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Blood Component Use in a Sub-Saharan African Country: Results of a 4-Year Evaluation of Diagnoses Associated With Transfusion Orders in Namibia

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ABSTRACT

National blood use patterns in sub-Saharan Africa are poorly described. Although malaria and maternal hemorrhage remain important drivers of blood demand across Africa, economic growth and changes in malaria, HIV/AIDS, and noncommunicable disease epidemiology may contribute to changes in blood demand. We evaluated indications for blood use in Namibia, a country in southern Africa, using a nationally representative sample and discuss implications for the region. Clinical and demographic data related to the issuance of blood component units in Namibia were reviewed for a 4-year period (August 1, 2007–July 31, 2011). Variables included blood component type, recipient age and sex, and diagnosis. Diagnoses reported by clinicians were reclassified into *International Statistical Classification of Diseases, 10th Revision* categories. Multiple imputation methods were used to complete a data set missing age, sex or diagnosis data. Descriptive analyses were conducted to describe indications for transfusions and use of red blood cells (RBCs), platelets, and plasma. A total of 39 313 records accounting for 91 207 blood component units were analyzed. The median age of Namibian transfusion recipients was 45 years (SD, ± 19). A total of 78 660 RBC units were issued in Namibia during the study period. Red blood cells transfused for "unspecified anemia" accounted for the single largest category of blood issued (24 798 units). Of the overall total, 38.9% were for diseases of the blood and blood-forming organs (D50-D89). Infectious disease (A00-B99), pregnancy (O00-O99), and gastrointestinal (K20-K93) accounted for 14.8%, 11.1%, and 6.1% of RBC units issued, respectively. Although a specific diagnosis of malaria accounted for only 2.7% of pediatric transfusions, an unknown number of additional transfusions for malaria may have been categorized by requesting physicians as unspecified anemia and counted under diseases of blood forming organs. During the study period, 9751 units of fresh-frozen plasma were issued. Nearly one-quarter of these units (23.1%) were issued for gastrointestinal (K20-K93) diagnoses. Malignant neoplasms (C00-C97) accounted for 38.1% of 2978 platelet units issued. Blood use in Namibia reflects changes in the health care system due to economic development, improvement in HIV/AIDS and malaria epidemiology, high rates of health care facility–based childbirth, and access to noncommunicable disease treatment. However, better documentation of the indications for transfusion is needed to confirm these observations. Changing patterns of health care will result in changing demands for blood components. Improved methods to evaluate blood use patterns in sub-Saharan Africa may help set realistic national blood collection goals.

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Studying blood use patterns is essential for forecasting and predicting future blood stock requirements. In industrialized countries, many surveys have been conducted to document blood use in a number of clinical settings, including surgical wards [1], trauma departments [2,3], and large academic or regional medical centers [4–7]. Other studies in industrialized settings have evaluated blood use to plan for demographic shifts related to an aging population [8] or the impact of transfusion alternatives [9–13]. Beyond blood stock management,

transfusion services in developed countries have also studied blood use to track the appropriate use of transfusions [14,15], the impact of interventions, such as training [16,17], or the introduction of new technologies on physicians' blood prescribing practices [18].

Similar studies describing blood use have been conducted in developing countries but are generally limited in sub-Saharan Africa [19–22]. The few available studies from the region are restricted to specific wards or regional or tertiary hospitals, and only cover short periods [23,24]. Based on these limited studies, the most common clinical indications for blood in sub-Saharan Africa are generally assumed to be maternal hemorrhage, trauma, and malaria-associated anemia in children. However, broader analyses that evaluate current blood use at a national level are lacking. Although traditional clinical indicators such as maternal hemorrhage and malaria-associated anemia undoubtedly remain significant in rural and less developed parts of sub-Saharan Africa, their importance may be overestimated in rapidly urbanizing areas, particularly in middle-income countries. For example, improvements in access to specialist care and the increasing burden of cancer and other chronic noncommunicable diseases have been reported in sub-Saharan Africa [25] and may result in changing blood use patterns.

Namibia is a geographically large, but sparsely populated country in southern Africa. The World Bank has classified Namibia's mining, fishing, and tourism-based economy as upper middle income. However, the country has one of the region's highest rates of maternal mortality [26] and one of the highest burdens of HIV/AIDS in the world [27]. Substantial economic inequalities also persist [28], contributing to Namibia's current ranking in the bottom third of countries (128/187 ranked countries) on the United Nations Development Programme's Human Development Index [29]. Despite the broad development challenges facing Namibia, the country's health care system, represented by a national network of public and private clinics, hospitals, and insurance schemes, has made substantial progress since Namibia achieved independence in 1990 [30]. The government has consistently sought to meet international targets for annual government spending on health [31,32], and significant improvements have been reported in malaria control indicators since 2000 [33]. The Blood Transfusion Service of Namibia (NAMBTS), a private nongovernmental organization with the exclusive mandate to collect, process, and distribute blood in Namibia, has also successfully expanded collections, screening, component production, and distribution systems to meet an increasing demand for blood and blood components over the last decade [34].

NAMBTS maintains an electronic database containing information about every transfusion blood unit issued nationally. The database does not capture information about actual blood use or patient outcomes because a feedback loop does not currently exist between hospital wards and NAMBTS. Because of this limitation, we presumed the majority of issued units were also transfused. Records were analyzed by diagnosis, age, and sex over a 4-year period. The findings presented here represent a unique cross-sectional portrait of estimated blood use in a middle income sub-Saharan African country. The findings also suggest that historical blood demand patterns may be changing in some parts of Africa as a result of economic development and changes in infectious and noncommunicable disease epidemiology.

Materials and Methods

Clinical and demographic data were reviewed for a 4-year period from August 1, 2007, through July 31, 2011. In Namibia, blood and blood components are issued from blood banks based on information provided by clinicians on a standardized, hand-written (electronic blood ordering systems are not used in Namibia), national Blood Request Form (BRF). For this study, the number and type of blood components ordered were analyzed and stratified against demographic variables, including patients' age, sex, and diagnosis. Although information about the number and type of unit ordered and the date and location of every BRF is captured in an electronic NAMBTS database for

billing purposes, and all demographic variables are required on the paper-based BRF submitted by clinicians, patients' age, sex, and diagnosis information were not routinely included in the electronic record. Prior to the analysis, a random sample representing more than two-thirds of the electronic records between August 1, 2007, and July 31, 2011, were retrospectively updated to include the 3 key demographic variables. Simple random sampling for date and facility was accomplished by selecting binders containing paper-based BRFs from different sections and shelves of the NAMBTS archive. Because BRFs are filed chronologically in the order they are received, each binder effectively represented a random sample of facilities reporting data during a given period. The full archive was not updated due to time and funding limitations. Records in the updated data set were 100% complete for date and location of the transfusion, as well as for the number and type of blood components ordered. However, 23.2%, 19.6%, and 9.9% of records were missing variables for diagnosis, age, and sex, respectively. Overall, 32.8% of all records were missing at least 1 of the 3 clinical variables. To complete the analysis despite missing variables, a fully conditional multiple imputation (FCS MI) method was specified and used [35]. Complete case analysis (also known as case-wise deletion or listwise deletion, where only observations that have no missing data in any variable are used) was also conducted in parallel for comparison with FCS MI.

To create a full, 4-year nationally representative data set and to minimize bias due to systematic differences between complete records and those with missing data, FCS MI was performed in 3 steps. First, FCS imputations were generated sequentially for each blank variable by considering the distribution and frequencies of all available variables, for example, location, date, and product type. Thus, the imputation model was based on information contained in the complete or partially complete records. This process was repeated multiple times, finally resulting in the creation of 20 complete imputed data sets. Second, multinomial logistic regression modeling was used with each imputed data set to compute conditional proportions and 95% confidence intervals (95% CI) for the 3 blood unit types (red blood cells [RBC], all red cell concentrate, and whole blood units; platelets; and fresh-frozen plasma [FFP]) and was stratified by diagnosis, age, and sex. Third, all 20 data sets were combined resulting in statistically valid estimates that translated the uncertainty caused by the missing data into the width of the CI. Outputs from the imputed data set were also compared against similar outputs calculated by excluding records with missing data. All statistical analyses, including multiple imputation methods, were conducted using SAS version 9.3 (SAS Institute, Cary, NC).

Total numbers of each type of blood component unit associated with each transfusion event were established and stratified by component type and by year. A transfusion event was defined as any patient record in which at least 1 type of blood component was ordered for an individual patient. The total numbers of RBC, platelet, and FFP units issued each year were further stratified by age and sex. Because actual transfusions are not documented by NAMBTS, all units in the analysis were presumed to have been transfused. Similarly, data were not available to assess instances in which blood units were not available to meet specific requests. NAMBTS recognizes that blood shortages may occur at the facility level; however, operational experience suggests that any gap between supply and demand nationally is likely smaller than observed elsewhere in sub-Saharan Africa. For this study, all requests were presumed to have been issued. The median age of transfusion recipients and the frequency of transfusion events by age were derived from the imputed database.

Certain subanalyses were conducted on the original nonimputed sample data set. This was necessary to avoid instability in the imputation model with large numbers of variables. For example, only the 20 broad *International Statistical Classification of Diseases* (*ICD*)–based diagnostic categories were included in the imputation model, not the more than 200 original diagnoses entered by prescribing clinicians in the BRF. Subanalyses conducted on the original data set included the frequency

Table 1
Distribution and frequency of diagnosis, age, and sex variables in original NAMBTS data sample

Missing variable patterns			2007/2008		2008/2009		2009/2010		2010/2011		Grand total	
Diagnosis	Age	Sex	n (records)	%	n (records)	%	n (records)	%	n (records)	%	n (records)	%
√	√	√	5825	66.2	7060	70.9	7418	70.5	6286	62.7	26 589	67.6
√	√	×	67	0.8	37	0.4	6	0.1	17	0.2	127	0.3
√	×	√	818	9.3	1031	10.4	875	8.3	586	5.8	3310	8.4
√	×	×	61	0.7	42	0.4	16	0.2	38	0.4	157	0.4
×	√	√	1080	12.3	819	8.2	1048	10.0	1875	18.7	4822	12.3
×	√	×	19	0.2	7	0.1	9	0.1	15	0.2	50	0.1
×	×	√	226	2.6	169	1.7	255	2.4	437	4.4	1087	2.8
×	×	×	704	8.0	798	8.0	891	8.5	778	7.8	3171	8.1
Grand total			8800	100	9963	100	10 518	100	10 032	100	39 313	100

√, variable present in the original sample; ×, variable not present in the original sample.

of specific diseases within the broad *ICD-10* categories for "infectious disease" and "diseases of the blood and blood-forming organs," and an analysis of changes in pediatric transfusion requests since the last NAMBTS assessment of blood use in 1998 [36].

Data collection followed approval from the ethics committee of the Namibian Ministry of Health and Social Services. Because the study involved the evaluation of routine public health program data, it was not considered research involving human subjects by the US Centers for Disease Control and Prevention, Atlanta, Georgia, USA.

Results

A total of 39 313 blood requests (each representing a transfusion event) were received by NAMBTS and partially entered into the national database during the study period. As noted above, NAMBTS only routinely enters data necessary for billing into the national electronic database. Of these, 26 589 (67.6%) electronic records were updated retrospectively to contain complete data on diagnosis, age, and sex. The remaining records were missing 1 or more of the 3 variables (Table 1). The multiple

imputation exercise successfully added missing diagnosis, age, and/or sex variables to 12 724 records, allowing the analysis to be conducted on all 39 313 records from the 48-month study period. These records accounted for 91 389 blood component units. One percent of RBC units were excluded from the final data set due to misclassification of male patients under pregnancy-related diagnoses. A total of 91 207 units were included in the final analysis. Of the 39 313 blood requests included in the study, 83.2% requested RBC units only (Fig 1).

The median age of patients receiving any kind of blood component was 49 years (interquartile range [IQR], 29) for men and 41 years (IQR, 30) for women (median for all patients, 45 years; IQR, 27). Patients in the 25- to 39-year age range consumed the highest number and proportion of units (34.8%; n = 31 736 units; Fig 2).

Red Blood Cells

A total of 78 660 units of RBC were requested and issued by NAMBTS during the study period. Of these, 38.9% (n = 30 616 units) were issued for diagnoses in the diseases of the blood and blood-forming organs and
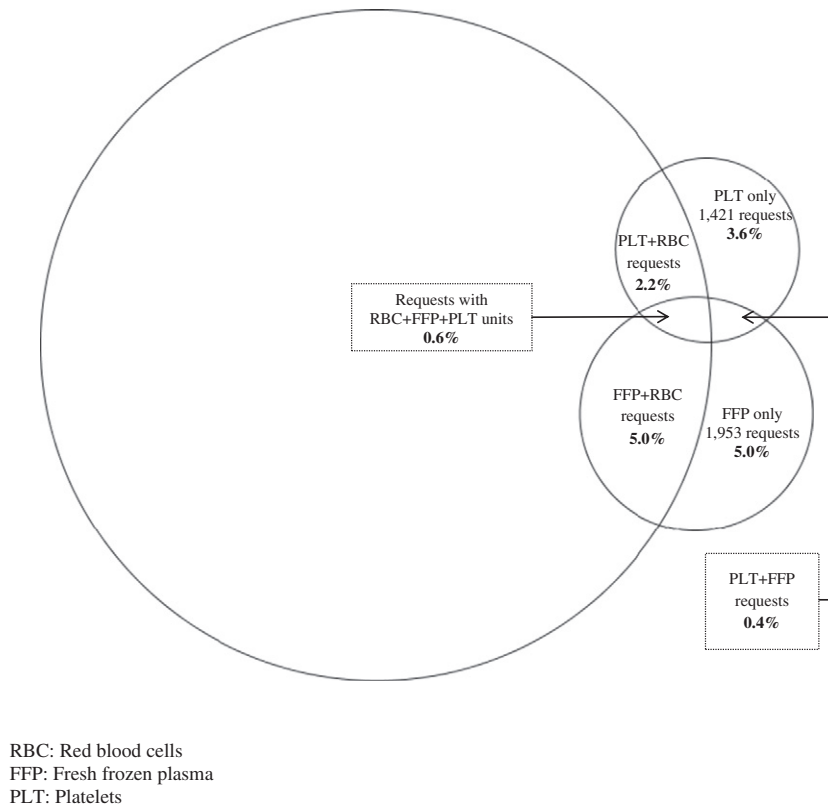

RBC: Red blood cells
FFP: Fresh frozen plasma
PLT: Platelets

Fig 1. Requests for blood components by component type and combination of components, Namibia, 2007-2009 (n = 39 313 transfusion request records).
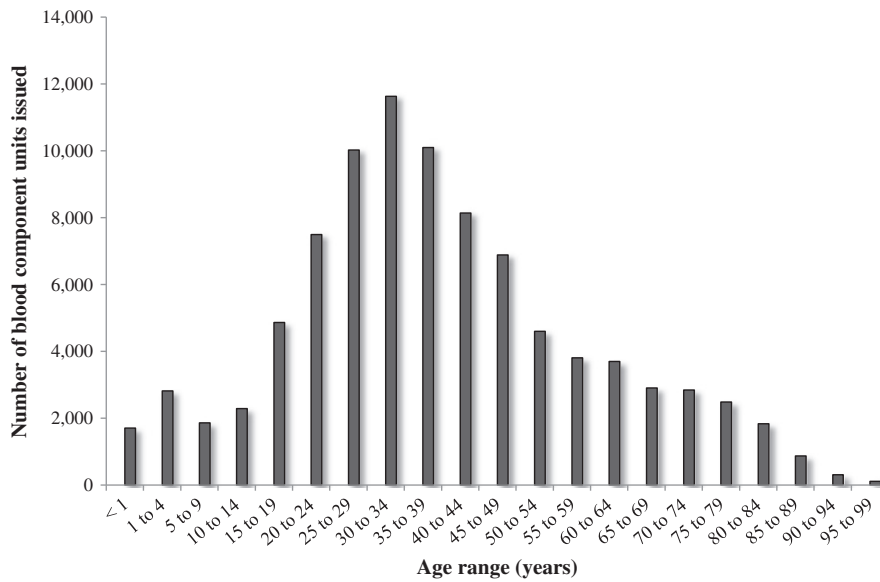
Fig 2. Four-year aggregate blood component use by age, Namibia, 2007-2011.

certain disorders involving the immune mechanism (D50-D89). Within this category, unspecified anemia accounted 81.0% (n = 24 799) of the units (Fig 3). Diagnoses in the Infectious Disease (A00-B99), pregnancy (O00-O99), and gastrointestinal (K20-K93) categories accounted for 14.8%, 11.1%, and 6.1% of units issued, respectively (Table 2). Within the infectious disease category (n = 11 648 units), patients with AIDS or persons living with HIV diagnoses accounted for 64.0% of units, followed by tuberculosis diagnoses (15.1%). In the pregnancy category (n = 8702 units), the most common indication was postpartum hemorrhage (22.6%), closely followed by abortion/miscarriage (21.6%) and ectopic

pregnancy/ruptured ectopic pregnancy (17%). Within the broad gastrointestinal category (n = 4796 units), 3 diagnoses accounted for 50.9% of all units: upper gastrointestinal bleeding (30.5%), gastrointestinal bleeding (14.9%), and peptic ulcer (5.4%) (Fig 3).

The remaining 30% of units issued were associated with 15 other *ICD* categories, none of which individually accounted for more than 5% of all units, and 6 of which accounted for less than 1% of all units. Patients in the 15- to 49-year age range accounted for more than 65% of all RBC units issued during the study period, with females between 15 and 49 years old accounted for 43% of all RBC units (Table 2).
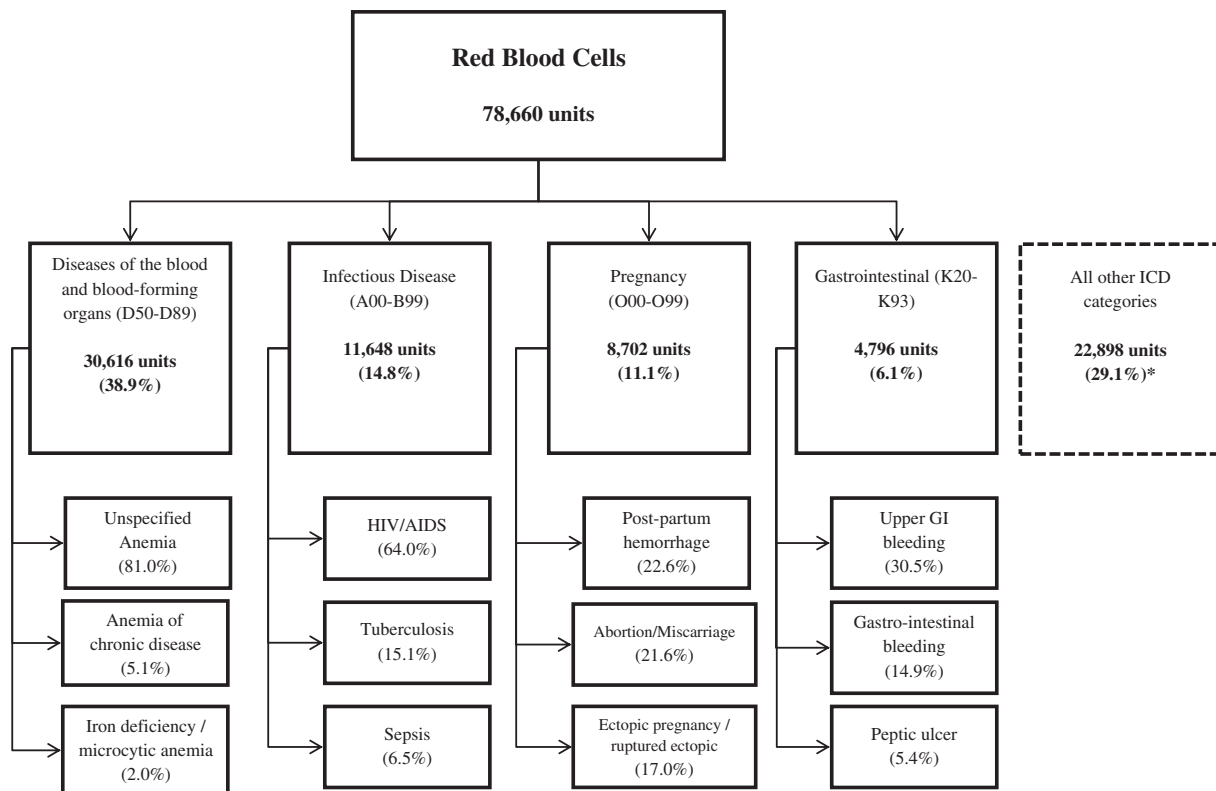

Fig 3. Estimated frequency of specific diagnoses within top 4 most common broad *ICD*-based diagnostic categories for RBC transfusions, Namibia, August 1, 2007–July 31, 2011.

Table 2
RBC use by *ICD-10* category, age, and sex, Namibia, August 1, 2007–July 31, 2011

ICD-10 category	Male						Female						Total units	
	0-14 y		15-49 y		50 + y		0-14 y		15-49 y		50 + y			
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	n	%
D. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)	2.3	(2.1-2.4)	9.2	(8.9-9.4)	4.5	(4.3-4.7)	1.9	(1.7-2.0)	16.3	(15.9-16.7)	4.8	(4.6-5.1)	30 616	38.9
A/B. Infectious disease (A00-B99)	0.6	(0.5-0.6)	4.2	(4.0-4.4)	1.6	(1.4-1.7)	0.5	(0.5-0.6)	6.4	(6.1-6.7)	1.5	(1.3-1.7)	11 648	14.8
O. Pregnancy (O00-O99)	n/a		n/a		n/a		0.3	(0.2-0.4)	9.9	(9.6-10.2)	0.8	(0.5-1.2)	8702	11.1
K. Gastrointestinal (K20-K93)	0.1	(0.0-0.1)	1.8	(1.7-1.9)	1.6	(1.5-1.8)	0.1	(0.0-0.1)	1.2	(1.1-1.4)	1.3	(1.1-1.4)	4796	6.1
All others	1.8	(1.7-1.9)	6.9	(6.6-7.2)	4.8	(4.6-5.1)	1.3	(1.2-1.4)	9.2	(8.9-9.5)	5.1	(4.7-5.6)	22 898	29.1
	4.8	(4.6-4.9)	22.1	(21.8-22.4)	12.5	(12.3-12.7)	4.1	(4.0-4.2)	43	(42.7-43.4)	13.5	(13.3-13.7)	78 660	100.0

Fresh-Frozen Plasma

Over the 48-month study period, 9751 units of FFP were requested and issued. Nearly one-quarter of these units (2251 units; 23.1%) were issued for diagnoses in the gastrointestinal (K20-K93) diagnostic category, followed by diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89; 1493 units [15.3%]), pregnancy (O00-O99; 1130 units [11.6%]), and a collection of surgical subcategories (1099 units [11.3%]; Table 3).

Platelets

Diagnoses in the malignant neoplasms (C00-C97) category accounted for 38.1% of the 2978 platelet units issued during the study period. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89), pregnancy (O00-O99), and infectious disease (A00-B99) accounted for 29.1%, 8.7%, and 5.7% of issued units, respectively. Male children aged 0 to 14 years with diagnoses in the malignant neoplasms category accounted for the single highest proportion of all platelet units issued (10.8%; Table 4).

When the above analyses were performed on a nonimputed data set including only records with complete information for all variables, the results were similar.

Discussion

To our knowledge, this is the first published report documenting the results of a multiyear evaluation of national blood component demand and presumed use in a sub-Saharan African country. Linked to a recent study showing improvements in the overall availability of blood components in Namibia since 2004 [37] and emerging reports from Uganda and Tanzania documenting current blood use patterns [38,39], these findings appear to be suggestive of some of the ways blood demand and use may be changing in sub-Saharan Africa (eg, increased demand for cancer therapies observed in both Namibia and Uganda), and other ways in which traditional drivers of blood demand remain important.

At 45 years, the overall median age of transfusion recipients in Namibia is much older than the median age nationally (22 years) [40] or in the rest of the region (18.4 years) [41]. It is also substantially older than the median age of transfusion recipients reported by blood use studies in other African countries, where younger adults and children have historically accounted for most transfusions [39,23,42]. Namibia's strong private health care sector, which is relatively unique in the region, means that a growing number of people have not only access to, but the means to pay for, specialist medical services [43]. This may result in older people receiving more advanced care including transfusions in Namibia than in neighboring countries. In addition, in Namibia, current estimates suggest that noncommunicable diseases account for 38% of overall mortality [44], driven in part by rising cancer incidence (Cancer Association of Namibia, personal communication). The overall trend toward a higher noncommunicable disease burden, which has been observed across sub-Saharan Africa [45], may drive patterns of transfusion use.

The proportion of red blood cell units used for pregnancy-related indications (11.1%) was lower than reported elsewhere in Africa [24,42,46] and much lower than might be expected based on recent estimates that up to 34% of maternal deaths in Africa [47], and 25% of maternal deaths in Namibia [48] are related to postpartum hemorrhage. This reduction may be partly associated with the fact that about 80% of Namibian women give birth in a health care facility with a trained health care worker in attendance [49], and that most hospitals performing deliveries are equipped to provide basic and/or comprehensive emergency obstetric care [50]. These 2 factors have been shown to contribute to improved maternal survival in developing countries [51,52]. Up to 86% of pregnant Namibian women report between 1 and 4 routine ANC visits before the onset of labor and delivery [49]—a factor that sets Namibia apart from many of its neighbors and may be a contributing factor to reduced blood demand during the peripartum and postpartum period.

Table 3
FFP use by *ICD* category, age and sex, Namibia, August 1, 2007–July 31, 2011

ICD category	Male						Female						Total units	
	0-14 y		15-49 y		50 + y		0-14 y		15-49 y		50 + y			
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	n	%
K. Gastrointestinal (K20-K93)	0.4	(0.2-0.6)	7.3	(6.4-8.2)	5.7	(4.6-6.8)	0.3	(0.1-0.4)	5.9	(4.8-7.1)	3.5	(2.9-4.0)	2251	23.1
D. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)	1.1	(0.9-1.4)	4.1	(3.6-4.6)	1.7	(1.3-2.1)	0.8	(0.5-1.1)	5.7	(5.1-6.3)	1.8	(1.5-2.2)	1493	15.3
O. Pregnancy (O00-O99)	n/a		n/a		n/a		0.4	(0.2-0.6)	10.8	(10.1-11.5)	0.4	(0.2-0.6)	1130	11.6
Surgical[a]	0.3	(0.1-0.5)	3.4	(2.5-4.3)	2.3	(1.7-3.0)	0.3	(0.2-0.5)	3.4	(2.7-4.1)	1.5	(1.1-2.0)	1099	11.3
All others	3	(2.6-3.4)	12.2	(11.1-13.4)	5.9	(5.0-6.9)	1.8	(1.4-2.2)	12.4	(11.3-13.5)	3.4	(2.7-4.0)	3778	38.7
	4.8	(4.4-5.2)	27	(26.1-27.9)	15.6	(14.9-16.3)	3.6	(3.3-4.0)	38.2	(37.2-39.2)	10.6	(10.0-11.2)	9751	100.0

[a] The "Surgical" category includes *ICD*-09CM codes 01.0-05.9; 08.0-16.99, 28.0-28.99, 31.0-31.99, 41.1-41.5, 43.0-46.99, 51.0-51.99, 53.0-55.99, 57.0-57.99, 60.0-60.99, 65.0-71.9, 76.0-84.99, and 86.0-86.99.

Table 4
Platelet use by *ICD* category, age and sex, Namibia, August 1, 2007–July 31, 2011

ICD category	Male						Female						Totals	
	0-14 y		15-49 y		50 + y		0-14 y		15-49 y		50 + y			
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	n	%
C. Malignant neoplasms (C00-C97)	10.8	(9.6-11.9)	8	(6.9-9.1)	2.9	(2.2-3.6)	6.6	(5.7-7.6)	7.6	(6.4-8.8)	2.2	(1.6-2.8)	1135	38.1
D. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)	3.2	(2.4-3.9)	8.8	(7.7-9.8)	2	(1.5-2.6)	3.7	(2.9-4.4)	9.6	(8.4-10.7)	1.9	(1.4-2.5)	868	29.1
O. Pregnancy (O00-O99)	n/a		n/a		n/a		0.3	(0.0-0.6)	8.3	(7.3-9.3)	0.1	(0.0-0.3)	260	8.7
A/B. Infectious disease (A00-B99)	0.6	(0.3-0.9)	1.9	(1.4-2.4)	0.5	(0.2-0.8)	0.7	(0.4-1.0)	1.8	(1.3-2.3)	0.2	(0.0-0.4)	170	5.7
All others	2.8	(2.2-3.4)	4.3	(3.6-5.1)	2.6	(1.9-3.2)	2.1	(1.5-2.6)	4.6	(3.8-5.4)	2	(1.4-2.5)	545	18.3
	17.4	(16.0-18.8)	23	(21.5-24.5)	8	(7.0-9.0)	13.4	(12.2-14.7)	31.9	(30.2-33.1)	6.4	(5.6-7.4)	2978	100.0

Of particular interest to blood services in Africa are the observed changes in pediatric blood use for malaria and HIV/AIDS indications and for pregnancy-related diagnoses, since the 1998 NAMBTS survey of blood use. During the first 10 months of 1998, 896 "blood transfusions" (number and type of component unit not specified) were recorded among pediatric patients in Namibian hospitals receiving blood components from NAMBTS [36]. Of these, 349 transfusions (39%) were ordered for children with malaria and 45 transfusions (5%) were ordered for children with HIV/AIDS diagnoses. Ten years later, those proportions had both declined substantially. The present study documented an annual average of 1090 pediatric transfusion events, or instances in which at least 1 unit of any blood component was ordered for an individual patient under the age of 15 years. Of these events, which we compared against the count of blood transfusions reported in 1998, an average of 35 events (3.2%) and 29 events (2.7%) were for malaria and HIV/AIDS, respectively [36]. This observation correlates with other epidemiologic data showing dramatic declines in malaria-related hospitalizations in Namibia [33], as well as substantial reductions in mother-to-child transmission of HIV over the last decade [53]. Similarly, the 1998 report found 19.2% of blood transfusions (1003 cases) were ordered for obstetrics and gynecology cases. Of these transfusions, 90% were for diagnoses related to pregnancy. This contrasts with an annual average of 966 transfusion events (14.5% per year) linked to pregnancy-related diagnoses in the current study. Reductions in blood use for pediatric and maternal diagnoses raise important questions for Namibia (and other African countries) about how changes in infectious disease epidemiology may challenge historical assumptions about the drivers of pediatric blood use in the region. Similar reductions in demand for infectious disease diagnoses, including malaria and HIV/AIDS, were also observed in a subanalysis of the units requested for infectious disease diagnoses across all age groups (Fig 3). Last, although the median age of transfusion recipients in Namibia was unexpectedly high, the fact that 10% of all platelet units were ordered for children with malignant neoplasms highlights changing diagnostic and clinical practices and capacity in Namibia.

This study is subject to the following limitations. First, the multiple imputation methods used here are open to misclassification errors which may have skewed the distribution of ages, sex, or diagnoses. Similarly, because of incomplete and nonstandardized reporting by prescribing clinicians (a chronic problem reported elsewhere in Africa [54]), the imputation model could not include diagnoses that were not captured during the retrospective data collection process. This may have resulted in a loss of fidelity on the diversity of diagnoses. Related to this, the predominance of "unspecified anemia" as the principal diagnosis noted on the BRF by physicians prescribing RBC may have contributed to an overestimation of the importance of diagnoses in the broad diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89) category—and an underestimate of other categories in which the underlying causes of the unspecified anemia would have been captured had the initial diagnosis been more specific (eg, malaria, HIV/AIDS, and postpartum hemorrhage). Other nonspecific diagnoses such as pancytopenia or general surgery likely mask other underlying diagnoses. Second, because the imputed model could not be used for subanalyses, proportions reported for specific conditions within each broad *ICD-10* category were calculated based on the original sample data set. This may have introduced some misclassification bias.

Conclusion

This evaluation demonstrates that despite ongoing challenges related to reporting and data capture, a national, multiyear, portrait of clinical blood use can be obtained in an African setting. Recognizing that Namibia's strong economy and infrastructure contributed to the success of this study, electronic data systems are nonetheless increasingly available to blood services in Africa [55,56]. Still, this study also illustrates the limitations of electronic data-collection systems that remain linked to paper-based clinical ordering forms and the need for regular, standardized data entry. Information collected through these systems can and should be used to plan for demographic changes in the general population and to identify emerging trends in transfusion practices. As a tool to manage changing transfusion practices, consistent reporting of standardized data by prescribing clinicians will be essential to identify and validate emerging drivers of blood demand that deviate from historical assumptions. For example, although diagnoses related to childbirth clearly remain an important driver of blood use in Namibia, this category was less important than anticipated when compared with historical data from other countries. To further reduce variability in reported blood use, national blood transfusion services in the region should also continue to invest in standardized appropriate use of blood guidelines, as well as training for clinicians in their use. As more African countries join Namibia in the ranks of upper middle-income economies, it would not be surprising to see shifts in pediatric blood component use away from historical indications such as malaria and toward noncommunicable causes such as cancer and gastrointestinal bleeding.

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