

## A new strategy to improve the cost-effectiveness of human immunodeficiency virus, hepatitis B virus, hepatitis C virus, and syphilis testing of blood donations in sub-Saharan Africa: a pilot study in Burkina Faso

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**BACKGROUND:** In Africa where blood-borne agents are highly prevalent, cheaper and feasible alternative strategies for blood donations testing are specifically required.

**STUDY DESIGN AND METHODS:** From May to August 2002, 500 blood donations from Burkina Faso were tested for hepatitis B surface antigen (HBsAg), human immunodeficiency virus (HIV), syphilis, and hepatitis C virus (HCV) according to two distinct strategies. The first strategy was a conventional simultaneous screening of these four blood-borne infectious agents on each blood donation by using single-marker assays. The second strategy was a sequential screening starting by HBsAg. HBsAg-nonreactive blood donations were then further tested for HIV. If nonreactive, they were further tested for syphilis. If nonreactive, they were finally assessed for HCV antibodies. The accuracy and cost-effectiveness of the two strategies were compared.

**RESULTS:** By using the simultaneous strategy, the seroprevalences of HBsAg, HIV, syphilis, and HCV among blood donors in Ouagadougou were estimated to be 19.2, 9.8, 1.6, and 5.2%. No significant difference of HIV, syphilis, and HCV prevalence rates was observed by using the sequential strategy (9.2, 1.9, and 4.7%, respectively). Whatever the strategy used, 157 blood donations (31.4%) were found to be reactive for at least one transfusion-transmissible agent and were thus discarded. The sequential strategy allowed a cost decrease of €908.6, compared to the simultaneous strategy. Given that approximately there are 50,000 blood donations annually in Burkina Faso, the money savings reached potentially €90,860.

**CONCLUSIONS:** In resource-limited settings, the implementation of a sequential strategy appears as a pragmatic solution to promote safe blood supply and ensure sustainability of the system.

The World Health Organization has set targets for safe blood in sub-Saharan Africa by 2012.<sup>1</sup> This challenge remains huge on this continent where blood-borne infectious agents such as human immunodeficiency virus (HIV), hepatitis B and C viruses (HBV, HCV), and syphilis are highly prevalent.<sup>2-4</sup> Most African countries must face many obstacles to transfusion security that include difficulties in the implementation of national transfusion policies;<sup>5</sup> recruitment of voluntary, nonremunerated blood donors (VNRBDs) at low risk of blood-borne and sexually transmitted agents;<sup>6</sup> adequate use of blood products;<sup>7</sup> and organization of hemovigilance.<sup>8</sup>

For performing serologic blood testing, most African countries are severely limited by the lack of financial and human resources, aggravated by inconsistent supplies of reagents.<sup>9,10</sup> In some African countries, blood transfusion services have been put in place with massive financial and technical support of international partners from developed countries. The question is often raised as to how such blood services are sustained after external funding sources are no longer available. Thus, in Africa, there is an urgent need to create new simplified and pragmatic

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**ABBREVIATION:** VNRBD(s) = voluntary, nonremunerated blood donor(s).

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Received for publication January 22, 2009; revision received April 17, 2009, and accepted April 19, 2009.

doi: 10.1111/j.1537-2995.2009.02276.x

TRANSFUSION \*\*,\*,\*\*.\*.

strategies that improve the cost-effectiveness of blood testing and ensure sustainability in the future.

The aim of this study, conducted in Burkina Faso (West Africa), was to evaluate the accuracy and cost-effectiveness of a new serologic strategy testing sequentially one blood-borne infectious agent after the other. Four blood-borne infectious agents were tested in the following order: HBV (hepatitis B surface antigen [HBsAg]), then HIV, then syphilis, and finally HCV. Only blood units found negative for HBsAg were tested for HIV, then only those that were negative for HIV were screened for syphilis, and finally only those that were negative for syphilis were assessed for HCV. Results were compared with those obtained on the same blood donations using a conventional strategy testing simultaneously the presence of these four blood-borne infectious agents.<sup>9,10</sup>

## MATERIALS AND METHODS

In this study conducted in Ouagadougou (the capital city of Burkina Faso), 500 blood donations from 500 VNRBDs aged between 18 to 65 years were randomly selected from May to August 2002. Blood collection sessions were performed in Ouagadougou at the blood bank located in the Centre Hospitalier Universitaire Yalgado Ouédraogo (internal recruitment, 27%) and in distinct peripheral places, such as universities, administrative buildings, and companies (external recruitment, 73%). Donors were first-time (80%), regular (11%), and family replacement (9%) donors.

Serum samples were screened for four blood-borne infectious agents: 1) HBV by screening HBsAg with Monolisa AgHBs Plus (Bio-Rad, Marnes-La-Coquette, France) enzyme-linked immunosorbent assay (ELISA), 2) HIV with the fourth-generation Genscreen Plus HIV antigen-antibody ELISA (Bio-Rad), 3) *Treponema pallidum* with the RP100 agglutination test (Bio-Rad), and 4) HCV with Monolisa anti-HCV Plus Version 2 (Bio-Rad).

In this study, two distinct screening strategies were used and compared in terms of accuracy and cost-effectiveness. The first one (termed simultaneous strategy, which is currently used in the Centre National de Transfusion Sanguine in Ouagadougou) was a simultaneous screening of all four blood-borne agents on all blood donations. The second strategy (called sequential strategy) was an initial screening of one given blood-borne agent on all blood donations. If results reacted for this agent, any further serologic test was performed. By contrast, blood donations nonreactive with this test were further assessed with another test assessing the presence of another blood-borne agent and so forth until the four blood-borne agents were tested.

The test order used in this strategy was defined according to two criteria: 1) the prevalence rates of

HBsAg,<sup>11</sup> HIV,<sup>12</sup> HCV,<sup>11</sup> and syphilis<sup>12</sup> infections in Burkina Faso (approx. 15-20, 5-10, 1-5, and <1% at the time of this study, respectively) and 2) the unit cost of each serologic reagent (€0.71, €2.50, €4.52, and €0.27 for HBsAg, HIV, HCV, and syphilis, respectively). We decided to start (Day n) the initial screening by HBsAg (representing the most prevalent marker in our population). Specimens that were nonreactive for HBsAg were further tested (Day n + 1) for HIV (the second prevalent transfusion-transmissible disease in our population, screened with a relatively cheap test). HIV-nonreactive samples were then (Day n + 1) tested for *T. pallidum* (performed with the cheapest assay). Finally, nonreactive samples for these three agents were tested (Day n + 2) for HCV (done with the more expensive assay).

HBV, HIV, syphilis, and HCV prevalences were estimated in percentages with 95% confidence intervals (95% CIs). The cost of the two strategies was calculated by taking into account unit prices of each serologic test multiplied by the number of blood units tested. Savings in percent (S%) were calculated according to the formula

$$S\% = [(a - b)/a] \times 100,$$

with a being the cost of serologic testing when using the simultaneous strategy and b the cost of serologic testing when using the sequential strategy.

## RESULTS

By using the simultaneous strategy (Fig. 1A), estimated (95% CI) HBsAg, HIV, syphilis, and HCV prevalence rates were 19.2 (15.8-22.9), 9.8 (7.3-12.7), 1.6 (0.7-3.1), and 5.2% (3.4%-7.5%), respectively. In terms of HIV, syphilis, and HCV prevalence rates, no significant difference was observed when using the sequential strategy (Fig. 1B). However, contrary to the sequential strategy, the simultaneous strategy allowed the identification of coinfections as follows: HBV/HIV (n = 12; 2.4%), HBV/HCV (n = 5, 1%), HIV/HCV (n = 3; 0.6%), HIV/syphilis (n = 1; 0.2%), and HCV/syphilis (n = 1; 0.2%). No infection associating more than two transmissible agents was detected. Overall, whatever the strategy used, 157 blood donations (157/500, 31.4%) were found to be reactive for at least one transmissible agent and were thus discarded.

As indicated in Table 1, the cost of the simultaneous strategy was higher than that obtained with the sequential strategy. More precisely, the sequential strategy allowed an overall cost decrease equal to €908.7 for 500 blood units tested, leading to savings of 22.7% compared to the simultaneous strategy. When considering the total number of donations in Burkina Faso (approx. 50,000 donations/year), savings of €90,870 per year could be potentially achieved by using the sequential testing strategy, compared to the simultaneous strategy.

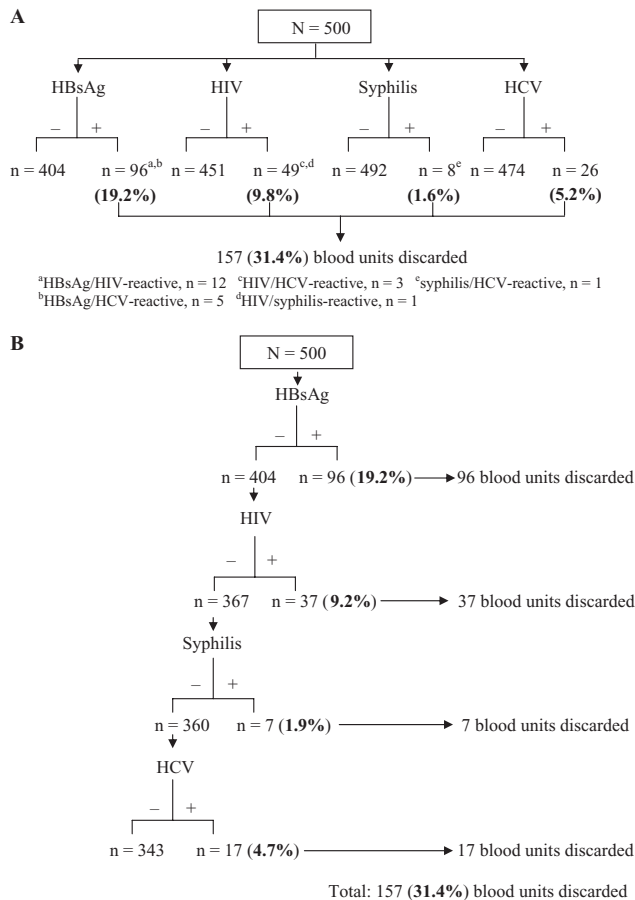
**DISCUSSION**

Our pilot study, conducted in Burkina Faso, showed that using a sequential strategy for blood-borne agents infectious testing is as accurate as using a simultaneous strategy. Each strategy yielded the same final number of blood units suitable for clinical use. One should keep in mind that the main task of blood transfusion centers from developing countries is to supply safe blood for a proper

clinical use. Contrary to the simultaneous approach which is somehow useless in resource-limited settings (since any blood donation found reactive with at least one blood-borne agent is obviously discarded), the step-by-step strategy appears as a pragmatic solution for blood testing in low-income countries.

Further, the step-by-step strategy is more cost-effective than the simultaneous one. Our data (based on the reagents cost only) clearly demonstrated that money can be significantly saved (approx. 25%) with the sequential strategy. The sums saved allow the risk of serologic reagents shortage to be strongly reduced. It also enables the purchase of additional reagents to implement serologic testing of other blood-borne infectious agents (such as human T-lymphotropic virus Type 1). It is obvious that the more the prevalence rates of blood-borne agents decrease, the less the financial benefit of the sequential strategy increases. As documented worldwide and as found in our study (data not shown), prevalence of blood-borne agents is much lower in VNRBDs than in first-time donors.<sup>13-15</sup> However, in sub-Saharan Africa, it is extremely difficult to retain VNRBDs (in our study, they represented only 11% of the studied population), for numerous social reasons (such as lack of education, religious and cultural taboos, fear of witchcraft, fear of acquiring a disease after donation, lack of patriotic feelings, etc.).<sup>16</sup> Depending mostly on VNRBDs, without turning to first-time and/or family donors, may deplete African blood banks. In this specific context, pragmatism rather than dogmatism should be applied in Africa to provide safe blood in all circumstances.

The use of sequential strategy nonetheless has some disadvantages. First, it slightly increased the turnaround time for results and delays in releasing blood and blood components. Cost savings from sequential testing should be balanced against those factors. Second, the prevalences of HIV, syphilis, and HCV infections were slightly under- (or over-) estimated by using this strategy which is not able to identify coinfections. However, punctual studies using the simultaneous strategy can be performed in reference centers to establish the exact prevalence rates (including coinfections). Further, physicians from blood banks have to counsel HBsAg-positive blood donors by



**Fig. 1. Results of the simultaneous (A) versus sequential (B) strategies for the HBV, HIV, syphilis, and HCV screening performed from 500 blood donations, Ouagadougou, Burkina Faso. + = reactive; - = nonreactive.**

**TABLE 1. Blood testing cost in Burkina Faso\***

Markers	Unit cost (€)	Simultaneous strategy		Sequential strategy		Savings between sequential and simultaneous strategies	
		Number of samples tested	Total cost (€)	Number of samples tested	Total cost (€)	€	Percent
HBsAg	0.71	500	355	500	355.0	0	0
HIV	2.50	500	1250	404	1010.0	240	-19.2
Syphilis	0.27	500	135	367	99.1	35.9	-26.6
HCV	4.52	500	2260	360	1627.2	632.8	-28.0
<b>Total</b>			<b>4000</b>		<b>3091.3</b>	<b>908.7</b>	<b>-22.7</b>

\* Comparison of simultaneous versus sequential strategies. Analysis on 500 blood units tested for HBV, HIV, HCV, and syphilis.

referring them to voluntary counseling and testing centers offering anonymous and free HIV testing, to identify those who are coinfecting with HIV-1.<sup>17</sup> Third, sequential testing can increase the risk of mix-up errors due to more frequent handling of blood samples. However, no sampling error occurred during our pilot study.

To our knowledge, this is the first study, conducted in Africa, demonstrating the financial benefit of an alternative sequential strategy for blood testing of prevalent blood-borne agents. This strategy is now used in some decentralized blood banks of Burkina Faso. If implemented in other African countries, it could yield considerable savings at the scale of the continent. The order of serologic tests to be performed must be adapted to the sanitary situation of each area. For instance, in Austral Africa where HIV is endemic,<sup>18</sup> it is likely that it should start by this retrovirus. In the Maghreb (from Morocco to Egypt) where HCV is predominant, it is likely that it should begin by this flavivirus.<sup>19</sup> Finally, within the same country, in rural zones where resources are very limited, rapid tests could be also evaluated for this transfusion purpose.<sup>20</sup>

#### ACKNOWLEDGMENT

We are grateful to "Secure The Future" of Bristol-Myers Squibb Company and Foundation for their financial support that allows us to carry out this study.

#### CONFLICT OF INTEREST

The authors declare no conflict of interest.

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