Chapter 7

# COST-EFFECTIVENESS OF INTRODUCING RED BLOOD CELL ALLOANTIBODY SCREENING AS PART OF PRE-TRANSFUSION TESTING IN UGANDA

Bernard Natukunda, Maarten Postma, Henk Schonewille, Anneke Brand and Marinus van Hulst. Cost-effectiveness of introducung red blood cell alloantibody screening as part of pre-transfusion testing in Uganda. *Manuscript in preparation.*

**Abstract**

**Aims/Objectives:** To determine the cost-effectiveness of introducing red blood cell (RBC) alloantibody screening as part of pre-transfusion serologic testing in Ugandan hospitals.

**Background:** Pre-transfusion immunohaematologic testing in Uganda is currently limited to ABO/D typing plus room temperature (RT) saline cross-matches with no screening for irregular RBC alloantibodies.

**Materials and methods:** Cost-effectiveness was evaluated from the health care providers' perspective. Costs of reagents, apparatus and drugs were estimated in 2011 US dollars. We compared a '*limited* testing scenario' covering 10,000 multiply transfused patients in 15 referral hospitals with a '*universal* testing scenario' involving all the 100,000 blood recipients in 65 district and referral hospitals countrywide per annum. Testing strategies included tube and gel techniques for RBC alloantibody screening and complete cross-matches.

**Results:** RBC alloantibody screening using the gel method in the '*limited* testing scenario' was the most expensive strategy costing US$23.60 while the cheapest strategy was to perform complete cross-matches countrywide using the tube method at a cost of US$8.57 per patient. Compared to *No Screening*, introduction of the *universal* TubeCC method was estimated to cost US$174,675 and would theoretically prevent 5,490 haemolytic transfusion reactions (HTRs) annually. Complete cross-matches using the tube method dominated the other testing strategies (i.e. they were the most cost-effective option). Compared to this testing strategy, other options were more expensive with no effect on health gains.

**Conclusion:** Introduction of RBC alloantibody screening as part of pre-transfusion immunohaematologic testing in Uganda appears to be cost-effective and would contribute to improving blood transfusion safety.

**Key words:** cost-effectiveness, pre-transfusion testing, RBC alloantibody screening, Uganda

**Introduction**

The purpose of pre-transfusion testing is to select, for each patient, blood components that when transfused will have acceptable survival and will not cause clinically significant destruction of the recipient's red blood cells (RBCs). If performed properly, pre-transfusion tests will detect most clinically significant unexpected alloantibodies and ensure that the patient is issued the designated blood components that are ABO/D compatible. Pre-transfusion testing consists of a series of serologic tests plus clerical and history checks that take place within the larger process of RBC administration. Elements of pre-transfusion testing include obtaining a labelled patient blood sample, comparing identifying information on the blood request form with that on the blood sample, checking previous transfusion records and history, testing patient sample for ABO/D types, screening patient sample for unexpected RBC alloantibodies, identifying the alloantibodies detected and performing a cross-match (BCSH Guidelines, 1996; Shulman *et al.,* 2001).

In Ugandan hospitals, pre-transfusion testing is currently limited to ABO/D typing plus room temperature (RT) saline cross-matches without the addition of antihuman globulin (AHG) reagent. No screening for irregular alloantibodies is carried out putting immunized blood recipients at risk of haemolytic transfusion reactions (HTRs). Transfusion-induced RBC alloantibodies have been implicated in both acute and delayed HTRs (Cox *et al.,* 1988; Vichinsky, 2001). Immune mediated HTRs may result in severe sequelae including disseminated intravascular coagulation, renal failure, and death (Hillman, 1979; Capon & Goldfinger, 1995). RBC transfusions to immunized patients with clinically significant antibodies require the availability of compatible blood units lacking the antigens to which the antibodies are directed. Recent studies reported a 6.1% rate of RBC alloimmunization following blood transfusion among Ugandans with different diseases (Natukunda *et al.,* 2010a; Natukunda *et al.,* 2010b).

The authors recommended that there was a need to improve pre-transfusion testing in Uganda, including the introduction of RBC alloantibody screening, in order to prevent the occurrence of HTRs. However, introducing RBC alloantibody screening would increase the costs. Therefore, we carried out an economic evaluation on whether it would be cost-effective to roll out such a program in Uganda. Economic evaluation [which can be defined as the ‘comparative analysis of alternative courses of action in terms of both their costs and consequences’ (Drummond *et al.,*

2004)] is important because resources are scarce and choices must be made concerning their deployment. Cost-effectiveness analysis (CEA) guides us in minimizing the opportunity cost by allocating resources where more wealth will be created. The goal of CEA is to improve the population's health by using available resources in the most effective way (Pereira, 2000). There is a need to streamline pre-transfusion testing procedures in Uganda by screening for unexpected RBC alloantibodies, both in the interests of cost-effectiveness and patient safety.

**Materials and Methods**

Using the health care providers' perspective, we evaluated the cost-effectiveness of introducing pre-transfusion RBC alloantibody screening in Uganda for the following three scenarios:

1. Blood transfusion recipients with sickle cell disease (SCD), cancer and other multiply transfused (OMT) patients ('*limited* testing scenario')
2. All blood transfusion recipients in public hospitals ('*universal* testing scenario')
3. *No Screening* at all (the current scenario)

According to the Uganda Blood Transfusion Service (UBTS), there were 187,000 units of blood collected in 2009 in Uganda. Given a discard rate of 7.2% for blood (Kajja *et al.,* 2010), approximately 173,536 units were administered and the remaining 13,464 units were discarded. A recent study by Natukunda *et al.* (2010c), reported that the mean number of units of blood transfused per recipient per year at Mbarara Regional Referral Hospital was 1.7. The total number of patients transfused countrywide i.e**.** in 65 hospitals in one year (in the '*universal* testing scenario') was therefore estimated to be 100,000. In the above report from a regional referral hospital, 10.3% of all blood recipients in 2008 were cancer, SCD and OMT patients. Thus, the number of patients who would receive blood transfusions in 15 referral hospitals annually (in the '*limited* testing scenario') was estimated to be 10,000.

*Testing strategies*

To estimate the costs involved in RBC alloantibody screening, complete cross-matches and management of HTRs in the *limited* and *universal* testing scenarios, the following four screening strategies were evaluated:

(i) *TubeSCREEN:* A tube method with normal saline and addition of AHG reagent followed by alloantibody identification in case of a positive antibody screen and an RT saline cross-match.

(ii) *TubeCC:* A tube method for a complete (indirect antiglobulin test, IAT) cross-match followed by antibody identification in case of a positive cross-match.

(iii) *GelSCREEN:* A manual LISS gel technique with *Cellbind* Screen® cards followed by alloantibody identification in case of a positive antibody screen and an RT saline cross-match.

(iv) *GelCC:* A manual LISS gel technique with *Cellbind* Screen® cards for a complete (IAT) cross-match followed by antibody identification in case of a positive cross-match.

We assumed that patients in either cohort received one unit of whole blood or an equivalent amount of RBC component. Therefore, alloantibody screening (using reagent RBCs) and cross-matching (using donor RBCs) of the patient's serum occurred only once. Testing procedures were as outlined (Appendix 1 and 2).

*Risk for haemolytic transfusion reactions (HTRs)*

In recent cross-sectional studies by Natukunda *et al.* (2010a; 2010b), the prevalence of RBC alloimmunization in transfused Ugandans with SCD and other diseases was reported to be 6.1% (95% confidence intervals: 3.0 – 10.0%). We assumed that an equivalent proportion of recipients (i.e. 610 patients in the '*limited* testing scenario' and 6,100 recipients in the '*universal* testing scenario') were at risk of developing HTRs on subsequent exposure to allogeneic blood transfusion, unless they were screened for RBC alloantibodies or complete cross-matches were performed during pre-transfusion testing. To quantify the beneficial effects of putting resources towards improved pre-transfusion testing in Uganda by introducing RBC alloantibody screening, costs for the management of an HTR were analyzed. It was assumed that 10% of the HTR cases prevented would be severe.

*Costs*

The costs of reagents, apparatus and drugs were quoted from the latest price catalogues of two leading Ugandan pharmaceutical distributors (*Joint Medical Store [JMS]* and *National Medical Stores [NMS]*, Kampala, Uganda) and *Cellbind* Screen®, Sanquin reagents, Amsterdam, the Netherlands (Appendix 1, 2 and 3). Current salary scales from the Ugandan Ministry of Health were used in the calculation of laboratory and clinical staff costs per hospital (2 laboratory technicians, 2 enrolled nurses and 1 medical doctor). Laboratory instruments (centrifuges, incubators, dispensers, working tables etc) were to be purchased for all the hospitals involved.

Also, the costs per HTR prevented were calculated and these included laboratory investigations and treatment (Appendix 3). All costs were calculated in 2011 US dollars and there was no discounting used for future costs because all expenses occurred within one year.

*Cost-effectiveness*

The incremental cost-effectiveness ratio (ICER) was estimated for each cohort of recipients i.e. the additional costs of a screening strategy divided by the additional health gains (HTRs prevented) compared with the next least expensive strategy. Strategies that cost more and prevented less HTRs were excluded. Additionally, the relative cost-effectiveness to the current strategy was estimated by dividing the additional costs and HTRs prevented relative to *No Screening*.

*Budget Impact*

The budget impact for implementing the most cost-effective screening strategy, i.e. the net cost to the health care system in Uganda, was estimated for both the *limited* and *universal* cohorts.

## Results

*Base case analysis*

The estimated costs of the four testing strategies and management of an HTR are shown in Table 1. Alloantibody screening for multiply transfused blood recipients in referral hospitals using the gel method (*limited* GelSCREEN) was the most expensive strategy costing US$23.60 per patient.

**Table 1.** Costs of the screening strategies investigated and the management of a haemolytic transfusion reaction (HTR).

| | **Cost per scenario (US$)** | |
|---|---|---|
| **Cost item (per patient)** | *Limited* | *Universal* |
| TubeCC | 8.75 | 8.57 |
| TubeSCREEN | 10.16 | 9.99 |
| GelCC | 20.50 | 18.98 |
| GelSCREEN | 23.60 | 22.07 |
| Management of a patient with an HTR | 111.92 | 111.92 |

On the other hand, the cheapest strategy was *universal* TubeCC at a cost of US$8.57 per patient. The cost of management of an HTR was estimated at US$111.92 per patient.

The annual cost of testing all blood recipients in Uganda would range from US$857,405 to 2,207,363 for *universal* TubeCC and *universal* GelSCREEN, respectively (Table 2). In comparison, introduction of pre-transfusion testing in only multiply transfused patients in 15 regional referral hospitals would range from US$87,509 to 235,969 annually for *limited* TubeCC and *limited* GelSCREEN, respectively. The net cost, hence the budget impact of introducing pre-transfusion immunohaematologic testing in Uganda, is shown in Table 2 column ΔC. The budget impact for all transfusion recipients per annum ranged from US$174,675 to 1,524,633 for *universal* TubeCC and *universal* GelSCREEN, respectively; while that in the '*limited* testing scenario' was estimated to be in the range of US$19,236 to 167,696 for *limited* TubeCC and *limited* GelSCREEN, respectively.

**Table 2.** Base case analysis for the four strategies to improve pre-transfusion testing in Uganda using either the *limited* or *universal* scenario relative to *No Screening*.

| **Testing strategy** | **Costs (US$)** | **HTRs** | **ΔC** | **ΔE** | **Cost-effectiveness ratio relative to '*No Screening*'** |
|---|---|---|---|---|---|
| *No Screening* | 682,730* | 0 | - | - | - |
| *limited* GelSCREEN | 850,425 | 610 | 167,696 | 610 | 275 |
| *universal* GelSCREEN | 2,207,363 | 6,100 | 1,524,633 | 6,100 | 250 |
| *limited* GelCC | 819,482 | 610 | 136,753 | 610 | 224 |
| *universal* GelCC | 1,897,932 | 6,100 | 1,215,202 | 6,100 | 199 |
| *limited* TubeSCREEN | 716,095 | 610 | 33,366 | 610 | 55 |
| *universal* TubeSCREEN | 1,016,385 | 6,100 | 333,656 | 6,100 | 55 |
| *limited* TubeCC | 701,966 | 610 | 19,236 | 610 | 32 |
| *universal* TubeCC | 857,405 | 6,100 | 174,675 | 6,100 | 29 |

HTRs, haemolytic transfusion reactions; ΔC = costs of the scenario relative to '*No Screening'*; ΔE = number of HTRs prevented; * Equivalent to the cost of investigation and treatment of all HTRs occurring as a result of no alloantibody screening, in the current *'No screening'* scenario

The costs and effects of the four testing strategies proposed in improving pre-transfusion testing in Uganda are shown in Table 2. When the cost-effectiveness ratios (CERs) relative to *No Screening* were calculated, it was found that those for *universal* TubeCC and *limited* TubeCC were the lowest and most favourable. The CER for *universal* TubeCC versus *No Screening* was US$29 while that for *limited* TubeCC versus *No Screening* was US$32 per HTR prevented (Figure 1). Therefore *limited* TubeCC was less cost effective than *universal* TubeCC and it was formally excluded by extended dominance. All other strategies showed higher costs and less or equal HTR prevention and were therefore dominated by *universal* TubeCC.

For Uganda, the per capita gross national income (GNI) in 2011 was US$490. To achieve a one to three times the GNI per capita per disability-adjusted life year (DALY) averted threshold of cost-effectiveness for *universal* TubeCC, the DALYs prevented per HTR should be at least 0.06 and 0.02, respectively.

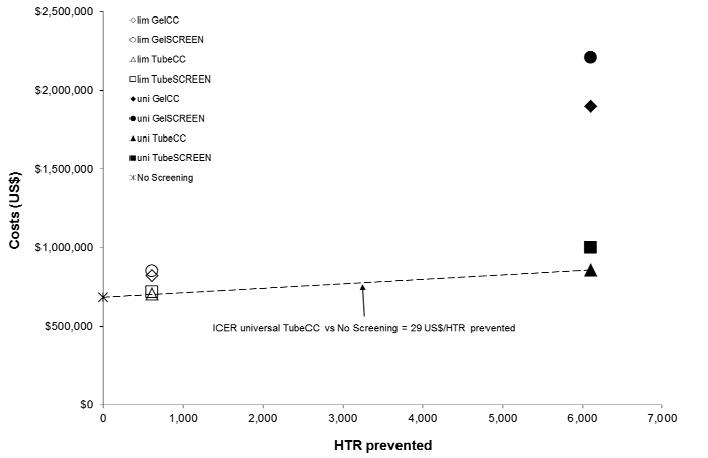


**Figure 1.** Total costs and HTRs prevented in the four screening strategies for the *limited* (open symbols) and *universal* (closed symbols) cohorts of transfused Ugandans. The CER of the *limited* TubeCC relative to *No Screening* was US$32 per HTR prevented. Therefore, the *limited* TubeCC was formally excluded by extended dominance. HTR = haemolytic transfusion reaction; lim = *limited*; uni = *universal*.

*Sensitivity analysis*

Sensitivity analyses were performed to determine which parameters had substantial impact on costs and outcomes. The prevalence of RBC alloimmunization in transfused Ugandans was assigned a range of 3 – 10% according to the published 95% confidence intervals (Natukunda *et al.,* 2010a; Natukunda *et al.,* 2010b). The proportion of HTRs that became severe was assumed to range from 5 – 20%. Other parameters (i.e. costs of antibody tests, management of HTRs, personnel and equipment) were varied using lower and upper limits of 50% and 200% of their original values respectively. Univariate sensitivity analyses revealed that the cost-effectiveness of *universal* TubeCC relative to *No Screening* was very sensitive to the test costs and the prevalence of RBC alloimmunization (Figure 2). Doubling the test costs to US$17.15 yielded a CER of US$169 per HTR prevented, a 6-fold increase in the base case value. TubeCC remained the most cost-effective strategy of the four strategies investigated. Decreasing the test costs to 50% of the base case value (i.e. to US$4.29 per patient) would achieve cost savings for *universal* TubeCC. The break-even point for cost savings was estimated at US$6.83, test costs below this value would make TubeCC a cost saving intervention. At a 2-fold increase in the TubeCC and TubeSCREEN costs, TubeCC still remained the most cost-effective strategy. *Universal* TubeSCREEN would become most cost-effective at costs higher than US$10.16 per patient for TubeCC. GelCC would be a dominant strategy if costs decreased from US$18.98 to 6.83 per patient.

The prevalence of alloimmunization had a profound impact on cost-effectiveness. Using the lower limit of the 95% confidence interval yielded a 6-fold higher CER for *universal* TubeCC relative to *No Screening* (Figure 2). TubeCC remained the most cost-effective strategy and at an alloimmunization prevalence rate higher than 7.7%, it would become cost saving.

Halving the costs of HTR management would yield a 3-fold higher CER. *Universal* TubeCC screening would become cost saving at HTR management costs higher than US$140.56. The severity of an HTR had a modest impact on cost-effectiveness. The sensitivity of the CERs to personnel and equipment costs was also very limited (Figure 2). The univariate sensitivity analyses for the *limited* cohort were not shown as they closely resembled those for the *universal* cohort.

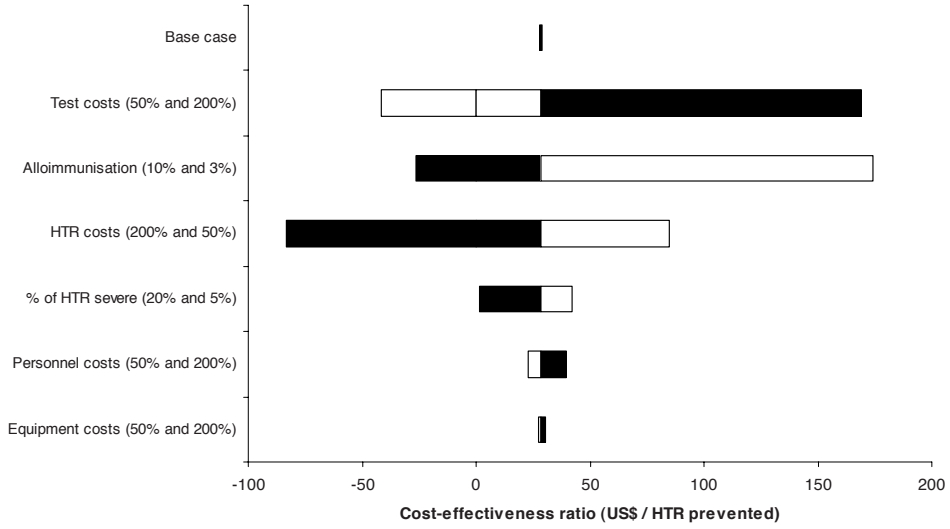


**Figure 2.** Tornado diagram showing the sensitivity of the cost-effectiveness ratio in the *universal* TubeCC screening strategy relative to *No Screening*. The solid line represents the base case cost-effectiveness ratio of US$29 per HTR prevented. Open and solid bars depict an estimation using lower or upper limit, respectively. Cost-effectiveness ratios below 0 (dashed line) represent cost-saving sensitivity analyses.

## Discussion

Using the health care providers' perspective, we investigated the cost-effectiveness of introducing RBC alloantibody screening in Uganda and found that it would be cost-effective. We assessed the '*limited'* and '*universal'* testing scenarios using tube and gel tests for alloantibody screening and complete cross-matches. To our knowledge, this is the first ever CEA study on pre-transfusion testing in Uganda and Africa at large. The cheapest (*universal* TubeCC) and the most expensive (*limited* GelSCREEN) strategies ranged from US$8.57 – 23.60 per patient, with a cost difference of US$15.03. In general, gel techniques were more expensive than tube tests. Furthermore, TubeCC dominated all the other testing strategies (i.e. it was the most cost-effective option). Alloantibody screening was a more expensive option than complete cross-matches without an effect on health gains relative to *No Screening*. CERs for all the testing

strategies were in the range of US$29 – 275 per HTR prevented. According to the WHO and World Bank thresholds for cost-effectiveness, *universal* TubeCC becomes a highly cost-effective intervention if DALYs per HTR prevented are higher than 0.06 and below 0.02 DALYs per HTR prevented, TubeCC does not become cost-effective.

To our knowledge, disability and quality of life weights for HTRs are not yet published. Our estimated DALYs per prevented range of 0.02 to 0.06 would correspond to 7 – 22 days of complete disability, or 14 – 44 days of 50% disability, comparable to severe chronic obstructive pulmonary disease, schizophrenia, and neurological sequelae of malaria (WHO, 2004).

Multivariate and univariate sensitivity analyses revealed that the cost-effectiveness of improved pre-transfusion testing was sensitive to test costs, the prevalence of alloimmunization and HTR management costs, in descending order. Univariate sensitivity analysis showed that the cost of TubeCC had to rise substantially before it was to become less cost-effective than other screening strategies. Also, a modest reduction in test costs for *universal* TubeCC would yield a cost-saving strategy.

A limitation of our study was that the analysis was based on a key assumption that the number of patients who would develop HTRs was equivalent to those who possessed transfusion-induced RBC alloantibodies. Whereas the prevalence of RBC alloantibodies was reported at 6.1% in transfused Ugandans in cross-sectional studies (Natukunda *et al.,* 2010a; Natukunda *et al.,* 2010b), the actual alloimmunization frequency might even be higher since alloantibodies are known to disappear with time (Schonewille *et al.,* 2000) negating the assumption that we could have overestimated the number of HTRs. At a slightly higher alloantibody prevalence of 7.7% the TubeCC strategy showed cost savings in the sensitivity analysis. This may well reflect the case with SCD and OMT patients. On the other hand, in first-time transfusion recipients (e.g. obstetric patients) the prevalence of RBC alloantibodies may be lower and hence less favourable cost-effectiveness can be expected from improved pre-transfusion testing. Data on the occurrence of HTRs in transfused Ugandans are lacking and there are no prospective studies on the frequency of post-transfusion RBC alloimmunization. We relied on clinical experience in the base case analysis. Because of the underlying statistical distribution, it is likely that costs of HTR management were higher relative to the base case value. The actual frequency of HTRs and associated management costs in sub-Saharan Africa warrants further research.

These findings provide additional evidence to support our earlier recommendations (Natukunda *et al.,* 2010a; Natukunda *et al.,* 2010b) that there was a need to introduce RBC alloantibody screening in Uganda for multiply transfused patients and those with prior blood transfusion or pregnancy. Our current health economic evaluation shows that *universal* TubeCC should be implemented in Uganda to prevent immunohaemolytic complications in transfused patients. Gel technology, based on the principle of controlled centrifugation of RBCs through a dextran-acrylamide-gel, is reported to have some advantages over tube tests. The technique addresses issues of standardization and the RBC washing step before the AHG phase is entirely eliminated saving time and requiring less skill (Lapierre, 1990; Delaflor-Weiss & Chizhevsky, 2005). However, in this health economic evaluation, gel technology was not found to be a cost-effective strategy. The cost of GelCC testing should have to decrease by more than 64% to become more cost-effective than the other screening strategies investigated. Introduction of RBC alloantibody screening calls for improvements in standards of laboratory and clinical transfusion practice. Issues of documentation on operational procedures, guidelines, manuals, storage conditions, error reporting and quality assessment schemes need to be addressed. Laboratory staff should liaise with their clinical colleagues and re-design blood request forms to allow for a record of alloantibody screening results (historical and/or current). Records on RBC alloimmunization should be properly kept by the local hospital transfusion laboratory and copies thereof given to the patients so as to prevent future HTRs. Since transfusion laboratory technicians are already conversant with saline tests, only limited extra training will be needed for them to appreciate the additional AHG phase with the introduction of *universal* TubeCC.

In conclusion, introduction of RBC alloantibody screening in Uganda appears to be cost-effective and would contribute towards improvement in blood transfusion safety. Therefore policy makers and other stakeholders should consider the implementation of the above recommendations on improved pre-transfusion testing. The UBTS can play an important role by supplying the necessary laboratory reagents to hospitals alongside blood components and in the overall monitoring of the program.

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**Appendix 1:** *A tube method with normal saline and addition of AHG reagent*

The tube method would be performed in a 12 x 75 mm glass tube with two drops of plasma being transferred using a plastic pipette. One drop of 3 - 4% RBC suspension and 2 drops of saline solution would be incubated for 10 minutes at 37˚C and test reactants would be washed 4 times before adding 2 drops of AHG reagent. Reactions would then be read macroscopically. Estimated costs calculated in performing tube tests are summarized in Table 3.

**Appendix 2:** *A manual LISS gel technique with Cellbind Screen® cards*

Fifty microlitres of each test cell reagent and 25 µL of patient's plasma would be transferred using an automatic pipette into the appropriate microtubes and the *Cellbind* cards would be incubated for 15 minutes at 37˚C in a *Cellbind* incubator. *Cellbind* screen gel cards would then be centrifuged for 10 minutes in a *Cellbind* centrifuge and read macroscopically. In this technology, the washing of test reactants and RBC button re-suspension steps are eliminated. Estimated costs calculated in performing gel technique tests are summarized in Table 4.

**Appendix 3:** *Management of a haemolytic transfusion reaction (HTR)*

Whenever a HTR was suspected, the transfusion would be stopped immediately and the patient hydrated with Normal Saline. Vigorous supportive care (to the patient's airway, blood pressure, urine output, and heart rate) would be applied while clerical and serologic investigations and notification of the blood provider were being carried out. The HTR would then be managed according to the laboratory and clinical findings. Average costs estimated in the management of a HTR are summarized in Table 5.

**Table 3.** Costs of RBC alloantibody screening and identification tests, including RT and complete cross-matches, using the tube method (US$1 = 2400 UG Shillings on 20.02.2011)

| ***(a) Antibody screening*** | | | | | |
|---|---|---|---|---|---|
| | **Total cost** | **Unit cost** | **Quantity per patient** | **Cost per patient (Sh)** | **US Dollars** |
| 100 Khan tubes | 43,400 | 434 | 3 | 1,302 | |
| 100 Pasteur pipettes | 16,000 | 160 | 3 | 480 | |
| K7210 *Cellbind* P3, 3x10 mL | 48.3 | | 3 drops | 725 | |
| Coombs' AHG reagent | 10,000 | | 6 drops | 300 | |
| 10820 Normal Saline 500 mL | 789 | 0.0789 | 24 drops | 1.9 | |
| ***Subtotal*** | | | | **2,809** | **1.17** |
| ***(b) Antibody identification*** | | | | | |
| | **Total cost** | **Unit cost** | **Quantity per patient** | **Cost per patient (Sh)** | **US Dollars** |
| 100 Khan tubes | 43,400 | 434 | 16 | 6,944 | |
| 100 Pasteur pipettes | 16,000 | 160 | 16 | 2,560 | |
| 10820 Normal Saline 500 mL | 789 | 0.0789 | 128 drops | 10.1 | |
| Coombs' AHG reagent | 10,000 | | 32 drops | 1,600 | |
| K7230 *Cellbind* D16, 16x3 mL | 114.1 € | | 16 drops | 6,270 | |
| ***Subtotal*** | | | | **17,384** | **7.24** |
| ***(c) RT Saline cross-match*** | | | | | |
| | **Total cost** | **Unit cost** | **Quantity per patient** | **Cost per patient (Sh)** | **US Dollars** |
| 100 Khan tubes | 43,400 | 434 | 1 | 434 | 0.18 |
| 100 Pasteur pipettes | 16,000 | 160 | 2 | 320 | 0.13 |
| ***Subtotal*** | | | | **754** | **0.31** |
| ***(d) Complete cross-match*** | | | | | |
| | **Total cost** | **Unit cost** | **Quantity per patient** | **Cost per patient (Sh)** | **US Dollars** |
| 100 Khan tubes | 43400 | 434 | 1 | 434 | 0.18 |
| 100 Pasteur pipettes | 16000 | 160 | 2 | 320 | 0.13 |
| Coombs' AHG reagent | 10000 | | 2 drops | 100 | 0.04 |
| ***Subtotal*** | | | | **854** | **0.35** |
| ***(e) Staff costs*** | | | | | |
| Laboratory technologists | | | *Time (min)* | *Cost/min* | *Labour (US$)* |
| *TubeSCREEN* | | | 60 | 0.0189 | 1.13 |
| *TubeCC* | | | 45 | 0.0189 | 0.85 |
| ***(f) Equipment costs*** | | | | | |
| | | | *Tests per annum/hosp* | *Cost/annum* | *Cost/test US$)* |
| *Limited* scenario | | | 666.67 | $208.08 | 0.312 |
| *Universal*scenario | | | 1538.46 | $208.08 | 0.135 |
| ***Overall total cost of Tube test per patient*** | | | | | ***(US$)*** |
| | *limited* TubeSCREEN (a+b+c+e+f) | | | | **10.16** |
| | *universal* TubeSCREEN (a+b+c+e+f) | | | | **9.99** |
| | *limited* TubeCC (b+d+e+f) | | | | **8.75** |
| | *universal* TubeCC (b+d+e+f) | | | | **8.57** |

**Table 4.** Costs of RBC alloantibody screening and identification tests, including RT and complete cross-matches, using the gel technique (US$1 = 2,400 UG Shillings on 20.02.2011)

| | | | | | | |
|---|---|---|---|---|---|---|
| ***(a) Antibody screening*** | | | | | | |
| | | **Total cost** | **Quantity per patient** | **Cost per patient** | **UG Sh** | **US$** |
| K7000 | *Cellbind screen*, 48x6 tests | 174.7 | 3 microtubes | 1.82 | 6,006 | 2.5 |
| K7210 | *Cellbind P3*, 3x10 mL | 48.3 | 150 uL | 0.72 | 2,376 | 0.99 |
| | Pipette tips, 500 in a pack | | 3 tips | | 122 | 0.05 |
| ***Subtotal*** | | | | | **8,504** | **3.54** |
| ***(b) Antibody identification*** | | | | | | |
| | | **Total cost** | **Quantity per patient** | **Cost per patient** | **UG Sh** | **US$** |
| K7000 | *Cellbind screen*, 48x6 tests | 174.7 | 16 microtubes | 9.7 | 32,010 | 13.34 |
| K7230 | *Cellbind ID16*, 16x3 mL | 114.1 | 800 uL | 1.9 | 6,270 | 2.6 |
| | Pipette tips, 500 in a pack | | 16 tips | | 652 | 0.27 |
| ***Subtotal*** | | | | | **38,932** | **16.21** |
| ***(c) RT Saline cross-match*** | | | | | | |
| | | **Total cost** | **Quantity per patient** | **Cost per patient** | **UG Sh** | **US$** |
| 100 Khan tubes | | 43,400 | 1 | 434 | 434 | 0.18 |
| 100 Pasteur pipettes | | 16,000 | 2 | 320 | 320 | 0.13 |
| ***Subtotal*** | | | | **754** | **754** | **0.31** |
| ***(d) Complete cross-match*** | | | | | | |
| | | **Total cost** | **Quantity per patient** | **Cost per patient** | **UG Ss** | **US$** |
| K7000 | *Cellbind* screen, 48x6 tests | 174.7 | 1 microtube | 0.6 | 1,980 | 0.83 |
| | Pipette tips, 500 in a pack | | 1 tip | | 40 | 0.02 |
| **Subtotal** | | | | | **2,020** | **0.85** |
| ***(e) Staff costs*** | | | | | | |
| Laboratory technologists | | | | *Time(min)* | *Cost/min (US$)* | *Labour (US$)* |
| | *GelSCREEN* | | | 45 | 0.0189 | 0.85 |
| | *GelCC* | | | 40 | 0.0189 | 0.75 |
| ***(f) Equipment costs*** | | | | | | |
| | | | *Tests per annum/hosp* | | *Cost/annum* | *Cost/test (US$)* |
| | *Limited* scenario | | 666.67 | | 1792.05 | 2.688 |
| | *Universal* scenario | | 1538.46 | | 1792.05 | 1.165 |
| ***Overall total cost of gel test per patient*** | | | | | | ***(US$)*** |
| | | | *limited* GelSCREEN (a+b+c+e+f) | | | **23.60** |
| | | | *universal* GelSCREEN (a+b+c+e+f) | | | **22.07** |
| | | | *limited* GelCC (b+d+e+f) | | | **20.50** |
| | | | *universal* GelCC (b+d+e+f) | | | **18.98** |

**Table 5.** Estimated costs involved in the laboratory investigation and treatment per HTR prevented. Severe HTR was assumed to occur in 10% of all HTR cases.

| Item | Cost (US$) |
|---|---|
| Repeat blood group; cross-match; and DAT (tube method) | 4.49 |
| Repeat blood group; cross-match; and DAT (gel method) | 5.32 |
| Alloantibody screening (tube method) | 1.20 |
| Alloantibody screening (gel method) | 3.54 |
| Haematology and clinical chemistry tests | 23.00 |
| Drug treatment for a *mild HTR* | 1.05 |
| Drug treatment for a *severe HTR* | 2.23 |
| Additional blood component therapy | 50.00 |
| Dialysis for acute renal failure (with tubular necrosis) | 316.60 |
| Staff costs: lab technologists, nurses and a medical doctor – *mild HTR;* tube method | 2.82 |
| Staff costs: lab technologists, nurses and a medical doctor – *severe HTR;* tube method | 3.96 |
| Staff costs: lab technologists, nurses and a medical doctor – *mild HTR;* gel method | 2.55 |
| Staff costs: lab technologists, nurses and a medical doctor – *severe HTR;* gel method | 3.69 |
| Equipment costs per HTR; *limited* scenario (tube method) | 0.31 |
| Equipment costs per HTR; *universal* scenario (tube method) | 0.14 |
| Equipment costs per HTR; *limited* scenario (gel method) | 2.69 |
| Equipment costs per HTR; *universal* scenario (gel method) | 1.16 |
| Cost of each HTR management; *limited* scenario (tube method) | 109.58 |
| Cost of each HTR management; *universal* scenario (tube method) | 109.56 |
| Cost of each HTR management; *limited* scenario (gel method) | 115.04 |
| Cost of each HTR management; *universal* scenario (gel method) | 113.51 |
| Average cost of investigation and treatment of each HTR | 111.92 |

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