



Published in final edited form as:

ISBT Sci Ser. 2014 November ; 9(2): 325–333. doi:10.1111/voxs.12107.

Investments in blood safety improve the availability of blood to underserved areas in a sub-Saharan African country

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Abstract

Background and Objectives—Since 2004, several African countries, including Namibia, have received assistance from the U.S. President’s Emergency Plan for AIDS Relief (PEPFAR). Gains have been documented in the safety and number of collected units in these countries, but the distribution of blood has not been described.

Materials and Methods—Nine years of data on blood requests and issues from Namibia were stratified by region to describe temporal and spatial changes in the number and type of blood components issued to Namibian healthcare facilities nationally.

Results—Between 2004 and 2007 (early years of PEPFAR support) and 2008–2011 (peak years of PEPFAR support), the average number of red cell units issued annually increased by 23.5% in seven densely populated but less-developed regions in northern Namibia; by 30% in two regions with urban centres; and by 35.1% in four sparsely populated rural regions.

Conclusion—Investments in blood safety and a policy decision to emphasize distribution of blood to underserved regions improved blood availability in remote rural areas and increased the proportion of units distributed as components. However, disparities persist in the distribution of blood between Namibia’s urban and rural regions.

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Disclaimer

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Author roles

JPP, SVB and RW participated in study design, study supervision, data collection and data interpretation; JT performed all spatial analyses; CSS, MP, MM, BvF and DL participated in data interpretation. All authors participated in writing the manuscript and approved the final content. JPP had full access to all of the data and takes responsibility for the accuracy of the data analysis.

Conflict of interest

None of the authors reports a conflict of interest.

Keywords

blood safety; Namibia; PEPFAR

Introduction

In sub-Saharan Africa, the prevention of transfusion-transmitted HIV infection has been a priority for donor-supported blood safety programmes. In addition to recruiting safer blood donors and strengthening laboratory screening practices based on World Health Organization (WHO) guidelines [1, 2], blood safety investments have also sought to improve availability of blood to reduce the risk of administering poorly screened or unscreened blood in life-threatening situations. While much has been done to quantify the risk of HIV transmission through blood transfusion [3–7] and identify successful risk-reduction strategies [8–12], there is limited information about the impact that blood safety investments have had on improving the availability of blood in sub-Saharan Africa.

In Namibia, a country of approximately two million people in southern Africa, only the Blood Transfusion Service of Namibia (NAMBTS) can collect, process and distribute blood. All units are collected from voluntary, nonremunerated blood donors (VNRD), of which approximately 73% are repeat donors, a population shown to have lower infection risk for HIV than family and replacement donors [13]. In 2011, NAMBTS collected 23 338 whole blood units and distributed 99.9% of all units as blood components. Based on these totals, NAM-BTS collected 11 units of whole blood per 1000 population, meeting a widely used blood collection target (10–20 whole blood units per 1000 population per year) for resource-limited countries [14]. However, blood components have not been evenly distributed around the country.

Historically, collection and use of blood have been greatest in Namibia's three urban centres (Windhoek, the capital, and two cities on the Atlantic coast) that contain less than 20% of the national population. More than two-thirds of Namibia's population, and 50% of health facilities, are located in seven regions along the northern border with Angola [15]. The remaining population resides in four rural regions with low population density. (Fig. 1) Economic and health disparities exist between the regions. Up to 60% of residents in the populous northern regions are classified as 'poor' compared to only six per cent of Windhoek residents [16]. Overall infectious disease burdens in the north are also higher than in the capital [17, 18].

Between 2004 and 2011, NAMBTS leveraged national funds with \$8.7 million in grants from the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) to increase the quantity of safe blood available for transfusion and to strengthen the national blood distribution system. Interventions included the development of an electronic inventory management database; launch of daily stock-management telephone calls with facilities; use of the national post's overnight delivery service; revision of national blood policies, guidelines and training programmes; procurement of cold chain and laboratory equipment; and renovation of blood banks and laboratories to enhance storage and capacity to perform ABO grouping and compatibility testing.

Reports have described PEPFAR's impact on key elements of national HIV/AIDS responses in sub-Saharan Africa, such as the prevention of mother-to-child transmission (PMTCT) and the reduction in HIV mortality due to increased use of antiretroviral therapy [19–21]. Studies have also evaluated the impact of WHO guidelines and strengthened laboratory systems on the safety of blood supplies in sub-Saharan Africa [9, 22–24]. However, studies examining the impact of PEPFAR support on the distribution of safe blood have not been conducted. This study evaluated whether PEPFAR support improved the distribution of safe blood nationally in Namibia. The lessons from Namibia are important for other countries in the region and provide a unique glimpse into PEPFAR's impact on the adequacy of blood supplies in Africa.

Materials and methods

Data collection followed approval from the Namibian Ministry of Health and Social Services (MOHSS). Because the study involved the evaluation of routine public health programme data, it was exempted from review by an institutional review board by the U.S. Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, USA.

Data on all blood and blood product units collected nationally and issued to a Namibian healthcare facility from January 1, 2003 to December 31, 2011 were analysed. To receive blood and blood products, physicians must submit a standardized national Blood Request Form (BRF) to hospital blood banks. Copies of all BRFs resulting in the issuance of blood units were returned to NAMBTS headquarters where data were entered into an electronic database. Information on BRFs that did not result in the issuance of blood units was not available. Each BRF that resulted in the issue of blood units was considered to represent a 'transfusion event' in which any combination of blood or blood components was requested and issued to an individual patient for one clinical indication. The BRF was introduced in 2003 and updated in 2007. While the BRF contained clinical variables related to the indications for transfusion, including diagnosis and haemoglobin level, only variables relevant to billing were routinely entered into the database. For this analysis, healthcare facility name, date of issue, and the number and type of blood components issued were reviewed. Clinical outcomes were not reported to NAMBTS, and data were not available to confirm that issued units were transfused. This analysis therefore only evaluated changes in the distribution of blood and blood components.

Annual blood collections data were derived from NAM-BTS records and stratified by year and component type. The number of units issued to health facilities was stratified by year, region, facility and component type. Facilities were matched to regions and categorized as public, private or faith based. Records without a facility name were categorized as 'unknown' and were excluded from the regional analyses. Records for units issued by small facilities that did not issue blood in any two consecutive years from 2003 to 2011 were excluded. To show changes in availability of blood products over time and by place, Namibian census data were used to stratify Namibia's 13 regions into three regional categories: the seven most populous but largely under-developed regions in the north ('northern'), the two regions containing Windhoek and two cities on the Atlantic coast ('urban'), and four regions with small, rural populations ('rural') [15]. Population density

was assessed spatially using data from the Global Rural-Urban Mapping Project (GRUMP; Columbia University, NY, NY).

The nine-year time frame was grouped into two multi-year periods, the ‘early PEPFAR period’ (2004–2007) and the ‘peak PEPFAR period’ (2008–2011). The latter time period represents the years in which the cumulative impact of PEPFAR funding was greatest. Yearly averages were calculated for indicators during both periods.

Blood components were stratified into four types to show the availability of different components over time: whole blood (WB), red cell concentrate (RCC), frozen fresh plasma (FFP) and platelets. Both platelets derived from WB donations and from apheresis were collected and issued; all were expressed as single units (apheresis units were counted as the equivalent of five platelet units derived from WB donations). Typically, three paediatric RCC units were derived from a single WB donation. For this analysis, however, paediatric RCC units were counted as individual units when issued.

Red blood cell use was measured as the combined number of WB and RCC units issued (WB-RCC) per 1000 population per year and as the mean number of WB-RCC units issued per transfusion event. Population estimates were obtained from Namibian government census estimates [15].

Descriptive statistics were calculated using Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Heat maps were developed to show population density by region. Choropleth maps were constructed to illustrate changes in the number of units issued and the number of units issued per 1000 population per year to each region in 2003 and in 2011. The number of units issued to facilities was indicated spatially by increasing or reducing the size of dots representing each transfusion facility. Maps were generated using ArcGIS (version 10.1, ESRI Corp., Redlands, CA, USA).

Results

From January 1, 2003 to December 31, 2011, NAMBTS collected 180 966 WB donations. During this period, 6.5% of collected units were discarded each year on average due to the presence of infectious disease markers or other damage to the unit (including over and under bled units). Of the units that were available for transfusion, approximately three per cent were discarded on average due to expiry. Annual WB collections increased 31% from 17 860 units in 2003 to 23 338 units in 2011.

A total of 194 706 WB-derived component units were issued nationally between 2003 and 2011. Of these, 167 424 (86%) were WB-RCC units. Of these WB-RCC units, 157 668 were issued by facilities whose records could be mapped to a geographic location; 9756 units were excluded due to a lack of information about the facility to which the units were issued. During this period, the number of facilities issuing blood or blood components for transfusion increased nationally from 35 in 2003 to 44 in 2011. (Fig. 2) Of the nine facilities that added transfusion services between 2003 and 2011, six (67%) were in the northern regions. (Fig. 2).

The total number of WB-RCC units issued per year in Namibia increased 46% from 2003 to 2011 while the population increased 16%. (Table 1) This resulted in a 26% increase in the number of WB-RCC units issued per 1000 population nationally from 7.8 units per 1000 to 9.8 units per 1000. Increases were seen in all three regional categories. In the more populous northern regions, there was a 25% increase in the number of units per 1,000 (6.4 units/ 1000 population in 2003 to 8.0 in 2011); in the urban regions, there was a 21% increase (15.6 units/1000 population to 18.9); and in the rural regions, there was a 20% increase (3.5 units/ 1000 to 4.2).

The greatest increases in availability in all three regional categories occurred during 2008–2011 period, the period of peak PEPFAR activity. (Fig. 3) Nationally, the total number of issued WB-RCC units increased 8.5% from 2003 to 2007, compared with a 17% increase from 2008 to 2011. In the rural regions, there was no increase in issued WB-RCC units from 2003 to 2007 compared with a 10.2% increase from 2008 to 2011. The rates of increase in the northern and urban regions were also greater from 2008 to 2011 than in 2003 to 2007.

Surprisingly, the number of transfusion events and the number of WB-RCC units transfused per transfusion event varied greatly between the urban and nonurban regions. Nationally, the total number of transfusion events increased 5% from 2003 to 2011. (Table 1) This increase was predominantly due to a 48% increase in the annual number of transfusion events in the urban regions from 2544 events in 2003 to 3617 events in 2011. The mean number of WB-RCC units per transfusion event did not substantially increase in the urban regions during this period. In contrast, the annual number of transfusion events decreased in the northern and rural regions by 10% and 30%, respectively. In these regions, the increased number of WB-RCC units issued was due to increases in the mean number of WB-RCC units transfused per transfusion event, not an increase in the number of events. In the northern regions, the mean number of units increased from 1.65 units per event in 2003 to 2.64 units per event in 2011. In the rural regions, the mean number of WB-RCC units per event more than doubled from 1.9 units per event in 2003 to 3.92 units in 2011.

In addition to the increasing number of units issued nationally and in the three regional categories, there was an increase in the number of red cell components issued. In 2003, of 14 675 red cell units issued to facilities, 7146 (49%) were issued as RCC. In 2011, of 21 351 red cell units issued to facilities, 21 331 (99.9%) were issued as RCCs (Fig. 4).

Increased availability of blood components

Nationally, 31 205 units of WB-derived and apheresis platelet units were issued between 2003 and 2011. Platelets were primarily issued in the urban regions, which consumed 91% and 84% of all platelets in 2003 and 2011, respectively. Two-thirds of the platelets issued to the urban regions in 2011 were issued to two large public referral hospitals in the capital. The proportion of platelets issued to the northern regions increased from approximately 8% of 2753 units issued nationally in 2003 to approximately 14% of 4111 units in 2011.

Nationally, 21 535 units of FFP were issued from 2003 to 2011. In the urban regions, the number of FFP units increased from 1179 in 2003 to 1918 in 2011. The greatest use of FFP was in the urban regions during this period, but the number of FFP units issued in the

northern regions also increased during this period. The urban regions accounted for 71% of all FFP units issued nationally in 2003 and 65% in 2011, while the northern regions accounted for 25% of the national total in 2003 but 35% in 2011; FFP issues to the northern regions increased from 407 units in 2003 to 1,011 units in 2011, a 148% increase. The number of FFP units issued to the rural regions declined from 2003 to 2011.

Conclusion

A recent report by the U.S. Institute of Medicine observed that while the distribution of blood remains a challenge in PEPFAR-supported countries, PEPFAR's investments in laboratory infrastructure and healthcare procurement systems had demonstrated positive 'spillover effects for [the] entire health system' [25]. This study examining the distribution of every blood unit issued in Namibia since the start of PEPFAR's blood safety project in Namibia describes an important example of this spillover effect. It also provides evidence that blood safety investments, which helped NAMBTS mobilize a low risk donor pool (HIV prevalence in donated units <1%) in a country with a high HIV population prevalence [24, 26], can also be effective in addressing barriers to distribution. Investments in inventory management and laboratory infrastructure, coupled with a strong emphasis on distribution logistics and training clinicians on the appropriate clinical use of blood, resulted in a measurable increase in the quantity of red cell units requested and issued for transfusion in remote regions throughout the study period, especially during the period of peak PEPFAR support (2008–2011).

While these findings demonstrate improvements in availability of blood nationally, disparities persist between Namibia's urban centres and less-developed or rural regions where the majority of the population lives. These disparities are linked to a number of geographical, structural and socio-economic issues, but distance and challenges preserving the cold chain may be the biggest barriers to further improvements in distribution to nonurban areas. The concentration of the country's major public and private referral hospitals in the capital region also contributes to increased blood use in the urban regions. While access to specialist healthcare services is still uncommon in Africa, in Namibia, the national blood supply is increasingly used to treat patients with cancers and other blood disorders (unpublished blood utilization surveillance data, NAMBTS). Elsewhere in the region, as countries reach middle income status and continue to work towards the Millennium Development Goals in maternal and child health [27, 28], similar changes in blood utilization patterns, which have traditionally been dominated by demand for malaria-associated anaemia in children and postpartum haemorrhage in pregnant women, may occur.

In addition to the improved distribution of blood components, this analysis identified several encouraging trends during the period of PEPFAR's peak investments in policy, infrastructure and clinical training. Distribution of components greatly increased. Most notably, by 2011, only 0.1% of red blood cell transfusions were performed using whole blood (vs. 49% in 2003); transfusing RCCs had become the national standard. By directing substantial proportions of WB collections into paediatric RCC from 2003 to 2006, NAMBTS was able to serve up to three patients from each WB unit fractionated into paediatric products. The number of platelet units issued in the northern regions was 2.6

times greater in 2011 than in 2003 – a positive reflection of the investments made to strengthen the efficiency of long-distance temperature controlled blood shipments, as well as improved storage facilities in the north. It also suggests a diversification of clinical services available in the north.

Factors other than PEPFAR have likely also contributed to changes in distribution. Since 2000, the Namibian government has contributed between 10% and 12% of its annual national budget to health – one of the highest proportions in Africa [29]. National investments in health care were supplemented by sizeable contributions from PEPFAR and the Global Fund to HIV/AIDS, malaria and tuberculosis programmes.¹ The finding that six of the seven facilities with fewer transfusion events in 2011 were located in malaria-endemic zones reflects an important trend in reduced malaria hospitalizations in northern Namibia since 2003 [30]. The reduction in paediatric RCC issues also suggests a decline in malaria and other clinical conditions that have traditionally driven demand for paediatric transfusions in sub-Saharan Africa. By 2010, PEP-FAR investments in emergency obstetrical and neonatal care [31] were also aligned with the government's Road-map for the Accelerated Reduction of Maternal and Childhood Mortality (2009). These factors may have resulted in increased awareness by clinicians and improved health-seeking behaviour by the public.

From 2005 to 2009, NAMBTS published revised guidelines on the appropriate use of blood and launched a national training programme. The guidelines were distributed nationally and used to train more than 500 doctors, nurses and laboratory technologists. Coupled with these guidelines, a revised National Blood Policy and a national strategic plan was published, and national transfusion standards and a national quality management program were launched. The availability of improved training and guidelines may have contributed to the increased number of units issued per transfusion event observed in most regions.

This study is subject to the following limitations. First, the lack of data on transfusion outcomes limits the ability to describe a causal association between blood safety investments and health outcomes. Therefore, while Namibia invested in ambitious targets for maternal and child health during the study period [32], we are unable to comment on whether any changes in childhood or maternal mortality in Namibia directly resulted from blood safety investments. Second, data on patient diagnoses were not available for all records, limiting the ability to evaluate the appropriateness of clinical blood use. Third, it was not possible to measure the impact of training and the introduction of new guidelines on changes in prescribing practices between clinicians. Fourth, although these data show improved distribution of blood components, they do not show whether the supply was able to meet the actual need for blood among hospitalized patients or among patients without access to healthcare facilities.

¹PEPFAR invested \$615 million in Namibia between US Government fiscal years 2004–2011, of which approximately \$6 million was direct support to NAMBTS. (<http://www.pepfar.gov/documents/organization/184791.pdf>) Global Fund provided \$324 million to the national HIV/ AIDS response, \$204 million for malaria and \$29 million for tuberculosis. (<http://portfolio.theglobalfund.org/en/Grant/List/NMB>).

The sustainability of these accomplishments will require attention by NAMBTS and its external partners. PEPFAR support for NAMBTS peaked in 2009 and has continued to decline as PEPFAR's overall support to Namibia is reduced [33]. While NAMBTS has a cost recovery system and generates revenue through the sale of excess plasma, reduced PEPFAR support may result in higher unit costs or reduced investments in staff, training and equipment – or both. Despite an overall trend towards more equal distribution of RCC, increased consumption of blood components by private facilities and the concentration of platelets in two urban facilities also mirror continuing inequalities in healthcare access in Namibia described elsewhere [34]. As PEPFAR and other donors develop sustainable transition strategies, studies are needed to establish causal pathways between blood safety investments and patient outcomes and describe long-term economic benefits associated with investments in blood safety and blood transfusion services. Improved models to estimate the adequacy of national blood supplies in developing countries is also needed. Finally, the potential for blood safety investments to impact maternal health [35] and other indicators related to the Millennium Development Goals also merits continued attention.

Acknowledgments

The authors thank Drs. Britta Lohrke and Regine Redecker, as well as Maritha Franks and Israel Chipare of NAMBTS for their input on the 'Better and Safer Transfusions' (BeST) initiative and the NAMBTS hemovigilance system; assistance exporting data from the NAMBTS data system; and updates on the National Blood Programme. Thanks, also, to CDC Namibia staff Naemi Shoopala and Dr. Gram Mutandi for their assistance identifying changes in health-care facilities in northern Namibia and to WHO consultant James Chitsva, who provided PEPFAR-supported technical assistance to NAMBTS between 2005 and 2010.

Funding source

This project has been supported by the President's Emergency Plan for AIDS Relief (PEPFAR) through the Centers for Disease Control and Prevention.

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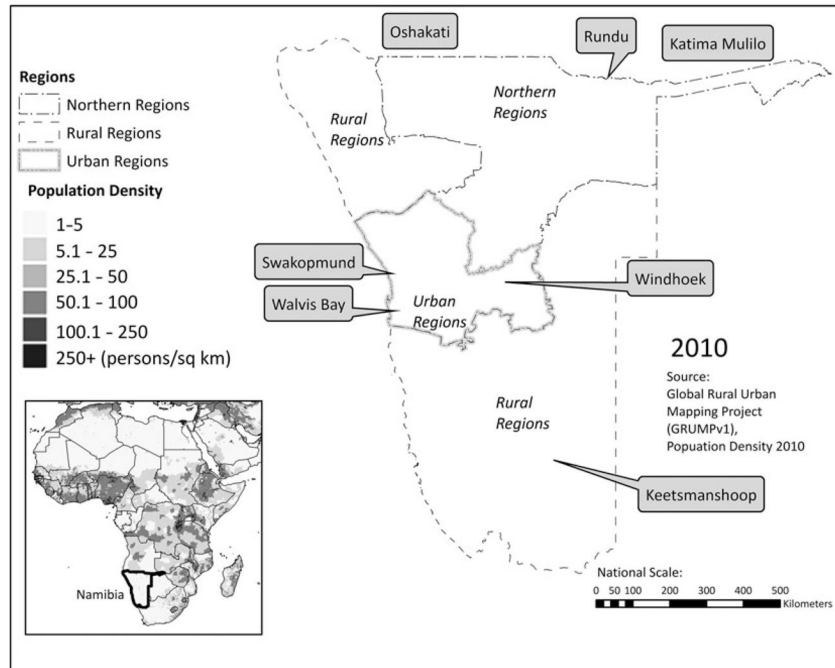


Fig. 1. Population density by region, Namibia, 2010.

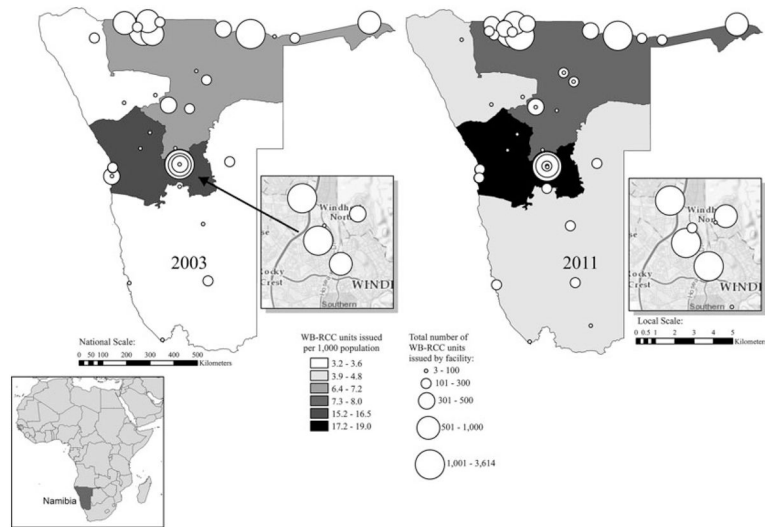


Fig. 2. Spatial distribution of whole blood and red cell concentrate by facility and region, Namibia, 2003 and 2011.

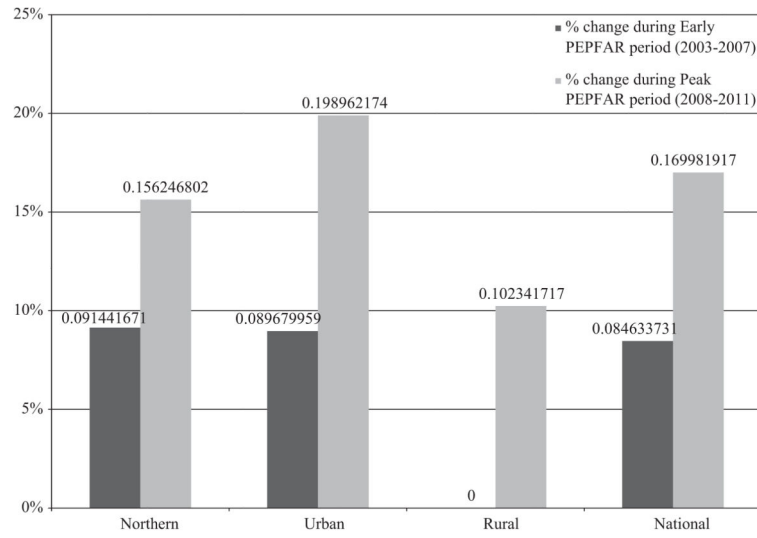


Fig. 3. Accelerated rates of change in the total numbers of units of WB-RCC issued by regional zone before (2003–2007) and during (2008–2011) the peak years of PEPFAR investments in blood safety in Namibia.

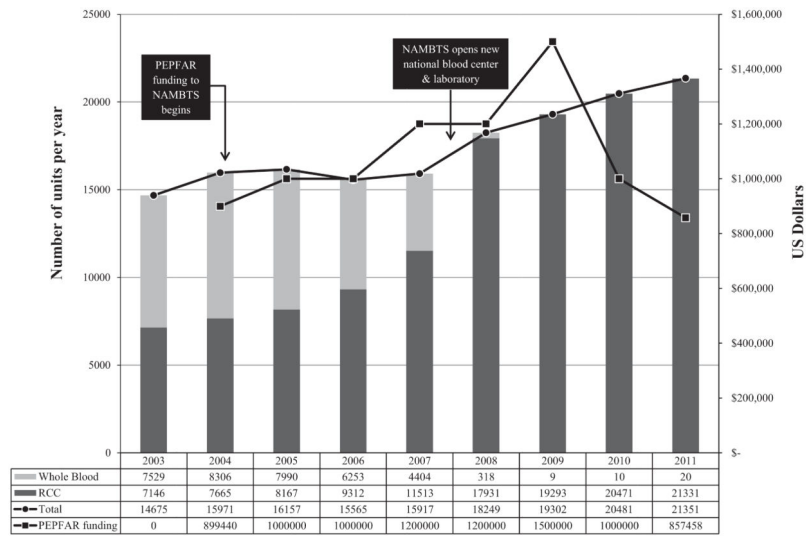


Fig. 4. PEPFAR funding to NAMBTS and changes in the proportion of red cell units issued to healthcare facilities as red cell concentrate (RCC) compared to whole blood (WB). Namibia, 2003–2011.

Table 1

Total national distribution of whole blood and red cell concentrate units to facilities by year and by geographic zone, Namibia, 2003 and 2011

	Whole Blood and Red Cell Concentrate Units		
	2003	2011	% change
Zone 1 (Seven Northern Regions)			
Population	1 235 843	1 416 413	+14.6%
Number of transfusion facilities issuing WB-RCC	16	22	+37.5%
Number of WB-RCC units issued	7852	11 318	+44%
WB-RCC units per 1000 pop.	6.4	8.0	+25%
Number of transfusion events	4758	4295	-10.5%
Mean (SD) number of WB-RCC units issued per transfusion event	1.65 ± 1.84	2.64 ± 3.28	+60%
Zone 2 (Two Urban Regions)			
Population	375 564	462 513	+23.2%
Number of transfusion facilities issuing WB-RCC	11	13	+18.2%
Number of WB-RCC units issued	5843	8780	+50.2%
WB-RCC units issued per 1000 pop.	15.6	18.9	+22%
Number of transfusion events	2544	3617	+48%
Mean (SD) number of WB-RCC units issued per transfusion event	2.40 ± 1.19	2.43 ± 1.13	+1.3%
Zone 3 (Four Rural Regions)			
Population	279 689	305 167	+9.1%
Number of transfusion facilities issuing WB-RCC	9	10	+11.1%
Number of WB-RCC units issued	980	1253	+27.9%
WB-RCC units issued per 1000 pop.	3.5	4.2	+20%
Number of transfusion events	516	318	-30%
Mean number of WB-RCC units issued per transfusion event	1.90 ± 1.32	3.92 ± 3.25	+106.3%
National Total (13 Regions)			
Population	1 891 096	2 184 093	+15.5%
Number of transfusion facilities issuing WB-RCC	36	45	+25.0%
Number of WB-RCC units issued	14 675	21 351	+45.5%
WB-RCC units issued per 1000 pop.	7.8	9.8	+25.6%
Number of transfusion events	7818	8230	+5.3%
Mean (SD) number of WB-RCC units issued per transfusion event	1.88 ± 1.64	2.60 ± 2.59	+38.3%