WHO Experts' Consultation on Estimation of Blood Requirements

03 - 05 February 2010, WHO-HQ, Geneva

Meeting report

World Health Organization

Summary

Robust methods to estimate blood transfusion requirements are needed to plan and evaluate systems of blood provision. Existing methods for estimating national blood requirements are either not sensitive to reflect the dynamic nature of blood needs in the health care system, or are difficult to apply due to the lack of required data. As a consequence, the WHO convened an experts' consultation to review experience from developed and developing countries and plan a way forward. The specific outputs from the meeting were consensus definitions of components of blood requirement and the outline of a document describing a toolkit to guide blood providers in the estimation of blood requirements.

Background

National planners and providers of blood for transfusion need to know how much blood is required for their populations and where and when it is needed so that blood is neither under- or over-supplied. If the blood supply is inadequate then this may result in the death or disability of patients requiring a blood transfusion. On the other hand, a surplus of blood may result in the outdating of blood products, which represents a waste of resource that is both expensive to produce and donated in the expectation that it will be used. Furthermore, the supply of blood should be equitable such that access to blood for transfusion is irrespective of age, gender or socio-economic status.

In recent years and especially since the emergence of HIV, there has been renewed focus on the importance of access to safe blood in the delivery of essential health care. In many developing countries perceived as having an inadequate or unsafe blood supply this has led to the expansion of existing models of blood provision or the establishment of a national blood transfusion service *de novo*. Under these circumstances, estimations of blood requirement are essential for health planners and funders to establish both the current and future capacity required. These are essential for the design of appropriate models of blood provision, their costing, and the evaluation of progress towards providing an adequate blood supply.

Despite the longstanding recognition of the importance of the estimation of blood transfusion requirements, progress in the development of practical methods to do so has been slow. For this reason, the Blood Transfusion Safety team of the WHO convened an experts' consultation to review what is currently known on the topic, to share their experiences in different settings and to decide the direction of future activity. A list of participants and their institutions is given in Annex 3.

Objectives

The objectives the consultation is to:

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

The programme of work of the consultation, which consisted of expert presentations and group work, is attached as an annex (Annex 2). The presentations were varied and covered the following areas:

1. Clinical drivers of blood transfusion and potential sources of secondary data
2. The perspective from developing countries (Guyana, Honduras, Africa)
3. The perspective from high-income countries (Canada, Quebec, US, Scotland, Hong Kong SAR)

Assumptions and definitions

Throughout this document blood transfusion requirements refer to red blood cell (RBC) or whole blood. This is based on the assumption that RBC or whole blood transfusion to correct anaemia and/or haemorrhage is the most frequent indication for blood transfusion. In countries where component preparation is undertaken then satisfying the requirement for RBC should satisfy that for other components such as platelets or plasma. Furthermore, it was anticipated that any models or tools developed for estimating blood transfusion requirements could be simply adapted for a specific component (or components).

An important output of the consultation was the development of a practical definition of blood transfusion requirement. Three components of blood transfusion requirement were identified: current use, current demand, and population need. The differences

between these terms, the relationships between them and how these relationships may alter in different settings are crucial. These definitions are described and represented graphically in the Outcomes section below and should be referred to before reading the rest of this document.

Key points from presentations

An overview of the presentations is given below.

Clinical drivers of blood transfusion

One approach to understanding and estimating blood transfusion requirements is to identify the clinical conditions and/or interventions for which a blood transfusion may be necessary. If the frequency of these is known in a particular population over a specified period of time, and the volume of blood required per transfusion episode is also known then theoretically the total volume of blood required can be estimated.

Clinical drivers of blood demand are heterogeneous both within and between countries and are influenced by epidemiological, ecological, geographical, socio-economic and health system factors. It is clear that the clinical drivers of transfusion in developed countries (malignancies and vascular surgery) are very different from those in developing countries (see below).

Clinical driver data is not routinely used in high-income countries to forecast blood transfusion demand (see below). Indeed, in the experience of the participants, transfusion services do not routinely collect this data. However, in Scotland a system has been introduced to try and merge transfusion and clinical data to understand demographic, socioeconomic and epidemiological influences on blood use (McClelland). It is anticipated that as well as better defining current use of blood, this data may be used to predict future demand. Furthermore, it allows variations in clinical practice to be identified and critically reviewed.

High-resolution data on blood use in developing countries is even more limited but it is known that, in terms of numbers of transfusions, young children and women of

reproductive age are major consumers of blood. Examples of important clinical drivers of transfusion in these groups are malaria, complications related to pregnancy and nutritional anaemias.

In those countries affected by it, *malaria* (particularly falciparum malaria) is an important clinical driver of transfusions in young children and where it is endemic and seasonal or epidemic underpins a temporal component to demand for blood. It was noted that there is evidence emerging of a decline in falciparum malaria in sub-Saharan Africa and that this is resulting in a parallel reduction in paediatric blood transfusions. This observation was backed up by data from Zambia in a later presentation and, in itself, is good evidence of the effect of a clinical driver on transfusion requirement.

Acute haemorrhage is implicated in a high proportion of *pregnancy-related* deaths in developing countries (34% in Africa; 31% in Asia; 21% in Latin and America and the Caribbean) and blood transfusion is one of the 9 signal functions of comprehensive emergency obstetric care. It is estimated that 28 deliveries in a 1000 require a transfusion for ante-partum haemorrhage, postpartum haemorrhage or puerperal sepsis. In addition blood is often required for newborn care especially in pre-term infants and in the management of sepsis and haemorrhagic disease of the newborn.

The burden of chronic anaemia in a community is likely to be an important clinical driver of transfusion and *micronutrient deficiencies* will be an important contributor to this. These may be specific e.g. iron or folate deficiency, or as part of general malnutrition. There are established databases of nutritional anaemia prevalence e.g. VMNIS (Vitamin and Mineral Nutritional Information System), which may be of use in determining blood transfusion requirements as part of a disease burden approach. Other acquired and inherited causes of chronic anaemia, such as helminth infection and haemoglobinopathies may also need to be considered as potential drivers of transfusion. Estimates of the frequencies of such conditions may already be spatially defined.

In certain specific instances i.e. civil or military conflict and major natural disasters, *trauma* may be a major clinical driver of blood transfusion. However, even in the

absence of these, injuries related to road traffic accidents, and self-inflicted and inter-personal violence are an important and increasing cause of death and disability particularly in young people. Haemorrhage is a leading cause of trauma death and is managed widely with blood transfusion although the evidence guiding the most appropriate use of blood (who should get it and how much) is not strong.

An important element of an epidemiological approach to determining blood requirements at the population level is the incidence of those conditions for which a blood transfusion may be needed. It is likely that in many cases there will be existing sources of data (secondary data) from which such data can be extracted. One such is the WHO's Global Burden of Disease (GBD) which prepares cross-national statistics on mortality and burden of disease. Like all such databases it is dependent on the quality of primary data with which it is provided and an important aspect of such aggregate data is the estimation and communication of uncertainty. This has important lessons for an epidemiological approach to estimating blood requirements.

The perspective from developing countries

The disease burden or clinical driver approach to estimating blood transfusion requirement has been tried to some degree in a number of developing countries. These efforts involved a number of common steps including: defining population or patient groups 'at risk of transfusion'; defining the frequency of these within a population; defining the proportion that requires a transfusion and the volume of blood required per transfusion.

In developing countries, where clinical and epidemiological data are few, experience suggests that populating these models is challenging. In Honduras- a small country with a single blood transfusion centre- clinicians were consulted using a Delphi process to attempt to define those *conditions* for which blood transfusion was most commonly indicated. The frequency of these conditions in the hospital population was estimated by a random sampling of clinical notes.

In Africa, Rao used a population approach in a resource determination model in four countries (Nigeria, Kenya, Cote d'Ivoire, Mozambique). In this case 'target groups' for transfusion were defined by age and gender through literature review and some facility-based primary data from Cote d'Ivoire. These 'target groups' were then further refined to take into account the proportion needing a transfusion and with access to health care services. The total blood requirement was then calculated by factoring in the number of units per transfusion by adjusted target group.

This approach to estimating blood requirement produced a figure of 1.48 million units for Nigeria for 2004 (the base year). The total number of blood donations at facilities in the same country in 2006, when BTS donations were few, was estimated to be 1.78 million. This figure was arrived at by enumerating donations at a sample of facilities, calculating the average number of donations per facility type per year and then multiplying by the total number of facilities by type.

Experience presented from Guyana cautioned that crude measures of demand for blood such as clinician requests might considerably inflate perceived blood requirements. At the main hospital, which consumes 80% of the national blood supply, 91.3% of demand was met with a population donation index of only 7.3 units per 1000 population. However the situation outside this main facility could not be taken into consideration.

Any disease burden approach to estimating blood requirements has to take into account changes in epidemiology, which may occur rapidly. In Zambia there is good evidence that the use of blood for paediatric transfusions at district hospitals is declining coincidentally with improved coverage of malaria control measures including bed nets, indoor spraying and effective pharmacological treatment. This change has occurred within a few years and highlights the need for recent data.

As well as changes in disease epidemiology, health service changes may also impact on blood transfusion requirement. A potential example of this is the possibility of an expansion of comprehensive obstetric services (including caesarean section and blood transfusion) to all first referral hospitals and health centres.

Experience from Zambia supports that from Guyana, Honduras, Nigeria and Kenya in that patterns of current blood use suggest that large, urban referral hospitals may be have a considerable influence on the blood requirements of an entire country.

The perspective from developed countries

Expert presentations from several developed countries highlighted major differences between the estimation of blood transfusion requirements in countries which currently have an adequate blood supply compared to those which do not. In developed countries, with mature and sophisticated blood transfusion services, current requirements for blood are met (current demand and population need are closely matched) and forecasting future requirements involves making adjustments to that baseline figure. There is no unmet and/or unknown demand or need and this fundamentally alters the process.

With regard to the consideration of clinical drivers of transfusion, it was apparent that this is not an approach that is used to forecast blood requirements in developed countries. Indeed blood transfusion services do not tend to know how and why blood is used as their 'clients' are facilities and not patients. Furthermore, it is of note that there is considerable (perhaps twofold) difference in RBC utilization between countries with similar population structure, availability of interventions, *and disease burden*. These differences are probably explained by differences in health systems and cultural differences in the training/ prescribing of clinicians although this phenomenon has not been explored in any detail.

In shorter term forecasting, blood transfusion services in developed countries can use detailed historical data of supply (units shipped) to predict incremental increases in demand (time series analysis). Although more complex forecasting methods can be used (e.g. exponential smoothing, Autoregressive integrated moving average (ARIMA)), which give greater weight to more recent historical data, they do not seem to perform better than simpler methods. This 'top-down' approach may be complimented by the 'bottom-up' where facilities are canvassed for their views on changes in blood use although

experience suggests that facilities also make formal or informal use of historical data/trends.

Undoubtedly the main driver of longer-term change (increases) in blood requirement in developed countries is change in population. This can be modelled by describing current blood use by age and applying this to predictions of future population size and structure. The development of new medical interventions may also impact on future blood requirement in developing countries but these are harder to predict and may in fact serve to reduce the need for blood transfusion as well as potentially increase it.

Outcomes

Definitions of blood requirement

In all health systems a proportion blood transfusions may be inappropriate. The first two definitions below include these transfusions which, however unnecessary, still create a demand for blood and cause blood to be transfused.

Current use of blood

The current use of blood for transfusion is the number of units of whole blood or RBC consumed by a defined number of facilities over a defined period of time (usually one year). This includes blood transfused for emergencies and elective procedures and also any wastage due to unused blood and/or outdating. Thus current blood use reflects disease burden, health services offered (facility factors), access to health care and prescribing practice (including inappropriate transfusions). It may also be constrained by inadequate supply. If the number of facilities is greater than one, then current use of blood will have a spatial component driven by the disease burden of the catchment population and facility factors such as facility type and services available. Disease burden (e.g. malaria) and/or facility factors (e.g. a visiting surgeon) may also introduce a temporal component to current blood use. Where a single provider (e.g. a national service) supplies all blood, current use will match the blood issued to all facilities by this provider. In countries without a national service or with a mixed system, current use will include units from facility-based blood banks or other sources (e.g. private providers).

Current demand for blood

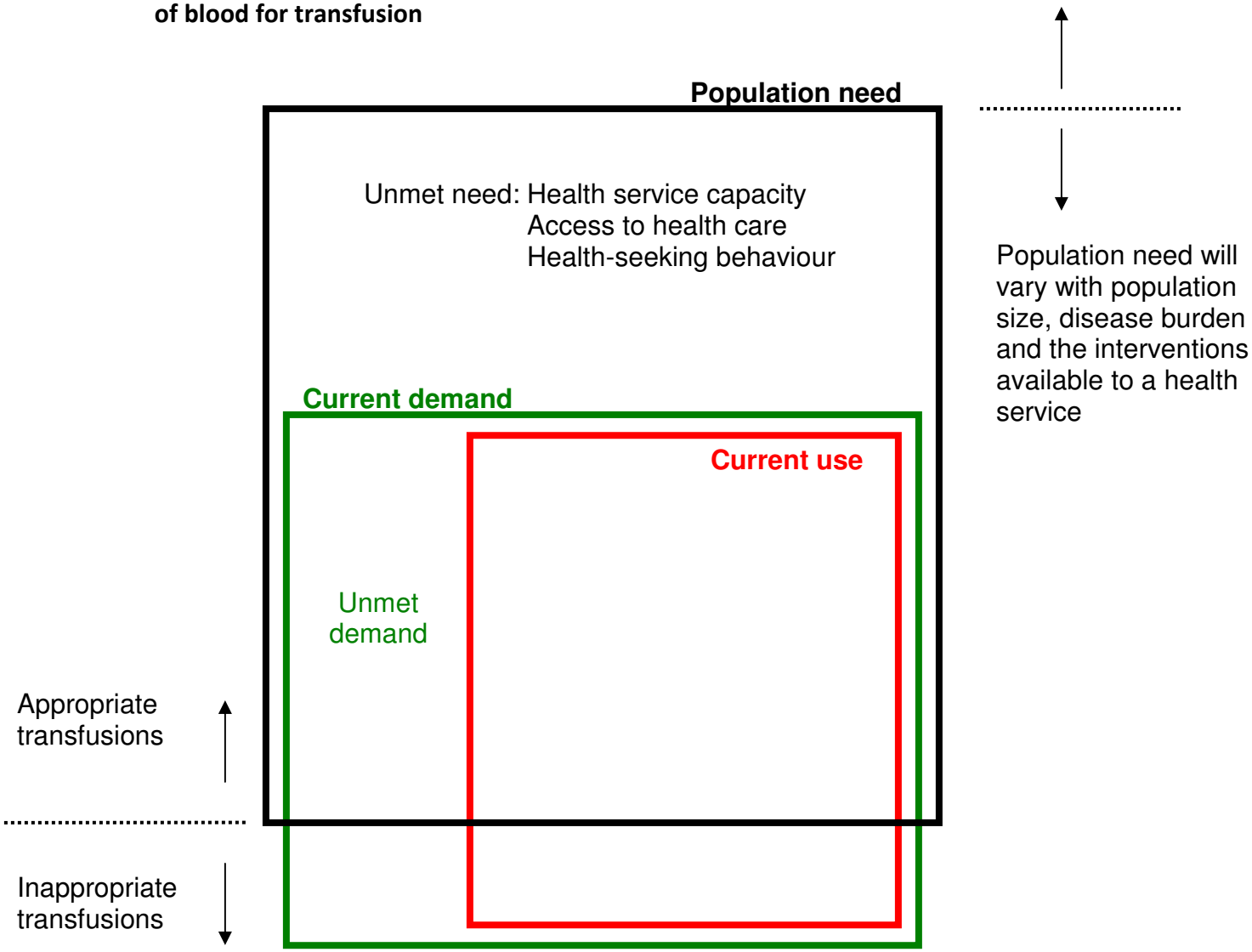
The current demand for blood is the number of whole blood units required to meet all confirmed requests for blood transfusion for emergencies and elective procedures at a defined number of facilities over a defined period of time (usually one year). Thus current demand reflects disease burden, health services offered (facility factors), access to health care and prescribing practice but is not directly affected by inadequate supply. As with current use, if the number of facilities is greater than one, then current demand for blood will have a spatial component driven by the disease burden of the catchment populations and facility factors such as facility type and services available. Seasonal disease burden and/or facility factors may also introduce a temporal component to current demand. In developed countries current demand will closely match current use and supply; in developing countries there may be unmet demand, which will have a cost in terms of death (unmet demand for emergency transfusions) and disability (unmet demand for transfusions for elective procedures). If the magnitude of the unmet demand and the demographic profile of those affected are known, its cost may be quantified in Years of Life Lost (YLL) or Disability Adjusted Life Years (DALY).

Population need for blood

The number of whole blood units that would be required to transfuse all individuals who require a blood transfusion in a defined population (usually a nation) over a defined time period (usually one year). This includes transfusions for emergencies and for those elective procedures that are provided by the health service that serves that population. Population need, therefore, reflects the disease burden of a population and the health care interventions available to that population but assumes universal access to the health service. Within populations, need for blood will have a spatial component as disease burden and/or population density is likely to be heterogeneous. For populations in developed countries with good access to health care and a sufficient blood supply with little wastage, the population need for blood will closely match what is supplied by blood providers and used in facilities. For populations in less developed countries, the unmet population need for blood includes, but is likely to exceed, the unmet demand

(as defined above). Contributing factors to unmet need in excess of unmet demand include lack of health service capacity and less than universal access to health care. The population need for blood (and its spatial distribution) is a key measure for health service planners and policy makers.

Figure 1. The relationship between *population need*, *current demand* and *current use* of blood for transfusion



Conclusion and the next steps

As a result of the meeting it became clear that it was extremely unlikely that a simple 'one size fits all' model or formula could predict blood transfusion requirements in all settings. As such, it was felt that a more appropriate output would be the justification for and description of a variety of approaches in a ‘toolkit’.

Annex 1

AGENDA

1. Opening Session
    - Welcome and introduction of participants
    - Objectives of the consultation, adoption of agenda and programme of work
2. Session 1: Blood requirements in Health System
    - Estimating blood requirements: search for a global standard
    - Global burden of disease and general approaches to unbiased and comparable health estimates
    - Requirements of blood and blood components for management of malaria, maternal health and care, trauma care, and Management of micronutrient deficiency, including anaemia
3. Session 2: Review of Existing Methodologies for Estimating Blood Requirements
    - Nigeria and Kenya
    - Zambia
    - Héma-Québec
    - Honduras
    - Scotland
    - Canadian Blood Services
    - Hong Kong SAR, China
    - Guyana
    - USA
    - Others
4. Developing a Model for Estimating Blood Requirements (Group Work)

• Key parameters to be considered while developing a model

5. Summary of discussions and recommendations
6. Next steps
7. Conclusion

Annex 2

Programme of Work

Day 1 - Wednesday, 3 February 2010		
Opening Session		
09:00 – 09:30	Welcome Introduction of participants Objectives of the consultation Adoption of agenda and programme of work Selection of Chair and Rapporteurs	Dr Neelam Dhingra
Session 1: Blood Requirements in Health Systems		
09:30 - 10:00	Estimating blood requirements: search for a global standard	Dr Neelam Dhingra
10:00 - 10:30	Global burden of disease and general approaches to unbiased and comparable health estimates	Dr Gretchen Stevens
10:30 - 11:00	Break	
11:00 - 11:30	Requirements of blood and blood components for management of malaria	Dr Peter Olumese
11:30 - 12:00	Requirements of blood and blood components for maternal health and care	Dr Matthews Mathai
12:00 - 12:30	Requirements of blood and blood components for trauma care	Dr Pablo Perel
12:30 - 13:00	Requirements of blood and blood components for management of micronutrient deficiency, including anaemia	Dr Luz Maria De Regil
13:00 - 14:00	Lunch	
Session 2: Review of Existing Methodologies for Estimating Blood Requirements		
14:00 - 14:30	Nigeria and Kenya	Dr Christie Reed
14:30 - 15:00	Zambia	Dr Lawrence H. Marum
15:00 - 15:30	Héma-Québec	Dr Francine Décary
15:30 - 16:00	Break	

16:00 - 16:45	Summary of needs assessment study in Honduras Epidemiology of transfusion in Scotland	Dr Brian McClleland
16:45 - 17:30	Discussion	
17:30	Summary of day 2	Chairperson
Day 2 - Thursday, 4 February 2010		
08:30 – 09:00	Report of day 1 and discussion	Rapporteurs
09:00 - 09:30	Canadian Blood Services	Mr Tony Steed
09:30 - 10:00	Hong Kong	Dr Che-Kit Lin
10:00 - 10:30	United States of America	Dr Jerry Holmberg
10:30 - 11:00	Break	
11:00 - 11:30	Guyana	Dr Sridhar Basavaraju
11:30 - 12:00	Estimating blood requirement	Dr Oliver Hassall
12:00 - 12:30	TBD	
12:30 - 13:00	TBD	
13:00 - 14:00	Lunch	
Session 3: Developing a Model for Estimating Blood Requirements		
14:00 – 15:.30	Key parameters to be considered while developing a model health system and clinical parameters feasibility of collecting data for these parameters possible models for consideration datasets and databases available definitions Parking lot- ABO distributions, pedipack etc	2 groups
15:30 - 16:00	Break	
16:00 - 17:00	Continued	
17:00	Summary of day 2	Chairperson
Day 3 - Friday, 5 February 2010		
08:30 – 09:00	Report of day 2 and discussion	Rapporteurs
09:00 - 10:30	Presentations and discussion on group work	Group rapporteurs
10:30 – 11:00	Break	

Session 4: Recommendations and next steps		
11:00 - 12:30	Summary of discussions and recommendations	Chair
12:30 - 13:00	Next steps - steps in developing the model - defining responsibilities - pilot testing	
13:00 - 14:00	Lunch	
14:00 - 15:00	Conclusion	

Annex 3

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