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## Achieving self-sufficiency of red blood cells based on universal voluntary blood donation in Latin America. The case of Nicaragua

René Berrios<sup>a</sup>, Alcides Gonzalez<sup>b</sup>, José Ramiro Cruz<sup>c,\*</sup><sup>a</sup> National Blood Service, Nicaraguan Red Cross, Managua, Nicaragua<sup>b</sup> National Center for Diagnosis and Reference, Ministry of Health, Managua, Nicaragua<sup>c</sup> Pan American Health Organization, Washington, DC, USA

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### ABSTRACT

In 2007, the blood collection rate in Nicaragua was 106.6 units per 10,000 inhabitants. Voluntary donation was 39%. The health authorities decided to pursue self sufficiency of blood by eliminating replacement donation and consolidating blood processing in two centers. Replacement donation was terminated in 2009, voluntary donation reached 100% in 2010, and the blood collection rate increased to 125.9 in 2011. The rate of red blood cell transfusion improved from 96.0 to 119.1 units per 10,000 during the 4-year period. The political will of the government, pertinent technical leadership, and a country-wide approach were essential for attaining those goals.

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### 1. Introduction

The importance of voluntary non-remunerated donors (VBD) for an adequate blood supply was first recognized by the World Health Assembly (WHA) in 1975 [1]. However, by 2001, only 39 countries in the world had achieved universal VBD [2], a situation that prompted the WHA to urge the World Health Organization (WHO) Member States to “establish or strengthen systems for the recruitment and retention of voluntary non-remunerated blood donors” and “to support the full implementation of well-organized, nationally coordinated, and sustainable blood programs with appropriate regulatory systems” [3]. In 2010, the WHO and the Federation of Red Cross and Red Crescent Societies recommended 20 strategies to be implemented by the national health authorities [4]. More recent publications from the WHO aim at strengthening VBD programs as the basis for self-sufficiency of blood products [5,6].

In Latin America, where only Cuba had 100% VBD, the Directing Council of the Pan American Health Organization (PAHO) adopted in 1999 a 5-year plan to strengthen blood banks [7]. The plan included a goal to improve VBD. Public and health worker education, advancement of blood donor services – infrastructure, accessibility, safety and personnel skills- and termination of the requirement for replacement donation were identified as essential factors. By 2005, Brazil, Colombia, Costa Rica and Cuba reported more than 50% VBD; nine of the other 15 Latin American countries had less than 10% VBD [8]. Consequently, the PAHO Member States agreed as part of the Regional Plan of Action for Transfusion Safety 2006–2010 that at least 50% of their blood collection should come from voluntary donors [9]. In 2008, when the regional indicators of VBD had not improved [10], PAHO recognized that 50% VBD “results in policy, ethical and operational challenges since half of the recipient patients have to provide replacement donors” and that “pursuing the goal of 100% VBD in the short term will result in the multidisciplinary approaches that were identified as vital in 2005” [11]. The present report documents how Nicaragua went from 48% VBD in

\* Corresponding author. Address: 44408 Maltese Falcon Sq, Ashburn, VA 20147, USA. Tel.: +1 (703) 729 0875; fax: +1 (703) 729 7380.

E-mail address: [jrcruz2004@aol.com](mailto:jrcruz2004@aol.com) (J.R. Cruz).

2008 to 100% VBD in 2009 by applying the strategies of the PAHO Regional Plan for Transfusion Safety 2006–2010.

## 2. Materials and methods

### 2.1. The Country

Nicaragua is the largest Central American country, with an extension of 130,370 Sq km, bordered by Honduras, Costa Rica, the Caribbean Sea, and the Pacific Ocean (Fig. 1). The Andes Mountain Range that runs Northwest-to-Southeast divides the country in three distinct areas, Central, Pacific and Atlantic [12]. The Nicaraguan climate is tropical. The rainy season extends from May to November. Tectonic and volcanic factors and its proximity to the oceans make Nicaragua prone to earthquakes, tsunamis, and hurricanes. Tropical storms, mudslides and floods are frequent. The Nicaraguan population, 5,676,000 in 2008 [13], lives in 7099 communities organized in 15 Departments (States) and two Autonomous Regions in the Atlantic coast. Only 35 communities have more than 15,000 inhabitants; 2.4 million people live in or around Managua. Fifty-four percent of the population inhabits the Pacific area, which represents 15.2% of the land. The Atlantic area, where English, Miskito and other autochthonous languages are spoken, occupies 56.4% of the national territory and holds 14% of the population. The country has 19,137 km of roadways, 2033 of which are paved. Transportation to the North and to the East of Lake Nicaragua relies on 2220 km of waterways and on small planes. Country-wide there are 258,000 telephone land lines, 3.8 million mobile cellular phones, and 199,800 internet users [14].

### 2.2. The people

Nicaraguans, except for the Miskitos in the Atlantic area, are mostly Spanish-speaking *mestizos*. Because of the ethnic diversity, the distribution of blood groups varies among the different areas of the country. Data from three sites show that the O positive type is the most prevalent (range 53–74%), followed by A positive (range 18–23%), B positive (range 2–11%), O negative (range 0–6%), AB positive (range 0.2–2%), and A negative (range 0.3–4%). Types B negative and AB negative are found in less than 1% of the population. Thirty-two percent of Nicaraguans are below 15 years of age and 4.5% are over 64 [14]. Life expectancy at birth is 72.18 years. The unemployment rate is 7.3%; 46.2% of the population lives below the poverty line. The county GDP is US\$ 19.12 billion and the GDP per capita US\$ 3200, the lowest in Latin America [14]. The Human Development Index (HDI) in 2011 was 0.589 [15], placing Nicaragua among the Middle HDI countries.

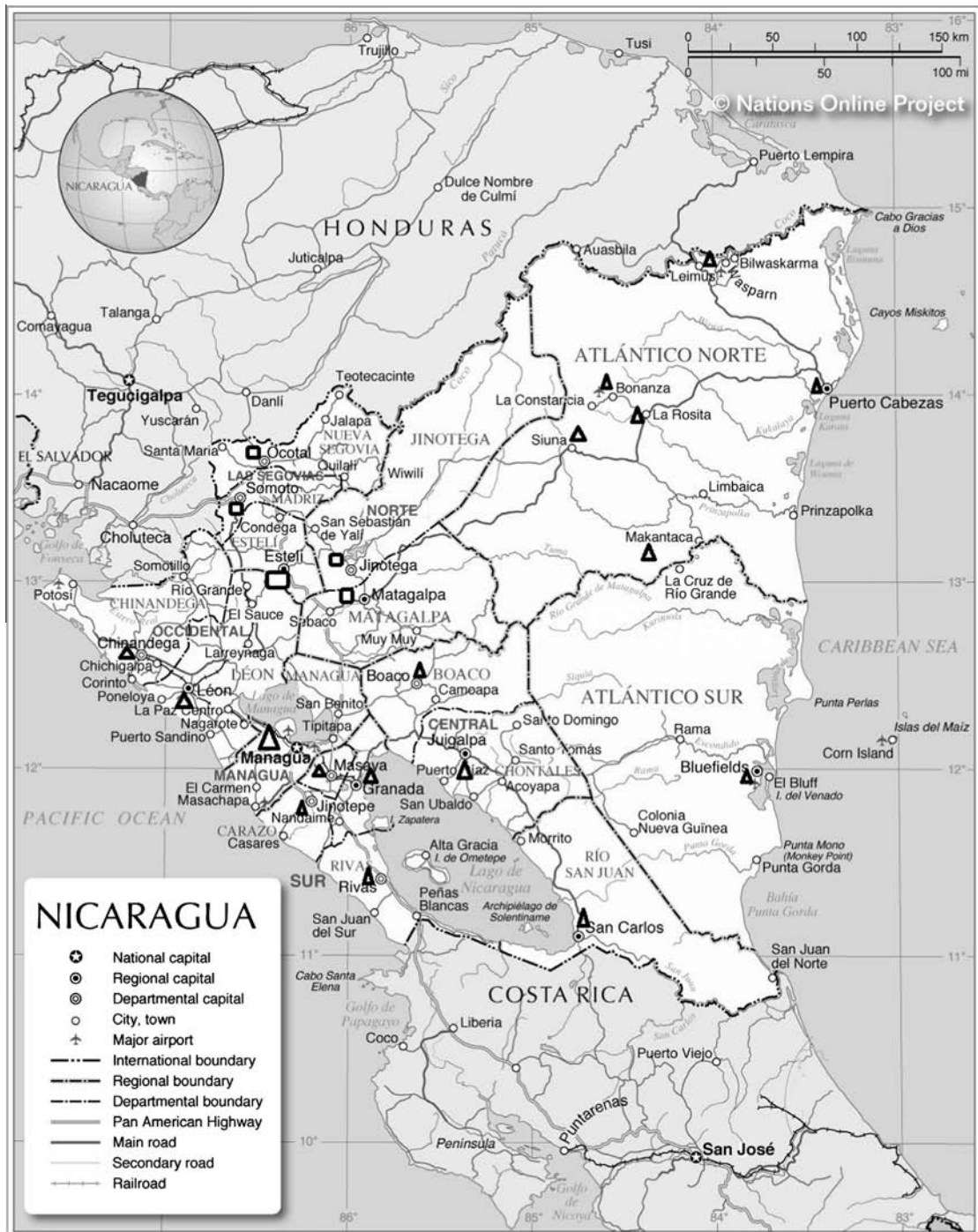
### 2.3. The health care system

Annually, Nicaragua invests 9.5% of its GDP on health care. Under the oversight of the central authorities of the Ministry of Health (MoH), 17 Department- or Autonomous Region-based Local Systems of Integrated Health Care (SILAIS) have the authority to plan and the responsibility

to provide preventive and curative services [13]. Twenty-eight percent of Nicaraguans have no regular access to health services. There are 50 hospitals, 36 public and 14 private, in the country, in addition to nine private maternity clinics [14]. In 2005, there were 24 blood banks nation-wide, 20 managed by the MoH and four operated by the Nicaraguan Red Cross (NRC). The 24 blood banks collected 54,117 blood units that year, equivalent to 98.63 units per 10,000 inhabitants; 56% of the units came from replacement donors [8], that is, people who are recruited by the patients to deposit blood on their behalf as a requirement for hospital admission and treatment. Once they donated blood, replacement donors received a “blood voucher” to be presented to the hospital administration as proof of the patient’s compliance with the requirement. The NRC was the only institution in the country that promoted VBD and collected blood from voluntary donors.

### 2.4. The intervention

In 2002 the Nicaraguan MoH and the NRC began to establish the basis for a centralized model of quality-assured blood collection, processing and distribution, with the leadership of the MoH and the active participation of the civil society [7,16]. The Nicaraguan law on blood safety, enacted in 2000, determines the NRC is responsible for providing free of charge all blood components needed in the country, and that the investments on blood collection, processing and distribution must be covered by the State through the MoH or, in the case of retirees, by the NSSI [17]. Operational and financial details of the national blood system were defined in an agreement between the MoH and the NRC in 2004. The financial aspects of the agreement are revised yearly, based on the costs of the NRC operations specific for the provision of blood. The analysis of the local epidemiology of blood transfusions, and of the national geographical, demographic and communication characteristics allowed identifying Managua, Estelí, Matagalpa, Leon and Juigalpa as the cities where regional blood banks were to be established. Strategies for transforming hospital-based blood banks into transfusion services and for achieving universal quality-assured laboratory testing of blood for HIV, hepatitis B and C, syphilis and *T. cruzi* were developed. A 5-year, € 5.9 million project to support the establishment of the new national blood system approved by the Grand Duchy of Luxembourg became effective in 2005. This project provided investment funds for infrastructure and training and an on-site technical director who coordinated national and international cooperation. The intervention activities, carried out under the authority of the MoH, followed the PAHO Regional Plan for 2006–2010 [9]. This plan, adopted by the Ministers of Health of all the countries in the Americas, intended to “contribute to reduction of mortality and to improving patient care in Latin America and the Caribbean by making safe blood available in a timely manner for all those patients who need it”. Better management of the national blood networks, promotion of VBD, establishment of quality assurance programs, and the appropriate clinical use of blood were defined as the strategies to pursue that goal. Nine objectives were adopted to monitor and assess



**Fig. 1.** Nicaraguan national blood network system. Larger triangle shows the location of the processing center in Managua. Smaller triangles show the location of either SILAIS or health centers that receive blood components from the Managua center. Blood components are sent by air to the services located in the departments in the eastern Caribbean coast. Larger square shows the location of the processing center in Estelí. Smaller squares show the location of either SILAIS that receive blood components from the Estelí center.

progress of the Regional Plan (Table 1). In Nicaragua, the costs associated with the operation of the national blood system were fully and permanently covered by the MoH. The NRC adjusted its administrative processes and estab-

lished separate and dedicated accounting procedures for the National Blood Service in 2007. A plan for personnel training in promotion of VBD, quality assurance, clinical use of blood, and management of blood services was

**Table 1**

Purpose, strategies, activities and indicators of the Regional Plan of Action for Transfusion Safety 2006–2010 [9].

<i>Purpose:</i> To contribute to the reduction of mortality and to the improvement of patient care in Latin America and the Caribbean, by making safe blood for transfusion available in a timely manner for all those patients who need it		
Strategies	Activities	Indicators
Planning and management of the national blood network system	Develop, implement and consolidate a national network model for blood services delivery Adjust the legal framework Analyze financial efficiency Optimize blood collection and processing Develop a national information management system Monitor quality of blood products and services	Legal framework revised  Geographic and temporal needs for blood estimated Regional blood collection and processing implemented
Promotion of voluntary blood donation	Revise and modify legal and regulatory framework Implement extramural collections Extend donor service hours Upgrade premises Develop a national strategic plan Partner with other sectors and with civil society	Universal voluntary blood donation achieved
Quality assurance	Adopt work standards for blood banks (PAHO publication) Establish audits Screen for infectious markers Establish programs of external evaluation of performance for laboratory testing of infectious markers and immunohematology Establish hemovigilance	National quality assurance plan implemented 95% of units fractionated into components Hemovigilance established
Appropriate use of blood and blood components	Develop national guidelines Implement hospital transfusion committees Train medical personnel	Guidelines for clinical use of blood implemented in all hospitals



developed in 2005. Once the transformation of hospital-based blood banks into transfusion services and the initial training of blood bank personnel were completed in 2008, a tactic to eliminate replacement donation and to rapidly achieve national sufficiency based on VBD was developed during a national seminar held in November 2008 (Table 2). The agreement was to continue collecting blood in the usual manner from both voluntary and replacement donors for no more than 4 months and, in parallel, to recruit enough additional voluntary donors to allow the NRC to store enough red blood cells (RBC) to cover 2 weeks of hospital needs. Voluntary non-remunerated donors were educated and recruited to donate whole blood every 6 months [11,18]. Mobile collection teams and Club 25, an initiative that operates in 63 countries to encourage youngsters under 25 years of age to donate blood on a regular basis and to motivate others to donate [19,20], were strengthened. Beginning the week prior to the deadline for abolishing replacement donation, the stored blood units were to be distributed to all treatment facilities following pre-established schedules and taking into consideration daily blood use and hospital distance from the processing or distribution centers (Fig. 1). During the November 2008 seminar, the projected collection of blood for that year was estimated to be 68,500 units. The consensus was to add 5% (3425 units) and to round up the annual need of RBC for 2009 to 72,000 units. In accordance with the PAHO recommendations, an emergency stock equivalent to 4%, or 2880 units, of the estimated annual need for RBC was included the collection plan. The annual collection goal for 2009 was set at 75,000 units of whole blood (Table 2). 1 March 2009 was chosen as the date to terminate replacement donation in the country. To validate the national plan, the PAHO methodology for estimating the need for blood was applied in nine hospitals in Chinandega, Estelí, Jinotega, Juigalpa, Managua, Matagalpa, San Juan and Somoto during 2009 [21].

### 3. Results

#### 3.1. The national blood network system

The National Center for Diagnosis and Reference (CNDR) of the MoH was designated as the regulatory unit responsible for overseeing the national blood system and for coordinating the implementation of the blood collection, processing and distribution network operated by the NRC. In discussions with the Directors of the 17 SILAIS, it was agreed that recruitment and care of blood donors and collection of blood were to be carried out by centers in Estelí, Juigalpa, Leon, Managua and Matagalpa. Blood units collected in Leon and Juigalpa were to be processed by the center in Managua, and those collected in Matagalpa were to be processed in Estelí (Fig. 1). The distribution of blood components to hospitals was to follow the inverse pattern. This set up took into consideration the geographic, climatic, demographic, epidemiologic, and communication characteristics of the country, and intended to protect the functional integrity of the blood services in the case of a disaster. The 20 blood banks based in

public hospitals would stop collecting and processing blood and focus on treating patients. Developing new skills, competences and attitudes among administrative and technical staff, and educating blood donors were chosen as the main strategies to reengineer the national blood system. Table 3 summarizes the training activities, the participants, and the technical documents used as reference. Between 2005 and 2007 twenty medical technologists working in the hospital-based blood banks received their diploma on blood banking from the National University of Nicaragua. Ninety-eight physicians were trained on transfusion medicine and received the corresponding diploma from the Teaching Section of the MoH. One hundred-seventy registered nurses successfully finished a course on Safe Transfusion Practice. Sixty-two hospital and public health administrators and 25 general practitioners attended courses on Management of Blood Services, while eight medical technologists at the Estelí center were trained in immunohematology. The University of Puebla, Mexico, granted diplomas to 19 promoters who successfully finished the distance course on “Making a Difference. Promoting Voluntary Blood Donation” [22]. Eleven medical technologists were awarded similar diplomas on “Safe Blood and Blood Products” [23]. Three physicians obtained Master degrees on Immunohematology and Transfusion from the University of Rosario, Argentina. The Unit of Quality and Training, created within the National Blood Service of the NRC in 2008, provided continued education to staff and training on the promotion of VBD to over 1200 community volunteers. Seminars were held at every SILAIS and hospital to make all parties aware of the plan to reduce the number of blood banks, and to engage them in the reform processes. These efforts resulted in the gradual reduction of the number of hospital blood banks and their elimination by 2009, when three blood processing centers, all operated by the NRC, existed (Table 4). By 2010, only the centers in Managua and Estelí functioned as processing hubs (Fig. 1).

#### 3.2. Voluntary blood donation

The NRC processing centers in Estelí and Managua and three blood banks operated by the MoH in Boaco, Chinandega and Jinotepe collected 14,094 blood units during January and February 2009 with the traditional approach that relied primarily on replacement donors. There were 8982 (63.73%) replacement donors in those 2 months. The hospital-blood banks did not collect blood from voluntary donors. The NRC began the VBD-targeted collection tactic on 18 February (Table 2) after intense donor education and recruitment in work places, universities, schools, neighborhood groups, social clubs, and churches by NRC promoters and community volunteers. The MoH stopped collecting blood units on 28 February 2009 and no replacement donors were accepted by the NRC after that date. The “blood voucher” ceased to exist on 1 March. VBD accounted for the 55,538 units that were collected from March to December, and, therefore, represented 87.10% of the 2009 annual collection (Table 4). The number of mobile collections increased 2.5-fold, from

**Table 2**

Operational tactic to achieve 100% VBD in Nicaragua.

Estimated annual need and collection goals (Whole blood units), 2009.

Annual need	4% reserve	Total annual collection	Annual goal	Expected TTI	Minimum stock
72,000 units	2880 units	74,880 units	75,000 units	1st semester 2.7% (N = 1012) 2nd semester 0.5% (N = 188)	1728 units (2.4%)
Daily use 198 units	Weekly use 1386 units		Corrected annual use 72,072 units		Maximum stock 2928 units (4.1%)

*Blood collection (whole blood units) and distribution of red cells, 2009*

Day/date	Collection	TTI	Available in centers	Delivered to hospitals	Transfused to patients	Available in hospitals	Total availability
Mo 16/02	300	8	292	–			
Tu 17	296	8	580	–			
We 18	295	9	866	–			
Th 19	299	7	1158	–			
Fr 20	300	7	1451	–			
Sa 21	–		1451	–			
Su 22	–		1451	–			
Mo 23	298	8	1741	–			
Tu 24	299	9	2031	–			
We 25	300	11	2320	–			
Th 26	298	4	2614	–			
Fr 27	297	10	2901	–			
Sa 28	–		2901	–			
Su 1/03	–		1515	1386			
Mo 2	299	7	1807	–	190	1196	3003 (15 days)
Tu 3	298	6	2099	–	190	1006	3105
We 4	300	8	2391	–	200	806	3197
Th 5	297	7	1988	693	198	1301	3298
Fr 6	300	8	2280	–	216	1085	3365
Sa 7	–		2280	–	198	887	3167
Su 8	–		1583	693	194	1386	2969
Mo 9	295	6	1876	–	190	1196	3072
Tu 10	300	9	2167	–	190	1006	3173
We 11	299	7	2459	–	200	806	3265
Th 12	298	10	2054	693	198	1301	3355
Fr 13	300	8	2346	–	216	1085	3431
Sa 14	–		2346	–	198	887	3233
Su 15	–		1653	693	194	1386	3039
Mo 16	296	9	1940	–	190	1196	3136
Tu 17	297	6	2231	–	190	1006	3237
We 18	298	7	2522	–	200	806	3328
Th 19	299	8	2120	693	198	1301	3421
Fr 20	300	9	2411	–	216	1085	3496
Sa 21	–		2411	–	198	887	3298
Su 22	–		1718	693	194	1386	3104
Mo 23	299	10	2007	–	190	1196	3203
Tu 24	294	7	2294	–	190	1006	3300
We 25	298	8	2584	–	200	806	3390
Th 26	299	8	2182	693	198	1301	3483
Fr 27	299	9	2472	–	216	1085	3357
Sa 28	–		2472	–	198	887	3359
Su 29	–		1779	693	194	1386	3165
Mo 30	300	9	2070	–	190	1196	3266
Tu 31	299	7	2362	–	190	1006	3368
We 1/04	299	7	2654	–	200	806	3460
Th 2	300	11	2250	693	198	1301	3551
Fr 3	143	7	2386	–	216	1085	3471
Sa 4	151	2	2535	–	198	887	3422
Su 5	149	4	1987	693	150	1430	3417
Mo 6	148	2	2133	–	120	1310	3443
Tu 7	149	4	2278	–	100	1210	3488
We 8	–		2278	–	100	1110	3388
Th 9	–		1978	300	98	1312	3290
Fr 10	–		1978	–	167	1145	3123
Sa 11	–		1978	–	134	1011	2989
Su 12	–		1285	480	105	1386	2671 (13 days)
Mo 13	300	6	1579	–	190	1196	2775
Tu 14	299	9	1869	–	190	1006	2875
We 15	298	8	2159	–	200	806	2965 (15 days)
Total	11,782	312 (2.65%)		9096	8290		

**Table 3**  
Training activities.

Target audience	Main messages	Reference documents
Administrative personnel	<p>Small blood banks are inefficient and more prone to errors</p> <p>Implementing quality management is highly difficult and expensive in a fragmented system</p> <p>Replacement blood donation promotes waste of resources</p> <p>Voluntary blood donors are safer than replacement donors</p> <p>Hospitals are patient treatment services and not manufacturing centers</p> <p>Centralized systems of collection and processing of blood are more efficient</p> <p>Obtaining blood components from specialized services reduces risks and liability to hospitals</p> <p>Having two processing centers in the country is efficient and reduces the risk of the system collapsing in case of a disaster</p>	<p>National Law</p> <p>Guideline for estimating costs of regionalization of blood banks [28]</p> <p>Comparative analysis of laws on blood safety [29]</p> <p>Data on blood supply in Latin America [8]</p>
Medical and technical personnel	<p>Blood transfusion is a medical act</p> <p>The focus of hospital transfusion services is appropriate patient care</p> <p>Transfusions may have untoward effects</p> <p>Hospitals are responsible for estimating their needs for blood components</p> <p>Blood components are medicinal goods</p> <p>The production and distribution of blood components is costly</p> <p>Production and distribution of blood components must comply with quality standards</p> <p>The mission of blood processing centers is appropriate and timely production of enough safe blood components</p> <p>National resources, including blood components, must be used efficiently</p> <p>Patients and blood donors have rights, should be treated with respect and provide informed consent</p> <p>Specially-trained staff is better suited to service donors, process blood, and tend to patients</p>	<p>Working standards for blood banks [30]</p> <p>Distance learning course on safe blood [23]</p> <p>Guidelines for estimating blood needs [21]</p>
General Public	<p>Blood for transfusion is needed at all times</p> <p>Humans are the only source of blood components for transfusion</p> <p>Blood donation is harmless when practiced regularly</p> <p>Adverse reactions to blood donation are more common among first-time donors</p> <p>Voluntary, educated donors are safer than replacement, forced donors</p> <p>Donors have the right to receive information and ask questions</p> <p>Donating blood voluntarily and regularly assures timely access to blood for all patients</p> <p>Blood components in Nicaragua are not sold</p> <p>Programmed mobile collections are convenient and efficient</p> <p>Establishing links with the blood services promotes better care of donors</p>	<p>Distance learning course on promotion of blood donation [22]</p> <p>Guidelines for education and selection of donors [18]</p>

903 in 2007, to 2250 in 2011 (Table 4), when they accounted for 78.4% of all units collected.

### 3.3. Availability and sufficiency of red blood cells

Table 5 summarizes the indicators of RBC availability. Annual collection increased by 14,157 units (23.9%) from 2007–2011. In 2011, 73,912 units of whole blood were donated by 59,889 individuals, equivalent to 1.23 units per donor. Two thirds, 66.6%, of donors had O positive blood type, 20.2% had A positive, 8.1% had B positive, 2.7% had O negative, 1.1% had AB positive, 0.85% had A negative, 0.34% had B negative, and 0.06% had AB negative.

Because the Nicaraguan population grew by 267,000 during the 4 years, the blood collection rate per 10,000 inhabitants rose by only 18.1%, from 106.9 to 125.9 (Table 5). Prevalence of TTI markers among blood donors was reduced from 3.32% to 1.50%, making 1159 more blood units available for transfusion in 2011 than in 2008. The proportion of outdated RBC was reduced to 3.89% by

2011. Packed RBC were prepared from all units (Table 4). The combination of increased annual collection, decreased TTI marker prevalence, higher number of units of packed RBC prepared, and reduced RBC obsolescence resulted in more units being transfused in 2011, 119.1 units per 10,000, than in any of the preceding 4 years.

## 4. Discussion

Nicaragua abolished replacement donation in March 2009 and collected blood for transfusion only from voluntary, non-remunerated, altruistic donors since that date, joining Canada, Cuba, Netherland Antilles, Suriname and the United States as the only American countries with universal VBD [10,24]. The latter five countries have traditionally obtained whole blood for transfusion only from voluntary donors [24]. Other American nations that significantly increased their VBD during the last years are Colombia, from 58% to 65%, Costa Rica, from 59% to 76%, Guyana, from 22% to 68%, and Haiti, from 15% to 70%

**Table 4**

Major landmarks in the evolution of the national blood system network.

Indicator	2007	2008	2009	2010	2011
Annual collection (N)	59,755	68,288	69,632	74,842	73,912
Processing centers (N)	12	7	3	2	2
Units processed per center (mean)	4980	9755	23,211	37,421	36,956
VBD (%)	39	48	87	100	100
Mobile collections (N)	903	1202	1752	2011	2250
<i>T. cruzi</i> screening <sup>a</sup> (%)	94.5	98.5	100	100	100
Separation of RBC (%)	86.97	88.04	89.50	95.00	100
NRC Personnel (N)	85	93	99	106	110
Cost of processing <sup>b</sup> per blood unit	15.00	17.00	16.00	15.00	21.50

<sup>a</sup> Universal screening for HIV, HBsAg, HCV and syphilis was attained in 2007.<sup>b</sup> Expressed in US Dollars. Includes donor education and recruitment, blood collection, component preparation, infectious markers and immunohematology testing, and component storage.**Table 5**

Major indicators of blood availability in Nicaragua, 2007–2011.

Year	Population <sup>a</sup>	Blood collection		TTI marker prevalence <sup>c</sup>		Outdated red blood cells <sup>d</sup>		Transfused red blood cells	
		Units	Rate <sup>b</sup>	Units	Percent	Units	Percent	Units	Rate <sup>b</sup>
2007	5.603	59,755	106.6	1613	2.70	4363	7.30	53,779	96.0
2008	5.676	68,288	120.3	2267	3.32	2336	3.42	63,685	112.2
2009	5.743	69,632	121.2	1079	1.55	5982	8.59	65,271	109.0
2010	5.822	74,842	128.6	1242	1.66	4585	6.12	69,015	118.5
2011	5.870	73,912	125.9	1108	1.50	2880	3.89	69,924	119.1

<sup>a</sup> Population × 1000.<sup>b</sup> Per 10,000 inhabitants.<sup>c</sup> Among blood donors.<sup>d</sup> Whole blood and packed red blood cells.

[10,25]. Guyana and Haiti are part of a group of 14 countries that receive financial and technical support from the United States aimed at improving their national blood services [26]. Five of the 12 African countries included in that program had 100% VBD since 2003, the first year when data were reported, while Kenya, Uganda and Zambia reached universal VBD after 5 or 6 years of work [26], even though their VBD baseline figures were 99.0%, 95.5% and 72.7%, respectively. A similar pattern of VBD growth was seen in Iran, where the proportion of VBD increased from 64% in 1997 to 95% in 2002, and reached 100% in 2007 [27]. To our knowledge, Nicaragua is the first country to augment its annual VBD from less than 50% to 100% in only 2 years. Even though the Nicaraguan blood systems relied primarily on replacement donors during the first 2 months of 2009, the NRC was able to draw enough voluntary donors to cover the needs of the hospitals once the hospitals stopped requiring patients to recruit donors to deposit blood on their behalf.

In the absence of a scientifically determined estimate of the need for blood components in all health care facilities, the annual collection goal was empirically set at 74,880 units of whole blood (Table 2). Despite this goal not being met in 2009, the outdated rate of RBC was the highest of the 6 years, 8.59% (Table 5). In 2010, when the annual collection reached 74,842 units, a lower but still unacceptable proportion of RBC, 6.12%, reached obsolescence. Adjustments were made to the estimated need of blood in the country and the collection and discard goals for 2011 were reduced to 74,000 units and 5%, respectively. The National Blood Service was able to attain the 2011 collection goal

but the discard rate was above the standard set, 5.39% (Table 5). Under these circumstances, in 2011 there were 119.1 units of RBC transfused per 10,000 inhabitants, a figure that is 24% higher than that observed in 2007, 96.0 (Table 5).

Attaining universal VBD and national self sufficiency of RBC in a 2-year span entailed a well-planned national approach for putting in place the PAHO Regional Plan of Action for Transfusion Safety [9]. The reduction in the number of hospital-based blood banks required the involvement of the authorities of the SILAIS and hospitals. The CNDR and the NRC advocated for the elimination of blood collection in the patient care facilities by showing that, in 2005, the 20 hospital-based blood banks collected 24,352 units of blood, or 1218 units per bank per year, a situation that contributed to the deferral of 15,721 prospective donors, to 595 units of blood being transfused without being tested for HCV, and to 22% of collected units not being separated into components [8]. The centralized processing of blood was presented to the local health authorities as an efficient alternative to produce safer components. Under these circumstances, the tactic to eliminate replacement donation in a 4-month period described in Table 2 became vital, relatively uncomplicated, and a potential model for other countries to adapt.

The intervention to transform small blood banks into transfusion services included readjusting attitudes, skills, and practices of medical and technical staff at the hospitals. In parallel, the NRC hired and trained personnel to promote and facilitate VBD, and to improve the quality of its products and services (Table 4). In 2011, there were



109 employees at the National Blood Service including 23 in administration, 60 in blood donor services, 19 laboratorians, and seven information managers. Community volunteers, including members of Club 25, actively participated in donor recruitment, education and support [18–20]. These changes resulted in a 2.5-fold increase in the annual number of extramural collections, from 903 in 2007 to 2250 in 2011, a year when mobile teams obtained 57,969 (78.4% of the annual collection) units of whole blood, with an average of 25.8 units per session. Collecting blood at places where community groups regularly meet made donation more convenient and removed the burden and cost of transportation from the donors.

The conversion of hospital blood banks into transfusion services resulted in better patient care and better use of resources. It is estimated that, prior to the intervention, each hospital blood bank needed to have as, a minimum, one donor interviewer and one phlebotomist for at least four continuous hours each morning, in addition to the unplanned collection of blood during patient emergencies, estimated at two more hours every day. One full time laboratorian was assigned to processing blood units in each hospital. The 20 h-person labor per day is equivalent to 2.5 full time employees in each of the 10 hospitals, or 25 employees who were subsequently assigned to patient care.

Despite the increase in numbers of personnel at the National Blood Service of the NRC, the cost of blood processing remained low, US\$21.50 per unit (Table 4). The investment in donor education, recruitment and service, blood collection, component preparation, laboratory analyses and storage in 2011, when 139,584 components were transfused, was US\$ 1,589,108, equivalent to US\$ 11.38 per component used. Costs of transportation are not included in the budget because the MoH transports blood components using the means of communication previously established to deliver perishable medical supplies to every SILAIS and hospital. This arrangement saves resources, avoids duplication of administrative processes, and assures the delivery of blood components to hospitals even under special circumstances, such as emergencies.

Taking the size of the country and the quality of roads into account, the blood distribution network comprises three regional blood banks, in Juigalpa, Leon and Matagalpa, in addition to the two processing centers in Managua and Estelí (Fig. 1). The center in Managua provides blood components to the regional banks in Juigalpa and in Leon which, in turn, distribute them to more peripheral hospitals situated no more than 90 km away. Blood components processed in Managua are flown once a week directly to the services located in the departments adjacent to the Caribbean Sea. The flying time from the capital city to Waspan, the farthest service located 380 km north of Managua (Fig. 1) is 29 min. The center in Estelí supplies blood to Matagalpa, 70 km away, by using land transportation. Additionally, and in the case of an emergency, helicopters for transportation of blood are available to the two NRC processing centers.

Better planned collections permitted to program the arrival of blood units to the NRC centers, and to assign laboratory staff to specific shifts for blood processing.

Centralized facilities allowed the application of quality assurance measures. Blood processing became more efficient, and by 2011, every unit of blood was tested for the required TTI markers and was separated into components (Table 4). In 2011, the public and private hospitals transfused 139,584 blood components, including 69,924 packed RBC, 35,609 units of platelets, 30,698 of frozen plasma and 3353 of cryoprecipitate. The appropriate stock and the efficient delivery of blood to hospitals provide a sense of security to health authorities, to hospital directors, and to medical personnel, and promote more sensible and accurate requests for components at all levels. The timely access to blood by patients and the absence of replacement donation serve as the best incentives for VBD. We firmly believe that, as a consequence of universal VBD and of quality management, the availability and the safety of blood for transfusion in Nicaragua attained highly acceptable levels. Proactive monitoring of patients, however, is necessary to document the actual clinical impact of transfusions in the country.

The experience of Nicaragua, the Latin American country with the least financial resources, demonstrates that the strategies, recommendations and technical documents of Plan of Action for Transfusion Safety developed by PAHO [9] are appropriate for the region. The political will of the government, however, is vital for their implementation at the country level. Universal VBD and national self-sufficiency of blood components can be achieved when a national approach is developed by consensus of all interested parties, and is implemented with the leadership and support of the MoH, with the efficient processing of blood by a specialized institution, and with the active participation of the society. These factors permit the execution of the steps necessary to fruitfully translate the plan into practice.

In a relatively short period of time, Nicaragua established a national blood system that collects blood only from voluntary, non-remunerated donors, tests all blood units for TTI markers, and applies quality measures. These are key elements of the national policy that the WHO recommends [3,4]. Our opinion is that they are expressions of well-planned blood services that are administratively, operationally and financially integrated into the national health care structure.

The collection and transfusion rates of RBC that appear to be sufficient for Nicaragua, where 28% of the population does not have regular access to health care and where only 4.5% of individuals are over 64 years of age, may not be appropriate for countries with more inclusive health systems and with older populations. The example of how to eliminate replacement donation given in Table 2 provides precise figures that can be used as a model for planning not only blood collection activities to achieve universal VBD but also RBC distribution plans that result in their timely access at the hospitals. Furthermore, we understand that the decision to centralize processing of 75,000 units per year in two centers may not be applicable to countries where natural disasters are not as prevalent as in Nicaragua, or where quality of roads permits efficient land transportation of blood components during the 12 months of the year. Our paper, however, shows that understanding

the local conditions, involving the local health authorities, re-training personnel and educating the public are vital for achieving universal VBD and self-sufficiency of RBC. Documenting the successful experience of the Latin American country with the lowest GNP should provide an incentive for other nations to implement similar interventions.

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