

## Assessing the pattern of blood supply and demand for the copperbelt province of Zambia

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### Abstract

The purpose of the study was to assess the pattern of whole blood supply and demand for the Copperbelt province of Zambia. The Zambian National Blood Transfusion Services (ZNBTS) regional office was selected as the institution of study, being the only institution mandated by law to collect and supply blood transfusion products on the Copperbelt. Descriptive quantitative research design was employed. The sample size included four senior ZNBTS employees working at the regional office in Kitwe. Data was collected using a structured questionnaire and analyzed using a statistical package called SPSS. The study findings reviewed that the highest quantity of whole blood was supplied in 2015 and further review of the data indicated that the highest and lowest quantities of whole blood were supplied in the second and third quarters of 2015. The average blood supply rate was also highest in 2015 at 7.8. The standard deviation for the mean quantity of whole blood supplied in 2015 was 4,587 with SD of 750 while the median quantity of whole blood supplied was 4,388 and IQR of 3,373 to 5,040. The mean quantity of blood supplied were highest in 2015 (4,587) and lowest in 2013 (4,117). The means of whole blood collected in 2013, 2014, 2015 and 2016 were computed and compared using ANOVA F-Test and revealed that they were not statistically different (P-Value 0.724). Analysis of whole blood supply and demand for the period 2013-2014 revealed the deficit of blood supply of approximately one-quarter and ranged from 22.3% to 29.6%. There was no statistically significant trends in the deficit in whole blood supply (P-Trend = 0.785). Further, the Copperbelt Province appear to have recorded a drop in the blood wastage in 2015 (16.3%), the year when the highest quantities of blood were collected, the trend in the percentage of blood wasted was not statistically significant (P-Trend = 0.334). The overall wastage of blood due to blood transfusion transmissible infections (HBV, HCV, HIV and Syphilis) under the study period was 19.1%. During the 2013-2016 periods more than three-quarters of the blood suppliers (donors) were in the 18-24 years age group and 24-44 years age group. The percentage of females donating blood ranged from 31.6% in 2013 to 37.4% in 2015. The main recommendation that emerged from the study is that Ministry of Health should encourage both widespread hospital-based systems and centralized blood donation services using non-remunerated voluntary repeat blood unit suppliers. It was further recommended to conduct a follow up study on estimation of the cost of the unit of whole blood or its components for Zambia and lobby ministry of health policy makers for inclusion of blood banking data into the hospital based health information system.

**Keywords:** blood samples, blood demand, blood supply

### 1. Introduction

#### 1.1 Background of the Study

Over the last twenty years, despite the Zambia national blood transfusion service (ZNBTS) benefiting greatly from donor support, it has been faced with the challenge of shortage of blood supply. In order to address the blood supply deficit through donor support, the country has been able to establish modern decentralised ZNBTS model based on the centralised western model that is recommended by the world health organisation (WHO) (Tapko, Toure and Sambo, 2010: 8) [23]. During the last twenty years, the ZNBTS has established state of the art regional blood transfusion services in nine provinces. Currently, there are plans to set up the tenth unit in Muchinga, which is a new province. The nine regional ZNBTS units were set up with support from the European Union (EU) under the European Development Fund (EDF) between 1994 and 1999 under the social sector support programme.

The main feature of the ZNBTS is the use of volunteer non-remunerated whole blood unit suppliers who walk in with or without an appointment or during whole blood supply camp

sessions. The supplied blood is then processed for clinical use in both government and private facilities with emphasis on equity of access to adequate and safe blood transfusion products and quality delivery of health care services (WHO, n.d.) [32]. Implementation of the WHO recommended model which focus on supply of adequate, high quality and safe blood transfusion products across the country in all government and private health facilities has operational and implementation challenges. Currently, blood transfusion services are supplied, when indicated at no extra cost to the patient. In other words, supplied blood transfusion products are not for sell in Zambia. Although the national whole blood supply deficit has been steadily declining over the years, the demand for blood transfusion products currently is more than what is supplied and varies across the country. For planning and budgeting purposes, the blood transfusion demand for Zambia is estimated at 1% of the population as recommended by WHO. So far, the country has been failing to meet the 1% population based demand estimated by the WHO. Furthermore, the demand for Zambia is a moving target because it is dependent on the type of medical and surgical

procedures performed, gross domestic product and disease pattern.

On-going modernisation and improvement of health care services, high prevalence of blood transmissible infections and high operational costs of the decentralised blood banking approach further worsen the blood supply deficit. In Africa, it is important to have good policies that mitigate against high mortality rates due to the blood supply deficit (Ala, *et al.*, 2012) [4]. According to the WHO (2005) [27], it costs \$2 million to prevent one transfusion related HIV infection. Therefore, it is the duty of each country to ensure that adequate investment is available to support the supply quality and safe blood transfusion services. Due to competing public health and clinical service priorities, the high cost of investment in blood product processing may be viewed as a burden on the health sector. In many countries, the level of investment in blood transfusion services and the supply of safe blood products depend on the gross domestic product (Mafirakureva, *et al.*, 2016) [15]. The supply of quality, safe and adequate blood transfusion products is an expensive but necessary cost to any health care system. Due to high operational costs of implementing and managing the ZNBTS, the ministry of health (MoH) has over the years been planning strategically to reduce the blood supply deficit and improve the sustainability of the ZNBTS by reducing the dependence on donor funding through improved government funding and implementation of efficient governance and management systems for health care service delivery. Therefore, it is very important to assess the whole blood supply and demand on the Copperbelt province, which is home to a population of 2,420,678 Zambians (CSO, 2012:33) [8].

### 1.2 Statement of the problem

Zambia developed the national health strategic plan (NHSP) (MOH, 2010) [18] which focused on reducing maternal, neonatal, child, malaria and trauma related morbidity and mortality through on-going modernisation and improvement of health care services including adequate supply of safe blood transfusion products (Tapko, Toure and Sambo, 2010: 6) [23]. Current performance indicators, show that the ZNBTS model of blood transfusion service has significantly reduced the blood transfusion product supply deficit over the years, although the demand for blood transfusion products has always exceeded blood supply. ZNBTS is now able to collect over 100,000 units annually compared to 40,000 units collected in 2004 (Malama, 2015) [16]. In order to make the ZNBTS more sustainable, the ZNBTS should reduce the blood supply deficit and dependence on donor support through increased local funding. The ZNBTS uses planning and costing estimates from WHO as this information is not available locally. Further, the demand for blood transfusion services over the years has been increasing and is related to the quality of health service delivery in the country. Failure to satisfy the market is common in many regional blood-banking institutions (WHO, 2005) [27]. Therefore, there was need to accurately assess the blood transfusion service demand and the current blood supply deficit for the Copperbelt province. This information is important for accurate blood supply and demand service planning and budgeting purposes. The study therefore sought to address the above identified knowledge gap. Assessing the blood transfusion service supply and demand shall also ensure implementation of sustainable

interventions that should guarantee that the country does not have a significant annual blood supply deficit.

### 1.3 Research Objectives

- To establish the age and gender of whole blood suppliers (donors) on the Copperbelt
- To assess the blood supply pattern on the Copperbelt province
- To estimate the wastage of supplied blood due to infectious contamination
- To determine the demand of blood transfusion services on the Copperbelt province

### 1.4 Significance of the study

Despite the current major advances in medical and laboratory science research, whole blood transfusion (red blood cells (RBC)) products cannot be manufactured to date and can only be supplied by human beings. Many times, patient clinical care and treatment interventions are delayed because of inadequate blood supply in developing countries. This contributes not only to increased morbidity and mortality but also to increased costs of treatment partly due to increased period of hospitalisation of patients because of blood shortage. Therefore, it is important for the health systems' managers to appreciate the pattern of supply and demand of this scarce and life-saving commodity (Sun and Abraham, 2012) [2]. In emergency situations, shortage of blood products in health facilities is a well-known life threatening risk factor (Ala, *et al.*, 2012) [4]. Further, blood transfusion services remain an important public health intervention in Africa where shortage or supply of unsafe blood adversely affects morbidity and mortality rates in the region (Bloch, Vermeulen, and Murphy, 2012) [6]. The pattern of blood supply and demand information is also useful for lobbying communities, health care partners and other key stakeholders as the ministry of health (MoH) becomes more innovative in implementation of PPP in order to ensure sustainable, adequate, quality and safe blood transfusion services in Zambia. The blood supply deficit information is also very useful in long term planning and budgeting as well as informing health policy. ZNBTS has in the past faced many challenges that include donor dependence and blood supply deficit. It is therefore important that evidence based blood supply and demand information be made available as this will contribute to more sustainable, efficient and effective planning and budgeting processes for the ZNBTS. Currently ZNBTS depends on WHO estimates when planning for its midterm expenditure framework (MTEF) which may not be accurate for Zambia. Further, it will help the ZNBTS employ mechanisms to reduce the blood supply deficit and dependence on donor support. This shall ensure quality health service delivery because the blood transfusion service supply and demand shall be matched with the demographic profile, modernisation and improvement of health service delivery and disease pattern prevailing in the country. Due to the on-going modernization and improvement of health care service delivery, there is need to have local evidence for better program planning, implementation and management. Therefore, this study has provided additional information that shall be used to strategically plan and budget for blood transfusion services in Zambia.

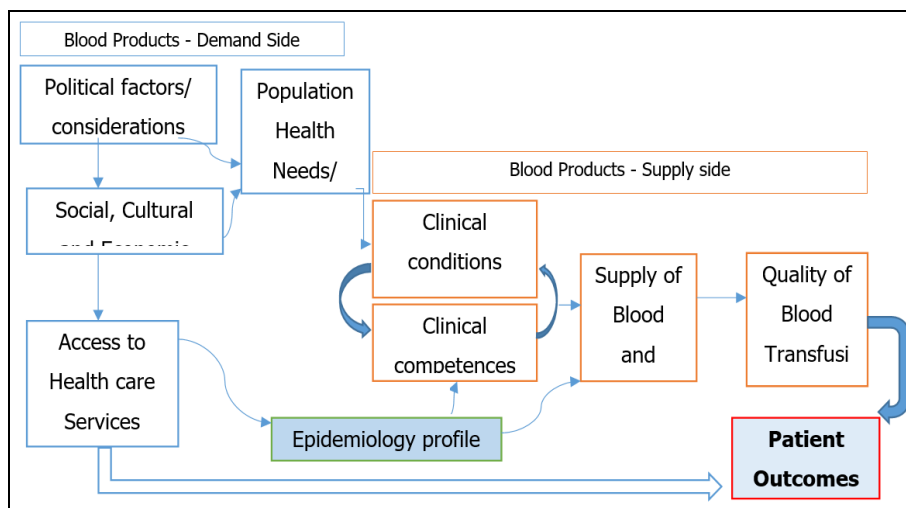
### 1.5 Limitations of the study

Many studies related to the supply and demand of blood transfusion products have been done in the past with results showing varying estimates for supply and demand for blood transfusion products. This was applicable to this study and could be attributed to research limitations such as urban rural settings, differences in demographic profile, GDP, aims, objectives, scope and methodology applied to assess the blood supply and demand pattern of blood transfusion services. This study been retrospective in nature presented challenges of access to the required documents given that most of the information was not computer based. Therefore, some vital records such as hospital records for blood transfusion product

requests were not available for inclusion in this study. Additional data was obtained from blood bank management records at the regional office. Despite this set up been urban rural in nature, generalisation of results should be done with caution.

### 1.6 Conceptual framework

The conceptual framework is an account of how key variables are interlinked with each other. This study focused on the conceptualization of the blood transfusion product supply and demand. The figure below depicts the blood supply and demand relationship.



Source: [http://www.who.int/bloodsafety/transfusion\\_services/estimation\\_presentations.pdf](http://www.who.int/bloodsafety/transfusion_services/estimation_presentations.pdf)

Fig 1

As the figure above shows, there is a direct relationship between patient blood transfusion supply and demand and epidemiology, social, cultural and economic conditions. Other factors that affect patient blood product supply and demand include scientific advances, clinical conditions, political considerations and access to available health care services.

## 2. Literature Review

### 2.1 Global Perspective

Globally, annual whole blood unit supplies are approximately 92 million. Though the developing countries account for 15% of the global whole blood unit supplies, more than 50% of the global whole blood unit supplies are in the developed world. The WHO has set targets to achieve voluntary non-remunerated blood unit supplies globally by 2020. The level of average annual whole blood unit supplies per blood collection center is closely related to the level of economic development with high, mid and low income countries supplying 30, 000, 7, 500, and 3, 700 whole blood units respectively (WHO, 2012) [29]. The American Red Cross collects 14% of all supplied whole blood units from the age group 16 – 18 years (Eder et al, 2012) [11]. In order to maintain and sustain the quality of clinical care services, it is important that the blood supply deficit is well managed and is within acceptable limits. Further, the right quantities and types of blood products should be available at all times in health facilities (McCullough, 1996) [17] and that the current not for profit business model of whole blood supply should

implemented as recommended by WHO (Whitsett, Vaglio, and Grazzini, 2012) [25].

Many times, patient clinical care and therapeutic interventions are delayed and this contributes to increased costs of clinical care partly due to increased period of hospitalization of patients. In emergencies, shortage of blood products in health facilities is a well-known life threatening risk factor (WHO, 2008) [28]. In 2013, globally, 289,000 women died during pregnancy and childbirth with sub-Saharan Africa contributing 62% (179,000) deaths (WHO, UNICEF, UNFPA, 2014) [30]. Severe bleeding was the main cause of death globally, accounting for 27.1% of the maternal deaths (Say, et al., 2014) [20]. Complicated malaria also causes severe anemia and contribute up to 20% maternal and 15% pediatric deaths in sub Saharan Africa (WHO, 2003) [26]. The current modernization and improvement of health facilities and service delivery with the accompanying performance of more complicated medical and surgical procedures and increasing life expectancy have contributed to the increased demand for blood products globally. Equity of access to quality, safe blood transfusion products is attributed partly to WHO insistence on 100% quality assurance and insurance and testing of all supplied blood while emphasizing 100% non-remunerated whole blood supplies (WHO, 2008) [28]. This achievement is possible as in the case of the Sri Lankan programme and can be explained by a well-coordinated national blood transfusion service, efficient community participation and mobilization (The Jakarta Post, 2014) [24]. The major contributor to the cost of blood is the need

to screen blood for blood transfusion transmissible infections (TTIs) such as HIV/AIDS and Hepatitis viruses (HBV and HBC).

## 2.2 Regional Perspective

In sub-Saharan Africa, women and children utilize most of the supplied blood transfusion products. The blood transfusion in women is mostly due to post-partum hemorrhage (PPH) and consequently about 100,000 maternal deaths are due to failure to manage this complication. A poorly functioning blood transfusion service could globally result in 16 million HBV, 5 million HCV and 160,000 HIV infections annually according to the WHO (WHO, 2005) [27]. Therefore, ensuring equity of access to cost effective, quality and safe blood transfusion services is a key element of any health system strengthening approach.

## 2.3 Zambian and Local Perspective

Zambia has a high burden of blood transfusion transmissible infections (TTIs) due to high prevalence of HIV/AIDS, Hepatitis and Syphilis infections. The prevalence of infection with hepatitis B virus (HBV) among adults aged between 15 and 59 years is higher among those who are HIV-positive (7.1%) compared to those who are HIV-negative (5.4%) while the HIV prevalence in the same age group is 12.3 percent (MoH, 2016) [19]. Therefore, the MOH has invested significantly in infrastructure, equipment, human resource and transport for ZNBTS in order to ensure supply of adequate, cost effective, quality and safe blood transfusion services in the country. The supply of quality and safe blood is not cheap and is estimated to be \$2 million for prevention of one HIV/AIDS transfusion related infection (WHO, 2005) [27].

Despite the major advances in medical and laboratory science research in the recent past, blood transfusion products cannot be manufactured to date but can only be supplied by human beings. Therefore, it is important for the health systems' managers to appreciate the supply and demand of this scarce life-saving commodity (Abraham and Sun, 2012) [1]. The blood supply deficit in Zambia varies from season to season and the worst times are when the schools are on holiday. This is because the majority of non-remunerated blood donors are school going children. In the recent past, developing countries have improved the supply of safe and quality blood transfusion products, although the supply deficit is still a concern. The most common conditions that demand for blood transfusion include anaemia, trauma, pregnancy and malaria (Whitsett, Vaglio, and Grazzini, 2012) [25]. Among adult men aged 15 – 59 years, injury was the main cause of death with road traffic accidents accounting for 25% of these deaths (WHO, 2016) [31]. There are several methods of assessing the blood transfusion service supply and demand proposed by the World Health Organisation. According to the WHO (2005) [27], an estimation of blood products supply could be based on the ratio of one unit of whole blood per ten admitted patients in the facility. Currently, the Zambia national blood transfusion service supply and demand is estimated at 150,000 units per year, or about 1% of the population (for low-income countries). Another population based method of estimating the blood transfusion requirements targets 2% of the population for mid income countries (WHO, n. d.) [32].

## 2.4 The economics of blood supply and demand

The most important concept of market economics is the supply and demand of products and services. The quantity of the product or service desired by buyers is the demand while the offer created by the market is the supply of the product or service. The supply of blood transfusion products is determined by the cost of production, which includes costs of inputs such as labour, capital and consumables. Although blood supply deficit is common globally, appropriate blood product quality and safety factors are also dependent on the gross domestic product (GDP), production costs and settings (WHO, 2005) [27]. The cost of production depends on the technology deployed in the processing and testing of blood transfusion products. For example, the US is one of the few countries where nucleic acid amplification tests are done for detecting infections such as HIV because this comes at a huge cost to the country (WHO, 2005, Mafirakureva, *et al.*, 2016). [27, 15] Other determinants of blood transfusion products supply include the number of available suppliers and the future expectations about the demand for blood transfusion products. The determinants of demand for blood transfusion products include the potential clients, which is the number of health facilities providing this service, level of available clinical expertise, epidemiological profile and the coverage population. The cost of blood transfusion product substitutes, life expectancy, access and quality of available health care services also determine the level of demand for blood transfusion products. The usage of blood transfusion services increase with age of patients, with patients who are older than 70 years using 46% and patients who are less than 30 years using 10% of the total blood transfusion products supplied respectively. In the UK, during the year 1999, blood transfusion product usage was estimated to cost 2 million pounds (Currie, *et al.*, 2007) [9]. The aging population has increased the demand for blood transfusion products globally. In Canada, over 53% of red blood cell (RBC) transfusions were done in people over the age of 70 years (Drackley *et al.*, 2012) [10].

## 3. Research Methodology

### 3.1 Research Design

This study was a quantitative research. Data collection in this study was done using questionnaires. The study was retrospective in nature and covered the period of four years from 2013, 2014, 2015 and 2016. Quantitative research is defined as research that is used when variables can be measured in terms of quantity while qualitative research is applicable to qualitative phenomenon that relate to quality. Descriptive research is concerned with the description of the state of affairs, as it exists.

### 3.2 Target population

The study drew its target participant population from the ZNBTS regional blood bank office in Kitwe. Selected participants included management, accounting, laboratory and information staff. The selected staff were purposefully selected as they deal with blood transfusion transactions and operations regularly at senior management and decision-making level. The required target sample size was therefore composed of one institution (ZNBTS regional office in Kitwe) and four senior members of staff from this institution.

### 3.3 Study Size

The research sample size was determined correctly in order to achieve statistical significance. Using too large a sample size is expensive while too small a sample size would result in a study been underpowered (Suresh and Chandrashekar, 2012) [21]. The sampling and sample size for this study is tabulated below.

Table 1

Institutional Sampling Frame	Sample Population	Sample Size
Zambia National Blood Transfusion Services – Regional Office	4	4
Totals	4	4

### 3.4 Sampling techniques

A purposefully selected health sector community used as a sample in this study included Copperbelt based ZNBTS regional office. The ZNBTS regional office based in Kitwe is the only institution that is mandated by law to supply blood transfusion products on the Copperbelt. This study sample was representative to the population for other parts of the country as well. In this study, the participating institution and officers were conveniently sampled. The selected sample was statistically representative of the whole population as the only available institution in the province participated in this study. The sample in convenient sampling is selected on the basis of the convenience of the investigator and in this study, the respondents were selected because they were at the right institution, management appointment and time during the study (Acharya, *et al.*, 2013) [3].

### 3.5 Instruments for data collection

In this study, data was collected by the principle investigator and his assistant using management records and structured questionnaires. A review and analysis of published content in journals and other printed materials was also conducted. Validity and reliability of data gathered was dependent on careful and informed selection of study instruments (Bastos, *et al.*, 2014) [5]. A questionnaire is a very common instrument for data collection and in this study; information was collected using a structured questionnaire. The written questionnaire had structured questions that helped to support information gathering from the sampled participants. Advantages of using questionnaires include its simplicity and easiness when collecting data from scattered participants within a short space of time (Tashakkori and Teddlie, 2003: 306) [22]. Questionnaires also have disadvantages that include the fact that responses may lack some details while some respondents may omit some information (Annum, 2016). In this study, management records were also used to collect data. Records may be defined as statistical and none statistical information that are kept by institutions that are used to support the day-to-day management transactions and decisions.

### 3.6 Procedure for data collection

The study employed one method of collecting data. The structured questionnaires were used for data collection. The institutional management records were also used during data collection. The questionnaires were distributed and administered on the spot by the researcher and his assistant

during the data collection process. Questions that required time for information gathering were addressed during the second visit, two weeks after the initial visit. The researcher also capacity built his assistant with some research techniques before collecting the data.

### 3.7 Data analysis

The Statistical analysis package called SPSS was use to analyze quantitative data Ccollected through questionnaires. The advantage of using the statistical package is that it helps to describe and summarize the data and make it presentable in form of tables and graphs. Graphical data presentation makes data interpretation easier.

### 3.8 Ethical considerations

As much as this study is expected to contribute to the body of knowledge, it is purely meant for academic purposes as well as to inform policy formulation. Therefore, all participates participated voluntarily and had an option to opt out and data collected was treated with utmost confidentiality. The collected information and results from this study will not be made public without explicitly authority from the ministry of health permanent secretary through the national research council of Zambia. Ethic approval has been approved by the TDRC ethics committee.

## 4. Data Presentation

Table 2: Quantities of whole blood units supplied (or donated) annually on the Copperbelt province

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
2013	4,708	5,021	3,614	3,126	16,469
2014	5,496	2,929	4,888	3, 521	16,834
2015	4,500	5,653	3,920	4,275	18,348
2016	3,844	5,962	2,793	4,439	17,038
Total	18,548	19,565	15,215	15,361	68,689

Source: Field Data 2017

Table 2 shows the distribution of the quantities of whole blood supplied on the Copperbelt province for the period 2013-2106 for the first, second, third and fourth quarters of each year considered. The quantities of whole blood supplied were overall lowest in 2016 at 16,469. Table 2 also shows that the quantity of whole blood supplied was lowest in the fourth quarter at 3,126 and highest in the second quarter at 5,021. The highest quantity of whole blood was supplied in 2015 and further review of the data indicated that the highest and lowest quantities of whole blood were supplied in the second and third quarters of 2015.

Table 3: Measures of variability central tendency for quantity of blood supplied on the Copperbelt province for the years 2013-2016

Year	Total	Mean	SD	Median	IQR
2013	16,469	4,117	894	4,161	3,494 to 4,786
2014	16,834	4,208	1,187	4204	3,373 to 5040
2015	18,348	4,587	750	4,388	3,373 to 5,040
2016	17,038	4,260	1,323	4,142	3,581 to 4,820

Source: Field Data 2017

Table 3 shows the summary statistics for the quantities of whole blood supplied on the Copperbelt Province for the

period 2013-2016. The mean and median quantity of whole blood collected in 2013 was 4,117 and 4,161, respectively. The standard deviation (SD) for the mean quantity of whole blood supplied was 894 while the inter-quartile range (IQR) for the median quantity of whole blood supplied was 3,492 to 4,786.

For the year 2015, the mean and median quantity of whole blood collected was 4,117 while the median quantity of whole blood supplied was 4,161. The standard deviation for the mean quantity of whole blood supplied in 2015 was 4,587 with SD of 750 while the median quantity of whole blood supplied was 4,388 and IQR of 3,373 to 5,040. The mean quantity of blood supplied was highest in 2015 and lowest in 2013.

The means of whole blood collected in 2013, 2014, 2015 and 2016 were computed and compared using ANOVA F-Test and revealed that they were not statistically different (*P-Value* 0.724). Further comparison of means between years was performed and multiple comparisons of means at 95% family-wise confidence level accounted using the Turkey HSD correction strategy. Table 3 reveals that the differences in the means of whole blood between years were not statistically significant.

**Table 4:** Pair-wise differences between group means comparisons

Year-Specific Means Comparisons	Difference in Means	P-Value
2014-2013	91	>0.05
2015-2013	469	>0.05
2016-2013	142	>0.05
2015-2014	378	>0.05
2016-2014	51	>0.05
2016-2015	-327	>0.05

Source: Field Data 2017

**Table 7:** Total amount of whole blood supplied (donated) that is discarded after laboratory screening

Type of Test	Year of Blood Collection				
	2013	2014	2015	2016	Total testing Positive
Syphilis - Positive	765	819	911	877	3372
Percentage of Syphilis Positive	4.6	4.9	5.0	5.1	
HCV - Positive	661	503	426	582	2172
Percentage of HCV Positive	4.0	3.0	2.3	3.4	
HBV - Positive	875	1011	827	843	3556
Percentage of HBV Positive	5.3	6.0	4.5	4.9	
HIV - Positive	1020	1296	818	879	4013
Percentage of HIV Positive	6.2	7.7	4.5	5.2	
Total Positive result (Syphilis; HIV; HBV and HCV)	3321	3629	2982	3181	13113
Percentage Positive result (Syphilis; HIV; HBV and HCV)	20.2	21.6	16.3	18.7	19.1
Total Tested	16469	16834	18348	17038	68689

Source: Field data 2017

Table 7 shows that the overall wastage of blood due to blood transfusion transmissible infections (HBV, HCV, HIV and Syphilis) was 19.1%. The lowest proportion of blood discarded due to HBV positive status was 4.5% in 2015 and highest was 6.0% in 2014. The lowest proportion of blood discarded due to HCV positive status was 2.3% in 2015 and

**Table 5:** Distribution of blood supply for the Copperbelt province for the period 2013-2016

Year (s)	Blood Demand	Blood Supplied	Deficit in Blood Supplied	Percentage (%)
2013	22498	16464	6034	26.8
2014	23053	16834	6219	27.0
2015	23622	18348	5274	22.3
2016	24207	17038	7169	29.6

Source: Field Data 2017

Table 5 shows the whole blood demand and supply for the period 2013-2014 and reveals the deficit of blood supply of approximately one-quarter and ranged from 22.3% to 29.6%. There was no statistically significant trends in the deficit in whole blood supply (*P-Trend* = 0.785). The demand for blood is computed using the 1% population estimate.

**Table 6:** Total blood available for use in blood transfusion annually

Year	Total Blood Supplied	Total Blood wasted	Total Blood Used	Percentage of Blood wasted
2013	16469	3321	13148	20.2
2014	16834	3629	13205	21.6
2015	18348	2982	15366	16.3
2016	17038	3181	13857	18.7

Source: Field data 2017

Table 6 shows the year-specific whole blood demand, supplied and wastage. Copperbelt Province appear to have recorded a drop in the blood wastage in 2015, the year when the highest quantities of blood were collected, trend in the percentage of blood wasted was not statistically significant (*P-Trend* = 0.334). Blood wasted was due to blood contamination by transfusion transmissible infections that included HBV, HCV, HIV and Syphilis.

highest was 4.0 in 2014. The lowest proportion of blood discarded due to HIV positive status was 4.5% in 2015 and highest was 7.7% in 2014. Table 7 also shows that the percentage of blood discarded due to positive syphilis status did not change markedly during the period 2013-2016.

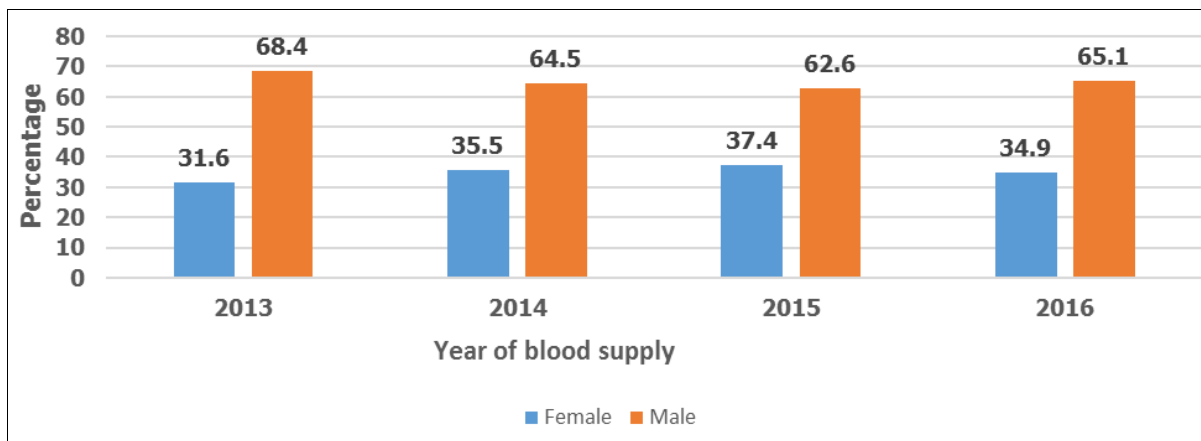
**Table 8:** Number of annual whole blood suppliers (donors) according to gender and age group

Age Group	Gender	2013	2014	2015	2016
<18	Male	3010	320	841	1335
	Female	1157	150	251	1000
Total		4167	470	1092	2335
Percent of Female		27.8%	31.9%	23.0%	42.8%
18-24	Male	5829	8227	9416	7320
	Female	2828	3762	5551	3540
Total		8657	11989	14967	10860
Percent of Female		32.7%	31.4%	37.1%	32.6%
25-44	Male	1921	2170	1080	1925
	Female	1021	1973	940	998
Total		2942	4143	2020	2923
Percent of Female		34.7%	47.6%	46.5%	34.1%
45-64	Male	444	102	114	452
	Female	165	70	90	361
Total		609	172	204	813
Percent of Female		27.1%	40.7%	44.1%	44.4%
>64	Male	66	42	43	63
	Female	31	18	22	44
Total		97	60	65	107
Percent of Female		32.0%	30.0%	33.8%	41.1%
Total Number of Female		5202	5973	6854	5943
Total Number of Donors		16472	16834	18348	17038

Source: Field Data 2017

Table 8: shows that during the 2013-2016 period more than three-s of the blood suppliers (donors) were in the 18-24 years age group and 24-44 years age group. Overall annual blood

donation from the 18-44 years age group was 70.4%, 95.8%, 92.6 and 80.9% for 2013, 2014, 2015 and 2016, respectively.



Source: Field Data 2017

**Fig 2:** Distribution of Blood Unit Donation on the Copperbelt Province By Gender

Figure 2 shows the distribution of blood unit donation by gender. Overall more males than females donated blood for the 2013-2016 period and the percentage of female blood donor changed only marginally. The percentage of females donating blood ranged from 31.6% in 2013 to 37.4% in 2015.

**5. Discussion of Research Findings**

This study presents the assessment of blood supply and demand for the Copperbelt province of Zambia. The Copperbelt is the second highest populated province in Zambia and consumes more blood transfusion products after Lusaka province based on demographic profiling. Provincial specific information available from this study on blood supply and demand is important for future blood transfusion service planning and budgeting.

Indeed, the provision of adequate, quality and safe blood transfusion services requires an assessment of whole blood supply and demand following the modernisation and on-going improvements of hospitals and health service delivery on the Copperbelt. This is because, it is anticipated that, the blood transfusion service demand will increase over the years due to population growth and improvements in health service delivery (Malama, 2014) [16]. The authors believe that this study provides important blood supply and demand information for blood transfusion service planning and budgeting not only for the Copperbelt, but for all provinces in the country.

We found that most of the blood transfusion units (18,348 units of blood) were supplied to the regional blood bank at Kitwe Teaching Hospital in 2015. This could be attributed to

the heightened blood supply sensitisation community activities before, during and after the World Blood Donor Day commemorations held on the Copperbelt in 2015. Further analysis of the blood supply data shows that there was marginal variation in the annual blood supply to the Copperbelt regional blood bank during the four year study period. The marginal variation in blood supply to the regional blood bank could be explained by similarities in the demographic profile (age groups and population growth), geographical features (infrastructure and transport network) and funding profile (logistics to support blood collection activities).

The means of whole blood supplied in 2013, 2014, 2015 and 2016 were computed and compared using ANOVA F-Test and revealed that they were not statistically different (P-Value 0.724). Further comparison of means between years was performed and multiple comparisons of means at 95% family-wise confidence level accounted using the Turkey HSD correction strategy. The differences in the means of whole blood supplied between years were also not statistically significant.

While the demand for blood transfusion products has progressively improved over the years in proportion to the population growth, there has been marginal variation in the supply of blood. This may be explained by the global trends observed between 2008 and 2013, which showed an increase of greater than 10.7 million blood unit supplies. Over 90% of the annual blood unit supplies have been supplied by non-remunerated blood donors. On average, blood unit supply rates mirror the level of economic development with developed countries supplying blood units at the rate of 33.1 per 1000 while developing countries supply blood units at the rate of 4.6 per 1000 (WHO, 2016) [31]. In this study, the blood supply rate ranged from 7.0 in 2016 to 7.8 in 2015. Globally, up to 92 million blood units are supplied annually mainly by non-remunerated blood donors. Unfortunately, about 30 million blood units are supplied by non-remunerated donors who do not resupply the whole blood units (WHO, 2012) [29].

According to the gender profile, globally, less than 28% of the blood donated is from women. This finding agrees with the findings in this study in which women supplied blood ranged from 31.6% in 2013 to 37.4% in 2015. Generally, the age profile of blood donors indicates that a lot of young people donate in the developing countries compared to developed countries. This finding agrees with our finding with more than 75% of the annual blood supply being supplied by men, the majority falling in the age group 18 – 24 years. Understanding the demographic profile is important for developing and implementing blood unit supply strategies (WHO, 2016) [32]. Therefore, an integrated multi-sectoral approach is needed to address the blood supply deficit. This should target all age groups and encourage repeat donation (Greinacher, 2010) [12]. In addition, a lot of community awareness and sensitisation programs should be conducted to demystify blood donation. Many people still believe that the donated blood is used for rituals (Malama, 2015) [16].

The provision of health services on the Copperbelt province with a population of approximately 2,500,000 people is faced with a shortage of blood supplies required to meet blood transfusion service demand. In this study, the supply deficit was about 1 quarter and ranged from 22.3% to 29.6% annually. The province is host to a number of mining

companies and this call for more vibrant blood banking services in the event of a mining disaster. According to WHO (2016) [31] estimates, blood donation supply from 1% of the population would be able to cover the blood transfusion demand for the Copperbelt population. The main challenge in blood transfusion service provision is the short life of whole blood, 35 to 42 days. This justifies the need for more regular, sustained and repeat supplies of blood units from non-remunerated donors.

Europe, with the increase in the older population and reduction in the younger population, is likely to face blood supply challenges as this demographic profile is not good for blood supply activities (Greinacher, *et al.*, 2011) [13]. Other authors argue that the aging population may not result in increased demand for blood transfusion services provided other factors such as optimal, appropriate and responsible use of blood transfusion services are in place (Borkent-Raven, Janssen and Van Der, 2010) [7].

The ministry of health is able to supply safe blood transfusion services through 100% non-remunerated blood donation. Another good example of a national blood transfusion service programme that has achieved 100% blood donation by non-remunerated blood donors is the Sri Lankan programme, which supplies about 380,000 blood units annually. This achievement can be explained by a well-coordinated national blood transfusion service, efficient community participation and mobilisation (The Jakarta Post, 2014) [24]. An assured and reliable supply of safe blood can made available and sustainable through blood unit supply by non-remunerated blood donors. Therefore, it is important for communities to appreciate and own the whole blood supply and demand and understand how this affects quality health service delivery. In hospitals, good clinical care practices and appropriate usage of supplied blood transfusion products can help to reduce the blood supply deficient.

With modernisation and improvement of health service delivery systems coupled with the general increase in life expectancy and the associated increase in prevalence of non-communicable diseases such as cancers that require blood transfusion as part of therapy, the demand for blood transfusion products will always be increasing. This implies that national demand for blood transfusion services is ever on the increase in many countries, including Zambia. Zambia should therefore, prepare for the increasing demand for blood transfusion services. This increased demand is partly due to the increase in life expectancy and improvement in health service delivery. During many major surgeries, it's an acceptable practice to have blood transfusion products readily available in many hospital settings.

Globally, bleeding during and after delivery is a common cause of maternal deaths. Therefore, when bleeding occurs, blood transfusion products must be readily available as this may save a life. In broad terms, blood transfusion services play a critical role in saving lives through improved health service delivery. Unfortunately, in developing countries, many patients do not have access to safe blood transfusion services (WHO, 2016) [31]. Zambia has implemented the WHO recommendation, that each country should have a nationally coordinated blood transfusion services in order to reduce the blood supply deficit.

Maternal, child and reproductive health services demand readily available safe blood transfusion services. In Africa,

about 70% of the blood transfusion services are provided for children in malaria endemic countries. Women with severe bleeding during or after delivery too demand safe blood transfusion services. About 100,000 maternal deaths are attributed to shortage of blood transfusion products (WHO, 2005) [27]. These deaths are preventable when safe blood supply is available for transfusion.

The WHO (2012) [29], reported that RTA are responsible for about 1.3 million deaths globally. Up to 90% of RTA deaths occur in developing countries. Severe bleeding is said to be the cause of about 468,000 deaths annually. The limitation of clinical management options in developing countries usually results in the use of blood transfusion to manage complicated cases of pregnancy, childhood anaemia and trauma, further worsening the shortage of blood transfusion products. Often times, this happens in the midst of blood supply deficit, while health service coverage increase alongside improved access to health services worsens the blood supply deficit (WHO, 2012) [29]. In low income countries, children under 5 years consume up to 65% of blood transfusion products while in high income countries, up to 76% of blood transfusion products are demanded by the people who over 65 years old (WHO, 2016) [31].

According to WHO (2005) estimates, around 5% of the HIV infections in Africa are attributed to blood transfusion services. Investment in RNA technology for HIV detection during the processing of blood transfusion products results in improved blood safety and significantly reduces the risk of HIV transmission to 1 in 2 million blood units (WHO, 2005) [27]. The ZNBTS regional office is able to provide safe and quality blood banking services. Safe and quality blood refers to blood that is free from transfusion transmitted infections such as HIV, HBV, HCV and syphilis. In this study, 19.1% of the supplied was wasted due to contamination by transfusion transmissible infections. This high rate of wastage of supplied blood could be reduced if repeat donors are encouraged to supply whole blood. This is because repeat donors have less likelihood of carrying blood transfusion transmissible infections (WHO, 2016) [31].

According to the law of demand, if all other determinants of demand remain equal, the higher the cost of the blood transfusion services, the less health facilities will demand this service. In other words, the quantity of blood transfusion services demanded by health facilities will be less as the cost of this service increases. This is because buying blood transfusion services would result in increased opportunity costs for health facilities (Heakal, n.d.) [14]. While this is true for profit making businesses, the law of demand principles cannot be fully implemented in blood transfusion services. This is because reducing the cost of blood transfusion products beyond the blood safety standards set by the WHO would result in poor quality of delivered health services. When blood transfusion service standards are not followed, the risk of transfusion transmissible infections would be very high (WHO, n.d.) [32].

This is the reason why government operates a centralised system in which the ministry of health has invested huge sums of money. Therefore, the ZNBTS are mandated by law to collect and supply blood transfusion products free of charge to all health facilities in the country, regardless of public or private ownership. This is one way in which the GDP affects the provision of safe and quality national blood transfusion

products. Health facilities should not naturally avoid pressing appropriate requests for blood transfusion products since this should not make them forgo other preferred investment opportunities in the interest of providing safe blood transfusion services at their health facilities.

Similar to the law of demand, the law of supply shows the quantities of blood transfusion products that should be sold and distributed at a definite price. This implies that the greater the price, the greater the quantities of supplied blood transfusion products (Heakal, n.d.) [14]. Therefore, the ZNBTS as a producer would supply more blood transfusion products at a higher price because selling more quantities at a higher price would significantly increase its revenue.

The law of supply and demand in the health sector should be applied in management of the health sector sparingly. This is because health should be provided for all the people no matter the cost of service delivery. A health national is a nation that is full of productive health people who are the most important economic resource.

## 6. Conclusion and Recommendations

The Copperbelt province is able to supply an average of 16,000 units of whole blood units annually which translates into a huge blood supply deficit of approximately 8,000 – 10,000 blood units annually. This deficit is made worse by the high discard rate of 19.1% annually due to blood transfusion transmissible infections. The percentage of females supplying blood ranged from 31.6% to 37.4% annually. Most of the whole blood unit supplies are from men in the age group 18 – 24 years. This requires government prioritisation of blood banking service awareness and community ownership. Zambia has established a centralised blood banking approach on the Copperbelt based on 100% non-remunerated voluntary blood suppliers. The following recommendations arose from the study: 1. Ministry of Health should encourage both widespread hospital based systems and centralised blood donation services using non-remunerated voluntary repeat blood unit suppliers. 2. Blood processing should be done centrally by the Zambia national blood transfusion service (ZNBTS) as this is more safer though expensive. 3. A Follow up study should be conducted by the authors of this study in collaboration with the Ministry of Health on estimation of the cost of the unit of whole blood or its components for Zambia as a nation. 4. The Blood banking data should be incorporated in the Hospital Based Health Information System (HIMS) by the Ministry of Health through the Zambia National Blood Transfusion Service (ZNBTS)

## 7. References

1. Abraham I, Sun D. The cost of blood transfusion in Western Europe as estimated from six studies. *Transfusion*. 2012; 52:1983-1988. doi: 10.1111/j.1537-2995.2011.03532.x
2. Abraham I, Sun D. Cost of allogeneic blood transfusion. *World J Hematol*. 2012; 1(3):8-13. viewed 10<sup>th</sup> July, 2016 from <http://www.wjgnet.com/2218-6204/full/v1/i3/8.htm>
3. Acharya SA, Prakash A, Saxena P, Nigam A. Symposium; Sampling: Why and How of it? *Indian Journal of Medical Specialties*. 2013, 4(2).
4. Ala F, Allain J-P, Bates I, Boukef K, Boulton F, Brandful J *et al*. External Financial Aid to Blood Transfusion

- Services in Sub-Saharan Africa: A Need for Reflection, viewed 13<sup>th</sup> September, 2016, PLoS Med. 2012, 9(9): e1001309. doi:10.1371/journal.pmed.1001309
5. Bastos JL, Duquia RP, González-Chica DA, Mesa JM, Bonamigo RR. Field work I: selecting the instrument for data collection. *Anais Brasileiros de Dermatologia*. 2014; 89(6):918-923. Viewed 21<sup>st</sup> December, 2016, from <http://doi.org/10.1590/abd1806-4841.20143884>
  6. Bloch EM, Vermeulen M, Murphy E. Blood Transfusion Safety in Africa: A Literature Review of Infectious Disease and Organizational Challenges. *Transfusion Medicine Reviews*. 2012; 26(2):164-180. <http://doi.org/10.1016/j.tmr.2011.07.006>
  7. Borkent-Raven, Janssen, Van Der. Survival after transfusion in the Netherlands. 2010. DOI: 10.1111/j.1423-0410.2010.01378.x
  8. Central Statistics Office. 2010 Census Of Population And Housing National Analytical. 2012. Report <http://www.zamstats.gov.zm/report/Census/2010/National/2010%20Census%20of%20Population%20National%20Analytical%20Report.pdf>
  9. Currie CJ, Patel TC, McEwan P, Dixon S. Evaluation of the future supply and demand for blood products in the United Kingdom National Health Service, *Transfus*. 2004; 14(1):19-24. Eder FA. Current efforts to reduce the risk of syncope among young blood donors. *Curr Opin Hematol*. 2012; 19(6):480-5.
  10. Drackley A, Newbold KB, Paez A, Heddle N. Forecasting Ontario's blood supply and demand. *Transfusion*. 2012; 52(2):366-74. doi: 10.1111/j.1537-2995.2011.03280.
  11. Eder A, Eschenhagen T, Vollert T, Hansen A. *American Journal of Physiology - Heart and Circulatory Physiology* Published. 2012; 303(2). H133-H143 DOI: 10.1152/ajpheart.00007.2012
  12. Greinacher A. Institut für Immunologie und Transfusionsmedizin, Ernst Moritz Arndt Universität, Sauerbruchstr/Diagnostikzentrum, 17487 Greifswald, Germany. 2010.
  13. Greinacher A, Fretschner R, Dietrich K. Management of liver transplantation in a patient with a history of heparin-induced thrombocytopenia; *Transplant International*. 2005-2011; 18(6):664-667. Version of Record online : 16 MAY 2005, DOI: 10.1111/j.1432-2277.2005.00111.x
  14. Heakal R. (n.d.) *Economics Basics: Supply and Demand*, viewed on 10<sup>th</sup> October, 2016, from <http://www.investopedia.com/university/economics/economics3.asp>
  15. Mafirakureva N, Nyoni H, Nkomo SZ, Jacob JS, Chikwereti R, Musekiwa Z *et al*. The costs of producing a unit of blood in Zimbabwe. *Transfusion*. 2016; 56:628-636. doi:10.1111/trf.13405, viewed 10<sup>th</sup> September, 2016, from <http://onlinelibrary.wiley.com/doi/10.1111/trf.13405/full>
  16. Malama B. World blood day: time to demystify blood donation, viewed 11<sup>th</sup> July, 2016 from <https://www.daily-mail.co.zm/?p=33070>
  17. McCullough J. *Blood Supply Fluctuations*. 1996. viewed 16<sup>th</sup> September, 2016, from <http://www.ncbi.nlm.nih.gov/books/NBK233113/>
  18. Ministry of Health. National Health Strategic Plan – 2011-2016, Ndeke House, Lusaka. 2010.
  19. Ministry of Health. Zambia Population Based Hiv Impact Assessment. 2016. Viewed 10<sup>th</sup> December, 2016, from [http://phia.icap.columbia.edu/wp-content/uploads/2016/09/ZAMBIA-Factsheet.FIN\\_.pdf](http://phia.icap.columbia.edu/wp-content/uploads/2016/09/ZAMBIA-Factsheet.FIN_.pdf)
  20. Say L, Chou D, Gemmill A, Tunçalp O, Moller A, Daniels J *et al*. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health*. 2014. VIEWED 17<sup>TH</sup> September, 2016, from [http://dx.doi.org/10.1016/S2214-109X\(14\)70227-X](http://dx.doi.org/10.1016/S2214-109X(14)70227-X)
  21. Suresh K, Chandrashekara S. Sample size estimation and power analysis for clinical research studies, *Journal of Human Reproductive Sciences*. 2012; 5(1):7-13.
  22. Tashakkori A, Teddlie C. *Handbook of Mixed Methods in Social & Behavioral Research*, Sage Publications India Pvt. Ltd, New Delhi, India, Viewed 21<sup>st</sup>. 2003-2016, from [https://books.google.co.zm/books?hl=en&lr=&id=F8BFO M8DCKoC&oi=fnd&pg=PA297&dq=instruments+for+d ata+collection+in+research&ots=gUiNwyusLd&sig=vzw pFt2Su\\_XUA5po16qkRD\\_- PJg&redir\\_esc=y#v=onepage&q=instruments%20for%20 data%20collection%20in%20research&f=false](https://books.google.co.zm/books?hl=en&lr=&id=F8BFO M8DCKoC&oi=fnd&pg=PA297&dq=instruments+for+d ata+collection+in+research&ots=gUiNwyusLd&sig=vzw pFt2Su_XUA5po16qkRD_- PJg&redir_esc=y#v=onepage&q=instruments%20for%20 data%20collection%20in%20research&f=false)
  23. Tapko JB, Toure B, Sambo LG. Status Of Blood Safety In The Who African Region Report Of The 2010 Survey. 2010. viewed 20 November, 2016, from [www.afro.who.int/index.php?option=com\\_docman&task=doc\\_download&gid=9135&Itemid=2593](http://www.afro.who.int/index.php?option=com_docman&task=doc_download&gid=9135&Itemid=2593)
  24. The Jakarta Post. Safe blood transfusions to save mothers: WHO. 2014. viewed 20th November, 2016 from <http://www.thejakartapost.com/news/2014/06/15/safe-blood-transfusions-save-mothers-who.html>
  25. Whitsett C, Vaglio S, Grazzini G. Alternative Blood Products and Clinical Needs in Transfusion Medicine. *Stem Cells International*. 2012, 639561. Viewed 18<sup>th</sup> September, 2016, from <http://doi.org/10.1155/2012/639561>
  26. WHO. Africa Malaria Report. 2003. Viewed 12 September, 2016, from [http://apps.who.int/iris/bitstream/10665/67869/1/WHO\\_C DS\\_MAL\\_2003.1093.pdf](http://apps.who.int/iris/bitstream/10665/67869/1/WHO_C DS_MAL_2003.1093.pdf)
  27. WHO. Blood Supply and Demand, *The Lancet*. 2005, Volume 365, Issue 9478, Pages 2151-2244, viewed 17<sup>th</sup> September, 2016, from [http://www.thelancet.com/journals/lancet/issue/vol365no9478/PIIS0140-6736\(05\)X6136-0](http://www.thelancet.com/journals/lancet/issue/vol365no9478/PIIS0140-6736(05)X6136-0)
  28. WHO. Universal Access to Safe Blood Transfusion. 2008. Viewed 10 September, 2016, from <http://www.who.int/bloodsafety/publications/UniversalAccessstoSafeBT.pdf>
  29. WHO. Blood Safety. 2011. viewed 18th September, 2016, from [http://www.who.int/worldblooddonorday/media/who\\_blood\\_safety\\_factsheet\\_2011.pdf](http://www.who.int/worldblooddonorday/media/who_blood_safety_factsheet_2011.pdf)
  30. World Health Organization, UNICEF, UNFPA, The World Bank & the United Nations Population Division. 2014. Trends in Maternal Mortality: 1990 – 2013. Estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division. Geneva: WHO. Viewed 15<sup>th</sup> September, 2016, from <http://www.mamaye.org/en/evidence/trends-maternal-mortality-1990-%E2%80%932013-estimates-who-unicef-unfpa-world-bank-and-united>

31. WHO. Voluntary unpaid blood donations must increase rapidly to meet 2020 goal. 2016. viewed 12<sup>th</sup> February, 2017, from <http://www.who.int/mediacentre/news/releases/2016/world-blood-donor-day/en/>
32. WHO (n. d.) Blood Safety, viewed 12<sup>th</sup> September, 2016, from [http://www.who.int/bloodsafety/transfusion\\_services/estimation\\_presentations.pdf](http://www.who.int/bloodsafety/transfusion_services/estimation_presentations.pdf)