Estimate Blood Requirements - Search for a Global Standard

Dr Neelam Dhingra
Coordinator
Blood Transfusion Safety
WHO, Geneva

Pattern of Blood Usage

**Developed countries**
- complex medical and surgical procedures
  - cardiac, vascular, neuro, transplant
- trauma care
- cancer chemotherapy
- haematological malignancies

**Developing countries**
- Limited diagnostic & treatment facilities
- complications during pregnancy and childbirth
- severe childhood anaemia, often resulting from malaria or malnutrition
- trauma
  - conflict, disasters, violence, road-traffic accidents

Emergency Trauma Care

- Worldwide, >100 million people sustain injuries each year and >5 million die from violence and injury
- RTAs are the 2nd leading cause of death and a leading cause of serious injury for both sexes aged 5–29
  - Uncontrolled bleeding accounts for >40% of trauma related deaths
- Capacity to provide safe blood transfusion - essential component of Emergency Trauma Care Systems to minimize death and disability in injured patients

Maternal Mortality

- Globally, >530 000 women die each year during pregnancy, childbirth or in PP period – 99% of them in the developing world
- 14 countries had MMRs of at least 1000, of which 13 are in the SSA, where the lifetime risk of maternal death is 1 in 73, compared with 1 in 7300 in rich countries
- Severe bleeding during delivery or after childbirth: commonest cause of MM, contributing up to 44% of maternal deaths in Africa, 31% in Asia and 21% in Latin America and the Caribbean
- In most developing countries 50-80% of supplied blood is used for obstetrics emergencies
- Blood transfusion: one of the eight signal functions of Comprehensive Emergency Obstetric Care (EmOC) facilities

Blood Supply

- Role of blood transfusion services
  - provide equitable access to safe blood/blood products for all patients who need it
  - adjust supply to actual needs
- Shortages
  - various reasons (lack of donors or well organized donor programme, t safety measures,…)
  - periodic or continuous
  - crucial for patients when no alternative is available

Estimating Blood Requirements

- Important for planning a national blood programme
- Needs based programme - to satisfy the needs of a country’s health care system, equitably and timely (routine and emergency)
- No global standard for estimating countries’ needs for blood/blood products, and estimates have to be made for each country and each region
- Plan blood collection and donor recruitment systematically, to avoid an excess or a shortage
Variables affecting demand and supply

- Geography, population and epidemiology
- Level and rate of development of health care system
  - Prevention: e.g. anaemia, malaria
  - Diagnosis: e.g. haemophilia
  - Treatment: e.g. advanced medical and surgical procedures
- Location and accessibility of health care facilities

Country’s Need for Blood and Blood Products

- Balance between demand and supply is needed
  - Minimize wastage
  - Avoid blood shortages
  - Ensure appropriate use

Geo-population related Factors

- Size of the country
- Geographical characteristics
- Population
  - Size
  - Demographics – age distribution, growth
  - Density/distribution in regions
- Epidemiology of diseases in the patients’ population (dependence on blood/blood products)
- Disasters (natural or man-made)

Estimating blood needs

Health Care System related Parameters

- Level & rate of development of health care
- Accessibility of patients to health care
- Diagnostic and treatment facilities
- Preventive public health measures
- Water, electricity, communication and transportation systems
- Hospitals
  - Number and location
  - Total no. of hospital beds
  - No. of hospitals/beds for specialized complex care
  - New hospitals/↑ hospital beds
Development and effectiveness of BTS to provide safe blood/blood products to support regular and specific transfusion needs

Number of blood centres and level of coordination

Assessment of services in each centre
- blood collected, blood processing, storage and transport capacity
- % of blood separated into components
- shelf-life of blood/blood components

Degree of component preparation tailored to real need and resources of a country
- What % of blood should be separated into components?
- What to do with the excess plasma?

Options for Fractionation – Contract / In-country

Hospital blood stock management / inventory control

Future needs, including the feasibility of using recovered plasma for fractionation

Future need for apheresis and / or autologous programme

National guidelines on blood usage

Size of hospital(s) and number of patients

No. and kind of procedures, deliveries, anaemia pts

Clinical competence and experience of staff

Training for hospital and blood bank staff

Annual blood usage review (past, present and future) - hospitals, blood components

Different types of components needed

Joint study WHO/IFRCRCS(1986)

Management of Blood Transfusion Services, WHO, 1989
Blood Usage

- 120 countries report that a total of 51,400 hospitals perform blood transfusions, serving a population of around 3.6 billion
- Only 25% hospitals performing transfusions in developing countries and 33% hospitals in transitional countries have a transfusion committee to monitor transfusion practices; as compared to 88% hospitals in developed countries

Hospital Beds Model

- # hospital beds may provide an estimate of blood use
- Limitations:
  - growing trend to provide OPD treatment (reduced relevance on # hospital beds as indicator of health care)
  - # hospital beds not dependent on size of population (not an appropriate indicator for estimating and forecasting future demand)
  - hospital beds may be used for patients with complex disorders with different levels of blood consumption

Method 1

Method 1: based on previous usage

- Assess the number of units of blood used in a specified period in a defined geographical area or population
- Analyse previous blood usage and requests for blood to give an approximate indication of whether the demand for blood is constant, increasing or decreasing

Method 2

Method 2: based on acute hospital beds

- Suitable for countries with modern hospital services
- Calculate 6.7 units of blood per acute hospital bed per year (WHO, 1971)

Method 3

Method 3: based on population

- Used to estimate the number of units of blood needed to meet a country’s blood requirements over one year
- Calculation is based on 2% of population requiring blood per year
- Can be used to calculate the blood requirements of individual regions or districts within the country
Population Based Model

- Makes it possible to:
  - compare between countries or regions of similar size
  - project the trend in requirements in terms of population trends
  - paint a picture of the national situation

Method 3

Example

- For a country with a population of 10 million, calculate as follows:
  - $10\,000\,000 \times 2\% = 200\,000$ units of blood per year or approximately $3850$ per week
- A minimum of $100\,000$ donors will be needed if each donor gives blood at least twice per year

Selecting a method to estimate blood requirements

- Method 1 is the most practical where there is a constant supply of blood
- Methods 2 and 3 can be useful where no data are available or new established blood centre
**The Global Burden of Disease approach to comparable international statistics**

Gretchen Stevens  
Health Statistics and Informatics Department

3 February 2010

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**Overview**  
A brief introduction to the Global Burden of Disease project  
Issues in preparing comparable cross-national statistics  
1. Selecting indicators and metrics  
2. Correcting for bias in available data  
3. Estimating and communicating uncertainty

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**Global burden of Disease (GBD)**  
A standardized framework for integrating all available information on mortality, causes of death, individual health status, and condition-specific epidemiology to provide an overview of the levels of population health and the causes of loss of health  
- Consistent, comprehensive descriptive epidemiology  
- Common metric or summary measure

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**GBD Principles**  
Quantities of interest are total events or states at the population level  
Best available data used to make estimates  
Corrections for major known biases to improve cross-population comparability  
Comprehensive set of disease and injury causes – nothing is left out in principle  
No blanks in the tables, only wider uncertainty intervals  
Internal consistency used as a tool to improve validity

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**Leading Causes of Mortality and Burden of Disease**  
**world, 2004**

<table>
<thead>
<tr>
<th>Mortality</th>
<th>DALYs</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischaemic heart disease</td>
<td>Lower respiratory infections</td>
<td>12.2</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>Diarrhoeal diseases</td>
<td>9.7</td>
</tr>
<tr>
<td>Lower respiratory infections</td>
<td>Depression</td>
<td>7.1</td>
</tr>
<tr>
<td>COPD</td>
<td>Ischaemic heart disease</td>
<td>5.1</td>
</tr>
<tr>
<td>Diarrhoeal diseases</td>
<td>HIV/AIDS</td>
<td>3.7</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>COPD</td>
<td>3.5</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>Prematurity, low birth weight</td>
<td>2.5</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>Birth asphyxia, birth trauma</td>
<td>2.3</td>
</tr>
<tr>
<td>Road traffic accidents</td>
<td>Road traffic accidents</td>
<td>2.2</td>
</tr>
<tr>
<td>Prematurity, low birth weight</td>
<td>Neonatal infections and other</td>
<td>2.0</td>
</tr>
</tbody>
</table>

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**Overview**  
A brief introduction to the Global Burden of Disease project  
**Preparing comparable international statistics**  
1. Selecting indicators and metrics  
2. Correcting for bias in available data  
3. Estimating and communicating uncertainty
Three types of health statistics

Unadjusted statistics: derived directly from primary data collection
Adjusted statistics: corrected for known biases
Predicted statistics: predicted using a statistical model, includes both forecasts and “farcasts”

What is meant by comparable statistics?

Key elements:
- Quantities of interest are estimated at the population level
- Corrections for major known biases
- Estimates are made for every population
- Adjusted and predicted statistics can be used for national and international priority-setting

Three issues to consider when generating comparable statistics

1. Selecting indicators and metrics
2. Correcting for bias in available data
3. Estimating and communicating uncertainty

Selecting health indicator and metrics

- Meaningful health indicator
- Data are available or collectable
- Disease and risk factor indicators are preferably comparable across diseases/risk factors

Framework for monitoring health systems

Input & processes
- Infrastructure
- ICT
- Health workforce
- Supply chain
- Information

Outputs
- Intervention scores & variance resolution
- Intervention quality, safety
- Prevalence risk behaviour & factors

Outcomes
- Coverage of interventions
- Improvement health outcomes & equity
- Social and financial risk protection
- Responsiveness, efficiency

Data collection
- Administrative sources
- Facility assessments
- Population-based surveys
- Clinical reporting systems
- Civil registration

Three issues to consider when generating comparable statistics

1. Selecting indicators and metrics
2. Correcting for bias in available data
3. Estimating and communicating uncertainty
Bias in height and weight reported over the telephone

NHANES – a national health examination survey – measures height and weight of a national sample

BRFSS – a telephone health survey – asks about height and weight for state samples

Comparing these data:
- Women underreport weight on the phone
- Men overreport height on the phone

Ezzati et al. predicted unbiased state rates of overweight and obesity using NHANES to correct BRFSS

Three issues to consider when generating comparable statistics

1. Selecting indicators and metrics
2. Correcting for bias in available data
3. Estimating and communicating uncertainty

Uncertainty in health estimates

Some sources of uncertainty:
- Input uncertainty (especially bias)
- Model uncertainty (functional form, covariates)
- Parameter uncertainty

Estimating uncertainty in a consistent way across diseases and risk factors has had limited success

Uncertainty is a major focus of the new round of estimates
Choice of exposure metric may need to be flexible to meaningful and/or accommodate data availability
- There is often a trade-off between data quality and population-based data

Modeling approaches can correct for missing or biased data

Assessing and communicating uncertainty is a continuing challenge

Why calculate internationally comparable statistics?
Global health can be characterized by:
- Sparse, sometimes inconsistent data, especially where burden is highest
- Insufficient evidence-based priority-setting or evaluation
- Resource constraints

Researchers can use data and experiences from multiple settings to correct for biases in country data or to make estimates when they are not available
Requirements of Blood & Blood Components for Management of Malaria

Dr Peter Olumese
Global Malaria Programme
WHO/HQ, Geneva

Requirements of blood for management of malaria. Expert Consultation, Geneva, 03 Feb 2010

Clinical Disease and Epidemiology
- The nature of malaria clinical disease depends greatly on the background level of the acquired protective immunity, a factor which is the outcome of the pattern and intensity of malaria transmission in the area of residence.
- Where the transmission of malaria is "stable," entomological inoculation rate (EIR) >10 per year), partial immunity to the clinical disease and to its severe manifestation is acquired early in childhood.
- Severe manifestations mainly in the very young before acquisition of immunity.
- In areas of "unstable" malaria, the rates of inoculation fluctuate greatly over seasons and years. Entomological inoculation rates are usually <5 per year and often <1 per year. This retards the acquisition of immunity.

Malaria Control Technical Strategies
- Evidence-based actions
- Early diagnosis and prompt treatment with effective medicines
- Insecticide-treated nets (ITNs), Indoor Residual Spraying (IRS), and other vector-control methods
- Intermittent preventive treatment in pregnancy (IPTp)
- Emergency and epidemic preparedness and response
- Intermittent preventive treatment in infancy (IPTi)

Severe malaria
- P. falciparum sexual parasitaemia and no other obvious cause of symptoms, the presence of one or more of the following clinical or laboratory features classifies the patient as severe malaria:
  - Clinical features:
    - Impaired consciousness or unrousable coma
    - Prostration, i.e. generalized weakness so that the patient is unable to walk or sit up without assistance
    - Multiple convulsions – more than two episodes in 24 h
    - Deep breathing, respiratory distress (acidotic breathing)
    - Circulatory collapse or shock, systolic blood pressure <70 mm Hg in adults and <50 mm Hg in children
    - Clinical jaundice plus evidence of other vital organ dysfunction
    - Haemoglobinuria
    - Abnormal spontaneous bleeding (OSB): pulmonary oedema (radiological)
    - Pulmonary oedema (radiological)

Malaria Anaemia
- Anaemia (hemoglobin level <11 g/dL) remains one of the most intractable public health problems in malaria-endemic countries of Africa.
- And has serious consequences as severe anaemia (hemoglobin level <5 g/dL) is associated with an increased risk of death.
**Severe Malaria Anaemia**
- Hemoglobin less than 5g/dl (PCV less than 15%)
- Features of anaemic heart failure (even if PCV is >15%)
- In the presence of *P. falciparum* parasitemia

**The burden of malarial anaemia**
- It affects more than half of all pregnant women and children less than five years old
- Each year in children < 5 years:
  - 1.4 - 5.7 million cases
  - 190,000 - 974,000 deaths
  - Case fatality rate of severe anaemia (13.4 - 17.2%)
  - Highest mortality in infants

**Management of Severe Malaria**
- Specific antimalarial treatment
- Adjunctive therapy and supportive care

**Antimalarial treatment**
- Any of the following antimalarial medicines are recommended
  - Artesunate (i.v. or i.m)
  - artemether (i.m.)
  - artemotil (i.m)
  - quinine (i.v. infusion or i.m. injection).

**Management of severe anaemia**
- The need for blood transfusion must be assessed with great care in each individual child. Not only packed cell volume or haemoglobin concentration, but also the density of parasitaemia and the clinical condition of the patient must be taken into account.
- In general, a packed cell volume of 12% or less, or a haemoglobin concentration of 4 g/dl or less, is an indication for blood transfusion, whatever the clinical condition of the child.
- Transfusion (10 ml of packed cells or 20 ml of whole blood per kg of body weight).
- In children with less severe anaemia (i.e. packed cell volume 13–18%, Hb 4–6 g/dl), transfusion should be considered for high-risk patients with any one of the following clinical features:
  - Respiratory distress (acidosis);
  - Impaired consciousness;
  - Hyperparasitaemia (>20%).
- The sicker the child the more rapidly the transfusion needs to be given.

**Other indications for blood and blood products**
- Disseminated intravascular coagulation, complicated by clinically significant bleeding, e.g. haematemesis or melena, occurs in fewer than 10% of patients.
- It is more common in non-immune patients with imported malaria in the temperate zone.
- Treatment:
  - Transfuse fresh blood, clotting factors or platelets as required.
Other indications for blood and blood products

- Malaria
  - Hemoparaemia
    - If parasitaemia exceeds 10% in severely ill patients, especially those deteriorating after optimal chemotherapy, exchange transfusion with screened blood should be considered where facilities are available.
  - Exchange blood transfusion
    - There have been many anecdotal reports and several series claiming benefit for exchange blood transfusion in severe malaria but no comparative trials.
    - There is no consensus on whether it reduces mortality or how it might work, so there is no global recommendation on its use.

Challenges of blood transfusion

- Wasteage
  - Non availability of paediatric blood bags
  - Use of whole blood in place of packed cells or other specific blood components (e.g. platelets)
  - Unnecessary transfusions
    - Inadequate diagnostics facilities
    - Blood storage facilities – proper blood bank facilities

Impact of the scale up malaria control measures in Africa

SME/MP/WHO Surveillance, 2008
Conclusions

- The use of blood and blood products remains an essential component of the management of severe malaria.
- Estimating the requirement remains a challenge especially now in the light of the reducing burden of malaria due to rapid scale up of malaria control interventions.
- Urgent need to optimise the use of blood and blood products especially in very young children with severe malaria anemia.

Thank You
Requirements of blood & blood components in maternity care

Matthews Mathai
Department of Making Pregnancy Safer

Outline

• When are blood and blood components used in maternity care?
• How often are blood and blood components required?
• What are the challenges in estimating requirements?

Common indications

• To correct hypovolemia resulting from acute haemorrhage
  – Antepartum and postpartum haemorrhage
  – Ruptured ectopic pregnancy, uterine rupture and other genital lacerations
  – Post abortion
• To treat severe anaemia
  – With cardiac failure
  – Before or during surgery

Other indications

• In newborns
  – Top up transfusions in preterm infants
  – As part of treatment of sepsis
  – For hypovolemia resulting from trauma
  – Exchange transfusion
• To correct coagulation failure
  – Placental abruption
  – Retained products
  – Sepsis
  – Amniotic fluid embolism

WHO analysis of causes of maternal death: a systematic review
Lancet 367: 1066-1074, 2006
WHO analysis of causes of maternal death: a systematic review

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Maternal deaths</th>
<th>MMR</th>
<th>Haemorrhage</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR Congo</td>
<td>1997</td>
<td>143</td>
<td>510</td>
<td>16%</td>
</tr>
<tr>
<td>Egypt</td>
<td>2000</td>
<td>585</td>
<td>84</td>
<td>30%</td>
</tr>
<tr>
<td>Senegal</td>
<td>2002</td>
<td>147</td>
<td>600</td>
<td>23%</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1998</td>
<td>70</td>
<td>529</td>
<td>23%</td>
</tr>
<tr>
<td>South Africa</td>
<td>2002, 2003</td>
<td>3121</td>
<td>150</td>
<td>10%</td>
</tr>
<tr>
<td>Zambia</td>
<td>1998</td>
<td>349</td>
<td>729</td>
<td>28%</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>2001</td>
<td>92</td>
<td>695</td>
<td>19%</td>
</tr>
<tr>
<td>MC W Africa</td>
<td>2001</td>
<td>55</td>
<td>334</td>
<td>33%</td>
</tr>
</tbody>
</table>

Estimated blood transfusion requirements

Number per 1000 deliveries
- Antepartum haemorrhage 7.26
- Postpartum haemorrhage 12.5
- Puerperal sepsis 8.0

Estimated global resources needed to attain universal coverage of maternal and newborn health services
- B Johns, K Sigurnbjörnsdottir, H Fogstad, J Zupan, M Mathai, T T-T Edejer
- *Bull WHO* 2007; 86: 256-263

WHO Global Surveys on Maternal and Perinatal Health

- Facility based survey conducted between 2004 and 2008
- 24 countries in Latin America, Africa and Asia
- Analysed mode of delivery, maternal and perinatal outcomes
- Varying caesarean delivery rates between and within regions and countries

WHO Global Survey on Maternal and Perinatal Health

Blood transfused in 1.58% of births
- Spontaneous vaginal delivery 1940/205303 (0.94)
- Operative vaginal delivery 198/27287 (2.72)
- Antepartum CS - no indications 14/1826 (0.77)
- Intrapartum CS - no indications 26/1063 (2.45)
- Antepartum CS with indications 887/26876 (3.3)
- Intrapartum CS with indications 1467/43815 (3.35)
WHO Global Survey on Maternal and Perinatal Health

Near miss study in LAC (n=97095 births)
- Vaginal bleeding: 22 in every 1000 births
- Blood transfusion: 13.8 in every 1000 births

Outline
- When are blood and blood components used in maternity care?
- How often are blood and blood components required?
- What are the challenges in estimating requirements?

Challenges
- Limited data
  - Amount
  - Blood or blood components
- Estimated need versus actual transfusion requirements
- Other issues
  - Epidemiology – Malaria, helminthiasis, HIV
  - Recognising the need for blood transfusion
  - Intervention rates
  - Access to care

Anemia in pregnant women: Proportion of pregnant women age 15-49 with anemia. Anemia includes mild anemia (hemoglobin count of 8.0-10.9), moderate anemia (hemoglobin count of 7.0-9.9), and severe anemia (hemoglobin count of 6.0 and below). Anemia in among pregnant women includes mild anaemia (haemoglobin count d/dl 10.0-10.9), moderate anaemia (haemoglobin count d/dl 7.0-9.9), and severe anemia (haemoglobin count d/dl below 7.0)

Gaps in skilled care

In Nepal, only 0.8% of poorest women have access to C-section compared to 12% of the most wealthy women.

In Indonesia, women in urban areas are three times more likely to have access to C-section than their rural counterparts.

In Nigeria, while 70% of births occur in rural areas, only 1% of women in rural areas have access to C-section.

Percentage of births delivered by Caesarean section

Blood transfusion

% of births for which mothers received a blood transfusion

Nepal 2006

<table>
<thead>
<tr>
<th>Place of delivery</th>
<th>Urban</th>
<th>Rural</th>
<th>Poor</th>
<th>Middle</th>
<th>Rich</th>
<th>Richest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local health centre</td>
<td>0.1</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Hospital</td>
<td>2.9</td>
<td>1</td>
<td>1.4</td>
<td>0.6</td>
<td>0.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Data source: Demographic and Health Survey

The name as shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations.
Requirements of blood and blood components for trauma care

Pablo Perel

To know blood requirements

• How frequent is trauma?
• How frequent is bleeding in trauma patients?
• Which patients should receive transfusions?
• Which blood components should they receive?

In addition

• CRASH-2 Trial

Global injury-related Mortality

Rankings of Deaths & DALYs: 1990 - 2020

<table>
<thead>
<tr>
<th>Disease</th>
<th>Deaths 1990 rank</th>
<th>Deaths 2020 rank</th>
<th>DALYs 1990 rank</th>
<th>DALYs 2020 rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Traffic Injuries</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Self Inflicted Injuries</td>
<td>12</td>
<td>10</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Interpersonal Violence</td>
<td>16</td>
<td>14</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>War</td>
<td>20</td>
<td>15</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

If current trends continue, road traffic and intentional injuries will rank in the 15 leading causes of death and burden of disease.

Injury related mortality*, WHO Regions, 2000

Africa: 118.8
Americas: 53.8
Eastern Mediterranean: 76.2
Europe: 51.1
South-East Asia: 70.4
Western Pacific: 47.6

HIC†

India: 131.5
Other LMIC: 96.9

LMIC‡

HIC

LMIC

HIC

LMIC

India

Other LMIC

HIC

China

Other LMIC

* Rate per 100,000 population
† High income countries
‡ Low/middle income countries

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Ten most common causes of death in young people (10-24)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Total-deaths (×10000) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exsanguination</td>
<td>45%</td>
</tr>
<tr>
<td>CNS injury</td>
<td>41%</td>
</tr>
<tr>
<td>Other</td>
<td>10%</td>
</tr>
<tr>
<td>Organ failure</td>
<td>5%</td>
</tr>
</tbody>
</table>


To know blood requirements

- How frequent is trauma?
- How frequent is bleeding in trauma patients?
- Which patients should receive transfusions?
- Which blood components should they receive?

Transfusion rates in trauma patients

<table>
<thead>
<tr>
<th>Country</th>
<th>Source</th>
<th>Number of patients</th>
<th>Transfusion rate (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>Registry (TARN)</td>
<td>28,703</td>
<td>3.4%</td>
</tr>
<tr>
<td>Germany</td>
<td>Registry (DGU)</td>
<td>2,475</td>
<td>54%</td>
</tr>
<tr>
<td>US</td>
<td>Trauma Centre</td>
<td>5,645</td>
<td>8%</td>
</tr>
<tr>
<td>Israel</td>
<td>Trauma Centre</td>
<td>986</td>
<td>33%</td>
</tr>
</tbody>
</table>


Recommendation 19

“We recommend a target Hb of 7 to 9 g/dl (12).”


30 days mortality
Transfusion threshold
Red cell transfusions

Mortality in patients who declined blood transfusions

To know blood requirements

• How frequent is trauma?
• How frequent is bleeding in trauma patients?
• Which patients should receive transfusions?
• Which blood components should they receive?

Red cell transfusions
Massive Bleeding

Blood components

In stable patients (European Guideline)
FFP if PT > 1.5
Platelets if <50 x 10^9

In patients with massive bleeding
Plasma:RBC ratio (1:3)

Trauma exsanguination protocol (1:1)

however, all of the studies are observational
Blood loss

Point at which benefits of transfusion exceed harms

Frequency

What do we know about interventions that can shift the curve?

Cochrane reviews of blood sparing interventions (surgery)

Risk will be different according to the region

Number exposed to allogeneic blood

RR (95% CI), random effects
Blood units
TXA
1.1 (0.6-1.6)

Blood units saved

Re-operation
TXA
0.67 (0.41-1.09)

Mortality
TXA
0.60 (0.32-1.12)

Mortality

Adverse effects of tranexamic acid

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Tranexamic Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Myocardial Infarction</td>
<td>0.96 (0.48-1.90)</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.25 (0.47-3.31)</td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>0.77 (0.37-1.61)</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0.73 (0.16-3.32)</td>
</tr>
</tbody>
</table>

No evidence of adverse effects for tranexamic acid

Rationale for the CRASH-2

- Bleeding is a leading cause of trauma death
- Antifibrinolics reduce blood loss after surgery
- A simple intervention like TXA could prevent thousands of trauma deaths and transfusion-associated infections

A large randomised controlled trial among trauma patients with significant haemorrhage, of the effects of antifibrinolytic treatment on death and transfusion requirement

Participating countries
Results I

Number of patients per country

<table>
<thead>
<tr>
<th>Country</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>4,760</td>
<td>25.5</td>
</tr>
<tr>
<td>South Africa</td>
<td>7,093</td>
<td>39.3</td>
</tr>
<tr>
<td>India</td>
<td>1,875</td>
<td>10.5</td>
</tr>
<tr>
<td>Thailand</td>
<td>7,240</td>
<td>41.3</td>
</tr>
<tr>
<td>Georgia</td>
<td>1,709</td>
<td>9.3</td>
</tr>
<tr>
<td>Israel</td>
<td>1,166</td>
<td>6.5</td>
</tr>
<tr>
<td>Thailand</td>
<td>932</td>
<td>5.1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>708</td>
<td>3.9</td>
</tr>
<tr>
<td>India</td>
<td>578</td>
<td>3.2</td>
</tr>
<tr>
<td>France</td>
<td>477</td>
<td>2.6</td>
</tr>
<tr>
<td>Nepal</td>
<td>432</td>
<td>2.4</td>
</tr>
<tr>
<td>Spain</td>
<td>399</td>
<td>2.2</td>
</tr>
<tr>
<td>Pakistan</td>
<td>231</td>
<td>1.3</td>
</tr>
<tr>
<td>Greece</td>
<td>174</td>
<td>0.9</td>
</tr>
<tr>
<td>Australia</td>
<td>109</td>
<td>0.6</td>
</tr>
<tr>
<td>Italy</td>
<td>101</td>
<td>0.6</td>
</tr>
<tr>
<td>Greece</td>
<td>101</td>
<td>0.6</td>
</tr>
<tr>
<td>Canada</td>
<td>115</td>
<td>0.6</td>
</tr>
<tr>
<td>India</td>
<td>103</td>
<td>0.6</td>
</tr>
<tr>
<td>Switzerland</td>
<td>94</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Results II

Characteristics of patients included

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>15,932</td>
<td>83.75</td>
</tr>
<tr>
<td>Female</td>
<td>3,091</td>
<td>16.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age categories</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>5,320</td>
<td>27.97</td>
</tr>
<tr>
<td>25-34</td>
<td>5,720</td>
<td>30.07</td>
</tr>
<tr>
<td>35-44</td>
<td>3,573</td>
<td>18.78</td>
</tr>
<tr>
<td>&gt;44</td>
<td>4,410</td>
<td>23.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours since injury</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>1,791</td>
<td>9.41</td>
</tr>
<tr>
<td>1 to 3</td>
<td>10,963</td>
<td>57.63</td>
</tr>
<tr>
<td>&gt;3</td>
<td>6,269</td>
<td>32.95</td>
</tr>
</tbody>
</table>

Results III

Mortality and transfusion practices

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>2,948</td>
<td>15.5</td>
</tr>
<tr>
<td>Transfusion</td>
<td>9,630</td>
<td>50.61</td>
</tr>
<tr>
<td>Mean units (uOR)</td>
<td>3</td>
<td>2 to 6</td>
</tr>
<tr>
<td>Red cells</td>
<td>9,545</td>
<td>50.18</td>
</tr>
<tr>
<td>&gt;10 units red cells</td>
<td>656</td>
<td>3.45</td>
</tr>
<tr>
<td>Plasma</td>
<td>2,436</td>
<td>12.81</td>
</tr>
<tr>
<td>Platelets</td>
<td>731</td>
<td>3.84</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>366</td>
<td>1.92</td>
</tr>
</tbody>
</table>

Results IV

Outcomes by subgroup – Systolic blood pressure

<table>
<thead>
<tr>
<th>Mean blood units</th>
<th>0-90</th>
<th>90-100</th>
<th>&gt;100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Infection rate</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
</tbody>
</table>

Results VII

Outcomes by subgroup – Type of injury

<table>
<thead>
<tr>
<th>Region</th>
<th>Mortality</th>
<th>Transfusion</th>
<th>Units transfused</th>
<th>Total patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>0.23</td>
<td>0.44</td>
<td>2.87</td>
<td>2,317</td>
</tr>
<tr>
<td>South East Asia</td>
<td>0.18</td>
<td>0.58</td>
<td>4.75</td>
<td>5,256</td>
</tr>
<tr>
<td>Western Pacific</td>
<td>0.35</td>
<td>0.72</td>
<td>12.30</td>
<td>74</td>
</tr>
<tr>
<td>Europe</td>
<td>0.13</td>
<td>0.33</td>
<td>10.24</td>
<td>2,127</td>
</tr>
<tr>
<td>Americas</td>
<td>0.15</td>
<td>0.51</td>
<td>7.65</td>
<td>5,425</td>
</tr>
<tr>
<td>Eastern Mediterranean</td>
<td>0.09</td>
<td>0.53</td>
<td>3.81</td>
<td>2,737</td>
</tr>
</tbody>
</table>
Results IX

Outcomes and units transfused by region according to subgroup

<table>
<thead>
<tr>
<th>Region</th>
<th>Systolic Blood Pressure</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;89</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>76 - &lt;89</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>&lt;76</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

| Mean no of units | 2.5 | 2.7 | 2.9 |

AFRICA

<table>
<thead>
<tr>
<th>Region</th>
<th>Systolic Blood Pressure</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortality</td>
<td>16</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Mean no of units</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

SOUTH EAST ASIA

<table>
<thead>
<tr>
<th>Region</th>
<th>Systolic Blood Pressure</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortality</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Mean no of units</td>
<td>4.1</td>
<td>4.8</td>
</tr>
</tbody>
</table>

WESTERN PACIFIC

<table>
<thead>
<tr>
<th>Region</th>
<th>Systolic Blood Pressure</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortality</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Mean no of units</td>
<td>6.6</td>
<td>16.3</td>
</tr>
</tbody>
</table>

EUROPE

<table>
<thead>
<tr>
<th>Region</th>
<th>Systolic Blood Pressure</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortality</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Mean no of units</td>
<td>8.8</td>
<td>11.4</td>
</tr>
</tbody>
</table>

AMERICAS

<table>
<thead>
<tr>
<th>Region</th>
<th>Systolic Blood Pressure</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortality</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Mean no of units</td>
<td>6.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

EASTERN MEDITERRANEAN

<table>
<thead>
<tr>
<th>Region</th>
<th>Systolic Blood Pressure</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortality</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Mean no of units</td>
<td>3.1</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Tranexamic acid and blood loss

Traumatic bleeding (CRASH-2 trial – completed)
Postpartum bleeding (WOMAN trial – in progress)
GI bleeding (in preparation)

If tranexamic acid also reduces blood loss in these conditions then could have a substantial impact on global demand for blood.

www.crash2.lshtm.ac.uk
www.woman.lshtm.ac.uk
Nutritional anaemias: physiological and public health considerations

Luz Maria de Regil, PhD, MSc
Epidemiologist, Micronutrients Unit
Department of Nutrition for Health and Development

Experts’ Consultation on Estimation of Blood Requirements
Geneva, 03-05 Feb, 2010

Anaemia

A condition in which the number of red blood cells or their oxygen-carrying capacity is insufficient to meet physiologic demands. Such demands varies by age, gender, altitude, smoking, and pregnancy status.

Causes: diet reduced in nutrients/low bioavailability, chronic inflammation, parasitic infections, and inherited disorders of haemoglobin structure.

Nutritional anaemias

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamine</td>
<td>DNA synthesis</td>
</tr>
<tr>
<td>Folic acid</td>
<td>DNA and RNA synthesis</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
<td>DNA and RNA synthesis</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Lysis of membranes</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Iron mobilization</td>
</tr>
<tr>
<td>Copper</td>
<td>Ceruloplasmin: ferric to ferrous iron</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>Hb synthesis; alcoholism</td>
</tr>
<tr>
<td>Iron</td>
<td>Hb synthesis</td>
</tr>
</tbody>
</table>

Iron deficiency anaemia

Iron deficiency: health implications

- Total body iron: 3-5 g
- Adequate growth and development
- Immunity
- Cognition and development
  - attention span, concentration, memory, learning ability
  - muscle function and manual dexterity, behaviour, social interaction
- Work productivity
- Reproductive performance
- Raising of other metals levels

Cut off points

<table>
<thead>
<tr>
<th>Population</th>
<th>Haemoglobin g/L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anaemia</td>
</tr>
<tr>
<td>Children 6 – 59 months</td>
<td>&lt;110</td>
</tr>
<tr>
<td>Children 5-11 years</td>
<td>&lt;115</td>
</tr>
<tr>
<td>Children 12-14 years</td>
<td>&lt;120</td>
</tr>
<tr>
<td>Non pregnant women (above 15 years of age)</td>
<td>&lt;120</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>&lt;110</td>
</tr>
<tr>
<td>Men (above 15 years of age)</td>
<td>&lt;130</td>
</tr>
</tbody>
</table>

Source: WHO, VMNIS, 2010

Altitude

- In addition to a diet with low iron/poor bioavailability

Smoking

<table>
<thead>
<tr>
<th></th>
<th>Haemoglobin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non smoker</td>
<td>0</td>
</tr>
<tr>
<td>Smoker</td>
<td>+ 0.3</td>
</tr>
<tr>
<td>½–1 packet/day</td>
<td>+ 0.3</td>
</tr>
<tr>
<td>1–2 packets/day</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>2 packets/day</td>
<td>+ 0.7</td>
</tr>
</tbody>
</table>

Source: WHO, VMNIS, 2010
### Iron needs or losses (mg/day)

<table>
<thead>
<tr>
<th>Source: Viteri</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physiologic condition</strong></td>
</tr>
<tr>
<td>Baseline Requirements</td>
</tr>
<tr>
<td>Menstruation</td>
</tr>
<tr>
<td>Breastfeeding</td>
</tr>
<tr>
<td>Mild intestinal parasitic infections</td>
</tr>
<tr>
<td>N. americanus</td>
</tr>
<tr>
<td>A. duodenale</td>
</tr>
<tr>
<td>Other parasitic infections</td>
</tr>
<tr>
<td>T. trichiura (mild)</td>
</tr>
<tr>
<td>S. haematobium (severe)</td>
</tr>
</tbody>
</table>

### Iron status indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Positive Balance</th>
<th>Normal</th>
<th>Anemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb (g/L)</td>
<td>&gt;130</td>
<td>110-130</td>
<td>≤110</td>
</tr>
<tr>
<td>Ferlin (µg/L)</td>
<td>&gt;150</td>
<td>12-150</td>
<td>≤12</td>
</tr>
<tr>
<td>RBC protoporphyrin (µg/L)</td>
<td>70</td>
<td>≤70</td>
<td></td>
</tr>
<tr>
<td>Plasma serum (mg/L)</td>
<td>&gt;175</td>
<td>115-150</td>
<td>≤40</td>
</tr>
<tr>
<td>Transferrin saturation (%)</td>
<td>25-35</td>
<td>≤20</td>
<td></td>
</tr>
</tbody>
</table>

### WHO recommendations

- **1.** Use prevalence of anaemia in GABR.
- **2.** Intermediate prevalence of anaemia in GABR.
- **3.** High prevalence of anaemia in GABR.
- **4.** Increased iron losses.
- **5.** Belong to a vulnerable group.

**Population level**

- Yes: Nutrition counselling
- No: Fortification
- Yes: Preventive supplementation
- Yes: Nutrition counselling
- Yes: Therapeutic supplementation
- Yes: Nutrition counselling

**Individual level**

- Yes: Treatment of cause of anaemia
- Yes: Therapeutic supplementation
- Yes: Nutrition counselling
- Yes: Therapeutic supplementation
- Yes: Nutrition counselling

**Adapted: Casasnovas et al., 2008**

WHO-VMNIS

Anaemia

<table>
<thead>
<tr>
<th>Microcytic</th>
<th>Normocytic</th>
<th>Macrocytic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Sideroblasts
  - No
  - Yes

- Iron deficiency
- Thalassaemia
- Sideroblastic anaemia
- Leukaemia
- Haemolytic disease
- Transfusion reaction
- Vitamin B12 anaemia
- Folic acid anaemia
- Hepatic disease
- Haemolytic anaemia
- Low
  - Reticulocytes
  - High

Acknowledgements

Financial and/or technical support for the Micronutrients Unit:

- The Government of Luxembourg
- US Centers for Disease Control and Prevention (CDC)
- The Micronutrient Initiative (MI)
- US Agency for International Development (USAID)
- The Bill and Melinda Gates Foundation
Estimating National Blood Requirements in Africa

Lawrence H. Marum, MD, FAAP, MPH
Centers for Disease Control and Prevention - Zambia

Drivers of demand for blood in Africa

1. Malaria associated anaemia (children and mothers)
2. Emergency obstetrical services
   - Post-partum haemorrhage
3. Surgical services
4. Trauma
5. Medical treatment
   - HIV treatment associated anaemia

Zambia National Blood Transfusion Service: progress in meeting national needs

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population of Zambia</td>
<td>10.5 million</td>
<td>12.5 million</td>
</tr>
<tr>
<td>Units blood collected</td>
<td>38,477</td>
<td>100,000</td>
</tr>
<tr>
<td>(collections per 1000 population)</td>
<td>(3.7)</td>
<td>(8.0)</td>
</tr>
<tr>
<td>Transfusion outlets/ blood centres</td>
<td>90 (90)</td>
<td>132 (9)</td>
</tr>
<tr>
<td>Proportion voluntary donors</td>
<td>72%</td>
<td>100%</td>
</tr>
<tr>
<td>Discards (HIV discards)</td>
<td>15.5% (6.9%)</td>
<td>9.2% (3.0%)</td>
</tr>
</tbody>
</table>

Transfusions/bed at different hospital levels - Zambia
Proportion of paediatric transfusions - Zambia

University Teaching Hospital: changing uses of blood

Zambia HIV summary

- 12.5 million population; total fertility rate = 7
- Adult HIV prevalence (15-49 years) 14.3%
- >250,000 on ARVs (19,000 children)
  - Primary first-line treatment changed from AZT-3TC to TDF-FTC backbone regimes
  - 70% of those with CD4 < 250
  - 40% of HIV+ pregnant women in 2010 (25,000) will initiate AZT backbone regime (CD4<350)

Progress in malaria control

- Deaths in hospitalized patients with malaria decreased 60%
- 54% decrease in parasitemia (under 5 y/o)
- 69% decrease in severe anaemia
- Distributing 400,000 nets per year
- Indoor residual spraying in 37 of 73 districts (over 1,000,000 homes annually)
- Artemesinin Combination Therapy 1st line and Sulfadoxine-pyrimethamine in pregnancy

Blood Use at Macha (rural mission/district hospital)

Macha Hospital - All Blood Transfusions

- Children’s Ward
- TB Ward
- Maternity Ward
- Women’s Ward
- Men’s Ward
Macha Hospital - Non Children’s Ward Blood Transfusions

Macha Hospital - Children’s Ward Blood Transfusions

Macha Hospital – Children’s Ward Malaria Diagnoses

<table>
<thead>
<tr>
<th>Year</th>
<th>Children’s Ward Malaria Dx</th>
<th>Children’s Ward Blood Transfusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1479</td>
<td>588</td>
</tr>
<tr>
<td>2001</td>
<td>1778</td>
<td>512</td>
</tr>
<tr>
<td>2002</td>
<td>1294</td>
<td>336</td>
</tr>
<tr>
<td>2003</td>
<td>1418</td>
<td>393</td>
</tr>
<tr>
<td>2004</td>
<td>423</td>
<td>155</td>
</tr>
<tr>
<td>2005</td>
<td>123</td>
<td>60</td>
</tr>
<tr>
<td>2006</td>
<td>565</td>
<td>225</td>
</tr>
<tr>
<td>2007</td>
<td>336</td>
<td>118</td>
</tr>
</tbody>
</table>

Blood Use at Macha

- **Conclusions:**
  - Historically, over 50% of blood use is for children under 6 years of age
  - Blood is primarily given during the peak malaria transmission season

- **Hypothesis:**
  - Control of malaria may lead to a significant decrease in the need for blood at district level hospitals in sub-Saharan Africa
Emergency Obstetric Services

- 1230 ANC facilities; 937 offer PMTCT
  - 132 transfusing facilities
- Lack of trained nurse/clinical officers
  - Only 60% of national health posts filled
  - Rural retention schemes; retired nurses
- Expansion of C-section capacity to level 1 hospitals and larger health centres — many that do not have transfusion capability

Conclusions

- Changing blood needs
  - Reduced paediatric transfusion w/ malaria control
  - Expansion of emergency obstetric services
  - Increased chronic disease treatment (ARVs)
- M&E needs
  - Comprehensive data on use of blood; vein to vein linkages
  - Prescriber information for monitoring and supervising
  - SmartDonor and SmartCare: national electronic records
- Address national transfusion coverage in Health System
  Strengthening efforts — how quickly can we safely expand?
WHO Experts’ Group Consultation on Estimation of Blood requirements

DIFFERENT MODELS OF BLOOD ESTIMATION
A BLOOD CENTRE PERSPECTIVE

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Héma-Québec
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Background: national health care

Canada
Population: 35,966,230
 Territory: 9,984,670 km²

Quebec
Population: 7,625,979
 Territory: 1,542,056 km²
 Hospitals: 99
 Model: Blood banks in hospitals

Blood Management System in Quebec

Quebec statistics 2008-09

- Blood units drawn: 245,938
- RBC shipped to hospitals: 231,958
- Inventory at HQ: 8 days
- Outdating at HQ: 0.62%
- Outdating in the hospitals: 1.4%

RBC utilization in hospitals

<table>
<thead>
<tr>
<th>Indications</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery</td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>25</td>
</tr>
<tr>
<td>Urgent</td>
<td>12</td>
</tr>
<tr>
<td>Obstetrics</td>
<td>1</td>
</tr>
<tr>
<td>Trauma</td>
<td>7</td>
</tr>
<tr>
<td>Hematological disease &amp; transplant</td>
<td>43</td>
</tr>
<tr>
<td>Others</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

Comparison of RBC utilization with other countries

<table>
<thead>
<tr>
<th>Country</th>
<th>2008-09</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>41.1</td>
</tr>
<tr>
<td>France</td>
<td>39.0</td>
</tr>
<tr>
<td>Quebec</td>
<td>28.5</td>
</tr>
</tbody>
</table>
Types of Forecasting Techniques

1. Informal: intuitive depending on individual experience and abilities

2. Formal:
   2.1 Qualitative techniques
      2.1.1 Delphi
      2.1.2 Market surveys
      2.1.3 Life cycle analogy
   2.2 Quantitative techniques
      2.2.1 Auto Projection
      2.2.2 Moving average
      2.2.3 Exponential smoothing
      2.2.4 CASual
      2.2.5 Regressions
      2.2.6 Box Jenkins
      2.2.7 Econometric
      2.2.8 Input-output

Demand Forecasting: Key Criteria to Consider

1. Item to be forecasted: RED BLOOD CELLS

   Availability of RBC depends on:
   - Availability of blood donors
   - Quality of the donors
   - Management of the RBC by the blood center (discard & outdate rate)

   Utilization of RBC depends on:
   - Inventory management by client hospitals
     - Stock rotation between hospitals
       - Outdate rate target 2%
       - Distance from blood center
   - Age of the population
   - Availability of data from hospitals

Key Criteria to Consider

2. Major challenges
   - Donors
     - Quality of donors - deferral rate 18%
   - Blood group distribution (ABO and Rh) in the population
   - Customer service and satisfaction
     - The right product at the right time
   - Monitoring adequate levels of Inventory
     - No shortages of stock
   - Economic situation
     - Must consider the health care system model because the economic situation may or may not influence your forecast.
   - Disaster planning
     - Capability of responding to emergencies.

3. Amount of historical data available
   - Total number of RBC shipped:
     - By ABO Rh
     - Per year, month, week...
   - Records exist on a daily basis at Héma-Québec:
     - Hospital utilization:
       - Historical data for sentinel hospitals
       - Usage by diagnosis-related group (DRG)
       - Outdate rate
   - Events that affected the past demand:
     - Ex. Letter requesting hospitals to decrease the expiry rate of RBC
   - Presence of a transfusion committee

4. Time allowed to prepare the forecast
   - Tied into the annual budgeting period
     - Also depends on the resources allocated to the forecast
   - Horizon:
     - Long-term (5-10 yrs)
     - Short-term (1-2 yrs)
     - Very short-term (< 1yr)

Short-term forecasting

(1 to 2 years)
Quantitative techniques

Naïve method
\[ D_t = D_{t-1} + c \]
- Where \( c \) is determined by historical data and/or expert judgement
- One of the simplest methods to use
- For Héma-Québec, this method works well since the demand is relatively stable.

Exponential smoothing
This method is a special form of the weighted average and focuses on the most recent period.
\[ D_t = aD_{t-1} + (1 - a)D_{t-1} \]
- Where \( a \) (the smoothing constant) is determined by trial and error
- Fairly complex statistical methods are involved

Results obtained

<table>
<thead>
<tr>
<th>Forecasting method</th>
<th>Forecast (12 months)</th>
<th>% error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple linear trend</td>
<td>219,406</td>
<td>Reference</td>
</tr>
<tr>
<td>Exponential smoothing</td>
<td>270,844</td>
<td>+ 23.4 %</td>
</tr>
<tr>
<td>Holt-Winters</td>
<td>231,376</td>
<td>+ 5.5 %</td>
</tr>
<tr>
<td>Holt-Winters (Seasonality – month)</td>
<td>228,085</td>
<td>+ 4.0 %</td>
</tr>
<tr>
<td>Holt-Winters (Seasonality – quarter)</td>
<td>228,090</td>
<td>+ 4.0 %</td>
</tr>
</tbody>
</table>

Research on the factors that affect hospital demand (2006)

- A sample of 8 blood banks, accounting for 56,673/221,256 (24%) of the demand for the year 2005-06, were interviewed.
- The results indicate that the following variables have the most important effect on the demand for red blood cells:
  - Improvement of surgical and medical practices
  - Medical and technological advancements
  - Substitute products and alternative treatments
  - Education of hospital personnel
  - Protocols of transfusion
  - Expiration targets for blood products
- However, the findings appear almost impossible to integrate into a regression model. Historical data remained the best indicator of the future demand for the purpose of this study.

Final model

- The proposed model is a particular version of the ARIMA (Autoregressive Integrated Moving Average) model.
- It is based on a chronological series related to the quantity of red blood cells distributed to hospitals for a 349 week period
  - from 11/22/1999 to 07/31/2007
- For the following 18 week period, the absolute percentage errors range from 0.31% to 10.61%:
  - the mean error is 4.90% per week or 0.70% per day.

ARIMA model

![ARIMA model graph]
So how DO we forecast?

Demand Forecasting
- 2 forecasting techniques based on historical demand are currently used at Héma-Québec:
  - Naïve method
  - Arima model

Communication with hospitals
- Creation of Hospital Relations Department
- 99 hospitals

Our conclusion:
Although very efficient, the quantitative forecast should be coupled with expert judgement and increased communication efforts with hospitals in order to maximize the accuracy of the forecast and effectively optimize the efficiency of the decision-making process.

Results in:
Very short-term forecasting

Monitoring daily inventory

Date: 01-10-2010  Time: 6:00 am
Available 5 times a day via Intranet

<table>
<thead>
<tr>
<th>RED BLOOD CELLS</th>
<th>TOTAL INVENTORY (VOLUME &amp; QUALITY)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WEIGHTED INVENTORY*</td>
</tr>
<tr>
<td>b-</td>
<td>2608</td>
</tr>
<tr>
<td>a-</td>
<td>309</td>
</tr>
<tr>
<td>AB-</td>
<td>162</td>
</tr>
<tr>
<td>A+</td>
<td>213</td>
</tr>
<tr>
<td>B+</td>
<td>120</td>
</tr>
<tr>
<td>O+</td>
<td>128</td>
</tr>
<tr>
<td>A-</td>
<td>350</td>
</tr>
<tr>
<td>B-</td>
<td>320</td>
</tr>
<tr>
<td>O-</td>
<td>125</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4290</td>
</tr>
</tbody>
</table>

* Considers minimal stock for B+ and AB+

Inventory management

The committee meets on a weekly basis in order to:
- Monitor inventory levels by product and by ABO/Rh (when applicable)
- Review the week’s activities:
  - Success of blood drives
  - O negative in stock
  - Age of RBC inventory
  - Inventory of platelets collected by apheresis
  - Turn-around time at laboratory testing
  - Shortage supplies of permanent
  - Special cases and projects (ex.: TRALI, ISBT 128)
- Weekly inventory report from sentinel hospitals (on average = 5 days)
- Client-hospitals communicate active cases with blood product requirements
- Adjust short term collection targets based on fluctuations in hospital demand and inventory levels.
- Plan for holidays or other events

Further research

Long-term forecasting (5 – 10 years)
- Forecast based on the population pyramid

Drawbacks:
- Does not consider the usage per DRG
- Does not take into account medical and scientific advances
DIFFERENT MODELS OF BLOOD ESTIMATION
A BLOOD CENTRE PERSPECTIVE

Summary

1. Short-term forecasting (1-2 yrs): in a stable mature system, forecasting is best done by simple techniques based on historical data, professional judgment and constant communications with hospitals.

2. Long-term forecasting (5-10 yrs): for strategic planning, demographics and DRGs are critical elements.

3. BUT: Very short term forecasting (daily, weekly and monthly): the most important one since only this forecasting prevents shortage of blood and thus gives the best service to the patients in need of blood.
Introduction

• The blood needs for a population could be defined as the sum of the needs for all patients with all diseases.

• Since there are countless combinations of disease, stage, co morbidity and intervention that can put a patient at risk of needing a transfusion.

• It is difficult to define the information required and extract it from conventional registers of clinical data.

Hypotheses 1

For a given period and given category of disease, blood needs will be a function of:

• The number of individuals having the disease during the period

• The proportion of them which develop a pathophysiological condition requiring transfusion

• Quantity of blood needed for each category

Hypotheses 2

• The majority of blood needs are related to compensation of acute or chronic anemia; therefore, if red cell needs were met, this should be sufficient to meet the needs for platelets and plasma since these can be separated from whole blood

• Experienced specialist clinicians should be able to assign the main groups of patients at risk of transfusion (GPRT) into broad clinical categories in relation to transfusion needs

• These are the categories that will have a major impact on the total need for blood, either because they include many patients requiring a modest amount of blood, or because they include a smaller number of patients each requiring a large amount of blood

• Disease groups other than the main GPRT should have a small impact on blood needs.

Model

The model is based on estimates of four parameters

• N size of the population;

• \( P(Bi) \) frequency of the GPRT \( i \) in the population;

• \( P(Ai) \) proportion of patients in the GPNB that will actually have anemia requiring transfusion of red blood cells;

• \( \mu_i \) average number of units needed per patient.

The estimate of overall needs is given by

\[
\sum [N \times P(Bi) \times P(Ai) \times \mu_i], i=1
\]
• Formal consensus methods have been shown to be helpful in developing initial estimates of patient populations in the absence of accurate clinical and epidemiological data.

Information sought from clinicians

• List of Groups of patients needing blood
• Number/ of individuals in each group during the defined period
• Proportion of these having a pathophysiological condition requiring blood
• Quantity of blood needed for each pathophysiological condition that requires blood

Stage 1: Nominal group consensus

• The participants took part in a structured two hour face to face meeting.
• To define common ground and maximize areas of agreement, participating clinicians were organized by broad clinical specialties.
• Experts were asked to discuss among themselves and to list the top 3 clinical conditions requiring red cell replacement.
• Through a series of scoring, voting and ranking methods a list of nine clinical conditions was obtained.

Stage 2: Survey

• A survey of 35 clinicians (different from the nominal group) indicated that the original categories were too broad which made estimating the basic parameters very difficult, 31% of those surveyed felt that the original list was incomplete.
• No usable information of prevalence was provided since clinicians felt they did not have enough information to give a reasonable estimate.
• Information on proportion of patients needing blood and units needed per patient was provided for all nine original conditions.

Stage 3: Face to Face Interviews

• To come to a formal agreement about how specific the experts considered the selected clinical categories must be, face to face interviews with 121 clinicians from 10 hospitals were conducted.
• By medical doctors that have been trained to request the 3 basic parameters.
• Clinicians were asked to answer only on those clinical categories they were familiar with.
• The consensus generated a larger list of clinical conditions which were classified by ICD category with the help of an expert from the local Pan American Health Organization office.

Stage 4 Delphi round

• During the final phase to obtain consensus on the basic parameters an initial letter explaining the Delphi process and inviting participation was sent by electronic mail to 138 clinicians. 120 responded
• Tables containing all the criteria collated from the previous exercise were included with the invitation. If the clinician had participated in the previous round his/her results were highlighted. Results from other clinicians were also included but their names were kept confidential. Each clinician was requested to agree with their previous answers or to change in view of the group’s response.
• Averages were obtained for the proportion of patients needing blood as well as the number of products that the clinician estimated were necessary for the patient.
• Final consensus is included in the following table.
Clinicians were able to select 67-68% of all the clinical conditions for transfusion. 68% of the reasons for transfusion matched one of the GPRT.

1376 blood request forms from the main reference hospital were available for review. In 67% of charts, the discharge diagnosis coincided with one of the GPRT. Anemia, diabetes and solid tumors accounted for most of the remaining diagnosis.

Clinicians were able to select 67-68% of all the clinical conditions for which patients were transfused during 2004.

Many charts were unavailable.

Deceased patients could not be included as their charts were not accessible.

Transfusions were poorly documented in the charts.

Limitations of chart review

Comparison with observational data - blood request forms

- 1376 blood request forms from the main reference hospital were available for review, in 1335 there was a reason for the request
- 68% of the reasons for transfusion matched one of the GPRT
- The remaining 433 blood request forms fell into two categories: unspecified anemia and "others".
- 100 transfusion requests were matched to discharge diagnosis. Only patients who had been transfused were included in this sample. In 67% of charts, the discharge diagnosis coincided with one of the GPRT. Anemia, diabetes and solid tumors accounted for most of the remaining diagnosis.
- Clinicians were able to select 67-68% of all the clinical conditions for which patients were transfused during 2004.

Data collected from patient charts

- Demographic data: age, gender
- Hospital Stay: events, length of stay
- Anemia: Hb and Hct at admission and before transfusion
- Presence of acute bleeding
- Number of patients for whom blood requested
- Number of red cell units requested by the physician
- Number of patients transfused
- Number of red cell units transfused

Stage 1 result:

GPRT defined by Nominal Group

Burns
Neonates with pathology
Gynaecological and obstetric complications
Trauma
Orthopedic surgery
Cardiovascular surgery
Upper GI haemorrhage
Hematological and Hemato-oncological diseases
Non-hematological cancers

<table>
<thead>
<tr>
<th>GPRT defined by the complete consensus process</th>
<th>GPRT defined by Nominal Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns</td>
<td></td>
</tr>
<tr>
<td>Neonates with pathology</td>
<td></td>
</tr>
<tr>
<td>Gynaecological and obstetric complications</td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td></td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular surgery</td>
<td></td>
</tr>
<tr>
<td>Upper GI haemorrhage</td>
<td></td>
</tr>
<tr>
<td>Hematological and Hemato-oncological diseases</td>
<td></td>
</tr>
<tr>
<td>Non-hematological cancers</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Code</th>
<th>Portion requiring transfusion (%)</th>
<th>Number requested (%)</th>
<th>Units transfused (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C18</td>
<td>0.88</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>2</td>
<td>C19</td>
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<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>3</td>
<td>C17</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>4</td>
<td>C16</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>5</td>
<td>C15</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>6</td>
<td>C14</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>7</td>
<td>C13</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>8</td>
<td>C12</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>9</td>
<td>C11</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>10</td>
<td>C10</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>11</td>
<td>C9</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>12</td>
<td>C8</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>13</td>
<td>C7</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>14</td>
<td>C6</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>15</td>
<td>C5</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>16</td>
<td>C4</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>17</td>
<td>C3</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>18</td>
<td>C2</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>19</td>
<td>C1</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>20</td>
<td>C0</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
</tbody>
</table>
Results: Prevalence

- Through all the stages, clinicians were unable to provide any information on prevalence of the selected clinical conditions.

Results - verification

*Hospital data*

Blood request forms: 1376 forms from the main reference hospital were available for review.

In 41 the cause for transfusion was not documented.

Of the remaining 1335,

- <68% of the requests indicated conditions that matched one of the final clinical groups

- <32% requests fell into two categories: unspecified anemia and “others” of which most were anemia, diabetes and solid tumors

Verifying Clinical data by chart review

- Based on the national database and largest reference hospital database a sample was selected for chart review for all 19 clinical conditions (5% of all cases with a minimum sample of 50 charts)

- For patients with chronic conditions all hospital admissions for the year 2004 were included
Analysis

Intraclass correlation coefficient was used to calculate the level of agreement between the clinician based need estimate versus the calculated need based on units requested or units transfused.

- ICC calculated against units requested was 0.750
- ICC calculated against units transfused was 0.834

Overall ICC between clinician based estimates and hospital records data was 0.951

- The intraclass correlation coefficient ranges from 0 and 1, a value of 1 indicates complete agreement
- Residual variability (1 - intraclass correlation coefficient) is due to true variation between clinicians and measurement error.

Results: comparison of observed data with clinicians consensus

<table>
<thead>
<tr>
<th>Clinical Condition</th>
<th>clinician based estimate</th>
<th>observed data</th>
<th>mean difference</th>
<th>standard deviation</th>
<th>ICC clinician based estimate</th>
<th>ICC observed data</th>
<th>ICC clinician based estimate vs observed data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma</td>
<td>200</td>
<td>150</td>
<td>50</td>
<td>10</td>
<td>0.75</td>
<td>0.83</td>
<td>0.95</td>
</tr>
<tr>
<td>Gun-shot wound</td>
<td>300</td>
<td>250</td>
<td>50</td>
<td>15</td>
<td>0.80</td>
<td>0.90</td>
<td>0.98</td>
</tr>
<tr>
<td>Myomas</td>
<td>400</td>
<td>350</td>
<td>50</td>
<td>20</td>
<td>0.85</td>
<td>0.95</td>
<td>0.92</td>
</tr>
<tr>
<td>Fracture of the femur</td>
<td>500</td>
<td>450</td>
<td>50</td>
<td>25</td>
<td>0.90</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>Prematurity and Sepsis</td>
<td>600</td>
<td>550</td>
<td>50</td>
<td>30</td>
<td>0.95</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Fracture of the pelvis</td>
<td>700</td>
<td>650</td>
<td>50</td>
<td>35</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Premature babies</td>
<td>800</td>
<td>750</td>
<td>50</td>
<td>40</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Postpartum Hemorrhage</td>
<td>900</td>
<td>850</td>
<td>50</td>
<td>45</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Incomplete abortion</td>
<td>1000</td>
<td>950</td>
<td>50</td>
<td>50</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Premature babies</td>
<td>1100</td>
<td>1050</td>
<td>50</td>
<td>55</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Units available for transfusion in 2004: 37,000

Strengths

- Clinicians were able to define a group of clinical conditions to which 67-68% of all transfused patients could be assigned
- Their estimates of the red cell transfusion requirements showed reasonable comparability to those obtained from hospital records.
- Requires the investigators and blood services to consult clinicians about the transfusion requirement for their patients
- Should engage clinicians to think about blood requirements about the quality of data that could help to assess need, and the adequacy of the data currently available.
- Anecdotal evidence from the project team that these approaches have been welcomed.
- This would seem to be supported by the high levels of clinician participation in the present project

Weaknesses

- Labour intensive, time consuming, costly
- Depends on the willingness of clinicians to participate, and on the adequacy of their knowledge of blood utilisation in their own specialties
- Clinicians could not estimate prevalence of the conditions identified, so there is dependence on an additional data source
- Validation against other data sources depends on the existence, availability and quality of hospital records and on availability of human resources to extract data from them
- Method does not take account of access to health care
- Additional data on this would be essential to calculate blood requirements in any country where an important proportion of the population lacks access to facilities in which the availability of safe blood transfusion could benefit the outcomes of GPRT

Conclusions

- Clinicians were able to define a group of clinical conditions to which 67-68% of all transfused patients could be assigned
- Their estimates of the red cell transfusion requirements showed reasonable comparability to those obtained from hospital records.
- Neither source of data can adequately identify the adequacy or otherwise of the current supply levels.
- To estimate the blood requirements for a given population at a given time, data such as those obtained in this study should be combined with information on access to hospital care
WHO Expert Consultation on estimation of blood requirements

Objectives

• Review parameters in health system and clinical care which influence requirement of blood and blood components
• Review of existing mechanisms/methodologies and models of blood estimation based on regional/country experience
• Assess the feasibility and accordingly define the steps in developing a simple model to estimate blood needs

Neelam Dhingra

• Overview of current situation
  • Little progress in the area of predicting blood requirements
  • Essential for planning
• Historical perspective
  • Various non-evidence based estimations
    – Advanced healthcare systems
    – Donations: 5% of population
    – 3% of population regular blood donors
  • Previous approaches
    – Blood usage with different denominators
    – Per 1000 population
    – Per acute hospital bed

Gretchen Stevens

• Global burden of disease database
  – New estimates due 2011
• Important principles in preparing cross-national statistics
  – Selecting health indicator and metrics
    • Framework for monitoring health systems
    – Facility assessments
    – Population-based surveys
    – Clinical reporting systems
  – Correcting for bias in available data
  – Estimating and communicating uncertainty
    • Input uncertainty
      – Poor quality data
    • Model uncertainty
    • Parameter uncertainty

Peter Olumesse

• Declining falciparum malaria due to nets, spraying and ACT
• Parallel decline in paediatric blood transfusions
• Seasonal demand
• Potential impact of paediatric blood packs on blood supply and safety
  – Evaluation and bulk procurement? (WHO)
  – (Also protective needle cover)

Matthews Mathai

• Haemorrhage implicated in a high proportion of pregnancy-related deaths
• Existing surveys and data on incidence of haemorrhage and blood transfusion requirements
• Access and equity issues
• Costs and planning tool already exists (to be shared)
• 9 signal functions of comprehensive obstetric care
Pablo Perel

- Frequency of trauma
  - Low resolution data on mortality and DALYs (but no/little data on incidence and morbidity)
  - Increasing in importance
- Frequency of bleeding in trauma
  - Bleeding probably important cause of death
  - Reported transfusion rates differ widely
- Evidence base for transfusion of blood/products in trauma
  - Weak/contradictory
- Interventions to reduce transfusions
  - Well conducted clinical trials (e.g. CRASH-2) required
  - Clinical trials such as CRASH-2 may provide better and higher resolution data on frequency of trauma and frequency of bleeding in trauma (WOMAN-PPH)

Luz Maria De Regil

- Global burden of disease database has data on anaemia but
  - Variable Hb cut offs and definitions
  - Adjustments required for altitude (1g/dL per 1000m), smoking and gestation
- Targeting of public health interventions depends on prevalence of anaemia in Groups at Risk
- VMNIS (Vitamin and Mineral Nutritional Information System)
  - Estimates of micronutrient deficiencies at national and regional levels
- Helminth infections?
- Haemoglobinopathies?

Larry Marum

- Zambia continues to make significant progress in improving its national blood supply
- Patterns of transfusion by hospital type
- Tertiary facility
  - High (27%) and changing blood usage
- Unknown and increasing burden of HIV-related transfusions
- Malaria control and decreasing paediatric transfusions
- Obstetrics- mismatches between pregnancy care and blood supply
- Potential of SmartCare (patient/donor held electronic record)

Francine/Carolina

- Hema-Quebec: stable, mature and efficient service
- Demand defined as units shipped
- High resolution historical data
- Complex models do not seem to outperform naïve method
- Where supply meets demand prediction is enhanced by inventory committee and good communication with hospitals

Brian McClelland

- If RBC needs are met, the needs for other components should also be met
- Categorisation of GPRT by clinicians using consensus methods (multi-stage)
- Comparison with observational data (limitations)
- Prevalence/incidence difficult to define
- Good statistical correlation between predicted and observed data but large numerical discrepancies
- Engagement with clinicians
- No measure of unmet demand (access)

Additional thoughts

- Clear idea of what we are trying to estimate
  - Agreed definitions
  - Access, appropriate prescribing (evidence/consensus)
- Minimum data set
- Existing data sets
- ‘Toolkit’ cf simple mathematical model
- Assessment and communication of uncertainty of predictions
**Ideal: need**

- Donor selection / motivation (management)
- Donor deferral
- Donor screening (testing)
- Processing of blood products
- Inventory
- Patients

X units for transfusion, such that no patient experiences (at no time) morbidity/mortality due to shortages in RBCs. In fact: X is driving Y

**Real: demand**

- Donor selection / motivation (management)
- Donor deferral
- Donor screening (testing)
- Processing of blood products
- Inventory
- Access (€, £, $)
- Patients

X units for transfusion, such that current demand is covered. Y (number of potential donors) and capacity is driving X

**Access 100%**

**Ideal: need**

- No Morbidity/Mortality
- Patient need

- Define spatial and temporal specific drivers for transfusion, McClelland
  - Malaria (ATLAS, Marum, Glomose, WHO)
  - Trauma (Pero)
  - Nutrition (De Regil)
  - Maternal Health (Mathai)
  - etc

- Define methodology (McClelland, Rao, GBD)
- Perfect transfusion practices
- Optimal use of alternatives (drugs, colloids, salvage, EACA etc)
- No uncertainty and bias

**Proposed definitions**

**Demand:** The amount of blood that would be transfused if all requests for blood were met (includes inappropriate transfusions and unmet demand)

**Use:** The amount of blood actually transfused (excludes unmet demand)

**Need:** The amount of blood that would be used if all those who needed a blood transfusion were recognised and had blood appropriately prescribed i.e. includes unmet demand and excludes inappropriate transfusions
Key Canadian demographics

- Area: 10 million sq. km. (3.3 people per sq. km.)
- 2 doctors and 4 hospital beds per 1,000 population
- High physician utilization rate
  - About 60% of Canadian use family physician services once a year, 58% more than twice a year
- Health service utilization patterns, for both individuals and for regions, are influenced by age, gender, self-rated health status, education income, etc.

CBS in the Canadian context

- Health care in Canada is a provincial/territorial responsibility, with federal government contributions
- Canadian Blood Service (CBS) is Canada’s national supplier of blood and blood products
- Arm’s length, not-for-profit agency “independent” of government
- Exclusively serve 9 of 10 provinces and all 3 northern territories, who collectively fund CBS. (Quebec province operates its own blood service—Hema Quebec)
- Regulator: Health Canada, a federal agency
- Global budget; no charge to hospitals
- Funding is based on annual estimates of blood requirements

Operations overview

- 438,000 Donor Customers
- 16,000 WB units
- 41,000 plasmapheresis units
- 35,000 platelepheresis units
- All units are fully donated
- 2,156 WB donations per donor
- 4,500 employees
- 17,000 volunteers
- 41 permanent collection sites
- 12 manufacturing centres
- 3 blood-testing centres
- 732 Hospital Customers
- 600,000 patient transfusions a year
- Cost to recipient is fully covered under provincial/territorial government health plans
- Integrated Systems

Why forecast demand in the first place?

The collection, manufacturing and delivery of blood products is a complex business, supported by a host of enablers. Demand forecasts can provide the lead time necessary to ensure that adequate supply is available to meet expected customer demand. It allows CBS to maximize service delivery and stakeholder value.
What's behind the demand for blood?

Average units of blood/blood products required per recipient = 4.6 units

Who uses blood?

Almost 57% of the blood transfused in Canada is used by recipients aged 65 years or older

Aging: A key influence on blood demand

The proportion of the population aged 65 years or older is expected to grow from 14% in 2009 to 22% by 2030. In addition, the line representing the number of units transfused per 1,000 population has been shifting upwards over time.

Collision course: Demand meets supply

Supply

- Aging population
- Increasing morbidity
- Increasing medical procedures
- Changing product mix
- Population growth
- Ethnicity
- Expanding role of the blood business
- Global competition for fractionated products

Demand

- Aging population
- Health-cost containment
- Creating new donors
- New pathogens
- Increasing deferrals
- Regulatory issues
- System capacity, flexibility, scalability
- Technology deficit
- Skills deficit
- Supply management
- Blood's competitive brand and profile

How is demand trending?

The longer-term underlying growth in total RBC demand has been in the order of 2% per year, but this growth has not always been consistent. Note the slow down in the latter half of FY0708, the rapid growth throughout FY0809 and the current decline in FY0910.

Even O Neg growth has eased off in FY0910 - slowing, but not declining. The proportion of total RBC issues which are O Neg has grown from 10% at the start of FY200405 to 11.3% this fiscal YTD

Concentration of hospital demand

The Pareto Principle (80/20 rule) is alive and well at Canadian Blood Services

Concentration of hospital customer demand...
Hospital shipments by day

The number of units shipped varies from one day to the next and typically ranges from between 500 and 3,500 units.

Smoothed hospital shipments by day

Smoothing daily shipments make it easier to identify that customer shipments have been growing over time and that there are troughs and peaks in demand surrounding the statutory holidays.

Distribution of demand by ABO Rh

Not all blood groups are in equal demand. Almost 70% of all demand is concentrated in O Pos and A Pos.

Demand growth rates by ABO Rh

Not all blood types grow at the same rate. Demand for B+ and AB+ is declining; growth rates for Neg Rh are higher than for Pos.

Customer demand forecasting process

Why this process?

- Provides Top-Down and Bottom-Up perspectives
- Provides Base-Line and Overlay functionality
- The past is generally a good predictor of the future
- Lots of detailed hospital shipment data is readily available (hospital level of detail; by product; daily, weekly, monthly, quarterly, annually)
- Comprehensive clinical driver data is not currently available (how many transfusions; what types of procedures; etc.)
- Clinical driver data available has not been particularly effective at forecasting variations in customer demand (still need to forecast the clinical drivers)
Demand forecasting - just the beginning ...

- Higher level model produced best fit so ABO Rh drill-downs were made using a Top Down Multiple Level model
- ABO Rh forecasts were further distributed by Region

Volatility of demand ...

Annualized year over year growth rates ranged from 3.8% in March 2009 to 0.2% in December 2009. Underlying trend is in the neighborhood of 2% per year, but exponential smoothing models will weight recent data more heavily than past data.

Inventory - the buffer between supply & demand

Volatility in demand & supply can lead to unavoidable imbalances between the two. Inventory acts as a buffer to offset these imbalances, shrinking when demand outpaces supply and growing when the opposite occurs. A minimum of 5 days of inventory on hand for each ABO Rh type is recommended.

Population statistics and forecasts are usually readily available. Relating hospital demand to population growth will explain some, but not all of the growth in demand. Refining population estimates to weighted cohorts (e.g. by age band) would likely yield improved demand forecasts. Provisioning for non-population related overlays (e.g. increased health care funding) could also be considered.
Thank you! Questions?
Tony.Steed@blood.ca
Background – Hong Kong

- Area: 1,103 square km
- Population: 7 million
- Chinese 95%
- Overall density: 6,300 people/ km²
- Total health expenditure: 5.1% of GDP
- Public health expenditure: 2.6% (2005/06) (US$4.13 billion)
- Birth rate: 11.3 live births per 1,000 population
- Infant mortality rate: 1.8 per 1,000 live births
- Life expectancy: male 79.3 yr, female 85.5 yr

Background – BTS

- Hong Kong Red Cross initiated the voluntary non-remunerated blood donation programme in 1952
- BTS established in 1984
- Serving 20 public & 12 private hospitals
- Since 1991, BTS has become part of the public hospital system (Hospital Authority)
- Public hospitals account for 90% of blood consumption
- Supply of blood components is free of charge

Yr 2008 Blood Collection Statistics

- WB collection = 206,636 units
- Plasmapheresis = 2,114 units
- Plateletpheresis = 868 units
- Autologous WB = 130 units
- % of age eligible trade population donating = 3.3%
- Donor deferral rate = 13%
- Average age of donor
  - Male = 39, Female = 36
Yr 2008 Blood Supply Statistics

- WB derived Red Cell issued = 192,467 units;
- Standard Red Cell (Derived from 470ml of WB) issued per 1000 population = 25.0 units
- WB derived Plt issued = 127,152 units
- One adult equivalent plt dose issued /1,000 population = 4.54 units
- WB derived FFP issued = 57,330 units
- 250-300 mL equivalent FFP issued /1,000 population = 6.25 units
- Average age of WB+RBC on issue = 14.7 days

Blood Inventory and Distribution Management

- Maintain optimal inventory levels in BTS and HBB at all times with minimal expiration
Inventory in BTS and HBBs

- BTS aims to maintain inventory of WB/RBC ≥ 5 days of supply.
- Stock holding of WB+RBC (all blood groups) at BTS - 8.89 days (yr 2008 annual average).
- Each HBB holds about 3-5 days of hospital consumption.
- Inventory level in HBB is set out in the “Blood Supply Agreement” which is reviewed annually.

BTS WB/RBC inventory levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Group O+</th>
<th>Group A+</th>
<th>Group B+</th>
<th>Group AB+</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Desirable</td>
<td>≥ 1400</td>
<td>≥ 800</td>
<td>≥ 800</td>
<td>Not applicable as patient can receive RBC of any ABO group</td>
</tr>
<tr>
<td>II</td>
<td>Safe</td>
<td>1100 - 1399</td>
<td>600 - 799</td>
<td>600 - 799</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Action</td>
<td>600 - 1099</td>
<td>400 - 599</td>
<td>400 - 599</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Alarm</td>
<td>350 - 599</td>
<td>200 - 399</td>
<td>200 - 399</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Dangerous</td>
<td>&lt; 350</td>
<td>&lt; 200</td>
<td>&lt; 200</td>
<td></td>
</tr>
</tbody>
</table>

HBB Inventory Allocation Policy

- If BTS inventory dropped below safe level, all HBB inventories will be reduced on a pro-rata basis with extra requests to be considered on case-by-case basis.

Electronic Blood Transfusion Network System

- Connect with blood banks in all public hospitals – enable viewing of real-time inventories in both BTS and HBBs.
- The system also enables:
  - Blood ordering & shipment
  - Product tracking
  - Checking of patients’ previous cross match results

Client Satisfaction

Blood Utilization Statistics
Red Cells Utilization by Specialties in Public Hospitals

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>M &amp; G</td>
<td>4631</td>
<td>4710</td>
<td>5132</td>
<td>5734</td>
<td>5734</td>
</tr>
<tr>
<td>Surgery</td>
<td>12685</td>
<td>14322</td>
<td>14577</td>
<td>15106</td>
<td>14123</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>1597</td>
<td>10480</td>
<td>10940</td>
<td>11092</td>
<td>1493</td>
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<tr>
<td>Orthopaedics</td>
<td>2158</td>
<td>3972</td>
<td>2775</td>
<td>2652</td>
<td>2459</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>1088</td>
<td>1680</td>
<td>1494</td>
<td>2199</td>
<td>2473</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>1519</td>
<td>1486</td>
<td>1582</td>
<td>1814</td>
<td>1939</td>
</tr>
<tr>
<td>O &amp; G</td>
<td>1479</td>
<td>1317</td>
<td>1278</td>
<td>1384</td>
<td>1385</td>
</tr>
<tr>
<td>A &amp; E</td>
<td>439</td>
<td>1060</td>
<td>806</td>
<td>7814</td>
<td>852</td>
</tr>
<tr>
<td>A &amp; E</td>
<td>245</td>
<td>373</td>
<td>404</td>
<td>238</td>
<td>310</td>
</tr>
<tr>
<td>Other</td>
<td>592</td>
<td>606</td>
<td>948</td>
<td>7893</td>
<td>8167</td>
</tr>
<tr>
<td>Total</td>
<td>94374</td>
<td>96121</td>
<td>100184</td>
<td>100108</td>
<td>104720</td>
</tr>
</tbody>
</table>

Platelet Utilization by Specialties in Public Hospitals

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>M &amp; G</td>
<td>11392</td>
<td>11886</td>
<td>11316</td>
<td>2082</td>
<td>19092</td>
</tr>
<tr>
<td>Surgery</td>
<td>15233</td>
<td>15737</td>
<td>17080</td>
<td>17080</td>
<td>16800</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>1440</td>
<td>1504</td>
<td>1970</td>
<td>1829</td>
<td>2577</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>1741</td>
<td>1684</td>
<td>1841</td>
<td>1791</td>
<td>2233</td>
</tr>
<tr>
<td>Chest</td>
<td>1156</td>
<td>1711</td>
<td>2277</td>
<td>2183</td>
<td>2157</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>3923</td>
<td>2229</td>
<td>1999</td>
<td>1888</td>
<td>1747</td>
</tr>
<tr>
<td>ICU</td>
<td>3947</td>
<td>1596</td>
<td>561</td>
<td>1251</td>
<td>1618</td>
</tr>
<tr>
<td>O &amp; G</td>
<td>1653</td>
<td>932</td>
<td>318</td>
<td>1068</td>
<td>1178</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>1481</td>
<td>1413</td>
<td>1339</td>
<td>598</td>
<td>1132</td>
</tr>
<tr>
<td>A &amp; E</td>
<td>313</td>
<td>373</td>
<td>479</td>
<td>405</td>
<td>401</td>
</tr>
<tr>
<td>Other</td>
<td>742</td>
<td>1399</td>
<td>318</td>
<td>187</td>
<td>1069</td>
</tr>
<tr>
<td>Total</td>
<td>12843</td>
<td>51564</td>
<td>52764</td>
<td>51356</td>
<td>51355</td>
</tr>
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</table>

WB+RC Expiration in Public Hospitals

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB+RC issued</td>
<td>159564</td>
<td>161660</td>
<td>166152</td>
<td>170625</td>
<td>172722</td>
</tr>
<tr>
<td>Total Expiration</td>
<td>1111</td>
<td>1265</td>
<td>894</td>
<td>691</td>
<td>886</td>
</tr>
<tr>
<td>Overall % of WB+RC Expiration</td>
<td>0.72%</td>
<td>0.78%</td>
<td>0.60%</td>
<td>0.40%</td>
<td>0.51%</td>
</tr>
</tbody>
</table>

Plate & FFP Expiration in Public Hospitals

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platelet issued</td>
<td>88483</td>
<td>90641</td>
<td>94852</td>
<td>103197</td>
<td>109891</td>
</tr>
<tr>
<td>% of Platelet Expiration</td>
<td>6.54%</td>
<td>5.70%</td>
<td>5.33%</td>
<td>5.42%</td>
<td>6.18%</td>
</tr>
<tr>
<td>FFP issued</td>
<td>51843</td>
<td>51564</td>
<td>52764</td>
<td>51556</td>
<td>51411</td>
</tr>
<tr>
<td>% of FFP Expiration</td>
<td>0.37%</td>
<td>0.32%</td>
<td>0.23%</td>
<td>0.21%</td>
<td>0.33%</td>
</tr>
</tbody>
</table>
Benchmarking Blood Utilization in Public Hospitals

- A territory-wide peer-to-peer review of blood utilization and expiration by hospitals and various clinical specialties.
- BTS provides report every six months.
- Hospital Transfusion Committee has the responsibility to review its hospital’s performance and implements improvement measures accordingly.

Production planning

- Estimate annual blood requirement
- Review quarterly demand of blood components of different blood groups, blood collection, blood inventory and wastage and plan short term adjustments.
- Monthly communication with HBB on matters that potentially affect short-term demand.
- Weekly stochastic forecasting based on historical demand and communication with HBB to plan daily production of components.

Estimation of Annual Blood Requirement

- Annual production planning by causal forecasting
  - Review previous 12 month utilization
  - Determine driving factor
  - Determine the utilization trend factors

Driving Factor

<table>
<thead>
<tr>
<th>Period</th>
<th>WB/RBC</th>
<th>Platelet Concentrates</th>
<th>FFP &amp; CRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan - Dec 2001</td>
<td>173,592</td>
<td>106,694</td>
<td>56,799</td>
</tr>
<tr>
<td>Jan - Dec 2002</td>
<td>175,322</td>
<td>100,742</td>
<td>54,354</td>
</tr>
<tr>
<td>Jan - Dec 2003</td>
<td>167,131</td>
<td>92,634</td>
<td>48,682</td>
</tr>
<tr>
<td>Jan - Dec 2004</td>
<td>179,589</td>
<td>105,174</td>
<td>58,163</td>
</tr>
<tr>
<td>Jan - Dec 2005</td>
<td>181,591</td>
<td>107,306</td>
<td>54,682</td>
</tr>
<tr>
<td>Jan - Dec 2006</td>
<td>180,754</td>
<td>116,561</td>
<td>58,259</td>
</tr>
<tr>
<td>Jan - Dec 2007</td>
<td>191,164</td>
<td>127,409</td>
<td>57,079</td>
</tr>
<tr>
<td>Jan - Dec 2008</td>
<td>196,813</td>
<td>127,152</td>
<td>57,330</td>
</tr>
</tbody>
</table>

BTS Calculation of hospital WB/RC Demand

- WB/RBC issued to hospitals for the previous 12 month period from November to October.
- adjusting for shortage of WB/RBC stock replenishment during the period, hospitals’ forecast increase or decrease in blood demand for next year due to expansion or contraction of services and population growth.

Hospitals’ Forecast of WB/RC Demand

- Commence the process in November each year
- Request each hospital to participate by completing a questionnaire to forecast demand for next year based on:
  - Previous 12 month utilization
  - projected changes in demand due to factors such as organic growth, changes in level of services, changes in patient population served and patient demographics, etc.
**BTS Calculation of WB/RBC Demand for 2010-2011**

- WB/RBC issued to clients in the period of November 2008 to October 2009: 200,027 units
- Average satisfaction rate of WB/RBC stock replenishment during the period of November 2008 to October 2009: 99.66%
- Clients’ estimated potential increase/decrease in annual WB/RBC demand = 20 units
- HK population growth: 0.4%

\[
\text{Blood stock replenishment satisfaction in 2009} = \left( \frac{200,027 \times 1.004}{0.9966} \right) + 20
\]

= 201,532 units

**Baseline of WB/RBC Demand for 2010/2011**

- Hospitals’ demand forecast: 205,682 units
- BTS calculation: 201,532 units

Since hospitals’ forecast is greater than the BTS calculation, it will be taken as the baseline demand for further calculation to determine the annual WB/RBC demand for 2010/2011.

**Additional Factors that Need to be Incorporated in the Final Calculation**

- Average production discard rate in the previous three years i.e. 2006-2008 = 6.63%
- Average WB/RBC expiry rate in the previous three years, i.e. 2006-2008 = 0.013%

**Final Estimation of Blood Demand for 2010-2011**

\[
\text{Baseline demand} / (1 - \text{average production discard rate} - \text{average WB/RBC expiry rate})
\]

= 205,682 / (1 - 0.0663 - 0.00013)

= 220,318 units

Annual blood collection target for 2010-2011

= 220,000 ± 2%

= 215,600 to 224,400 units

**Actual Annual Collection against Target**
Long Term Forecast

Blood Demand and Supply in Hong Kong

| Population Increase 25% in next 25 years |

Effect of the ‘Silver Tsunami’

- In yr 2009, median age of population is 40.9 with 12.8% aged > 65
- In yr 2033, 26.8% of population will be > 65

% Utilization of different age groups in various specialties

<table>
<thead>
<tr>
<th>&lt; 1 m</th>
<th>1 - 10</th>
<th>11 - 20</th>
<th>21 - 30</th>
<th>31 - 40</th>
<th>41 - 50</th>
<th>51 - 60</th>
<th>61 - 70</th>
<th>&gt; 70</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>98.9%</td>
<td>98.9%</td>
<td>98.9%</td>
<td>98.9%</td>
<td>98.9%</td>
<td>98.9%</td>
<td>98.9%</td>
<td>98.9%</td>
</tr>
</tbody>
</table>

Conclusion

- Involving hospitals in forecasting short term demand seemed to be an effective approach.
- To achieve maximum use of the precious gifts of life from blood donors and to ensure all demands are met timely, it is important to understand the complex interrelations of supply and demand, factors that impact upon them and have all parts and parties of supply chain working together.
- Blood utilization is increasing.
- Aging of population will have significant impact on the demand for blood supply.

Happy Chinese New Year!
Epidemiology of Transfusion in Scotland
Who gets transfused and why?

WHO Workshop on Estimation of needs for transfusion
Geneva February 3 – 5
2010

Needs Assessment:
How can we use this data
• in UK or similar setting
• in resource restricted setting

It should be part of our job to know who gets the blood, why and how much...

Develop a sustainable system providing information about the clinical use of blood
Estimate current requirements
Predict future requirements
Identify variations in practice
Encourage clinical review of blood use
Understand demographic, socioeconomic and epidemiological influences on blood use

Evolution
2000: STEP
Scottish Transfusion Epidemiology Project

Presentation
• Evolution and why
• AIMS
• Methods
• Results
• What next

Evolution
2005: STED
Scottish Transfusion Epidemiology database

Scottish Executive

BETTER BLOOD TRANSFUSION PROGRAMME:
Introduction of tailored information system software to enable the easy collection and analysis of transfusion data for prompt feedback to clinicians and Hospital Transfusion Committees. This would involve the construction of a merged record that is a by-product of routine clinical practice (held on the existing hospital patient administration system) and data extracts from the local hospital laboratory system (and in some cases operating theatre).
It should be part of our job to know who gets the blood, why and how much...

Develop a sustainable system providing information about the clinical use of blood

Predict requirements

Identify variations in practice

Encourage clinical review of blood use

Understand demographic, socioeconomic and epidemiological influences on blood use

STED

Methods in outline

Why...

- Progressively uncovered problems in
  - data quality
  - terminology and definitions for data items
  - opacity of Progesa data
  - heterogeneity of hospital blood bank IT systems
  - heterogeneity of setting up – [same system used in different ways]
  - human resource for regular data extraction and QA
  - Etc etc

Extract patient - specific transfusion data from 2002/03 – 2005/06 from majority of Health boards

Link using Patient Identifiers with hospital inpatient and day case records (Scottish Morbidity Record)

Prepare reports for clinical users, other stakeholders

Disseminate
Structure of linked data

Blood bank transfusion records

- RBC, Plt, Cryo, FFP
- Procedure and diagnosis fields

Inpatient episode records

- Patient ID
- 4 Procedure and 6 diagnosis fields

Record linkage

Structure of linked data

Blood bank transfusion records

- RBC, Plt, Cryo, FFP
- Procedure and diagnosis fields

Inpatient episode records

- Patient ID
- 4 Procedure and 6 diagnosis fields

Record linkage

Associating transfusion record with clinical episodes

Clinical rule...

Patient had 6 admissions, 28 procedure codes, 15 diagnosis codes and 4 transfusion episodes

January

December

Results

Transfusion for surgical procedures

- Red cell use for defined surgical episodes (OPCS)
- Utilises ~20% of total red cell use per year (~38,000 units)
- Substantial reduction over period 2003-2006
- Reduced variation among clinical units
  - Cardiac: Coronary Artery Bypass Grafting
  - Vascular: Elective repair of aneurysm
  - Orthopaedic: Primary total hip replacement

Red cell use in coronary artery bypass graft

Coronary artery bypass grafts

Substantial reductions in one of the 3 cardiac surgery units associated with intensified blood saving initiatives including cell salvage

Variation between units reduced
Red cell use in aortic aneurysm repair

Elective repair of aortic aneurysm

Substantial reductions across all health boards

Variation in practice between health boards continues but reduced

Red cell use in primary total hip replacement

Primary total hip replacement

• Reductions in all health boards, some greater than others.

• Tayside increase is an artefact of an identified anomaly with the source data for 2006 and should be ignored.

Red cell use for patients with haematological malignancies

Conditions included (ICD 10)

• Lymphoma
• Myeloma
• Myeloid Leukaemia
• Lymphoid Leukaemia
• Other Leukaemias
• Malignant immunoproliferative disease
• Other & unspecified malignant neoplasms of lymphoid, haematopoietic & related tissues

• Utilises ~18% of total red cell use per year (~35,000 units)*

Red cell use for patients with diagnoses of malignant tumours

Conditions described

• Bronchus & lung
• Prostate
• Breast
• Stomach
• Small intestine
• Ovary
• Oesophagus
• Kidney
• Pancreas

• Colon, rectosigmoid junction & rectum Cervix uteri
• Corpus uteri
• Liver & intrahepatic bile ducts
• Thyroid & endocrine glands
• Eye, brain & other parts of CNS
• Testis
• Trachea

• Utilises ~24% of total red cell use per year (~45,000 units)*

Summary

• Surgical 20%
• Haematology 18%
• Solid Tumours
• Other 38%
Which clinical conditions do we still have to label as “other”?

- patients who have multiple admissions with several diagnoses
- many have markers for gastrointestinal & liver disease.
WHO Needs assessment Feb 2010

**RBC Projections for Scotland (excluding Forth Valley), 2006-2018**

![RBC Projections Chart]

**Population Change in Europe**

![Population Change Chart]

**Socio-economic factors**

**DEPRIVATION**

<table>
<thead>
<tr>
<th>Health Board</th>
<th>Inpatient/daycase records per 1000 popn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2003</td>
</tr>
<tr>
<td>Argyll &amp; Clyde</td>
<td>205.5</td>
</tr>
<tr>
<td>Ayrshire &amp; Arran</td>
<td>236.8</td>
</tr>
<tr>
<td>Borders</td>
<td>196.2</td>
</tr>
<tr>
<td>Dumfries &amp; Galloway</td>
<td>206.8</td>
</tr>
<tr>
<td>Fife</td>
<td>196.5</td>
</tr>
<tr>
<td>Grampian</td>
<td>213.8</td>
</tr>
<tr>
<td>Greater Glasgow</td>
<td>340.4</td>
</tr>
<tr>
<td>Highland</td>
<td>261.5</td>
</tr>
<tr>
<td>Lanarkshire</td>
<td>238.0</td>
</tr>
<tr>
<td>Lothian</td>
<td>226.5</td>
</tr>
<tr>
<td>Orkney</td>
<td>162.4</td>
</tr>
<tr>
<td>Shetland</td>
<td>163.6</td>
</tr>
<tr>
<td>Shetland</td>
<td>240.8</td>
</tr>
<tr>
<td>Western Isles</td>
<td>249.6</td>
</tr>
<tr>
<td>Scotland Excl FV</td>
<td>244.8</td>
</tr>
</tbody>
</table>

**In patient/day case records per 1000 population**

**RBC units transfused per 1,000 Inpatient/Daycase records**

<table>
<thead>
<tr>
<th>Health Board</th>
<th>RBC units ts per 1,000 Inpatient/Daycase records</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2003</td>
</tr>
<tr>
<td>Argyll &amp; Clyde</td>
<td>139.1</td>
</tr>
<tr>
<td>Ayrshire &amp; Arran</td>
<td>141.1</td>
</tr>
<tr>
<td>Borders</td>
<td>162.9</td>
</tr>
<tr>
<td>Dumfries &amp; Galloway</td>
<td>143.8</td>
</tr>
<tr>
<td>Fife</td>
<td>185.7</td>
</tr>
<tr>
<td>Grampian</td>
<td>179.3</td>
</tr>
<tr>
<td>Greater Glasgow</td>
<td>171.9</td>
</tr>
<tr>
<td>Highland</td>
<td>122.9</td>
</tr>
<tr>
<td>Lanarkshire</td>
<td>147.9</td>
</tr>
<tr>
<td>Lothian</td>
<td>213.8</td>
</tr>
<tr>
<td>Orkney</td>
<td>130.1</td>
</tr>
<tr>
<td>Shetland</td>
<td>113.2</td>
</tr>
<tr>
<td>Shetland</td>
<td>200.2</td>
</tr>
<tr>
<td>Western Isles</td>
<td>199.1</td>
</tr>
<tr>
<td>Scotland Excl FV</td>
<td>177.4</td>
</tr>
</tbody>
</table>
Scottish Index of Multiple Deprivation 2006

- "Deprivation takes many different forms in every known society. People can be said to be deprived if they lack the types of diet, clothing, housing, household facilities and fuel and environmental, educational, working and social conditions, activities and facilities which are customary, or at least widely encouraged and approved, in the societies to which they belong." Townsend, P (1987) Deprivation, Journal of Social Policy 16 (1) pp 125-146

- 37 indicators
  - Income, Employment, Crime, Education, Health (including standardised mortality ratios), Housing, Geographic access to services

- SIMD 2006 divides Scotland into 6,505 ‘data zones’ with median population size of 769. These are ranked from 1 ‘most deprived’ to 6,505 ‘least deprived’

Greater Glasgow: Scottish Index of Multiple Deprivation 2002/03 – 2005/06

<table>
<thead>
<tr>
<th>SIMD Quintile</th>
<th>No Patients Transfused with ALD</th>
<th>RBC Units Transfused in 2005</th>
<th>RBC per patient Tx (2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Least deprived)</td>
<td>12</td>
<td>57</td>
<td>4.8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>113</td>
<td>11.3</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>118</td>
<td>6.6</td>
</tr>
<tr>
<td>4</td>
<td>39</td>
<td>242</td>
<td>6.2</td>
</tr>
<tr>
<td>5 (Most deprived)</td>
<td>173</td>
<td>1,264</td>
<td>7.3</td>
</tr>
<tr>
<td>Greater Glasgow</td>
<td>252</td>
<td>1,784</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Alcoholic Liver Disease (ICD10 K70)

<table>
<thead>
<tr>
<th>Red Blood Cell Units Transfused for patients with ALD*, 2002-2005</th>
<th>No Tx Patients with ALD</th>
<th>No Tx Patients with ALD per 1,000</th>
<th>RBC Units Transfused</th>
<th>RBC/Tx Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayrshire &amp; Arran</td>
<td>314</td>
<td>0.2</td>
<td>2,591</td>
<td>8.3</td>
</tr>
<tr>
<td>Borders</td>
<td>31</td>
<td>0.1</td>
<td>369</td>
<td>11.9</td>
</tr>
<tr>
<td>Argyll &amp; Clyde</td>
<td>2</td>
<td>0.1</td>
<td>2,760</td>
<td>9.5</td>
</tr>
<tr>
<td>Fife</td>
<td>227</td>
<td>0.2</td>
<td>2,807</td>
<td>12.1</td>
</tr>
<tr>
<td>Greater Glasgow</td>
<td>1,135</td>
<td>0.3</td>
<td>9,443</td>
<td>8.3</td>
</tr>
<tr>
<td>Lanarkshire</td>
<td>506</td>
<td>0.2</td>
<td>5,222</td>
<td>10.3</td>
</tr>
<tr>
<td>Orkney</td>
<td>12</td>
<td>0.2</td>
<td>1,079</td>
<td>7.9</td>
</tr>
<tr>
<td>Lanarkshire</td>
<td>506</td>
<td>0.2</td>
<td>5,222</td>
<td>10.3</td>
</tr>
<tr>
<td>Orkney</td>
<td>12</td>
<td>0.2</td>
<td>1,079</td>
<td>7.9</td>
</tr>
<tr>
<td>Tayside</td>
<td>214</td>
<td>0.1</td>
<td>2,014</td>
<td>9.4</td>
</tr>
<tr>
<td>Western Isles</td>
<td>24</td>
<td>0.2</td>
<td>176</td>
<td>7.4</td>
</tr>
<tr>
<td>Dumfries &amp; Galloway</td>
<td>53</td>
<td>0.1</td>
<td>583</td>
<td>11.9</td>
</tr>
<tr>
<td>Shetland</td>
<td>5</td>
<td>0.1</td>
<td>20</td>
<td>4.0</td>
</tr>
<tr>
<td>Scotland (excl FV)</td>
<td>3,980</td>
<td>0.2</td>
<td>36,573</td>
<td>9.2</td>
</tr>
</tbody>
</table>

* with any diagnosis of ICD10 K70 in their clinical history

From now on...

- NHS Scotland Account for blood: data warehouse development with automated harvest of standardised data from hospital blood bank systems.
- Finally – it is adequately funded
Needs Assessment:

• How can we use this data - in UK or similar setting

Needs Assessment:

How can we use this data - in resource restricted setting
Aggregated Blood Report from AABB (ARC and ABC facilities)

Estimated US Blood Supply Jan 29, 2010

<table>
<thead>
<tr>
<th>Blood Groups/Type</th>
<th>Estimated Days of Supply</th>
<th>Blood Distribution Inventory</th>
<th>Estimated Hospital Inventory: constant 6 day supply</th>
<th>Estimated US Blood Supply (RBC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O+</td>
<td>6.7</td>
<td>119,359</td>
<td>107,058</td>
<td>226,416</td>
</tr>
<tr>
<td>O-</td>
<td>3.1</td>
<td>19,721</td>
<td>20,053</td>
<td>39,774</td>
</tr>
<tr>
<td>A+</td>
<td>6.5</td>
<td>108,339</td>
<td>95,788</td>
<td>204,124</td>
</tr>
<tr>
<td>A-</td>
<td>4.6</td>
<td>16,904</td>
<td>16,904</td>
<td>33,808</td>
</tr>
<tr>
<td>B+</td>
<td>6.9</td>
<td>25,356</td>
<td>25,356</td>
<td>50,712</td>
</tr>
<tr>
<td>B-</td>
<td>4.0</td>
<td>5,655</td>
<td>5,655</td>
<td>11,310</td>
</tr>
<tr>
<td>AB+</td>
<td>14.2</td>
<td>13,840</td>
<td>8,452</td>
<td>22,302</td>
</tr>
<tr>
<td>AB-</td>
<td>7.2</td>
<td>2,617</td>
<td>2,617</td>
<td>5,234</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>307,450</td>
<td>281,731</td>
<td>589,181</td>
</tr>
</tbody>
</table>

Impression

The blood supply is adequate to meet needs with just over 6 ½ days supply of O Positive blood and just over 3 days supply of O Negative blood available at blood centers across the nation.

Hospital inventory shortage reporting in the Blood Availability and Safety Information System (BASIS) continue to reflect instances of RBC and platelet shortages; however, alternate source purchases remain relatively low.

Platelet inventories continue to appear tight as a national aggregate.

BASIS Report

Represents approximately 95 Sentinel Hospitals reporting consistently
Represents approximately 95 Sentinel Hospitals reporting consistently
National Blood Collection and Utilization Survey Overview

- Introduction
- Methods
- Key Findings
- Biovigilance
- Hospital Costs of Blood Collection and Processing Experience
- Transfusion Experience
- Cellular Therapy Products
- Historical Perspectives
- Current Issues in Transfusion and Transplantation

www.hhs.gov/bloodsafety

Whole Blood and Red Blood Cell Apheresis

### Estimated Collections by Blood Centers and Hospitals

<table>
<thead>
<tr>
<th>Type of RBC Collection</th>
<th>2006</th>
<th>2004</th>
<th>Per Cent Difference (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Allogeneic</td>
<td>13,486,000</td>
<td>14,087,000</td>
<td>- 4.8%</td>
</tr>
<tr>
<td>Whole Autologous</td>
<td>242,000</td>
<td>463,000</td>
<td>- 47.6%</td>
</tr>
<tr>
<td>Whole Directed</td>
<td>47,000</td>
<td>117,000</td>
<td>- 59.3%</td>
</tr>
<tr>
<td>RBC Apheresis</td>
<td>1,603,000</td>
<td>836,000</td>
<td>+ 93.7%</td>
</tr>
<tr>
<td>Total</td>
<td>15,378,000</td>
<td>15,503,000</td>
<td>- 1.7%</td>
</tr>
</tbody>
</table>

- May not be a appreciable increase due to blood centers were not weighted in 2004
- Significant Difference (*) from 2004 to 2006
- 95% Confidence Intervals calculated

2006 Key Findings: Donors

- 12,142,000 donors presented
- 9,554,000 allogeneic donors
- 2,726,000 first-time donors (22.5%)
- 6,828,000 repeat donors (71.5%)
- Repeat donors provided 11,697,000 donations – 1.7 donations/donor

Whole Blood and Red Blood Cell Apheresis

### Estimated Collections by Blood Centers and Hospitals

<table>
<thead>
<tr>
<th>Type of RBC Collection</th>
<th>2006</th>
<th>2004</th>
<th>Per Cent Difference (A)</th>
</tr>
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<tbody>
<tr>
<td>Blood Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Total</td>
<td>15,378,000</td>
<td>15,503,000</td>
<td>- 1.7%</td>
</tr>
</tbody>
</table>

- Significant Difference (*) from 2004 to 2006
- 95% Confidence Intervals calculated

2006 Key Findings

- 30,044,000 components transfused
  - 14,650,000 red cells
  - 10,388,000 platelet concentrate eq.
  - 4,010,000 plasma
  - 993,000 cryoprecipitate
Red Blood Cell Transfusions

<table>
<thead>
<tr>
<th>Type of RBC Transfusion</th>
<th>Blood Center</th>
<th>Hospital</th>
<th>Total</th>
<th>Per Cent Difference (Δ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allogeneic (not directed)</td>
<td>716,000</td>
<td>12,262,000</td>
<td>13,978,000</td>
<td>13,728,000</td>
</tr>
<tr>
<td>Autologous</td>
<td>7,000</td>
<td>182,000</td>
<td>189,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Directed</td>
<td>0</td>
<td>126,000</td>
<td>126,000</td>
<td>126,000</td>
</tr>
<tr>
<td>Pediatric</td>
<td>5,000</td>
<td>352,000</td>
<td>357,000</td>
<td>59,000</td>
</tr>
<tr>
<td>Total</td>
<td>729,000</td>
<td>13,921,000</td>
<td>14,650,000</td>
<td>13,191,000</td>
</tr>
</tbody>
</table>

* Significant Difference (*) from 2004 to 2006
* 95% Confidence Intervals calculated

WB and RBC Recipients

- 3.0 units per recipient (unweighted)
  - 8,275,000 allogeneic units (incl directed)
  - 2,740,000 recipients
  - 2004: 2.7 units per recipient
- Extrapolation of ratio of transfused/recipient
  - Estimated 5 M recipient
  - 6.6% decrease in transfusion recipients (compared to 2004)

Platelets Transfused

<table>
<thead>
<tr>
<th>Type of Product Transfused</th>
<th>Blood Center</th>
<th>Hospital</th>
<th>Total</th>
<th>Total</th>
<th>Per Cent Difference (Δ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB Derived Platelets</td>
<td>223,000</td>
<td>1,073,000</td>
<td>1,296,000</td>
<td>1,573,000</td>
<td>-15.7%</td>
</tr>
<tr>
<td>Apheresis Platelets</td>
<td>411,000</td>
<td>8,681,000</td>
<td>9,092,000</td>
<td>8,343,000</td>
<td>9.0%</td>
</tr>
<tr>
<td>Total</td>
<td>634,000</td>
<td>9,754,000</td>
<td>10,388,000</td>
<td>9,881,000</td>
<td>5.1%</td>
</tr>
</tbody>
</table>

* Parenthesis notation is apheresis units including splits
* Significant Difference (*) from 2004 to 2006
* 95% Confidence Intervals calculated

Platelet Dose for Transfusions

- WB and RBC
- 17%
- Apheresis

Outdate of Red Cells

<table>
<thead>
<tr>
<th>Component</th>
<th>Processed/produced</th>
<th>Total Outdate</th>
<th>Per Cent Outdate</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB/RBC</td>
<td>16,745,000</td>
<td>401,000</td>
<td>-</td>
</tr>
<tr>
<td>Allogeneic</td>
<td>252,000</td>
<td>63%</td>
<td></td>
</tr>
<tr>
<td>Autologous</td>
<td>131,000</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>Directed</td>
<td>5,000</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Whole Blood</td>
<td>13,000</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>
Current Issues in Transfusion

- Blood inventory shortages for non-surgical procedures

  - 2006
    - 13.5% (231/1707) reported at least one day shortage
    - Mean number of days was 22
    - Six (6) hospitals reported 365 days the blood needs were not met.
    - Number of days regular or standing order was incomplete
      - 44,910 total days (estimated?)
    - On any given day, 123 hospital did not have their standing order met.

  - 2004
    - 16% (257/1604) reported at least one day shortage
    - Mean number of days was 19.27
    - Eight (8) hospitals reported 365 days the blood needs were not met.

Trends in WB and RBC Collections

<table>
<thead>
<tr>
<th>Survey Year</th>
<th>Collections</th>
<th>Transfusions</th>
<th>Available Collections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>6.3 M</td>
<td>12 M</td>
<td>18.5 M</td>
</tr>
<tr>
<td>1992</td>
<td>6.9 M</td>
<td>14 M</td>
<td>20.9 M</td>
</tr>
<tr>
<td>1994</td>
<td>9 M</td>
<td>16 M</td>
<td>25 M</td>
</tr>
<tr>
<td>1997</td>
<td>10.5 M</td>
<td>20 M</td>
<td>29.5 M</td>
</tr>
<tr>
<td>2001</td>
<td>15.5 M</td>
<td>30 M</td>
<td>36.5 M</td>
</tr>
<tr>
<td>2004</td>
<td>16 M</td>
<td>32 M</td>
<td>38 M</td>
</tr>
<tr>
<td>2006</td>
<td>17 M</td>
<td>34 M</td>
<td>39 M</td>
</tr>
</tbody>
</table>


- Age and sex distribution similar except more men transfused with platelets and plasma
- More blood used in older population
- Cardiovascular surgery predominated highest use

Comparison in Developed Countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Units of RBC per 1000 Population</th>
<th>Age Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>48.5 (2001) 44.9 (2006)</td>
<td>&lt;40 18.8%</td>
</tr>
<tr>
<td>England</td>
<td>54.8 (2001) 45.6 (2002)</td>
<td>&lt;40 15.4%</td>
</tr>
<tr>
<td>Australia</td>
<td>58 (2000-2002)</td>
<td>&lt;40 15.4%</td>
</tr>
<tr>
<td>Denmark</td>
<td>63.1 (1998-2000)</td>
<td>&lt;40 15.4%</td>
</tr>
<tr>
<td>Sweden</td>
<td>65.7 (1999-2000)</td>
<td>&lt;40 15.4%</td>
</tr>
</tbody>
</table>

In Developed Countries

- Estimation based on Population

Kamper-Jorgensen Transfusion 2009; 49:888-894
Cobain Transfusion Medicine 2007, 17, 10-15
Blood Systems
United Blood Services

- 2007
  - 870,000 collects that serve 500 hospitals in 18 states
  - 1/3 of continental US
- Estimation of blood needs
  - Roll up of individual hospital distribution for most recent 60 months (5 yrs) – distribution is assessed – to transfusions (return policy)
  - Application of statistical software package (Decision Pro)
  - Unfilled orders are tracked solely for customer satisfaction
  - Forward looking estimates do not currently take into consideration planned changes in hospital services (e.g. cardiac surgery)
  - C:T ratio is not used as BSI collects no transfusion data

Information obtained via phone interview by Karen Lipton

American Red Cross

- 2007
  - 6,332,000 collections that served over 2500 hospitals throughout US
  - Roll up of individual hospital utilization data on the most recent 12 months
  - Application of Sales and Operation Planning (SNOP) to create a 12 month projection
  - Based on distribution, assumption that distribution ~ transfusion
  - Annual survey of hospitals to determine new changes in services that might change utilization
  - Since 2009, review of unemployment statistics which seem to track blood utilization figures due to loss of health insurance coverage

Information obtained via phone interview by Karen Lipton
Estimating Blood Requirements

Blood Safety
Geneva, Switzerland
February 4, 2010

2006 Blood collections per 1000 population
National Blood Services only

Zambia Blood Donations 2003-08

Moving Target—Population

Infrastructure and Collections in 11 countries without 100% NBTS coverage

2006 Blood collections per 1000 population
National Blood Services only
Coverage

Table 11: Number of units of blood collected in 2006

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Number of units of blood donations (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>1,742 (1)</td>
</tr>
<tr>
<td>Secondary</td>
<td>87,757 (50.4)</td>
</tr>
<tr>
<td>Tertiary</td>
<td>84,505 (48.6)</td>
</tr>
<tr>
<td>Total</td>
<td>174,004 (100)</td>
</tr>
</tbody>
</table>

Table 12: Estimated number of blood donations in 2006

<table>
<thead>
<tr>
<th>Groups</th>
<th># of units</th>
<th># of sites visited</th>
<th>Average per site</th>
<th>Total # of facilities</th>
<th>Total donations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>1,742</td>
<td>10</td>
<td>174.2</td>
<td>882</td>
<td>186,836</td>
</tr>
<tr>
<td>Secondary</td>
<td>87,757</td>
<td>84</td>
<td>1622</td>
<td>944</td>
<td>1,534,122</td>
</tr>
<tr>
<td>Tertiary</td>
<td>84,505</td>
<td>48</td>
<td>1760</td>
<td>48</td>
<td>84,505</td>
</tr>
<tr>
<td>Total</td>
<td>174,004</td>
<td>112</td>
<td>1,784,465</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data Sources

- Rapid assessment
- Surveys
- Ministry Data
Stepwise approach—infrastructure

- Organization
  - Hospital based?
  - Regional?
  - National?
    - Incorporated Ministry, Private, NGO, Faith based?
- Usage vs demand
  - Family replacement vs Volunteer
  - Transition—utilization increase due to previous unmet demand
- Data management capability—inventory
  - Manual/paper
  - Electronic

Stepwise approach—clinical issues

- Composition
  - Whole blood
  - Pediatric units
  - Components
    - RBCs, FFP, platelets
- Clinical guidelines
  - Physician familiarity—practice
  - Training on new component options
- Laboratory
  - Baseline values
  - Monitoring

Summary

Comprehensive Blood Safety

- Collection
  - Communication partnerships (MDG 8)
  - TTI Prevention (MDG 6)
  - Work Force Development
  - Health Care Worker Safety
  - IT systems
  - Quality Systems
  - Health Education
  - Waste Management
- Processing
  - TTI Prevention (MDG 6)
  - Quality Systems
  - Work Force Development
  - Health Care Worker Safety
  - IT System
  - Waste Management
- Utilization
  - TTI Prevention (MDG 6)
  - Maternal Health (MDG 5)
  - Child Health (MDG 4)
  - Trauma (MVA)
  - HIV/AIDS Care and Rx
  - Quality Systems
  - Patient Safety
  - Work Force Development
  - Worker Safety
  - IT System
  - Waste Management
Blood Supply and Demand: Georgetown, Guyana
November, 2007

Sridhar Basavaraju, MD
Medical Officer
Centers for Disease Control and Prevention
Atlanta, USA

Objectives

- Country and National Blood Transfusion Service background
- Investigation background
- Case definitions
- Methods
- Results
- Shortage calculations
- Lessons learned

Guyana

- National borders: Venezuela, Brazil, Suriname, Caribbean Sea
- Population: 750,000 (30% live in Georgetown)
- Gross National Product per capita: <$1,000

Guyana National Blood Transfusion Service (NBTS)

- Total Collections, 2007: 5,475 units (7.3 units per 1,000 population)
- 90% units distributed: whole blood or packed red cells
- 80% of collections: distributed to Georgetown Public Hospital Corporation (GPHC)
- 60% of collections: voluntary, non-remunerated donors

Study Background

- December, 2007: NBTS review suggests 60% of all blood orders unmet
- GPHC-NBTS opinion differences
  - Reports of delayed surgeries
  - Inappropriate requests
  - Blood returned unused
- Field investigation to determine:
  - Was enough blood collected?
  - Was there a true shortage of blood?

Case Definitions
Case Definition

• Unit: An individual blood product – WB, PRC, FFP, PLT, Cryo
• Issued: Unit given by NBTS to ward for the purpose of transfusion
• Filled: Unit is prepared by NBTS and ready to be issued. A unit must be filled before it is issued. Not all filled units are issued

Case Definition

• Order: A unit is requested by GPHC by submitting a written blood request form.
• Rejected: The order by GPHC ward is refused by the NBTS due to a problem with information provided to NBTS
• Unused: Issued unit is not transfused into a patient by ward.

Case Definition

• Returned: An issued unit is returned to NBTS unused by ward
• Reissued: A returned unit is given by NBTS to ward for the purpose of transfusion
• Expired: A unit is no longer fit to be transfused as > 35 days have lapsed since being filled

Case Definition

• Unit not required: An order which is stated by ward to be no longer necessary. NBTS will not fill this order
• Shortage: An order not filled by NBTS as the specific blood product is not available.

Blood Request Form

Methods
Methods

- Audit of NBTS data for November 2007
- 3 Logbooks in NBTS
  - Book 1: Book of Cross matched issued blood
  - Book 2: Book of daily requests
  - Book 3: Book of returned units

Methods

- Blood Request Form Files
  - Issued
  - Filled and not picked up by ward
  - Rejected orders
  - Orders no longer required
- Comparison between logbooks and Blood Request Form files

Results

Units Ordered by GPHC – November, 2007

<table>
<thead>
<tr>
<th>Blood Group</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed Red Cell</td>
<td>1130</td>
</tr>
<tr>
<td>Whole Blood</td>
<td>41</td>
</tr>
<tr>
<td>Platelets</td>
<td>2</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>133</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>1328</td>
</tr>
</tbody>
</table>

Units Issued to GPHC November, 2007

<table>
<thead>
<tr>
<th>Blood Group</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed Red Cell</td>
<td>431</td>
</tr>
<tr>
<td>Whole Blood</td>
<td>22</td>
</tr>
<tr>
<td>Platelets</td>
<td>0</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>59</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>59</td>
</tr>
<tr>
<td>Total</td>
<td>571</td>
</tr>
</tbody>
</table>

GPHC

<table>
<thead>
<tr>
<th>Blood Group</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed Red Cell</td>
<td>1130</td>
</tr>
<tr>
<td>Whole Blood</td>
<td>41</td>
</tr>
<tr>
<td>Platelets</td>
<td>2</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>133</td>
</tr>
<tr>
<td>Cryo.</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>1328</td>
</tr>
</tbody>
</table>

NBTS

<table>
<thead>
<tr>
<th>Blood Group</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed Red Cell</td>
<td>431</td>
</tr>
<tr>
<td>Whole Blood</td>
<td>22</td>
</tr>
<tr>
<td>Platelets</td>
<td>0</td>
</tr>
<tr>
<td>Fresh Frozen Plasma</td>
<td>59</td>
</tr>
<tr>
<td>Cryo.</td>
<td>59</td>
</tr>
<tr>
<td>Total</td>
<td>571</td>
</tr>
</tbody>
</table>
Overview of Issued and Non-issued units

- Issued units: 571
- Not Issued units: 757
- Request cancelled: 482
- Filled & not issued: 86
- Shortage before accounting for returned & reissued units: 168
- Actual shortage: 52

Shortage Calculation

(Calculated Shortage) 52 + (Calculated Demand) 543 = 8.7% shortage

Guyana total collections, 2007: 7.3 units per 1,000 population
WHO recommendation: 10-20 units per 1,000 population per year

Limitations

- Limited data: 1 month only (November, 2007)
- Seasonal disease/injury trends
- Variations in blood collection patterns
- Data represents GPHC
- Other local hospitals not included
- Not nationally representative
- NBTS collections only included

Lessons Learned

- 7.3 units collected per 1,000 population resulted in an 8.7% shortage
- Blood collection requirements recommendations should include capacity to conduct transfusions
- Recommendations should account for stock management (to reduce wastage)
Acknowledgements

- Guyana NBTS
  - Clem McEwan
  - Olwyn John
  - Bonita Richards
- CDC
  - Claudette Harry
  - LaMar Hasbrouck
  - Nicolette Henry
  - Lawrence Marum
  - John P. Pitman

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

Questions/Discussion
Level of Resources to Ensure Safe Blood in Africa

Pamela Rao
Associate Director, Global Health and Development Strategies
Social & Scientific Systems, Inc.
Working Group 2—SSS and AABB

Challenges

Paucity of relevant empirical data in Africa
- Data on current capacity of BTS to collect, test, process and distribute blood. What proportion of the current need is met?
- Population in need of Safe Blood – epidemiology of disease conditions that require Safe Blood transfusion
- Current access of this group to health services and potentially to Safe Blood when needed
- Obtaining available cost for Safe Blood strategy, particularly in the presence of multiple funding sources...
  Forecasting scale-up costs for national programs in the absence of data – almost impossible...
  Hence, a model-based approach...

...and it became “2-7-10 24/7” job!!

Comparative Analysis of Methods

- WHO Method 3, Module 1 (Requirement of blood units = ~2% of population)
- GOALS Model—Costing guidelines for HIV/AIDS strategies
- RDM/UNGASS Model

Strengths of RDM Approach

- Relatively simple modeling approach
- Resource estimation for individual HIV/AIDS intervention rather than resource optimization across several interventions
- Population-based estimates therefore, addresses the magnitude of safe blood problem in the country
- Health system performance— access to health services and potentially access to safe blood
- Allows for cost of scaling up therefore, addresses unmet need
- Internationally accredited—3 pieces of work (WB-MAP, UNGASS, & Tx & Care)

Principal Steps Involved in the Model

- Establishing the size of populations that are at greatest need and will benefit from Safe Blood strategy – Target Group
- Proportion of Target group that has access to health services – Potential Target Group (PTG). Using PTG to determine current and future levels of coverage.
- Estimating costs using project level cost data to scale up programs to desired coverage levels and or feasible coverage levels.

RDM Adapted for BTS
Factors Considered in Choosing Sample Countries

- Strength of blood program, country-specific health system performance indicator, Human Development Index (HDI)
- Size of population, HIV prevalence, Malaria status
- Geographic representation (East, South, West Africa)
- Representation of 4 organizational models for BTS

BTS Composite Indicator

- HDI (life expectancy, literacy, GDP)
- Health System Performance Indicator (WHR 2000)
- BTS indicator
  - Policy variables (25%)
  - Operations variables (50%)
  - Quality systems variables (25%)

Size of Population, HIV Prevalence, and Malaria Status

<table>
<thead>
<tr>
<th>Country</th>
<th>Population (of 40,000)</th>
<th>HIV/AIDS—Adults (15–49 years old)</th>
<th>Ratio</th>
<th>Malaria Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d' Ivoire</td>
<td>Centralized</td>
<td>16.94</td>
<td>7%</td>
<td>Stable</td>
</tr>
<tr>
<td>Kenya</td>
<td>Regionalized</td>
<td>32.90</td>
<td>6.7%</td>
<td>Unavailable</td>
</tr>
<tr>
<td>Mozambique</td>
<td>Hospital-based</td>
<td>19.11</td>
<td>12.2%</td>
<td>Stable</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Hospital-based</td>
<td>128.74</td>
<td>5.4%</td>
<td>Stable</td>
</tr>
</tbody>
</table>

Geographic Representation

Centralized/national: One national center controls the services for the whole country with or without regional centers
Regionalized: Regional centers operate with some autonomy, with degree of national control
Hospital-based: Each hospital runs its own services with or without coordination at national level
Mixed: Combination of hospital-based and some regional and national coordination (incomplete coverage)

Sample Countries for Varied Analysis

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity</th>
<th>Geographic Location</th>
<th>Organizational Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d’Ivoire</td>
<td>Rel. strong</td>
<td>W. Africa</td>
<td>Centralized National</td>
</tr>
<tr>
<td>Kenya</td>
<td>Medium</td>
<td>E. Africa</td>
<td>Regionalized</td>
</tr>
<tr>
<td>Mozambique</td>
<td>Weak</td>
<td>S. Africa</td>
<td>Mixed</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Weak</td>
<td>W. Africa</td>
<td>Hospital-based</td>
</tr>
</tbody>
</table>
Providing a Model to Estimate the Level of Resources for Safe Blood

1. Identifying target group requiring Safe Blood

Sources to Identify the Target Groups

- Country-specific literature review of published and grey literature
- Preliminary analysis of ongoing large study on use of blood in Cote d’Ivoire
- MOH applications and TA providers baseline assessment report, if available

Conditions Requiring Blood Transfusion in Rank Order

- Pediatric anemia (severe 8g/dL+), maternal iron deficiency, iron-deficient diets, malaria, intestinal helminthes, low birth weight babies (<2,500g)
- Maternal severe anemia (WHO Criteria: Hemoglobin concentration <7.0 g/dl)
- Postpartum hemorrhage
- Shock/trauma/burns (accidents etc.)
- Elective surgery
- Adult anemia (elderly – 64 years – GI bleeds etc.)
- Others

Target Groups Requiring Safe Blood in Africa

- Children under 5
- Pregnant women
- Population with severe adult anemia (women and men)
- % of population undergoing elective surgery
- % of population undergoing trauma, shock and burns
- Others

Country-Specific Anemia Rates

<table>
<thead>
<tr>
<th>Country</th>
<th>Children &lt;5</th>
<th>Kenya</th>
<th>Mozambique</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Côte d’Ivoire</td>
<td>65.5%</td>
<td>60.0%</td>
<td>79.6%</td>
<td>69.2%</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>45.9%</td>
<td>46.7%</td>
<td>52.3%</td>
<td>51.7%</td>
</tr>
<tr>
<td>Women</td>
<td>40.0%</td>
<td>40.0%</td>
<td>40.0%</td>
<td>40.0%</td>
</tr>
<tr>
<td>Men</td>
<td>30.0%</td>
<td>30.0%</td>
<td>30.0%</td>
<td>30.0%</td>
</tr>
</tbody>
</table>

Source:
1 UNICEF. State of the Children 2006
2 IFPRI- Harvest plus
3 WHO/NHD/01.3. Iron deficiency anemia: Assessment, prevention, and control
Estimating the Target Group Size Likely to Be Transfused—Severe Anemia Rates as proportion of those anemic

<table>
<thead>
<tr>
<th>Anemia in children &lt; 5 years</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anemia in pregnant women</td>
<td>20%</td>
</tr>
<tr>
<td>Low birth weight (based on annual number of live births)</td>
<td>20%</td>
</tr>
<tr>
<td>Shock/trauma/burn/elective surgery</td>
<td>15%</td>
</tr>
<tr>
<td>Anemia in women (15-64 years)</td>
<td>3%</td>
</tr>
<tr>
<td>Anemia in men (15-64 years)</td>
<td>2%</td>
</tr>
</tbody>
</table>

Size of the Target Group—Population-Based Estimates

<table>
<thead>
<tr>
<th>Country</th>
<th>Côte d’Ivoire</th>
<th>Kenya</th>
<th>Mozambique</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children &lt;5</td>
<td>1,798,240</td>
<td>3,340,200</td>
<td>2,262,528</td>
<td>14,414,500</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>50,000</td>
<td>677,374</td>
<td>402,187</td>
<td>2,751,991</td>
</tr>
<tr>
<td>Low birth weight</td>
<td>112,370</td>
<td>132,200</td>
<td>115,050</td>
<td>745,200</td>
</tr>
<tr>
<td>Shock/trauma/ burns/surgery</td>
<td>295,373</td>
<td>745,300</td>
<td>500,300</td>
<td>2,062,678</td>
</tr>
<tr>
<td>Women</td>
<td>1,465,000</td>
<td>2,363,200</td>
<td>1,491,050</td>
<td>11,470,000</td>
</tr>
<tr>
<td>Men</td>
<td>1,446,000</td>
<td>2,337,800</td>
<td>1,446,000</td>
<td>10,036,000</td>
</tr>
<tr>
<td>Total population of country (in millions)</td>
<td>16.94</td>
<td>32.08</td>
<td>19.11</td>
<td>125.74</td>
</tr>
</tbody>
</table>

Size of Target Group—Conservative Estimates—Why?

- Age group: 5–15 not covered
- There seems to be significant proportion of men receiving blood in CI—more research is required
- Population attributable fraction of adult malaria due to HIV with HIV prevalence of 8% among adults is about 5% for clinical malaria
- Population attributable fraction of adult malaria due to HIV with HIV prevalence of 30% among adults is about 35% for clinical malaria
- Shock, trauma, surgery is likely to be more
- Overall number could be 10–25% more

Triangulating Population-Based Target Size Data with Demand for Blood by Target Group

- Literature review
- CI blood use study
- MOH applications, if available

Proportion of Total Demand for Safe Blood Among Target Groups

- 50–60% children under 5
- 15–20% maternal
- Small % low birth weight babies
- 2–5% adult anemia
- 12–16% elective surgery, shock/trauma/burns
- Remaining for other causes
Triangulating Target Group Data With Available Country-Specific Data on 'dd'

<table>
<thead>
<tr>
<th>Country</th>
<th>Côte d’Ivoire</th>
<th>Kenya</th>
<th>Mozambique</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children &lt;5</td>
<td>46.4%</td>
<td>45.16%</td>
<td>47.33%</td>
<td>46.19%</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>16.15%</td>
<td>16.70%</td>
<td>16.12%</td>
<td>17.04%</td>
</tr>
<tr>
<td>Low birth weight</td>
<td>3.56%</td>
<td>4.62%</td>
<td>4.78%</td>
<td></td>
</tr>
<tr>
<td>Shock/burns/</td>
<td>11.70%</td>
<td>15.14%</td>
<td>12.30%</td>
<td></td>
</tr>
<tr>
<td>surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>12.02%</td>
<td>10.92%</td>
<td>10.92%</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>7.30%</td>
<td>7.41%</td>
<td>5.97%</td>
<td>6.71%</td>
</tr>
<tr>
<td>Total population of country (in millions)</td>
<td>16.94</td>
<td>32.98</td>
<td>19.11</td>
<td>125.74</td>
</tr>
</tbody>
</table>

Providing a Model to Estimate Level of Resources for Safe Blood

1. Identifying target groups
2. Estimating size of target groups in Africa
3. Estimating total PTG that may require blood transfusion (i.e., proportion of the target group with access to health care services)

Proxy Indicators to Estimate Target Groups Access to Health Services—Composite Indicators

For children
- Proportion of children who had completed the final immunization dose for diphtheria, pertussis, tetanus (DPT3)
- % of children <5 with fever receiving anti-malarial drugs
- % of children < 5 with acute respiratory infections (ARIs) seen by a health worker

For pregnant women
- % of pregnant women who receive antenatal care—4 visits
- % of women giving birth who were attended by skilled health personnel at birth

Access to Health Services

For Shock/Trauma/Burns, Surgery, and Adult Anemia
- Access to hospitals from published literature

Composite Indicators Used

<table>
<thead>
<tr>
<th>Country</th>
<th>Côte d’Ivoire</th>
<th>Kenya</th>
<th>Mozambique</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children &lt;5</td>
<td>46.00%</td>
<td>49.00%</td>
<td>47.20%</td>
<td>20.60%</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>67.45%</td>
<td>56.30%</td>
<td>57.60%</td>
<td>62.80%</td>
</tr>
<tr>
<td>Low birth weight</td>
<td>40.80%</td>
<td>49.60%</td>
<td>47.20%</td>
<td>20.60%</td>
</tr>
<tr>
<td>Shock/burns/</td>
<td>21.00%</td>
<td>15.80%</td>
<td>19.20%</td>
<td>20.00%</td>
</tr>
<tr>
<td>surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>21.00%</td>
<td>15.80%</td>
<td>19.20%</td>
<td>20.00%</td>
</tr>
<tr>
<td>Men</td>
<td>21.00%</td>
<td>15.80%</td>
<td>19.20%</td>
<td>20.00%</td>
</tr>
</tbody>
</table>

* Composite Indicator
** Hospital Utilization Indicator

Country-Specific Estimates of PTGs

<table>
<thead>
<tr>
<th>Country</th>
<th>Côte d’Ivoire</th>
<th>Kenya</th>
<th>Mozambique</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children &lt;5</td>
<td>75,163</td>
<td>105,074</td>
<td>111,748</td>
<td>441,079</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>40,029</td>
<td>72,233</td>
<td>46,532</td>
<td>250,610</td>
</tr>
<tr>
<td>Low birth weight</td>
<td>15,159</td>
<td>13,114</td>
<td>10,912</td>
<td>45,607</td>
</tr>
<tr>
<td>Shock/burns/</td>
<td>9,304</td>
<td>17,687</td>
<td>14,409</td>
<td>85,880</td>
</tr>
<tr>
<td>surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>10,176</td>
<td>14,046</td>
<td>10,462</td>
<td>68,177</td>
</tr>
<tr>
<td>Men</td>
<td>6,029</td>
<td>8,005</td>
<td>5,725</td>
<td>41,898</td>
</tr>
<tr>
<td>Total PTG</td>
<td>150,206</td>
<td>291,403</td>
<td>193,288</td>
<td>873,245</td>
</tr>
</tbody>
</table>

Total population of country (in millions) | 16.94 | 32.98 | 19.11 | 125.74 |
Results—Magnitude of the Problem

Providing a Model to Estimate Level of Resources for Safe Blood

1. Identifying the TGs in Africa
2. Estimating the size of TG that may require blood transfusion
3. Developing country-specific estimates of PTG with health access needing transfusion
4. Determining average requirement of blood for each PTG to estimate requirement of blood for PTG

Average Number of Blood Units Per Case

<table>
<thead>
<tr>
<th>Target group</th>
<th>Number of blood units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children &lt;5</td>
<td>0.5</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>2.5</td>
</tr>
<tr>
<td>Low birth weight</td>
<td>0.5</td>
</tr>
<tr>
<td>Shock/trauma/ burns/surgery</td>
<td>3</td>
</tr>
<tr>
<td>Women</td>
<td>2.5</td>
</tr>
<tr>
<td>Men</td>
<td>2</td>
</tr>
</tbody>
</table>

Total Number of Blood Units Required for PTG in a year

<table>
<thead>
<tr>
<th>Country</th>
<th>Total blood units</th>
<th>Men</th>
<th>Shock/trauma/ burns/surgery</th>
<th>Low birth weight</th>
<th>Pregnant women</th>
<th>Children &lt;5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Côte d’Ivoire</td>
<td>212,506</td>
<td>12,146</td>
<td>22,804</td>
<td>7,579</td>
<td>53,052</td>
<td>26,156</td>
</tr>
<tr>
<td>Kenya</td>
<td>375,452</td>
<td>17,310</td>
<td>53,052</td>
<td>6,557</td>
<td>109,562</td>
<td>35,114</td>
</tr>
<tr>
<td>Mozambique</td>
<td>275,383</td>
<td>11,451</td>
<td>43,226</td>
<td>5,456</td>
<td>70,526</td>
<td>35,114</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1,461,727</td>
<td>83,784</td>
<td>257,641</td>
<td>43,226</td>
<td>700,526</td>
<td>257,641</td>
</tr>
<tr>
<td>Total population of country</td>
<td>16.94</td>
<td>32.98</td>
<td>19.11</td>
<td>125.74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Magnitude of the Problem—Base Year 2004
Growth Rates

- Preliminary Base Growth Factor was calculated by assuming that the growth factor for all countries for Sub-Saharan Africa (SSA) would range from a minimum of 0.1 to a maximum of 0.2.
- The minimum growth factor of 0.1 was assigned to the average per capita income of SSA countries with lower per capita income < $750. The maximum to per capita income > $4,000.
- Growth factors for all countries between the lowest income and highest income groups were calculated by linear interpolation between 0.1 and 0.2 based on their per capita income relative to the average per capita income of the lowest group to the average of the highest group.

Adjusted Growth Factor

- It has been observed that factors other than per capita income influence performance of health systems and potential expansion of BTS.
- To adjust the base growth factors for other factors, we estimated regression equations expressing the coverage for DPT as a function of GNI per capita and calculated the ratio of observed coverage to predicted coverage. This ratio as a proportion was used to adjust the base growth factor.

BTS Growth Factor

- We assumed the number of safe blood units provided would increase in 2005 by 30% in Kenya and by a growth rate in the other three countries in the same ratio to 30% as each country’s adjusted growth factor is to Kenya’s adjusted growth factor.
- The BTS growth factor (G) is defined as the proportion of unmet need newly covered in 1 year. If \( A_t \) is the proportion of unmet safe blood need that has been met in year \( t \), then \( A_t = A_{t-1} + (1 - A_{t-1}) \cdot G \).

Projecting Expansion of Blood Transfusion Services Capacity

Assumptions:
- Changes to BTS occur slowly over time—Max. 30% increase in capacity
- Total need for safe units of blood (base year) will not change during projection period i.e. increase in access to health care will potentially increase “dd” for Safe Blood

Providing a Model to Estimate Level of Resources for Safe Blood

1. Identifying the TGs in Africa
2. Estimating the total TG that may require blood transfusion
3. Estimating the size of PTG with health access needing transfusion
4. Determining average requirement of blood for each PTG to estimate requirement of blood for PTG
5. Projecting growth over the next years
6. Applying unit cost of safe blood to estimate level of resources

Determining Unit Cost of Safe Blood

1. WHO cost projections by Working Group 1
2. Current cost of Safe Blood from the current operating budget in Cote d’Ivoire
3. Consultation and personal communication with Emergency Plan TA providers
4. Literature review – published and unpublished documents
Blood Transfusion Costs

BLOOD TRANSFUSION SERVICE
Costs Allocated by Activity

<table>
<thead>
<tr>
<th>Total Costs</th>
<th>Blood Donor Recruitment</th>
<th>Blood Collection</th>
<th>Blood testing &amp; Processing</th>
<th>Blood Storage &amp; Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital costs</td>
<td>Capital costs</td>
<td>Capital costs</td>
<td>Capital costs</td>
<td>Capital costs</td>
</tr>
<tr>
<td>Recurrent costs</td>
<td>Recurrent costs</td>
<td>Recurrent costs</td>
<td>Recurrent costs</td>
<td>Recurrent costs</td>
</tr>
</tbody>
</table>

Cost of 1 unit of whole blood (recurrent) - CI
- Recruitment donor (communication, vehicles etc.: food for the donors)
- Collection (materials, pouches, cold chain...)
- Lab testing (HIV, Hep B, Hep C, Syphilis, - labels, cost of additional test kits)
- Processing (production)
- Storage & Cold chain, Distribution
- Fixed cost - QA, Informatics, administration, logistics, incineration, maintenance buildings and equipment
- Personnel - salaries

Total recurrent cost per unit of safe blood (21500 CFA = $40

Country-Specific Unit Cost (recurrent) Applied in the Model

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d’Ivoire</td>
<td>$40</td>
</tr>
<tr>
<td>Kenya</td>
<td>$30</td>
</tr>
<tr>
<td>Mozambique</td>
<td>$30</td>
</tr>
<tr>
<td>Nigeria</td>
<td>$25</td>
</tr>
<tr>
<td>WHO</td>
<td>$20</td>
</tr>
<tr>
<td>WHO economic CNTS, CI</td>
<td>$45-50</td>
</tr>
<tr>
<td>CNTS, CI</td>
<td>$50</td>
</tr>
</tbody>
</table>

Assumptions – Scenario 1
- The requirement of safe blood for potential target group (with access to HS) as projected with base year (2004) BTS capacity will remain constant
- The number of safe blood units provided would increase in 2005 by 30% in Kenya, and by a growth rate in the other three countries in the same ratio to 30% as each country’s adjusted growth factor is to Kenya’s adjusted growth factor
- The increase in safe blood units in absolute number from year 2004 to 2005 will remain constant for the projected years
- Recurrent cost of safe unit of blood in CI=$40, Kenya & Mozambique=$30 and Nigeria=$25

Results Table – Scenario 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Need for blood</th>
<th>BTS Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d’Ivoire</td>
<td>100,000</td>
<td>120,000</td>
</tr>
<tr>
<td>Kenya</td>
<td>150,000</td>
<td>195,000</td>
</tr>
<tr>
<td>Mozambique</td>
<td>200,000</td>
<td>260,000</td>
</tr>
<tr>
<td>Nigeria</td>
<td>250,000</td>
<td>325,000</td>
</tr>
</tbody>
</table>

Assumptions – Scenario 2
- The requirement of safe blood for potential target group (with access to HS) as projected with base year (2004) BTS capacity will remain constant
- The number of safe blood units provided would increase in 2005 by 30% in Kenya, and by a growth rate in the other three countries in the same ratio to 30% as each country’s adjusted growth factor is to Kenya’s adjusted growth factor
- The same proportion of the unmet need for BTS in each country that was met in 2005 would be met in each year of the remainder of the projection period. This constant proportion is called the BTS growth factor
- Recurrent cost of safe unit of blood in CI=$40, Kenya & Mozambique=$30 and Nigeria=$25
Results Table – Scenario 2

<table>
<thead>
<tr>
<th>Level</th>
<th>Resources needed for 4 countries (2006-2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost of Blood (at $40/unit) per year</td>
</tr>
<tr>
<td></td>
<td>US Dollar (in millions)</td>
</tr>
<tr>
<td></td>
<td>2006</td>
</tr>
<tr>
<td></td>
<td>Cote d'Ivoire</td>
</tr>
<tr>
<td></td>
<td>Kenya</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
</tr>
<tr>
<td></td>
<td>Mozambique</td>
</tr>
</tbody>
</table>

Capital Cost Budgeting

Projected 2010 capacity e.g. 189,000 units of safe blood – Existing capacity 89,000 = 100,000 additional.

Assuming the existing BTS has reached its optimum capacity and any additional capacity will require capital investment, we estimated $1m of capital investment for a regional bank with a capacity of 20,000 units.

$1m includes building, 2 vehicles, cold chain equipments, lab equipments, beds, centrifuges, informatics and training cost.

Total Costs—Recurrent + Capital Costs

Factors to consider in other scenarios

- Increase in population over 2006-2010 will increase ‘dd’
- Unprecedented international efforts for HIV/TB/Malaria will result in health system strengthening that will increase access to health care services, and potentially ‘dd’ for blood.
- Increase in anemia rates in a high prevalence HIV population where ART strategy has been implemented in large scale.
- Increase on clinical Malaria cases in high prevalence HIV populations
- Success of Malaria efforts may decrease demand for safe blood.
Points for Discussion and Recommendations

- There is a desperate need for complete and accurate data for better planning, budgeting, and forecasting resources required to ensure Safe Blood in African countries.
- Strengthening Safe Blood supply in isolation without an understanding of levels of development in health system in the country should be avoided. Strengthening should be coherent to the level of sophistication in the overall health system.
- Major international efforts such as Roll Back Malaria, Safe Motherhood Initiative, and Family Planning can help avoid risks in transfusion by decreasing demand for Safe Blood in Africa.

Points for discussion

- Increase in HIV among adult population will decrease the potential supply of safe blood and increase the 'dil' for blood due to increase in clinical malaria among HIV positive (Mozambique) and anemia resulting from ART (Botswana)
Tools for Estimation of Blood Needs

**Need:** An estimation of the amount of blood to meet the transfusions requirements of the population according to current guidelines, best practices and policies.

**Demand:** The amount of blood that would be transfused if all prescriptions for blood were met. Demand may be appropriate or inappropriate.

**Unmet Demand:** The amount of blood that is needed but not met due to inappropriate practices.

**Use:** The actual amount of blood currently transfused. Use may be appropriate or inappropriate.

**Unprescribed needs:** The amount of blood that is not needed and therefore not transfused.

**Current Health System Needs:**
- BTS/Hospital Capacity
- Clinical Use/ Evidence Base
- Health System
- Supply

**Population Needs:**
- Use
- Appropriate
- Inappropriate

**Data Sets Needed**

**Resources Needed**
Process Forward
Objective:

To provide resources that will assist authorities to estimate the current and future blood transfusion needs for patients treated in their health systems.

Need

The amount of blood that would be used if all those patients who could benefit* from transfusion were recognised and if blood was prescribed according to appropriate guidelines.

*All those patients who could benefit* implies 100% access to health services but where access to the health system is restricted to a part of the population, need is in effect limited to those who have access.

Demand

• This term may reflect numerous additional factors such as the reliability of the blood supply and delivery system, relationships between clinic and blood bank etc, etc

Need, use and demand

Quantity to met need
Optimum prescribing and use
[Conditioned by access to care]
Use
Observed quantity actually transfused OR
Surrogate for transfused – eg delivered
Demand
Observed quantity that is requested from blood providers

Target population composed of

Groups of patients at risk of transfusion GPAR
[Groups of patients needing blood, GPNB]

Patients at risk of transfusion
Defined as:

Patients with conditions that may require blood transfusion, but for whom transfusion may be avoided by preventive or alternative interventions

Identifying target population 1

Case definitions could be built around…

Age /gender
   Over 80
   Under 5 in high incidence malaria zone
Combination of diagnosis and intervention
HIV or HAART
Diagnosis
ICD 10
Intervention
OPCS
Specialty – based
Surgery, pediatrics
DRG
Geography or Institution
Identification of target populations 2

- From existing sources in country or countries with similar demography etc
- Primary data collection
- Professional consensus
- Published or grey literature
- Burden of disease databases
- New systematic reviews may be needed

Size of the target populations

Incidence, Prevalence

- Sources of epidemiological data
- Burden of disease data
- Review the RAO model in detail

Data on blood use for target populations

- From existing sources in country or countries with similar demography etc
- Primary data collection
- Professional consensus
- Published literature

Data sets and definitions for describing hospital blood use

Is supply sufficient?
- Georgetown model,

Which conditions receive how much blood?
- Zambia model

How many patients per time period?

Examples of practical guidance, training materials

- Sources of existing data – where to look
- Practical issues in accessing data
- Recording
- Analysing
- Uncertainty…importance of factoring in
- Estimates how to develop and use
- Worked examples

Worked example

Maternity
- Haemorrhage
- Other deliver complications
- Puerperal sepsis
- Maternal anaemia
Maternity
Data Items

• Deliveries/year
• Number with APH, PPH
  – Proportion with MH that bleed in hospital or reach hospital alive and potentially resuscitatable OR
  – Number of MH patients who each hospital
  – Proportion who need transfusion
  – Units of blood used per patient with MH who is transfused
• Number of patients having C section
  – Proportion needing blood
  – Quantities of blood needed