | 73,009 (39.8) | 40.9 | 35.9 | 37,434 (38.2) | 22.9 | 17 | 25,874 (20) |
| Age (years) | | | | | | | | | |
| 18 to <25 | 25.7 | 21.8 | 45,427 (24.8) | 29.1 | 25.7 | 26,769 (27.3) | 29.3 | 22.5 | 33,546 (26) |
| 25 to <35 | 37.3 | 34.9 | 67,283 (36.7) | 39.1 | 39 | 38,230 (39) | 32.6 | 35.3 | 43,797 (33.9) |
| 35 to <45 | 22.4 | 24.7 | 42,044 (22.9) | 20.5 | 22.9 | 21,352 (21.8) | 22.5 | 26.4 | 31,488 (24.4) |
| 45 to <55 | 11.2 | 14.1 | 21,824 (11.9) | 9.3 | 10.2 | 9,599 (9.8) | 12.1 | 12.8 | 16,075 (12.4) |
| 55+ | 3.4 | 4.5 | 6,719 (3.7) | 2 | 2.2 | 2,033 (2.1) | 3.4 | 3.0 | 4,162 (3.2) |
| Education† | | | | | | | | | |
| A—<8 years | 10.5 | 16.3 | 12,417 (11.5) | 11.9 | 16.2 | 5,587 (14.2) | 14.4 | 15.2 | 8,347 (14.8) |
| B—8 years | 12 | 14.7 | 13,507 (12.5) | 16.8 | 18.7 | 7,004 (17.8) | 21.8 | 21.3 | 12,144 (21.6) |
| C—11 years | 58.2 | 51.6 | 61,492 (57) | 54 | 52 | 20,830 (52.9) | 53.5 | 52.5 | 29,844 (53) |
| D—College and above | 19.3 | 17.4 | 20,482 (19) | 17.4 | 13.1 | 5,957 (15.1) | 10.3 | 11 | 6,006 (10.7) |
| Race† | | | | | | | | | |
| Black | 10 | 8.4 | 10,521 (9.7) | 18.1 | 18 | 8,132 (18.1) | 8.4 | 10.4 | 6,211 (9.4) |
| Mixed | 33.7 | 33.6 | 36,367 (33.7) | 45.8 | 48.4 | 21,211 (47.1) | 59.0 | 62.6 | 40,142 (60.8) |
| White | 54.3 | 56 | 58,987 (54.6) | 34.4 | 32.2 | 14,994 (33.3) | 32.1 | 26.6 | 19,312 (29.3) |
| Other | 2 | 2.1 | 2,197 (2.0) | 1.7 | 1.4 | 687 (1.5) | 0.5 | 0.4 | 317 (0.5) |
| Donor type | | | | | | | | | |
| FT only | 33.1 | 59.7 | 72,532 (39.6) | 28.1 | 46.7 | 37,305 (38.1) | 31.4 | 42.3 | 47,369 (36.7) |
| FT who returned | 7.8 | 5.8 | 13,412 (7.3) | 7.7 | 7.1 | 7,197 (7.3) | 11.2 | 6.3 | 11,374 (8.8) |
| Rpt only | 59.1 | 34.5 | 97,362 (53.1) | 64.2 | 46.3 | 53,481 (54.6) | 57.4 | 51.5 | 70,378 (54.5) |

* Data are reported as percentage or number (%).

† Data for race and education were collected starting April 2008. Therefore, only 2008 data were reported. Nine donors in São Paulo and 66 donors in Recife did not report age.

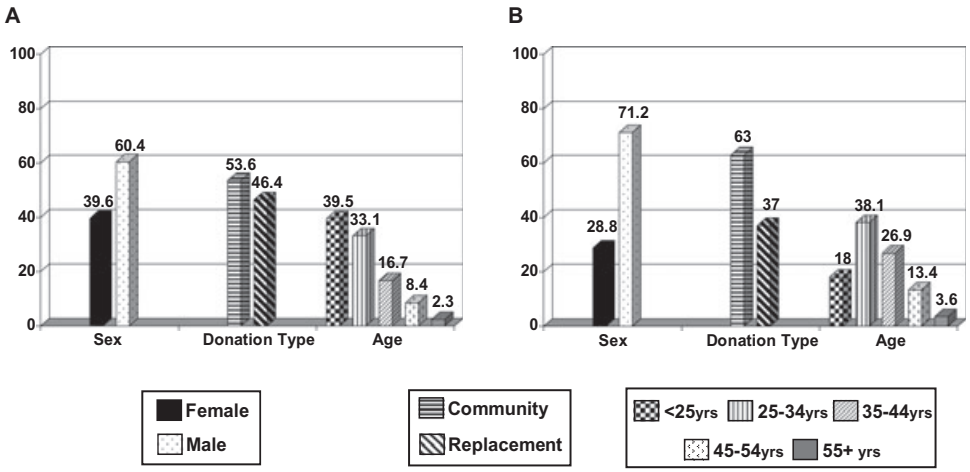


**Fig. 2. Percentage of FT (A) and Rpt (B) donors by sex, donation type, and age in the three centers, Brazil, 2007 to 2008.**

replacement donations in a 2007 report.[9] In sub-Saharan Africa, 75% to 80% of blood still comes from hospital-based replacement donors.[4] In this study, we have found that community donors now contribute the majority of donations in the three Brazilian centers studied, but that substantial variability exists across the centers.

A recommendation by the Ministry of Health, issued in 1993, advised the blood center recruitment personnel to talk to the families about blood donation, appealing to humanitarian feelings of family and friends of hospitalized patients, but avoiding coercing donation.[1,2] To enhance community donation, one strategy would be to deliberately convert replacement donors to community donors. A possible approach to achieve this is to talk to replacement donors after their first donation, showing them the importance of donation and how their blood type is necessary. A study conducted by Chamla and coworkers[10] revealed that sending a personalized and informative letter to new donors increased the number returning to donate again. Another study showed that the shorter the donation interval between the first and next donation, the more likely the donor was to make subsequent donations.[11] For example, if a donation appointment is set up right after the first replacement donation, it could help to convert a replacement donor into a "dedicated" community donor. Another study showed that donor satisfaction varies with demographics and is positively correlated with the intent to return for future donation. Therefore, incentives to future donation may need to be adjusted to demographic subgroups.[12]

Gonçalez and colleagues[13] studied the evolution of altruistic donors in FPS, and documented the substantial impact produced after the enhancement of the recruitment department in 1998.[13] There was a considerable increase in the proportion of community and Rpt donors that stabilized after a certain time at approximately 60%. These changes have led to an approximately 50% decrease in the rate of discarded blood units from 1995 to 2001, due to lower levels of reactive serologic tests.

One concern is about the "spurious altruistic donation," defined as a donor who donated blood for nonmonetary compensation, for example, blood testing.[14] It was shown by Barreto and colleagues[3] that community FT donors in São Paulo, Brazil, had higher HIV prevalence than replacement FT donors, and test seeking apparently plays an important role in bringing at-risk people to donate blood. In this case, offering anonymous testing to the general public and not immediately releasing negative results from blood bank testing may be effective in reducing this behavior, stimulating the test seeker to get tested in free anonymous testing centers, available in large urban centers in Brazil or in a regular laboratory.

To expand the safe donor pool it is fundamentally important to understand what segments of population are donating, both as community/altruistic and as replacement donors; this includes an understanding of demographic correlates of donation behaviors including sex, age, race/skin color, and educational level.

Although donors were and still are mostly males in Brazil, female donations have increased in the past few years, with diverse campaigns targeting women, a segment of the population that was historically not donating, probably due to myths on the health impact of donation, related to menstrual blood losses, pregnancies, and lactation.[1] Our data document that females still contribute a smaller proportion of donations than males in Brazil in all three regions represented in REDS-II. However, there were regional differences in the gender of donors, with the center in the northeast (FH-PE) having the lowest proportion of female donation (19.3%, vs. 37.6% in FH-MG and 39.0% in FPS). This could be due to the high proportion of anemia in the female population in Recife, possibly caused by iron deficiency and/or the presence of sickle cell trait in this population. However, further research is

needed to better understand this heterogeneous sex distribution among the centers.

Gonçalez and colleagues[13] showed differences in the evolution of type of donor in FPS Foundation. In 1995, only 20% of the donors were females, but their numbers increased steadily and, in 2001, female donors comprised 37% of the total and, as we have shown, in 2008 reached 39%. Another study in Brazil, from Hemominas Foundation, Belo Horizonte,[15] conducted in 1994 to 1995, showed that the proportion of females was 23.5% at that time, whereas it is presently 37.6%. This increase is likely attributable to recruitment campaigns and educational programs, such as "Donor of the Future," that educate children and teenagers of both sexes about the importance of blood donation. The REDS-II data confirm that donations by females have increased and with the monitoring system in place we will be able to track changes in the sex composition of the donor base.

The majority of donors in the three centers studied were below 34 years of age. FT donors were younger (most were 18-34 years old) than Rpt donors and concentrated in the 25- to 44-year age range. This result was expected, since the prototype of the Brazilian blood donor used to be a young male. Donors tended to be younger in Minas Gerais (FH-MG) and had similar age patterns in São Paulo and Pernambuco (FPS and FH-PE). In Germany, a study revealed that the percentage of donors was higher among the youngest age group (18-24 years).[16] The age distribution of Rpt whole blood donors roughly resembled that of the general population (most in the 35- to 44-year range). In the three centers studied in Brazil we found that the distribution of donors also tends to be younger than the general population.

The REDS-II centers captured data on the educational level of blood donors for the first time in Brazil. Most donors completed high school, which follows the population pattern, as observed in the official Brazilian census (Datasus). The proportions of different categories of donor educational levels varied among the centers, likely reflecting the educational levels in the populations in the corresponding regions.

Due to the high degree of racial mixture in Brazil, considered one of the highest in the world,[17] it is difficult to assess race or ethnicity based on skin color. The study of Parra and coworkers[17] indicated that in Brazil, at an individual level, color, as determined by physical evaluation, is a poor predictor of genomic African ancestry, estimated by molecular markers. Therefore, we used self-reported skin color in this study, not race evaluation. There were differences in skin color of donors in the three centers studied, with a majority of white donors in São Paulo (FPS) and nonwhite donors in Belo Horizonte (FH-MG) and Recife (FH-PE). These proportions are similar to the population distribution in these cities.[7] In some countries, for example, the United States, it is important to monitor the presence of minority groups (Hispanic, African American, and others) in part due to the fact that these groups tend to have lower blood donation rates.[18,19] In Brazil these differences are not clearly defined, and therefore skin color may not yield useful information, except for rarer blood groups and due to the fact that nonwhites tend to be in the lower socioeconomic stratum of the population and could have higher infectious disease rates.

Blood transfusion is a frequent event and one study in Denmark and Sweden has shown that at the age of 80 years, approximately one in five persons in the general population had received blood at least once.[20] We may anticipate that up to 30% of a given population will need transfusion during their lifetime and benefit from the blood supply, even if only as a blood reserve for surgery. This may be even more conspicuous in countries like Brazil, where urban violence and traffic accidents have a relatively higher incidence.[21]

It is estimated by WHO that the suitable percentage of donors in a given population is approximately 5% of the individuals in the usual donation age range,[22] which is the reported proportion of individuals donating blood each year in the United States.[23] In Germany, it was reported that overall 4% of the population eligible to donate were active as Rpt whole blood donors in 2006.[16] This work indicates that the Brazilian REDS-II centers collect blood from a mean of 2.3% of their eligible catchment populations, with a range of 1.6% to 3.1%. The variation observed among the centers is in part due to differences in the proportion of local coverage of the centers. FH-PE, where there is the highest proportion of the population donating blood (3.1%), is practically the sole blood center in the state of Pernambuco, supporting more than 95% of its transfusion needs. In São Paulo there are multiple blood services, and it is estimated that FPS provides 33% of the units transfused, whereas FH-MG provides 92% of the units transfused in Minas Gerais State, but approximately 85% in the Belo Horizonte metropolitan area.

Although there is a recognized need to increase donation in Brazil including the states covered in this report, it is also necessary to conduct more studies to determine what percentage of the population are eligible candidates for blood donation, taking into consideration the local variations in the complexity of the medical procedures and demand for blood. The study about the actual size of the potential donor pool in the United States published by Riley and colleagues[24] takes into account other donor-exclusion factors besides age, and this calculation likely reflects the proportion of the potential donor population closer to the real one. It reduces the denominator in the eligible donor equation dramatically, by excluding an additional 37.2% of the population due to permanent (cancer, heart disease, sexually transmitted diseases, among others) or temporary deferrals (flu, cold, anemia, tattoo, etc.). It remains to be determined what the

adequate supply of blood should be for Brazil and what factors would be needed to be considered for each region, balancing inadequate supply versus blood loss due to outdating of blood components. While these US estimates are useful, we doubt that they can be extrapolated to the Brazilian donor population. Future work to estimate the likely eligibility of donors in the broader population of Brazil will determine the proportion of the population that actually qualifies to be donors in Brazil and whether there are differences in the regions. This study represents the first effort to comprehensively describe the demographic characteristics of blood donors at three large blood centers in Brazil and is the first step toward understanding differences in donor characteristics compared to the general population of the corresponding catchment area.

#### ACKNOWLEDGMENTS

This study was supported by the NHLBI Retrovirus Epidemiology Donor Study-II: International Component.

#### CONFLICT OF INTEREST

There are no conflicts of interest for the authors of this manuscript.

## REFERENCES

1. Brazilian Ministry of Health. Política nacional de sangue e hemoderivados. 2009. [cited 2009 Mar 16]. Available from: URL: http://portal.saude.gov.br/portal/saude/area.cfm?id_area=1296
2. Anvisa (Brazilian National Agency of Sanitary Vigilance, Department of Blood, Tissues and Organs). 2009. [cited 2009 Mar 16]. Available from: URL: http://www.anvisa.gov.br/sangue/publica/index.htm
3. Barreto CC, Sabino EC, Gonçalez TT, Laycock ME, Pappalardo BL, Salles NA, Wright DJ, Chamone DF, Busch MP. Prevalence, incidence and residual risk of human immunodeficiency virus among community and replacement first-time blood donors in São Paulo, Brazil. Transfusion 2005; 45:1709-14.
4. Bates I, Manyasi G, Medina Lara A. Reducing replacement donors in Sub-Saharan Africa: challenges and affordability. Transf Med 2007;17:434-42.
5. Gibbs WN, Corcoran P. Blood safety in developing countries. Vox Sang 1994;67:377-81.
6. Carneiro-Proietti AB, Cioffi JG. The Hemominas foundation of Brazil: quality management in a hybrid model. In: Simpson M, editor. Strategies for centralized blood services. Bethesda (MD): AABB Press; 2006. p. 155-74.
7. Datasus. 2009. [cited 2009 Mar 16]. Available from: URL: http://w3.datasus.gov.br/datasus/datasus.php
8. Sullivan P. Developing an administrative plan for transfusion medicine—a global perspective. Transfusion 2005;45 Suppl:224S-40S.
9. Sampath S, Ramsaran V, Parasram S, Mohammed S, Latchman S, Khunia R, Budhoo D, Poon King C, Charles KS. Attitudes towards blood donation in Trinidad and Tobago. Transf Med 2007;17:83-7.
10. Chamla JH, Leland LS, Walsh K. Eliciting repeat blood donations: tell early career donors why their blood type is special and more will be given again. Vox Sang 2006;90: 302-7.
11. Ownby HE, Kong F, Watanabe K, Nass C. Analysis of donor return behavior. Retrovirus Epidemiology Donor Study. Transfusion 1999;39:1128-35.
12. Nguyen DD, DeVita DA, Hirsler NV, Murphy EL. Blood donor satisfaction and intention of future donation. Transfusion 2008;48:742-8.
13. Gonçalez T, Sabino EC, Chamone DF. Trends in the profile of blood donors at a large blood center in the city of São Paulo, Brazil. Pan Am J Public Health 2003;13:144-8.
14. Fernández-Montoya A. Altruism and payment in blood donation. Transf Sci 1997;18:379-86.
15. Brener S, Caiaffa WT, Sakurai E, Proietti FA. Factors associated to clinical aptness for blood donation—demographic and socioeconomic determinants. Rev Bras Hematol Hemoter 2008;30:108-13.
16. Ritter S, Reinhard B, Offergeld R, Hamouda O. Demography and donation frequencies of blood and plasma donor populations in Germany. Bundesgesundheitblatt Gesundheitforschung Gesundheitsschultz 2008;51:915-25.
17. Parra FC, Amado RC, Lambertucci JR, Rocha J, Antunes CM, Pena SD. Color and genomic ancestry in Brazilians. PNAS 2003;100:177-82.
18. Wu Y, Glynn SA, Schreiber GB, Wright DJ, Lo A, Murphy EL, Kleinman SH, Garratty G; Retrovirus Epidemiology Donor Study (REDS) Group. First-time blood donors: demographic trends. Transfusion 2001;41:360-4.
19. Gillum F, Eder AF, McLaurin-Jones TL. Hispanic ethnicity, race and blood donation in the United States. Transfus Med 2008;18:366-70.
20. Kamper-Jørgensen M, Edgren G, Rostgaard K, Biggar RJ, Nyrén O, Reilly M, Titlestad K, Shanwell A, Melbye M, Hjalgrim H. Blood transfusion exposure in Denmark and Sweden. Transfusion 2009;49:888-94.
21. Souza ER, Lima ML. The panorama of urban violence in Brazil and its capitals. Ciênc saúde coletiva [online] 2006; 11:1211-22. [cited 2009 Jul 12]. Available from: URL: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1413-81232006000500011&lng=en&nrm=iso
22. Schmunis GA, Cruz JR. Safety of the blood supply in Latin America. Clin Microbiol Rev 2005;18:12-29.
23. Gillespie TW, Hillyer CD. Blood donors and factors impacting the blood donation decision. Transfus Med Rev;16:115-30.
24. Riley W, Schwei M, McCullough J. The United States' potential blood donor pool: estimating the prevalence of donor-exclusion factors on the pool of potential donors. Transfusion 2007;47:1180-8.