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ORIGINAL PAPER

Development of a web-based application and multicountry analysis framework for assessing interdicted infections and cost-utility of screening donated blood for HIV, HCV and HBV

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Vox Sanguinis

Background and Objectives Most countries test donations for HIV, HCV and HBV using serology with or without nucleic acid testing (NAT). Cost-utility analyses provide information on the relative value of different screening options. The aim of this project was to develop an open access risk assessment and cost-utility analysis web-tool for assessing HIV, HCV and HBV screening options (<http://www.isbtweb.org/working-parties/transfusion-transmitted-infectious-diseases/>). An analysis for six countries (Brazil, Ghana, the Netherlands, South Africa, Thailand and USA) was conducted.

Materials and Methods Four strategies; (1) antibody assays (Abs) for HIV and HCV + HBsAg, (2) antibody assays that include antigens for HIV and HCV (Combo) + HBsAg, (3) NAT in minipools of variable size (MP NAT) and (4) individual donation (ID) NAT can be evaluated using the tool. Country-specific data on donors, donation testing results, recipient outcomes and costs are entered using the online interface. Results obtained include the number infections interdicted using each screening options, and the (incremental and average) cost-utility of the options.

Results In each of the six countries evaluated, the use of antibody assays is cost effective or even cost saving. NAT has varying cost-utility depending on the setting, and where adopted, the incremental cost-utility exceeds any previously defined or proposed threshold in each country.

Conclusion The web-tool allows an assessment of infectious units interdicted and value for money of different testing strategies. Regardless of gross national income (GNI) per capita, countries appear willing to dedicate healthcare resources to blood supply safety in excess of that for other sectors of health care.

Key words: blood screening, cost-effectiveness analysis, cost-utility, HBV, HCV, HIV, methods.

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Introduction

Most countries test donated blood for HIV, HCV and HBV using serology and sometimes nucleic acid testing (NAT).

The adoption of blood safety screens is based on the need to prevent the transmission of infection by transfusion. The quantity of available healthcare resources which should go towards blood safety in any country is a topic with some level of debate. Should the resources spent on blood safety be based on achieving the smallest possible risk to blood recipients regardless of cost or should the risk be mitigated to a level as low as reasonably achievable (ALARA)? If ALARA is used as a governing principle, to what degree should blood collection organizations mitigate risk and at what cost? Cost-utility (also known as cost-effectiveness) analysis provides information on relative value of health interventions. Comparative health economic analyses can highlight patterns of blood safety decision-making common to all jurisdictions.

Risk assessment and health economic evaluation are pivotal tools to help decision makers in resource allocation [1, 2], but expertise to conduct these analyses is not widely available. The greatest benefit to aid decision-making occurs when local data are included in the analysis. Limitations of previous analyses in blood safety include incomparability of models and analysis assumptions [3, 4]. The World Health Organization (WHO) has produced several publications that seek to develop and describe methods under the CHOICE (*CHOosing Interventions that are Cost Effective*) framework [5–8]. The goal of these methods is to structure and conduct analyses in such a way that the interventions considered are relevant in specific and across settings. One approach to assessing whether an intervention is cost effective is to define it terms of the country-specific gross domestic product (GDP) or gross national income (GNI) per person, where any intervention with cost-utility results between one times the GNI to three times the GNI can be classified as cost effective, and results above three times the GNI as not cost effective. Recently, the WHO has further redefined some of the ideas around appropriate thresholds in countries where the presence of informal economies may mask the true GNI, and also emphasized including consideration of budget impact, feasibility and other factors alongside cost-utility results [9]. Many of these concepts are consistent with those recommendations developed as part of the ABO Risk-Based Decision-Making (RBDM) Initiative [1, 2].

Van Hulst and colleagues developed and demonstrated how standardized models can be used to assess estimated infections remaining in the blood supply and the cost-utility of testing for HIV, HCV and HBV in countries with large differences in development status [10]. These analyses were facilitated by a web-based user interface developed by Hubben and colleagues that allowed for entry of country-specific data in a simple and consistent manner [11]. Building on the previous work, the objective of this project was to develop a common set of tools, and to assess the

cost-utility of different combinations of infectious marker screens for HIV, HCV and HBV. Our aim was to create an open access platform to enable relevant analyses of blood safety interventions using a centralized web-based cost-utility tool, available at <http://www.isbtweb.org/working-parties/transfusion-transmitted-infectious-diseases/>, and then to use the tool to conduct analyses for six countries (Brazil, Ghana, the Netherlands, South Africa, Thailand and USA) to discern potential patterns in resource allocation decision-making in blood safety adoption across countries with a range of human development.

Material and methods

Four strategies; (1) antibody assays (Abs) for HIV and HCV + HBsAg, (2) antibody assays that include antigens for HIV and HCV (Combo) + HBsAg, (3) NAT in minipools of variable size (MPx NAT) and (4) individual donation (ID-NAT) can be evaluated using the tool. Country-specific data on donors, donation testing results, recipient outcomes and costs are entered using the online interface. Consistent with the previous model, this version of the model assumes a single transfusion or transfused component exposure. An online appendix accompanying this report provides screenshots of the pages of the model and additional instruction on the process for conducting and results from the analyses (Online Supplement 1).

Risk model options

The first analytical decision to be made is to determine which risk model to use. The decision should be based on the available data. There are three choices: (1) Yield, (2) Prevalence and (3) Incidence models. The Yield model uses the observed yield of testing (counts of positive donations) of specific tests and is appropriate when no information on blood donors is available. Note, this definition of 'yield' is a standard one, rather than the NAT-yield (or NAT-only) concept used in blood safety. The Prevalence model requires that testing results are available on a donor basis, and therefore will provide more accurate results than the Yield model. The Incidence model will provide the most accurate measure of residual risk and therefore better estimation of the cost-utility in a particular setting, but requires the most complete information on both testing results and characteristics of blood donors.

Changes to the underlying models

The underlying HIV, HCV and HBV disease progression and structure of the cost models were updated to reflect current progression probabilities and cost elements. The selection of the set of screening options included in any

analysis was modified to permit checkbox inclusion or exclusion of specific strategies. For example, some countries or settings may wish to assess the consequences of adopting ID-NAT without regard to MPx NAT. MPx NAT (or any other set of interventions) can be 'deselected' as a strategy included in the analysis.

The previous version of the model reported results as cost per disability-adjusted life years. This version has been modified to report results as quality-adjusted life years (QALYs) gained for the population through the prevention of infection and as the aggregate result of cost per QALY gained in US dollars. Health state preference weights used for calculating QALYs are built into the model. The analysis uses local data on recipient outcomes and costs of treatment. For example, local data on the mean age of the transfused population and the survival probabilities following transfusion are used on top of life table data to adjust post-transfusion life expectancy to the local context.

Changes to the online interface

The interface was redesigned so that data entry and analyses may be conducted more easily. This included functional improvements such as a tab in the centre of the bottom of each page and other aids to allow for direct navigation to other pages of input or output data, or to jump back to the introductory page to move to a different country or scenario. In addition, a number of explanatory content pop-up boxes were included to help facilitate understanding of various components of each analysis.

A public access version of the model is free and available to anyone to use. The open access model has limited capabilities. It will allow you to conduct analyses using your own data, but you will not be able to save your inputs. Access to full model functionality is available for free to anyone who registers to use the tool. To register please send an email to bcuster@bloodsystems.org with "CUA Tool" in the subject line. A link to the model including the six country data sets will be provided. If you register to use the tool, the model input values and output results are downloadable as a consolidated PDF summary report of all numerical data for each country or setting. Access to the model is through one of two uniform resource locator (URL) paths. First, the model can be accessed by navigating to the Transfusion-Transmitted Infectious Diseases Working Party section of the ISBT website: <http://www.isbtweb.org/working-parties/transfusion-transmitted-infectious-diseases/>. Under this section of the ISBT website, a Surveillance Risk Assessment and Policy (SRAP) subsection has a pull-down menu that says 'Access web-tool here'. An alternate URL route is via the software as a service provider, BaseCase Interactive:

<https://interactive.basecase.com/s/app?id=14143&key=KfzkHJWbGXtWW7>.

In order to save your analysis or to conduct multiple different analyses at the same time you will have to register as user of the tool. The first page of the tool also provides the contact information for registration or for technical aspects of the model. Once you have registered, all model values can be saved and held in the online tool under a scenario name of the user's choice. Each specific account allows the user to create his/her own workspaces containing information that is visible to only that account holder. Any currently up to date web browser can be used to access the model, but the layout could appear slightly different based on the configuration and display options of the computer used to access the website.

Analysis results

Within the Results section four different sets of outcomes are provided as follows: (1) Number of infections remaining, costs and QALY gained, (2) Incremental Cost-Effectiveness Ratios (ICERs) and Average Cost-Effectiveness Ratios (ACERs), (3) Ratio of the ICER to the Gross National Income (GNI) per capita and (4) Cost-Effectiveness (CE) Plane. In the Online Supplement, the contents of each results output tab are described.

Six country analysis - model inputs

Each of the following model parameters were obtained from in-country contacts or by literature review for Brazil [12, 13], Ghana [14, 15], the Netherlands, South Africa, Thailand [16] and USA. Note that data presented here for the Netherlands and USA are not the same as those used in a parallel project from the ABO RBDM (reported in a separate manuscript by Janssen and colleagues) because of non-disclosure agreements in place for the ABO project. Country-specific data on the prevalence (and incidence where available) of each infection, percentage of first time and regular donors, cost of different testing methods, average age of transfusion recipients, transfusion survival and related parameters were used. All cost data were inflation adjusted to 2014 values using the respective Consumer Price Indices for each country. For Ghana, the Netherlands and Thailand, the cost data are inflation adjusted from the previous publication [10].

For all six countries all strategies were evaluated, and the MPx was a pool size of 16. All of the input data used in the six country analysis are available online. The six country data provide a key reference set of information available to all users. When an analysis is conducted for a new country, and the data are not available for that setting, the data from one of these six countries may be

used as surrogate information based on similarities in the general level of human development and other characteristics such as of the epidemiology of HIV, HCV and HBV in relation to the country or setting of interest. These are decisions under the control of each user of the tool.

Sensitivity analysis

Formal approaches for conducting sensitivity analyses are not available within the existing tool structure. However, it is straightforward to create scenario analyses in which one or more of the model input values are altered one at a time or together and to assemble these scenario analyses into sensitivity analysis results. By varying model parameter values one at a time and jointly, both one-way and multi-way sensitivity analysis results can be generated using the tool.

Results

Although all of the screening strategies included in this analysis may not have regulatory approval or be available for use in each of the countries, we report the estimated impact of each screening strategy for each country. The number of infections remaining in the blood supply on a

per million donations screened basis following the use of each strategy, along with the total QALYs gained by donation screening show a wide-range, depending primarily on the reported rates of infections in donations in each country (Table 1). Employment of any set of screening options leads to at least a 96.4% reduction in the number of HIV, HCV and HBV infections in the blood supply for each country with a corresponding substantial gain in QALYs for the recipient population.

Interventions which are less costly to the healthcare system and/or more effective, meaning they generate more population-level health, are defined as 'dominant' over competing interventions. Incremental cost-utility results for each country show serology screening with anti-HIV, anti-HCV, and HBsAg is more effective and less costly in each country, except in the Netherlands and USA where the results are cost effective, but not cost saving (Table 2). The incremental benefit of adding HIV and HCV antigen screening is variable, with results shown to be cost effective in Ghana and South Africa, but less so in other countries. In Ghana and South Africa, the use of NAT is estimated to be relatively cost effective.

A different picture of the cost-utility of each intervention emerges when each strategy is compared to no intervention in an ACER framework. This assessment provides an

Table 1 Effectiveness estimates in terms of infections remaining and total quality-adjusted life years (QALYs) gained per 1 million donations screened using different blood safety screening strategies for HIV, HBV and HCV

Donation screening strategy Risk model used	Effectiveness Category	Country					
		Brazil Incidence	Ghana Prevalence	the Netherlands Incidence	South Africa Incidence	Thailand Prevalence	USA Incidence
No interventions	HIV infections	417	20 596	29	6830	4347	37
	HCV infections	1103	87 672	304	109	1771	244
	HBV infections	405	28 373	648	760	3693	54
	Total QALYs Gained	0	0	0	0	0	0
HIV Ab + HCV Ab + HBsAg	HIV	21.2	228.9	0.5	95	48.3	1.3
	HCV	15	636.1	0.6	3.1	12.8	8
	HBV	4.9	220	5.5	33.8	28.6	2.7
	Total QALYs Gained	2761.7	452 541	394.9	46 670	33 901	131
HIV Combo + HCV Combo + HBsAg	HIV	15.7	169.2	0.3	70.2	35.7	1
	HCV	3.2	136.4	0.1	0.7	2.8	1.5
	HBV	4.9	220	5.5	33.8	28.6	2.7
	Total QALYs Gained	2792.8	454 261	395.3	46 842	33 998	133.4
Minipool multiplex NAT (pool size 16)	HIV	10.3	112.2	0.2	46.6	23.6	0.6
	HCV	1.9	78.8	0.08	0.4	1.6	0.9
	HBV	3.4	152.9	4.2	25.8	19.9	2
	Total QALYs Gained	2814.6	455 183	396.4	47 017	34 091	134.4
Individual donation NAT	HIV	5.8	63.2	0.1	26.2	13.3	0.4
	HCV	1.3	53.5	0.05	0.3	1.1	0.6
	HBV	2.6	118.3	2.9	18.2	15.4	1.5
	Total QALYs Gained	2831.3	455 826	396.5	47 156	34 160	134.8

indication of the overall number of infections identified without regard to overlap between donations that would test both serology and NAT reactive. The ACER of each option is very good in all countries, and each is cost saving and/or more effective compared to no intervention in Brazil, Ghana, South Africa and Thailand (Table 3). The ACER results for the Netherlands and the USA suggest that each option as a standalone intervention would be considered cost effective.

Linking the ICER results in Table 2 to the $3 \times$ GNI threshold for each country brings to attention a different set of considerations (Table 4). Other than serology screening for all countries, or serology screening using antigen–antibody combination assays in South Africa and Ghana, the ICER/GNI ratios do not meet a ≤ 1 or even 1–3 range for the ratio defined as cost effective or conditionally cost effective. Note, in each of these incremental analyses, the costs and effects for the screening strategy presented in the previous row are the comparator. Removal of a screening strategy would lead to different ICER results, therefore, different ICER/GNI ratios also.

The ability to conduct scenario analyses as a form of sensitivity analysis using the tool is highlighted. For two

countries, we estimated the impact on cost-utility if the costs of screening were 25% lower and 25% higher for the specific interventions in use in those countries (Table 5). Three times the GNI per capita is provided for context. If screening test costs were 25% lower in South Africa, the cost-utility of ID-NAT would approach the ICER/GNI ratio of 3 suggesting this intervention could be classified as cost effective in the South Africa context. The results for the USA show that serology testing is cost effective even if the cost of testing increases by 25%. Conversely, MP NAT does not achieve thresholds considered cost effective, regardless of the range of cost of testing we evaluated.

Discussion

Most countries face limited financial resources, where the selection of one healthcare intervention may prevent implementation of another. Because choices are often exclusive, cost-utility analyses can play an important role to help determine more optimal allocation of resources to increase population health. In many developing country settings, health economics plays an even more limited

Table 2 Incremental cost-utility ratios for each blood safety screening strategy for HIV, HBV and HCV [In 2014 USA dollars per quality-adjusted life year gained (QALY)]

Donation screening strategy ^a	Country					
	Brazil	Ghana	the Netherlands	South Africa	Thailand	USA
HIV Ab + HCV Ab + HBsAg	Dominant	Dominant	7377	Dominant	Dominant	78 920
HIV Combo + HCV Combo + HBsAg	150 794	1432	5 418 259	8724	25 774	1 123 001
Minipool multiplex NAT (pool size 16)	198 125	7574	8 710 956	38 661	71 241	1 669 739
Individual donation NAT	325 987	8497	77 375 017	38 195	92 458	24 571 090

^aThe HIV and HCV Abs + HBsAg options are compared to no intervention, and then each option is compared incrementally to the strategy in the row above. Strategies indicated by the word 'Dominant' are more effective and less costly than the comparator.

Table 3 Average Cost-Utility Ratios for Each Blood Safety Screening Strategy for HIV, HBV and HCV Compared to No Screening [In 2014 USA dollars per quality-adjusted life year gained (QALY)]

Donation screening strategy compared to no intervention	Country					
	Brazil	Ghana	the Netherlands	South Africa	Thailand	USA
HIV Ab + HCV Ab + HBsAg	More effective and/or less costly	More effective and/or less costly	7376	More effective and/or less costly	More effective and/or less costly	78 920
HIV Combo + HCV Combo + HBsAg	More effective and/or less costly	More effective and/or less costly	12 167	More effective and/or less costly	More effective and/or less costly	97 802
Minipool multiplex NAT (pool size 16)	More effective and/or less costly	More effective and/or less costly	36 336	More effective and/or less costly	More effective and/or less costly	109 197
Individual donation NAT	More effective and/or less costly	More effective and/or less costly	63 947	More effective and/or less costly	17	176 999

role in decision-making than in developed countries, contributing reasons include limited awareness and knowledge of health economics methods, limited availability of data and limited funds to conduct this type of research. As a consequence, the use of health economics and risk assessment is most difficult in those regions where it is most needed. A central goal of the development of this tool has been to promote the relevance and use of health economic methods in international blood safety. Countries where the largest numbers of infections are interdicted through testing tend to have the most favourable cost-utility estimates. As expected, the cost of testing has a strong influence on cost-utility results. The value of the addition of NAT to serological testing is highly dependent on the country-specific prevalence and incidence of viral infections in donors. Even so, the cost-utility ratio results for adopted blood safety interventions in some countries do not meet the $3 \times$ GNI threshold previously developed by the WHO; many of the observed cost-utility ratios reported here for blood safety interventions far exceed any country-specific threshold likely to be defined as 'cost-effective' healthcare.

Models, including the underlying one used in this web-tool, are difficult to validate. One approach to show face

validity is to compare the results to those from countries where the cost-utility of screening donations for HIV, HCV and HBV has been independently assessed. For both the USA and the Netherlands, previous assessments of the cost-effectiveness of NAT screening have been published. In the most comprehensive analysis conducted for the USA, Marshall and colleagues reported results of \$1.5 million/QALY and \$7.3 million/QALY for MP and ID-NAT, respectively, compared to anti-HIV, anti-HCV and HBsAg serology testing [17]. Using this ISBT CUA web-tool, compared to anti-HIV, anti-HCV and HBsAg testing, the results are estimated at \$1.3 million/QALY and \$3.6 million/QALY for MP16 and ID-NAT, respectively. Similarly, for the Netherlands, Borkent-Raven and colleagues reported results of €5.2 million/QALY and €4.7 million/QALY for MP6 and ID-NAT, respectively [18]. Using the ISBT CUA web-tool, results are estimated to be \$7.2 million/QALY and \$14.1 million/QALY for MP16 and ID-NAT, respectively compared to serology testing. While the results from the web-tool and previous publications are not identical, they are of the same order of magnitude for both countries which suggests that the methods and models used here replicate previous analyses. In our analyses, we did not use the same data inputs, our results are based on more recent data. With due

Table 4 Incremental cost-utility ratios/three times the gross national income per capita for each blood safety screening strategy for HIV, HBV and HCV [In 2014 USA dollars per quality-adjusted life year gained (QALY)]

Donation screening strategy ^a	Country					
	Brazil	Ghana	the Netherlands	South Africa	Thailand	USA
HIV Ab + HCV Ab + HBsAg	Dominant	Dominant	0.1	Dominant	Dominant	1.5
HIV Combo + HCV Combo + HBsAg	12.9	1.0	104.0	1.3	4.3	20.6
Minipool multiplex NAT (pool size 16)	16.9	5.3	167.2	6.0	11.9	30.7
Individual donation NAT	27.9	5.9	1485.1	5.9	15.5	451.7

^aHIV and HCV Abs+HBsAg are compared to no intervention, and then each strategy is compared incrementally to the strategy in the row above.

Table 5 Sensitivity analysis for incremental cost-utility ratios for each blood safety screening strategy for HIV, HBV and HCV [In 2014 USA dollars per quality-adjusted life year gained (QALY)] for the actual interventions in use in two countries and an assessment of the impact of 25% lower and higher screening costs for each intervention

Donation screening strategy	Country					
	South Africa			USA		
3 × 2014 GNI per capita	19 410			163 200		
	–25% Screening Cost	Basecase Screening Cost	+25% Screening Cost	–25% Screening Cost	Basecase Screening Cost	+25% Screening Cost
HIV Ab + HCV Ab + HBsAg	Dominant	Dominant	Dominant	56 178	78 920	101 739
HIV Combo + HCV Combo + HBsAg	–	–	–	–	–	–
Minipool multiplex NAT (pool size 16)	–	–	–	946 692	1 280 256	1 602 013
Individual donation NAT	20 629	27 933	35 155	–	–	–

consideration of the completeness of the data which were obtained for each country, by extension the results for the other countries should be reflective of the cost-utility of these blood screening strategies.

The web-based model has limitations in its design and content. First, only HIV, HCV and HBV are included in the current model, and analyses for these infections are only available for the predefined screening strategies. Other strategies such as a mixed model of serology testing for one of the viruses coupled with NAT testing for the other two viruses is not possible with the given structure. Blood safety strategies such as pathogen inactivation are not included as available strategies for analysis. Even so, significant adjustments can be made to the actual test performance of each screen by accessing 'advanced model inputs' on different tabs within the tool. These advance inputs allow the model to be updated as improved performance data and next generation assays become available.

The model output for the estimated infections identified is in terms of per million donations. This analysis approach can appear to over- or under-estimate the count of infections in a country's blood donor population. To place the results in the context of the number of collected donations in a country each year, they have to be adjusted to the number of donations collected. For example in the US annual donations are approximately 11–12 million, thus results in Table 1 need to be multiplied by 11 or 12. This creates a limitation around the direct interpretation of the results output for each country, but at the same time allows for the head-to-head comparison of infections interdicted for countries that have very different total numbers of donations collected by assuming a common denominator for number of donations. Note, assuming narrow impact of economies of scale this limitation does not change the cost-utility results, which are correctly estimated regardless of the number of donations collected because each ratio represents a linear relationship between costs and effects, that is, is an equation for the slope of a line.

While the web-interface provides an easy to use tool for conducting cost-utility analyses in blood screening, it does not overcome the challenge of access to data. Any analysis that draws on data from another setting rather than country-specific data has the potential to lead to bias in the estimation of the infections averted and cost-utility of screening. For example, country-specific data on post-transfusion survival are an influential section of the model. A few countries have published data on post-transfusion survival [19–21], but even these data may not reflect current expected survival given changes in transfusion practice [22, 23]. Such data are critical for the analyses of cost-utility because QALY calculations rely on

accurate estimates of both short-term and long-term post-transfusion survival. Our effort to include data from different countries highlights the need for more robust haemovigilance efforts to estimate post-transfusion survival in a larger number of countries.

Simplifying assumptions were necessary to develop the model and web-interface. The model does not account for the number of blood components transfused during a transfusion episode. In most settings, the probability of transfusion-transmission is sufficiently small that there is little chance a patient will receive more than one infected unit. However, the number of transfused components is also a predictor of survival. The model assumes a single transfusion exposure. It also does not account for differences in the risk of infection transmission by the type of components (red cells, platelets or plasma) transfused [24].

Technical limitations include assumptions around specific test performance. The MPx function that allows users to define the pool size uses a mathematical equation based on the estimated window period of the mini-pool assay to interpolate the window period at different pool sizes. These data rely on either the known window period of the individual donation format of the same testing system or the window period for a specific pool size such as 6 or 16 donations. Performance of vendor-specific NAT testing platforms may not be accurately accounted for by use of interpolation. When known, the actual performance data in terms of window period length based on a specific pool size can be entered.

Not all countries may be able to perform health economic and risk assessment evaluations in support of the decision-making process customized to their particular setting. By providing lower barriers to conduct these analyses, we seek to raise awareness of the important joint role of health economics and risk assessment in blood transfusion, and to stimulate the uptake of these methods by other investigators. The results from the development and use of this tool for six countries provide a more complete assessment of these blood screens than has previously been available. Results indicate that in any setting the use of antibody assays is very cost effective or even cost saving. NAT has varying cost-utility depending on the setting, but blanket statements or conclusions are not easy to make. The local epidemiology, cost structure and funding mechanisms will most directly influence which interventions are acceptable.

In summary, countries where the largest number of infections are interdicted through testing have the most favourable cost-utility results. As expected, the cost of testing has a predominate influence on cost-utility ratios. Previous studies in countries where such analyses have been conducted typically have reflected cost-utility values

proximate to the apex of virus epidemics as opposed to the current cost-utility. The cost-utility of blood safety interventions across different countries does not meet the threshold developed by the WHO. Regardless of GNI, countries appear willing to dedicate healthcare resources to blood supply safety in excess of that for other sectors of healthcare. This implies that across cultures and regions, the societal willingness to pay for blood safety exceeds that of other areas of healthcare.

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Conflict of interests

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Supporting information

Additional supporting information may be found online in the supporting information tab for this article:
Data S1 Online Supplement.