



Revista Brasileira de Hematologia e Hemoterapia
Brazilian Journal of Hematology and Hemotherapy

www.rbhh.org



Original article

Seroprevalence, cost per donation and reduction in blood supply due to positive and indeterminate results for infectious markers in a blood bank in Lima, Peru



Jeel Moya-Salazar^{a,b,*}, Roberto Ubidia-Incio^c, Maritza Incio-Grande^d, Jorgelina L. Blejer^e, Carlos A. Gonzalez^f

^a Hospital Nacional Docente Madre Niño San Bartolomé, Lima, Peru

^b Universidad Continental, Facultad de Ciencias de la Salud, Huancayo, Peru

^c Universidad Peruana Cayetano Heredia, Facultad de Ciencias y Filosofía, Lima, Peru

^d Hospital Central de Policía Nacional del Peru, Lima, Peru

^e Fundación Hemocentro Buenos Aires, Buenos Aires, Argentina

^f Hospital de Infecciosas F.J. Muñiz, Bueno Aires, Argentina

ARTICLE INFO

Article history:

Received 21 June 2016

Accepted 29 November 2016

Available online 23 January 2017

Keywords:

Seroprevalence

Infectious marker

Indeterminate screening

Blood donor

ABSTRACT

Introduction: Safety in Transfusion Medicine is subject to regulations and government legislation within a total quality framework. The aim of this study was to evaluate the impact of seroprevalence and indeterminate results on lost units and cost per donation.

Methods: A prospective cross-sectional study was performed in the Blood Bank and Transfusion Therapy Department of the Hospital Central de la Policía Nacional del Perú in Lima, Peru. All completed donations (replacement/voluntary) without complications were included in this study. Every donation met the institutional requirements and quality criteria of Programa Nacional de Hemoterapia y Bancos de Sangre (PRONAHEBAS). Data analysis was achieved using the Statistical Package for the Social Sciences.

Results: A total of 7723 donations were evaluated during 2014 and 2015 with 493 being seropositive (overall prevalence 5.25%) and 502 having indeterminate results (overall prevalence 5.35%). Thus total loss was 995 units, 437.8L of blood and 49,750 US dollars. The most common seropositive infectious markers were the core antibody of hepatitis B virus (2.82%) and syphilis (1.02%), and the most common indeterminate results were Chagas disease (1.27%) and the core antibody of hepatitis B virus (1.26%). There was no significant change in the prevalence of seropositivity (p -value = 0.243) or indeterminate results (p -value = 0.227) over the two-year period of the study. A statistical correlation was found between the cost per lost donation and the most prevalent markers (ρ = 0.848; p -value = <0.001).

* Corresponding author at: M.T. Jr. Pacífico 957 Urb. San Felipe, Lima 07, 51001 Lima, Peru.

E-mail address: jeel.moya.s@upch.pe (J. Moya-Salazar).

<http://dx.doi.org/10.1016/j.bjhh.2016.11.007>

1516-8484/© 2017 Associação Brasileira de Hematologia, Hemoterapia e Terapia Celular. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Conclusion: Seroprevalence was lower than the regional mean, but the prevalence of indeterminate results was elevated causing a great impact on blood supply and economic losses to this institution.

© 2017 Associação Brasileira de Hematologia, Hemoterapia e Terapia Celular. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Safety in Transfusion Medicine is subject to regulations and government legislation within a total quality framework. Safety in transfusion therapy and during donation is an ethical issue in blood banks that must have protective mechanisms that detect noxae and diminish risk, making the transfusion practice efficient, safe and individualized for each patient with donations being free of adverse-reaction events. Nevertheless, new difficulties affect blood supply safety, such as strict donor selection questions, an affordable blood supply, seroconversion periods and emergent agents, among others.^{1,2}

The relative risk from donations is considerable and changing, the reason for which its estimation and its extrapolation to other communities are frequently hindered. In undeveloped countries, the relative risk from donations is heterogeneous due to geographic diversity, the habitat and population groups, as well as to the socioeconomic and educational conditions, and access to healthcare resources.³ Donations in Peru require screening for at least five infectious markers: surface antigen (HBsAg) and the core antibody of hepatitis B virus (HBcAb), antibodies against human immunodeficiency virus (HIV) type 1 and 2 (anti-HIV 1 and/or anti-HIV 2), antibodies against hepatitis C virus (HCV) and anti-*Treponema pallidum* (syphilis).⁴ Additionally, antibodies against human lymphotropic viruses (anti-HTLV-1/2) and markers for Chagas–Mazza disease are tested in endemic zones.^{5,6} The number of tests is not the same in each country because of different socio-sanitary conditions and based on sero-epidemiological data. Additional tests are included for Chagas disease in South America, Canada, Mexico, and some Western Pacific countries, for anti-human T-lymphotropic virus (HTLV)-1/2 in Portugal, France, Taiwan, Japan and Greece, but not in Turkey, for Creutzfeldt–Jacob disease variant (vCJD) in the United Kingdom, Germany, Chile, Portugal and Austria, for West Nile Virus (WNV) in United States, Canada, Australia and India and for anti-plasmodium in Benin.^{7–13}

The effect usually associated to seropositive units is the loss of blood units (biological and economical costs). During the last fifteen years, the reduced blood supply to the Blood Banking Service of a Hospital specialized in maternal care at Lima, Peru, and the great economic impact of discarded blood components was 457.2 L of blood and 61,893 US dollars, with limitations in the donation chain. This is also affected by the high-risk of transfusion-transmitted infections in non-healthy populations.⁶ The prevalences of infectious markers were 0.23%, 4.19%, 0.56%, 1.19% and 0.5% for HIV, hepatitis B virus (HBV), HCV, syphilis and Chagas disease, respectively in

units of blood screened in Peru; the overall prevalence was higher than for other countries in the region.^{6,14–16}

Thus, behavioral risk factors, donor quality and geographical endemism generate variable factors that complicate the functioning of blood banks where screening for infectious markers constitutes an invaluable measure to eliminate unsafe blood and avoid adverse transfusion reactions.¹⁷

The aim of this study was to evaluate the impact of seroprevalence and the cost per donation in the Blood Bank and Transfusion Service of the Hospital Central de la Policia Nacional del Perú in Lima, Peru during 2014 and 2015.

Methods

An analytical-correlational cross-sectional prospective study was performed in the Blood Bank and Transfusion Service of the Hospital Central de la Policia Nacional del Perú in Lima. The group of blood donors included in this study was chosen based on all donations with positive and indeterminate results for one or more of the seven infectious markers: HBsAg, HBcAb, HIV 1–2, HCV, Chagas disease, syphilis and HTLV-1/2. The overall prevalences of these infectious markers in Peru were 0.23% for HIV, 0.38% for HBsAg, 0.56% for HCV, 1.19% for syphilis, 0.5% Chagas disease, 0.88% for HTLV-1/2 and 4.19% for HBcAb.¹⁶ The cutoff point was derived from the average of three negative calibrators plus a fixed value; indeterminate results were defined as results within the gray zone established by this institution.

All serological tests were performed in duplicate during separate routines. Only samples that had two positive results in two different runs were classified as positive. These results were notified to the Instituto Nacional de Salud de Peru for confirmation using molecular methods, as defined in the epidemiological evaluation programs for disease and patient follow-up.¹⁸

Donated blood units considered in this study were selected respecting the donation criteria established by the Programa Nacional de Hemoterapia y Banco de Sangre (PRONAHEBAS) and standard operational process.^{6,18,19} The ages of all donors were between 18 and 55 years old, donations that were incomplete due to technical issues, those that were associated to complications or were evidently contaminated, were excluded. All the blood donations (replacement/voluntary) were collected in Terumo quadruple blood bags (Shibuya-ku, Tokyo, Japan). As this project was performed at a hospital for police officers, most donors were officers and their families and thus a population group with important and similar risk behavior factors such as their socioeconomic and educational conditions.

Table 1 – Percentage of seropositive donations for seven infectious markers (n = 493).

Year	HIV	HBsAg	HCV	Syphilis	HBcAb	HTLV	Chagas disease	Total
2014	0.22	0.15	0.42	0.90	2.80	0.42	0.13	5.05
2015	0.12	0.19	0.43	1.13	2.84	0.58	0.14	5.44
Of both years	0.17	0.17	0.43	1.02	2.82	0.50	0.14	5.25

$\chi^2 = 0.96$; p -value = 0.243 (non-significant).

Table 2 – Percentage of indeterminate results in blood donations (n = 502).

Year	HIV	HBsAg	HCV	Syphilis	HBcAb	HTLV	Chagas disease	Total
2014	0.13	0.57	1.10	0.64	1.15	0.31	0.49	4.39
2015	0.45	0.60	0.82	0.66	1.36	0.35	2.01	6.24
Of both years	0.30	0.59	0.96	0.65	1.26	0.33	1.27	5.35

$\chi^2 = 0.07$; p -value = 0.227 (non-significant).

Technical data collection and processing of the sample

Data collection was carried out using the register book of the Donation Service where samples were discriminated by seropositivity and data were grouped in months and years. The method used for screening was Architect Chemiluminescent Microparticle Immunoassay (Abbott Park, IL, USA). The serological screening was automated using the Architect i1000sr Immunoassay Analyzer (Abbott Park, Illinois, USA) with an incubator and programmable temperature control regulated by Architect i1000sr Software.

The data from the Data Management System for Blood Banks e-Delphyn[®] register system (Hemasoft, Singapore) was tabulated into the matrix in Microsoft Excel 2010 for Windows (Redmond, USA) where it was coded and the criteria for the verification of methods was evaluated. Data analysis was performed using the IBM Statistical Program for Social Sciences v21.0 (Armonk, USA). KMO and Bartlett's test of sphericity was employed to correlate variables and Varimax Rotation was used for factorial analysis. The Chi-square test was used to assess differences in prevalence between the years of study. Seroprevalence was calculated as the mean, standard error and 95% confidence interval (95% CI) and a p -value <0.05 was considered statistically significant.

Results

A total of 9388 donations were evaluated during 2014 and 2015, with 493 having seropositive results (Table 1) giving an overall prevalence was 5.25%. The infectious marker with the most positive results was HBcAb ($n = 265$; 2.82%), followed by syphilis ($n = 96$; 1.02%) and HTLV-1/2 ($n = 47$; 0.50%; p -value <0.01 – Table 1). Five hundred and two units (5.35%) had indeterminate results (gray zone), where Chagas disease ($n = 119$; 1.27%) and HIV ($n = 28$; 0.30%) were the most and least prevalent, respectively (p -value <0.05 – Table 2). There was no significant change in the prevalence of seropositivity (p -value = 0.243) or indeterminate results (p -value = 0.227) over the two year period of the

Table 3 – Blood loss and cost for seropositive and indeterminate donations (n = 995).

	2014	2015	Total
Total seropositive units – n	229	264	493
Total indeterminate units – n	199	303	502
Discarded units – n	428	567	995
Lost blood – L	188.3	249.5	437.8
Total cost – US \$ ^a	21,400.00	28,350.00	49,750.00

^a Considering the price for Terumo quadruple bags and blood tests. Unitary cost: 170.00 Nuevos soles (PER) (50.00 USD).

study. Figure 1 shows the prevalence in this study compared with the regional and national prevalences.

When seropositive and indeterminate losses were compared, the number of seropositive units with a loss of 216.9L of blood (493 units) was lower than the indeterminate results (220.9L, 502 units); moreover, there was a 24.5% increase in lost blood from 2014 to 2015 (Table 3). Similarly, when the direct cost of seropositive and indeterminate units was analyzed, there was a higher cost related to indeterminate units (25,100 USD) compared to seropositive units (24,650 USD – Table 3).

A statistical correlation was found between the cost per lost donation and the most prevalent markers ($\rho = 0.848$; p -value = <0.001). Factorial analysis of the seropositive results showed four components that explain the variance: first, the association between HBsAg and HBcAb; second the association between HTLV-1/2 and HIV 1–2; third, the association between Chagas disease and HCV; and the solitary component syphilis (p -value = <0.001). For the indeterminate results, three components were found: First the association between HBcAb, HCV and syphilis; second, between Chagas disease, HTLV-1/2 and HBsAg; and finally HIV alone (p -value >0.004).

Discussion

This study evaluated the prevalence of infectious markers in police offers and their families who donated blood during the study period and the association with the loss and supply of

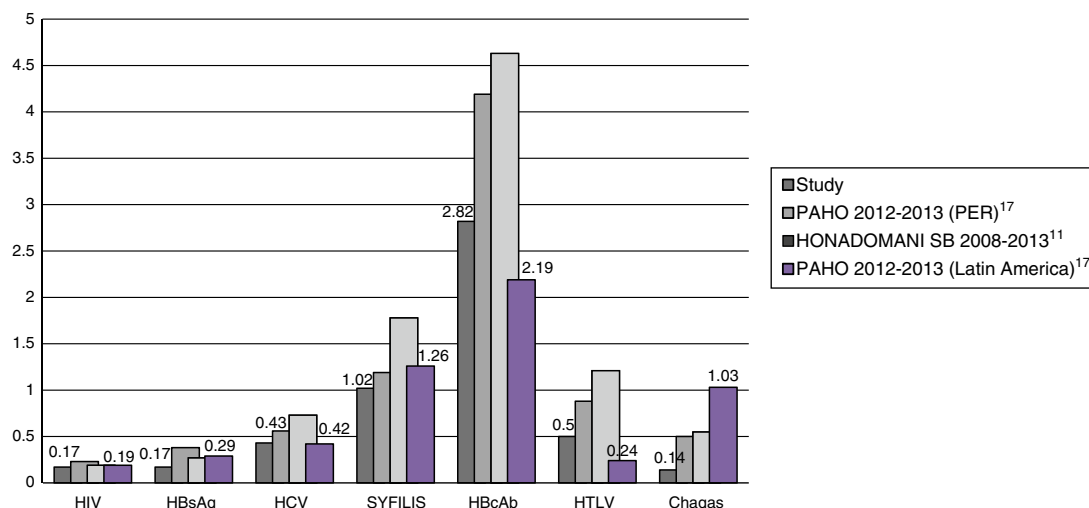


Figure 1 – Prevalence comparing this study and the last report of the Pan-American Health Organization (PAHO) for Latin American and Peru, and a study about seroprevalence and costs in Hospital Nacional Docente Madre Niño San Bartolome (HONADOMANI SB), Lima, Peru.

blood. In Latin American countries, the indicators of safety and supply of blood showed 100% of screening units for infectious markers that determined an overall prevalence of 1.13%.¹⁶ Nevertheless, there are few studies about indeterminate, gray zone results and the implications to transfusion medicine and processes of quality assurance.

In the last report, the Pan-American Health Organization (PAHO) reported prevalences of 0.29%, 2.19%, 1.26%, 0.24%, 1.03%, 0.42% and 0.19% for HBsAg, HBcAb, syphilis, HTLV-1/2, Chagas disease, HCV and HIV in Latin American countries, respectively.¹⁶ In Peru, only syphilis (1.19%) and Chagas disease (0.5%) are below the regional averages; the values far exceeded the averages for all the others markers, such as HBcAb (4.19%), HIV (0.23%) and dramatically for HTLV-1/2 (0.88%) (Figure 1). In this study we report low prevalences for Chagas disease, HIV and HBsAg, and high prevalences for syphilis and HBcAb in comparison with the last report of the PAHO. It is noteworthy that the overall prevalence of seropositive results increased considerably since the start of the study (0.39%) with values under the regional and national means,^{6,16} but far below the recent report.²⁰ Furthermore, on comparing the prevalence observed in this study with a previous report in a Mother and Child Hospital which belongs to the Peruvian Ministry of Health (MINSa), all the results were low (half of the previous reported values) similar to the evaluation performed by the PAHO for blood supply in Peru¹⁶ (Figure 1). In principle, this suggests that the prevalences of infectious markers in this donor group are correct for this population group of police officers and their families, all of whom had similar risk behavior factors and other conditions.

Similarly, when the overall prevalence of indeterminate results was assessed, most results in the gray zone were related to Chagas disease, HBcAb, HCV and syphilis (Table 2). Two of these diseases are considered endemic in Peru and other countries of Latin America. The risk for Chagas disease constitutes an important problem for transfusion medicine as the screening in blood banks is commonly affected by different

factors such as the high prevalence in donors, lack of sensitivity and specificity of the assays, lack of confirmatory tests and cross-reactions. All these factors increase the number of indeterminate results and require the use of techniques that diagnose inconclusive units.^{14,21,22}

In a previous report, 5% of indeterminate results were found for HCV, a percentage far above the regional mean (0.42%).^{14,16,23} With HCV, approximately 7% of indeterminate units resulted in negative confirmatory tests using a second sample. Thus, we believe that it is necessary to use a confirmatory test and to follow-up these indeterminate donors to demonstrate possible seroconversion which would result in a significant impact on blood banks.²³ The high proportion of indeterminate results for HBcAb and syphilis is because the majority of donors have common risk factors for these conditions with a substantial consequence on serological screening in blood banks.^{13,16,24,25} A 10.6% overall prevalence of seropositive and indeterminate results was estimated. This points to a low quality of donors, high prevalence of infectious markers, the failure of interviews, organizational problems in the blood bank and poor sanitary-epidemiological control of transfusion-transmitted infections in this population.^{16,20,26}

We found a low prevalence for HIV, HBsAg and HTLV-1/2; this rate was similar to several previous reports.²⁷ The current study shows that the risk of HIV- or HTLV-contaminated transfusions is an important difficulty in blood banks due to the characteristics of the life cycles of these viruses. HTLV causes serious leukemoid reactions and chronic myelopathy that has been poorly clarified hitherto.^{28,29} This disease is characterized by geographic grouping placing Peru at the top of the ranking in Latin America,¹⁶ a situation that may explain why the values in this population were less than half those of other studies.^{6,16} Furthermore, as the infections produced by HIV have increased considerably during the last two decades, and due to advances in technology, molecular tests with enhancements in the detection of pathogens have been developed, but without complete standardization of

blood bank laboratories in the community. It is for this reason that the screening for this marker is being improved using conventional tests in order to obtain safe blood.^{14,25,30-32} The mean rate for HIV-positive blood samples in this study was coincident with previous reports.^{6,16,27}

In addition, in Latin American countries, 29% of discarded blood is related to seropositivity or units reactive for transfusion-transmitted infections, without considering indeterminate units; these results undoubtedly, differ significantly to blood banks in developed countries.³³⁻³⁵ In respect to blood loss for seroprevalence of infectious markers, our results are very low (216.9 L per year) compared to a study carried out in a Hospital in Lima where 457.2 L of blood of 9560 blood units were discarded over five years, and reports from the Instituto Superior de Medicina Militar in La Habana.^{6,36} The majority of these discarded units were fresh plasma and red blood cells as mentioned in the last report of PAHO. Our results (10.6%) are also consistent with this report about discarded units (11.3%) (Table 3).¹⁶ On the other hand, the values are very different for indeterminate units; in a previous study we reported that in one year 1977 indeterminate (gray zone) units tested using ELISA were discarded in the Hospital of the Seguro Social de Salud del Perú (EsSalud) generating a blood loss of 863.9 L.²⁰ The difference with this study is clear as only 220.8 L of blood were discarded in one year, 25.4% of that reported in EsSalud. This is due to the 50% of gray zone in screening the institution established for its population of donors (police officers and their families), as a measure to prevent unsafe blood transfusions, but points to a need for standardization of the size of the gray zone for each marker in different populations with different risks and prevalent diseases.

The principal consequence of the discard of units with positive or indeterminate (gray area) results is the quasi-measurable economic impact and the limitations in chain donations, principally, in the supply of blood components for institutions. In previous reports on the cost of seropositive-eliminated donations in Peru, 61,893 USD were lost in a quinquennium.⁶ Here, in two years of evaluation, 24,650 USD were lost by discarding seropositive units.^{6,16,36} This varies considerably in the case of indeterminate units, which in the present study corresponds to 25,100 USD lost, a relatively low value compared to a study by EsSalud where in only one year 92,640 USD were lost, a result that surpasses previous reports about reactive and positive donations.^{16,20,36,37} These results show a great economic, social and sanitary impact for blood banks attempting to guarantee quality and transfusion safety.

We believe that guaranteeing quality in an initial step could improve processes in all stages of donation and transfusion,^{2,38-41} through a more efficient process that prevents errors, reduces costs, and satisfies users, etc. This, with the application of good practices in Transfusion Medicine, the promotion of voluntary donations and the implementation of new screening strategies in the health care system will increase safe donations that will save lives.

Conclusion

To conclude, in principle, seropositivity is diminishing compared to the overall prevalence in the region where testing for

prevalent diseases is maintained. For indeterminate results, Chagas disease and HbcAb infectious markers are high with the overall prevalence being higher than for positive results. These results depleted the blood supply (discarded units) with a high economic impact.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

We are grateful to Dr. José Girard Clavo, Ronald Torres-Matinez, O.R., and to Hospital Central de Policía Nacional del Peru for all their support in this study.

REFERENCES

1. Goodnough LT, Shander A, Brencher ME. Transfusion medicine: looking to the future. *Lancet*. 2003;361(9352):161-9.
2. Callery MF, Nevalainen DE, Kirst TM. Quality systems and total process control in blood banking. *Transfusion (Paris)*. 1994;34(10):899-906.
3. Cruz JR, Pérez-Rosales MD, Zicker F, Schmunis GA. Safety of blood supply in the Caribbean countries: role of screening blood donors for markers of hepatitis B and C viruses. *J Clin Virol*. 2005;34 Suppl. 2:S75-80.
4. American Association of Blood Banks. Transfusion-transmitted disease. In: AABB technical manual. 14th ed. Bethesda, MD: AABB; 2002. p. 613-23.
5. Vega MC, Montoro AJ. Manual de Medicina Transfusional. España: Mosby Doyma Libros; 1994. p. 11-7.
6. Moya SJ, Julcamanyan TE. Seroprevalence infectious markers causing loss of donation in the blood bank service in Hospital Nacional Docente Madre – Niño San Bartolome January 2008 to December 2013. *Horiz Med*. 2014;14(4):6-14.
7. Sertöz R, Turhan A, Bozkurt H, Samhoğlu P, Değirmenci A, Aydınok Y, et al. Investigation of anti-HTLV-I/II seroprevalence in healthy blood donors in Izmir region, Turkey. *Mikrobiyol Bul*. 2010;44(4):579-84.
8. Prata A. Clinical and epidemiological aspects of Chagas disease. *Lancet Infect Dis*. 2001;1(2):92-100.
9. Center of Biologics Evaluation and Research. Revised Precautionary Measures to reduce the possible risk of transmission of Creutzfeldt-Jakob Disease (CJD) and new variant Creutzfeldt-Jakob Disease (nvCJD) by blood and blood products. US: Guidance for Industry; 1999. p. 3-7.
10. German Federal Ministry of Health. Overall Blood Supply Strategy with regard to variant Creutzfeldt-Jakob Disease (vCJD). Report of the Working Group Commissioned by the German Federal Ministry of Health April 13, 2006. *Transfus Med Hemother*. 2006;33 Suppl. 2:VII.
11. Center for Disease Control and Prevention (CDC). Transfusion-associated transmission of West Nile Virus – Arizona, 2004. *Morb Mortal Wkly Rep*. 2004;53(36):842-4.
12. Kindel-Gazard OJ, Gnahoui I, Massougbdji A. The risk of malaria transmission by blood transfusion at Cotonou, Benin. *Sante*. 2000;10(6):389-92.
13. Blejer JL1, Carreras Vescio LA, Salamone HJ. Riesgo de transmisión de infecciones por vía transfusional. *Medicina (BAires)*. 2002;62(3):259-78.

14. Cortés BA, Gutiérrez MG. Prevalencia de marcadores para infecciones transmisibles por transfusión en donantes voluntarios. *Colomb Med.* 1996;27(1):3-10.
15. De la Cruz SR, Barrera CT, Vidal EJ, Rodríguez SI. Marcadores serológicos de sífilis, hepatitis B y VIH en donantes de sangre en el Hospital Nacional Cayetano Heredia, Lima - Perú. *Rev Med Hered.* 1999;10(4):137-43.
16. Pan-American Health Organization. Supply of blood for transfusion in Latin American and Caribbean countries 2012 and 2013. Washington, DC: PAHO; 2015.
17. Alleyne GA. El próximo cuatrienio. Washington, DC: OPS; 1998.
18. Ministerio de Salud. Sistema de Gestión de la Calidad del PRONAHEBAS. Manual de Calidad. Norma Técnica. No. 011-MINSA/DGSP-V.01; 2004.
19. AABB. Standards for blood banks and transfusion services. 29th ed. Bethesda, MD: American Association of Blood Banks (AABB); 2014.
20. Moya SJ, Pio DL, Diaz RM. Depletion of blood supply and cost for indeterminate donations at Hospital Nacional Guillermo Almenara Irigoyen. *Horiz Med.* 2017;17(1):31-7.
21. Blejer JL, Saguier MC, Salamone HJ. Antibodies to *Trypanosoma cruzi* among blood donors in Buenos Aires, Argentina. *Int J Infect Dis.* 2001;5(2):89-93.
22. Blejer JL, Sartor PA, Bottasso O, Salamone HJ, Leguizamón MS. Trans-sialidase Inhibition Assay for the detection of *Trypanosoma cruzi* infection in blood donor samples from Argentina. *Vox Sang.* 2008;95(3):189-96.
23. Iborra-Bendicho AM, Albert-Hernández M, Márquez-Contreras C, Segovia-Hernández M. ARCHITECT Chagas® : una nueva herramienta diagnóstica en la enfermedad de Chagas. *Enferm Infecc Microbiol Clin.* 2012;30(8):463-5.
24. Aguirre GG, Martínez AJ, Arenas EI. Resultados en zona gris del tamizaje para VIH y VHC, pueden indicar seroconversión inmediata. *Rev Mex Patol Clin.* 2005;52(1):63-8.
25. Tramont E. *Treponema pallidum* (syphilis). In: Mandell G, Bennett J, Dolin R, editors. Principles and practice of the infectious diseases. 4° ed. New York: Churchill Livingstone; 1995. p. 2117-33.
26. Porto FA, de Almeida-Neto C, Teixeira MC, Strauss E. Health-related quality of life among blood donors with hepatitis B and hepatitis C: longitudinal study before and after diagnosis. *Rev Bras Hematol Hemoter.* 2015;37(6):381-7.
27. Chattoraj A, Behl R, Kataria VK. Infectious disease markers in blood donors. *Med J Armed Forces India.* 2008;64(1):33-5.
28. Zur Hausen H. The search for infectious causes of human cancers: where and why. *Virology.* 2009;392(1):1-10.
29. Khabbaz RF, Heneine W, Grindon A, Hartley TM, Shulman G, Kaplan J. Indeterminate HTLV serologic results in U.S. blood donors: are they due to HTLV-I or HTLV-II? *J Acquir Immune Defic Syndr.* 1992;5(4):400-4.
30. Busch MP, Lee LL, Satten GA, Henrard DR, Farzadegan H, Nelson KE, et al. Time course of detection of viral and serologic markers preceding human immunodeficiency virus type 1 seroconversion: implications for screening of blood and tissue donors. *Transfusion.* 1995;35(2):91-7.
31. Beelaert G, Fransen K. Evaluation of a rapid and simple fourth-generation HIV screening assay for qualitative detection of HIV p24 antigen and/or antibodies to HIV-1 and HIV-2. *J Virol Methods.* 2010;168(1-2):218-22.
32. Branson BM, Owen MS, Wesolowski LG, Bennett B, Werner BG, Wroblewski KE, et al. Laboratory testing for the diagnosis of HIV infection. Updated recommendations. Center for Disease Control and Prevention (CDC); 2014.
33. Food and Drug Administration (FDA). Requirements for blood and blood components intended for transfusion or for further manufacturing use. *Fed Regist.* 2015;80(99):29842-906.
34. World Health Organization (WHO). Blood safety and availability. WHO; 2015. Fact sheet No. 279. Available from: <http://www.who.int/mediacentre/factsheets/fs279/en/> [internet; cited 22.02.16].
35. Allen J, Bowler P, Burta O, de Kort W, Folléa G, Hajiyev A, et al. Report of the survey on blood supply management organised by the TS003 Working Group in member states and observer states of the Council of Europe. France: European Directorate for the Quality of Medicines & HealthCare of the Council of Europe (EDQM); 2014.
36. Viamonte RF, Pérez HM, Delgado EL, Longres Manguar AL. Marcadores serológicos causantes de pérdidas de donaciones. *Rev Cubana Med Milit.* 2000;29(1):41-5.
37. Sánchez AS, Gonzales NP, Alvarez VJ. Costos en la Transfusión Sanguínea. *Rev Mex Anest.* 2000;23(2):66-70.
38. Grifols EJ, Martín VC, Hernández SJ, Pujol BM, Grifols RJ, García RE. Seguridad en Medicina Transfusional. Menarini Diagnósticos. 1ª ed. España: Pecaló; 1998. p. 73.
39. Moya-Salazar J, Díaz RR. Planificación Analítica de la calidad en Pruebas cualitativas de tamizaje serológico de Banco de Sangre. In: XV Congreso Argentino De Medicina Transfusional. Buenos Aires: Asociación Argentina de Hemoterapia, Inmunohematología y Terapia Celular; 2015. p. 215-31.
40. ISO. Norma Internacional 9001:2000. Sistemas de gestión de la calidad-Requisitos. Ginebra: ISO; 2000.
41. Pataccini G, Cánepa C, Salido J, Delfino CM, Blejer J, Fernández R, et al. Comparison of human T cell leukemia virus-1/2 (HTLV-1/2) screening assays in South America: implications in the loss of blood units. *Retrovirology.* 2014;11 Suppl. 1: O16.