National Estimation of Blood Requirement in India

National AIDS Control Organization (NACO), India,
U.S. Centers for Disease Control and Prevention (CDC), New Delhi
National Institute of Medical Statistics, India
Christian Medical College, Vellore, and
Christian Medical Association of India (CMAI), India

राष्ट्रीय स्वास्थ्य मिशन
NATIONAL HEALTH MISSION

Sanjeeva kumar
Additional Secretary
Tele : 23061066
Telefax : 23063809
E-mail : ash-mohfw@nic.in

सत्यमेव जयते

भारत सरकार
स्वास्थ्य एवं परिवार कल्याण मंत्रालय
निर्माण भवन, नई दिल्ली - 110011
Government of India
Ministry of Health & Family Welfare
Nirman Bhavan, New Delhi - 110011

Foreword

It is vital for a health care system to guarantee the provision of affordable, appropriate, adequate, safe and quality blood and blood products to all who are in need of a transfusion. In order to ensure universal access to safe blood transfusion, the blood transfusion services of a county need to know the quantum of blood requirement for their population. Besides, a realistic assessment of blood requirements is essential to ensure effective planning and implementation of programmes related to Blood Transfusion Services.

The study on "National Estimation of Blood Requirement in India" is first of its kind in the world which has estimated the population need, clinical demand that arises in the health facilities, the supply and utilization of blood. The study details out the diseases and conditions under Medicine, Surgery, Obstetrics & Gynaecology, and Paediatrics that require a blood transfusion. The report has successfully unravelled the amount of blood required in the country and emphasizes the key issues pertaining to the blood supply and utilization. It has detailed out the actual gap between need and demand; demand and supply; supply and utilization. The regional level information has also been presented in the report.

Besides explaining the population need and clinical demand per hospital bed, the report has described the number of donations required per 1000 eligible population in a year to address the estimated population need and clinical demand in the country. The study has developed two models to predict the demand for blood in health care facilities as well as for a population in a specific geographic region.

This report will be a great resource for healthcare institutions where transfusions are performed, providers of blood, programme managers and policymakers at different levels to effectively plan and implement programmes related to Blood Transfusion Services.

Date: 23rd March 2018
Place: New Delhi

(Sanjeeva Kumar)

आलोक सक्सेना
संयुक्त सचिव
Alok Saxena
Joint Secretary

राष्ट्रीय एड्स नियंत्रण संगठन
स्वास्थ्य एवं परिवार कल्याण मंत्रालय
भारत सरकार
National AIDS Control Organisation
Ministry of Health & Family Welfare
Government of India

Preface

An efficient Blood Transfusion Service (BTS) is an essential element of any health care delivery system to achieve universal access to quality and affordable blood and blood products. An accurate estimation of blood requirement is critical to ensure availability of sufficient blood for patient care and to ensure evidence-based programmes and policies in Blood Transfusion Services.

"National Estimation of Blood Requirement in India" was carried out to estimatethe population need, clinical demand, supply and utilization of blood for the country's population. Apart from a comprehensive literature review, the methodology included Delphi exercises among clinicians from different medical specialties, and primary data collection from 251 public and private facilities representing primary, secondary and tertiary care facilities from five regions of the country. One of the important outcomes is that the study enlisted all the diseases and clinical conditions that require blood transfusions. This comprehensive nationwide study brings out evidence to predict the demand for blood based on a number of beds in health care institutions and population in a specific geographic region which will be very useful to institutional, district, state, and regional authorities to plan and implement Blood Transfusion Services effectively and efficiently.

In addition to understanding the demand-supply gap, two mathematical models have been established which would enable to predict the demand for blood either based on the number of beds in a health facility or population in a geographic region and other parameters associated with the demand. The study provided an overall picture of the requirements, supply and utilization which would facilitate working towards rational use and self-sufficiency of blood through appropriate policies, programmes, strategies and an implementation framework.

I am confident that this study will enable health authorities, policy makers and service providers in the ambit of Blood Transfusion System at the State, Regional and National level to establish a sustainable National Blood Transfusion System ensuring adequate supply and rational use of safe blood and blood products.

Date: 23rd March 2018
Place: New Delhi

(Shri Alok Saxena)

Message

Maintaining an adequate supply of safe blood and ensuring their appropriate use have been a great challenge for developing countries like India. In order to ensure universal access, it essential to establish a sustainable national blood system which is supported by a comprehensive and evidence-based national blood policy, strategic plan and appropriate legal instruments. In this context, the knowledge on current and future requirements of blood and blood products is crucial towards attaining self-sufficiency in blood.

The study on " National estimation blood requirement in India" is a unique one which aims to estimate the population need, clinical demand, supply and utilization which will be useful for guiding the policies and developing evidence-based planning and programmes towards strengthening the blood transfusion services in the country. The methodology adopted in the study was robust and comprehensive which can be used in other similar settings. Besides, the mathematical models that were developed to predict the demand based on beds in a facility and population in a specific geographical region would hold importance from a programmatic point of view.

On behalf of Centres for Disease Control (CDC), I would like to congratulate the blood transfusion services(BTS) division of National AIDS Control Organization, for their leadership and overall guidance to conduct the study in India. I extend my gratitude to Christian Medical Association of India(CMAI), Christian Medical College, Vellore and other key partners involved in the study.

I am confident that the findings of the study will be widely used to efficiently plan and implement programmes pertaining to blood transfusion services across the country.

Dr. Sunita Upadhyaya MD, IFCAP
Senior Laboratory Advisor - CDC/DGHT India

NBTC
राष्ट्रीय रक्त संचरण परिषद
National Blood Transfusion Council

Director

Tel. : 91-11-23736851
Fax : 91-11-23731746
E-mail : nbtcmohfw@gmail.com

सत्यमेव जयते

राष्ट्रीय रक्त संचरण परिषद
स्वास्थ्य एवं परिवार कल्याण मंत्रालय
भारत सरकार

National Blood Transfusion Council
Ministry of Health and Family Welfare
Government of India

Acknowledgment

The study on "National estimation of blood requirement in India", the first of its kind in the world and attempts to unfold the various aspects of blood transfusion requirements by assessing the population need, clinical demand, supply and utilization and thereby highlighting the gap between all these domains, thus helping to iron out the distribution inequities.

I would like to express our sincere thanks and gratitude to Shri Sanjeeva Kumar, AS &DG NACO, Shri Alok Saxena, Joint Secretary NACO and Dr. R.S. Gupta, Deputy Director General, NACO for their overall guidance and motivation for the successful completion of this very important study. I extend my appreciation to the Governing Body and Technical Resource Group members of NBTC for their incessant support and timely interim guidance. BTS team in NACO/NBTC and the respective State AIDS Control Societies/ State Blood Transfusion Councils in UP, Assam, West Bengal, Tamil Nadu, Karnataka and Maharashtra have been instrumental in facilitating the pilots and data collection across 251 facilities. Heartfelt gratitude and thanks are due to Dr. Timothy H. Holtz, Director, CDC/DGHT India and Dr. Sunita Upadhyaya, Senior Laboratory Advisor, CDC/DGHT India, for their leadership and technical assistance for completing this study successfully.

I am very grateful to Dr. Joy Mammen, Christian Medical College (CMC), Vellore for his invaluable technical support and for being the driving force from the conceptualization stage to completion of the study. I express my gratitude and thanks to Dr. Edwin Sam, Christian Medical Association of India (CMAI) and team members - Dr. Ratnali Maladhia, Ms. Charishma Sarman, Dr. Varsha Ranjan and Zonal Managers for their constant efforts and perseverance for the successful completion of the study, analysis, and development of the report. I would like to thank Dr.Mahalingam and Mr.Lokesh Sridharan, CMAI for their continuous technical inputs. Dr.L. Jeyaseelan and team, Department of Biostatistics, CMC Vellore are acknowledged and eulogized for providing technical assistance from designing the methodology to data analysis and report writing.

It gives me immense pleasure to thank Dr. Arvind Pandey, Former Director, National Institute of Medical Statistics for all the technical support and expertise extended to the study. Special gratitude is expressed to Dr. Bimal Charles, General Secretary, CMAI for his vision and approach in the completion of the study and report.

I would like to thank all the institutions, individuals, and experts who have participated in the study and thank the entire team for extraordinary and sincere work for successful completion of this study.

Date: 23rd March 2018
Place: New Delhi

Shobini

(Dr. Shobini Rajan)

Abbreviations

AIC	:	Akaike Information Criterion
AIHA	:	Autoimmune Haemolytic Anaemia
ALOS	:	Average Length of Stay
APH	:	Antepartum Haemorrhage
ATSDR	:	Associate Administrator for Science
AUB	:	Abnormal Uterine Bleeding
BIC	:	Bayesian Information Criterion
BMFS	:	Bone Marrow Failure Syndromes
BOR	:	Bed Occupancy Rate
BTS	:	Blood Transfusion Service
CABG	:	Coronary Artery Bypass Graft
CAD	:	Coronary artery disease
CBR	:	Crude Birth Rate
CDC	:	Centers for Disease Control and Prevention
CDMC	:	Clinical Data Management Centre
CGHS	:	Central Government Health Scheme
CHC	:	Community Health Center
CHD	:	Congenital Heart disease
CI	:	Confidence Interval
CKD	:	Chronic Kidney Disease
DH	:	District Hospital
DHHS	:	Department of Health and Human Services
DIC	:	Disseminated Intravascular Coagulation
DLHS	:	District Level Health Survey
EDQM	:	European Directorate for Quality of Medicines & Health Care
ESRD	:	End-Stage Renal Disease
FFP	:	Fresh Frozen Plasma
GOI	:	Government of India
HC	:	Highest Component
HDFN	:	Haemolytic Disease of the Foetus and New-born
HDN	:	Haemorrhagic Disease of the New-Born
HELLP	:	Haemolysis, Elevated liver enzymes and Low Platelet count
HUS	:	Hemolytic Uremic Syndrome
ICC	:	Intra Class Correlation
ICMR	:	Indian Council of Medical Research
IIPS	:	International Institute for Population Sciences
IQR	:	Interquartile Range
ITP	:	Idiopathic Thrombocytopenic Purpura
LBW	:	Low Birth Weight
MHA	:	Microangiopathic Haemolytic Anemia
NCRR	:	National Center for Research Resources
NFHS	:	National Family Health Survey
NHP	:	National Health Profile
NICPR	:	National Institute of Cancer Prevention and Research

NIH	:	National Institute of Health
OBG	:	Obstetrics and Gynaecology
PIP	:	Project Implementation Plan
PLHIV	:	People Living with HIV
PN	:	Population Need
PPH	:	Post-partum Haemorrhage
RBC	:	Red Blood Cells
REDCap	:	Research Electronic Data Capture
RSBY	:	Rashtriya Swasthya Bima Yojana
SDH	:	Sub-District/Divisional Hospital
SPSS	:	Sciences Statistical Product and Service Solutions
TRG	:	Technical Resource Group
UCHC	:	Urban Community Health Centres
UGIB	:	Upper Gastrointestinal Bleed
UN	:	United Nation
UPHC	:	Urban Primary Health Centres
VBD	:	Voluntary Blood Donation
VLBW	:	Very Low Birth Weight
WB	:	Whole Blood
WHO	:	World Health Organization

Table of Contents

Tables

Figures

National estimation of blood requirement in India

1. Background

Blood Transfusion Service (BTS) is a vital component of any health care delivery system. The timely availability of safe blood and blood products is essential in health facilities where transfusion is performed (WHO 2010a). Policy makers at different levels, programme managers and providers of blood for transfusion need to know how much blood is required for their population, where and when it is needed so that blood is neither under- nor over-supplied (WHO 2009c). Today, many countries including India face challenges in maintaining an adequate supply of safe blood and blood products and ensuring their appropriate use. In context to the recent Rome Declaration on achieving self-sufficiency in safe blood and blood products, the national health authorities are mandated to have the knowledge on the current and future requirements of blood for their population towards attaining self-sufficiency (WHO 2013). The national government is primarily responsible to ensure an adequate supply of safe blood and blood products and rational use. It is essential to establish a sustainable national blood system that should be supported by a national blood policy, strategic plan and appropriate legal instruments (WHO 2011a).

The national blood requirement in part is determined by the capacity of the country's health care system and its coverage of the population (WHO 2010a). Social and economic development, along with increased health care coverage, has created shifts in the clinical demand for blood in, both developed and developing countries. In developed countries, advanced health systems, sophisticated medical and surgical procedures, trauma care and management of blood disorders, and an increase in ageing populations are the key factors that lead to a requirement for blood (WHO 2010b). Recent reports from developed countries indicated a decline in collection and utilization of blood. In the United States, the overall blood collection declined by 9% and the units of blood transfused dropped by 8.2% between 2008 and 2011 (DHHS 2011). Similar trends have been found in recent European Union surveys as well (EDQM 2011). However, the demand for blood and blood products seem to be still high in developing and underdeveloped countries. For instance, the demand for blood transfusion is high in Sub-Saharan Africa because of the high prevalence of anaemia especially due to malaria and pregnancy-related complications (Osaro and Charles 2011). The demand is high in Nigeria due to anaemia, malnutrition and pregnancy-related complications (Erhabor, Adias, and Mainasara 2013). A recent publication indicates that the clinical demand for blood in China has increased due social and economic development, along with increased health care coverage (Shi et al. 2014). In general, the demand for blood in developing countries is to support acute haemorrhage during pregnancy-related complications, new-born care especially in pre-term infants, management of sepsis, haemorrhagic disease of the new-born, chronic anaemia, HIV related anaemia, micronutrient deficiencies etc (WHO 2010b)

According to WHO, blood donation by 1% of the population is generally taken as the minimum need to meet a nation's basic requirements for blood; while the requirements are higher in countries with more advanced health care systems (WHO 2009b). However, there is no evidentiary support or accessible statistical model to substantiate this hypothesis. As per the above norm, India's demand for blood is around 13.1 million blood units (1% of 1.3 billion population). Several studies and reports indicated varying amount of annual blood collection in India. In 2007, the total collection in India was reported as 4 million against the need of 10 million (WHO 2008). In 2011, it was reported that Indian blood banks were able to collect 5.5 million blood units against the requirement of 9 to 9.5 million per year which is a serious mismatch in the demand and availability (Sa and Kulkarni 2011). Another study indicates that India has 2,433 blood banks that can collect 9 million units of blood annually, but collects only 7 million (Agarwal 2012). The requirement of blood for the country is estimated to be 8.5 million to 10 million units/year, whereas the available supply is only 7.4 million units/year (Siromani et al. 2013). As per these studies and reports, it is evident that there is a huge mismatch between demand and supply (Sa and Kulkarni 2011, WHO 2008, Aggarwal and Sharma 2012, Siromani et al. 2013). There are huge variations in the estimated demand, supply and utilization of blood and blood products as well.

Considering the mixed health care system (public, private and not-for-profit) with a huge proportion of unregulated private sector, changing epidemiological and demographic pattern, inequitable distribution of health services, and ever-increasing population size, the estimation or forecasting of blood requirements in India has been a challenge. Annual plans and projections including, budgetary outlay, training, procurement and logistics are generally made based on the estimated number of blood requirement. Since there is no accurate number, targets that are set vary widely and achievement of goals cannot be verified. This affects the planning process of distribution of blood and ensuring access to blood across the country. The current methods of estimating national blood requirements, especially when applied to developing countries, are either not sensitive to reflect the dynamic nature of blood needs in the health care system, or difficult to apply due to the lack of necessary data (WHO 2009c, d). It would also be desirable to understand the conditions which influence requirement of blood beside the current supply and use of blood. This calls for a study on estimation of blood requirements[1] using a robust methodology in India.

2. Objectives

The purpose of the study is to estimate the overall requirement for blood in the country. The specific objectives are:

- To understand the conditions and clinical interventions, influencing requirement of blood.
- To estimate the blood transfusion need of the population, the current clinical demand, current supply and current use of blood and components.
- To estimate the demand and supply gap.
- To develop a model for predicting the demand for blood.

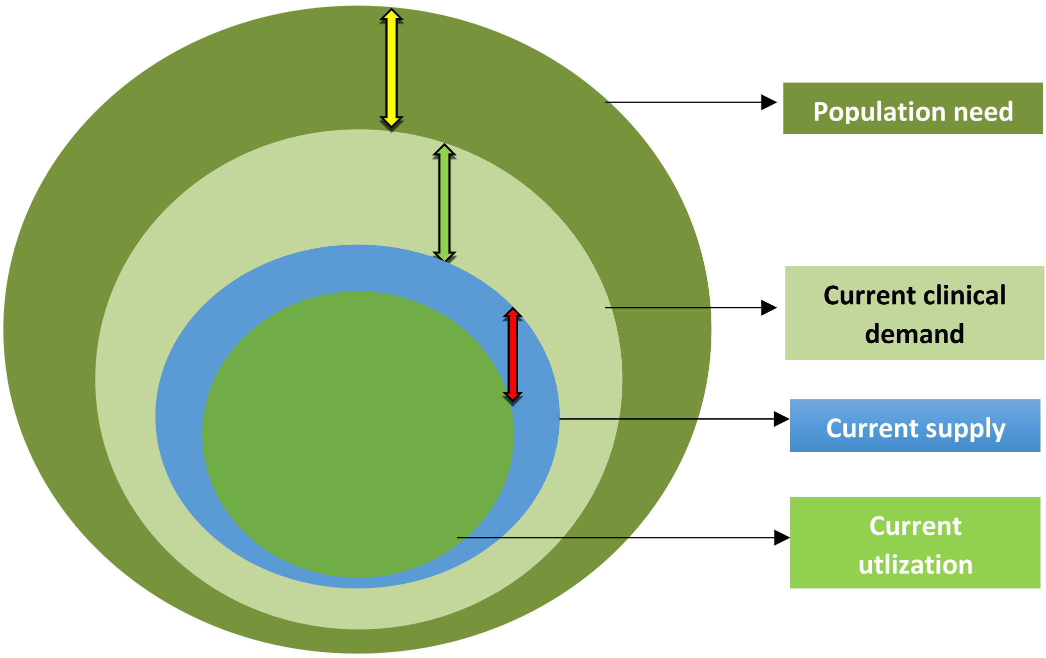
[1] Blood transfusion requirements refer to whole blood or components. The components include, red cells, plasma, platelets, and cryoprecipitate AHF.

3. Conceptual Framework

3.1 Population need for blood

Population need is defined as the total number of units of whole blood and components that are required to transfuse all individuals who require blood transfusion in a defined population over a defined time period (usually one year).

Figure 1 - Population need, demand, supply and utilization



This indicates the total blood transfusion need of the population which is independent of all factors which may influence or prevent the population to get transfused in a healthcare setting. Population need is estimated through an epidemiological approach which requires estimation of incidence or prevalence of those conditions and interventions that require blood transfusion, the proportion of those who require transfusion, and the quantum of blood or component requirement.

3.2 The current clinical demand for blood

Current clinical demand for blood is defined as the total number of units of whole blood and components requested/demanded to meet all blood transfusion for emergencies and elective procedures at a defined number of health facilities over a defined period of time (usually one year).

The current clinical demand depends on the capacity of the healthcare system. Ideally, all population need for blood should be converted into clinical demand in healthcare facilities. However, this is rarely achieved in low-resource settings, resulting in gaps between the need and demand for blood. In developing countries like India, a greater proportion of population need is presumed to be not met due to several factors such as lack of healthcare access, due to supply and demand-side factors, lack of health infrastructure, clinicians' knowledge/skills, the health-seeking behaviour of the population etc. (Nanu 2001, Ramani, Mavalankar, and Govil 2009, Choudhury 2011, Lowalekar and Ravichandran 2013).

3.3 Current supply and utilization of blood

The current supply of blood is the total number of units of whole blood and components supplied to healthcare facilities, against all requests/demand for blood transfusion over a defined period of time, usually taken as one year. The supply of blood is generally from licensed blood banks or blood storage centres across the country.

Ideally, a health care system should address 100% of demand for blood by ensuring uninterrupted supply within its catchment area. However, there exists a gap between clinical demand and supply due to the low volume of voluntary blood donation, lack of awareness, irrational demand, poor supply chain management system etc. (Siromani et al. 2013, Bagcchi 2014, Kurup et al. 2016). According to available estimates, 25% of all maternal deaths are due to haemorrhage (Murthy, Murthy, and Prabhu 2013) and the incidence of post-partum haemorrhage varies from 9.2% to 21% in India (Geller et al. 2008, Yadav K, Namdeo A, and M.A 2013). Reports indicate that 70% of the PPH related deaths are due to lack of immediate availability of blood (Yadav K, Namdeo A, and M.A 2013).

Current utilization of blood is the total number whole blood units and components utilized by a defined number of healthcare facilities over a defined period, usually one year. There may be a gap between supply and utilization due to wastages, expiry, non-utilization in the health facilities (Far et al. 2014); (Patil, Bhake, and Hiwale 2016).

It is hypothesized that there are gaps between,

- Population need and current clinical demand
- Current clinical demand and current supply
- Current supply and utilization

4. Methodology

This was a cross-sectional study, aiming to estimate the blood requirement for a period of one year. The **first part** of this exercise aimed to assess the population need, current clinical demand, current supply and current use. The **second part** involved mathematical modeling to estimate the blood requirements based on the number of beds and population.

4.1 Population need

The population need depends on the burden of diseases and clinical interventions that require a blood transfusion if there is universal access to health care services.

The variables required to estimate the population need are,

i. ***The population at risk*** which is the actual total population (group or sub-group of the population such as age, gender, geography etc.), who can potentially acquire or get affected/infected or susceptible to a disease or clinical condition.

ii. ***Prevalence or incidence of diseases or conditions*** that require transfusion under medical, surgical, obstetrics & gynaecology and paediatrics.

iii. ***Percentage of people who need transfusion*** out of the total population who has the disease or condition.

iv. ***Quantum of blood or components*** required (average units required).

A comprehensive review of the literature was carried out to understand the population at risk and prevalence or incidence of diseases, conditions and interventions that require blood. Prevalence was taken for chronic conditions such as leukaemia, haemolytic anaemia, oncological conditions etc. Incidence was used for acute conditions such as dengue, malaria etc. The literature and secondary data sources include, data from healthcare institutions, national and international reports/publications of national and international organizations such as WHO, UN organizations, Ministry of Health, report on Global Burden of Diseases(GBD), diseases registries such as National Cancer Registry and Global Cancer Registry, National Family Health Survey (NFHS-3 and NFHS-4), National Health Profile (2017), District Level Health Survey (DLHS 2007-08), health insurance data (RSBY) and other published journal articles.

Delphi exercise was conducted to estimate the percentage of people requiring transfusion and the quantum of blood or components required (average of units) using a Delphi questionnaire. In addition, the estimated prevalence and incidence of those diseases and conditions, for which literature was not available, was obtained from Delphi exercises. The Delphi technique is a way of obtaining a collective view from individuals about issues where there is no or little definite evidence and where opinion is important (Thangaratinam and Redman 2005). It is a widely used and accepted method for achieving convergence of opinion concerning real-world knowledge solicited from experts (Hsu and Sandford 2007). The process can create group ownership and enable cohesion among individuals/experts with diverse views. It is an iterative questionnaire exercise with controlled feedback to a group of experts. It allows experts to reappraise their views in the light of the responses of the group. Its original purpose was to “obtain a consensus opinion of a group of experts.

Before the exercise, the participants were briefed on the objectives of the exercise, the processes and the guidelines to be followed during the exercise. As the first step, the list of diseases and conditions that require blood/components was circulated and the participants were asked individually to add or delete the diseases or conditions that require blood. Complete anonymity was ensured as they were not asked to indicate their name or other personally identifiable information. These data were then triangulated to arrive at a final list based on consensus. After finalizing the list of diseases and conditions, the remaining variables (percentage requiring transfusion and average units required) were obtained.

The Delphi process in the present study consisted of three-iteration questionnaire rounds. In the first round, each expert was given a questionnaire, in which they were asked to answer the following,

i. Prevalence and incidence of diseases or conditions for which data were not provided (The prevalence/incidence data were otherwise indicated)
ii. The percentage of people requiring blood/components
iii. Average number of units required

At the end of the first round, the data were entered in SPSS and basic descriptive analysis was done, which included mean, median, standard deviation, range, and histogram. The results were displayed on a projector which allowed each participant to look the variability and outliers. Participants were given an opportunity to discuss and provide their views on the outputs.

In the second round, a new questionnaire was circulated with the same variables and the participants were given an opportunity to review and if necessary revise their inputs. These data were once again entered in SPSS and analyzed. The results were once again displayed on a projector which allowed each participant to look the variability and outliers. Participants were given an opportunity to discuss and provide their views on the outputs.

The same was repeated for the third round and the data were once again analyzed and displayed to the participants for discussion and finalization based on consensus.

All four Delphi exercises were conducted among the technical experts of medicine, surgery, paediatrics, obstetrics and gynaecology. These were conducted in New Delhi, Mumbai and Chennai. Around 15 technical experts were invited from each speciality from different regions of the country. The technical experts were postgraduates and post-doctoral (e.g. Neurosurgery, Cardiothoracic surgery etc.) representing primary, secondary and tertiary facilities across the country.

4.2 Current clinical demand, current supply, and utilization of blood

The current clinical demand, supply, and use were computed by collecting information from health care facilities using, a structured assessment tool. The assessment tool consists of following:

- **Basic administrative details** such as location, type of facility (public/private), level of care, average outpatients, average number of PLHIVs, total admissions, bed occupancy rate, number of beds, the average length of stay, number of staff etc.,
- **Transfusion details** which include the number of patients with a particular disease condition followed by the number of patients requiring transfusion, number of units required per patient, the percentage of blood supplied, utilisation, discard and returned to blood bank under medicine, surgery, obstetrics and gynaecology and paediatrics.

4.2.1 Estimation of sample size – Assessment of clinical demand, supply & utilization

Five states were randomly selected from five regions that were, North, East, West, South and Northeast. It was assumed that all states under a region are homogenous, in terms of, geography, the level of health care system, and health outcome (infant and maternal mortality rates). Based on this, the proposed states under the respective regions are shown in Table 1.

Table 1 - Regions and states

Region	State	IMR[2]	MMR[3]
North	Uttar Pradesh	57	292
East	West Bengal	32	145
West	Maharashtra	25	87
South	Tamil Nadu	22	90
North East	Assam	21	136
India		**44**	**178**

Sampling Frame: It consists of the list of primary, secondary and tertiary health care facilities (both public and private) from these states. This was obtained from State Programme Implementation Plans (PIP) of National Health Mission (NHM), State Health Resource Centers, Health Information System of selected states, Indian Medical Association (IMA), State Medical Associations, National Health Portal of India, list of public/private hospitals empanelled under Rashtriya Swasthya Bima Yojana (RSBY), list of private hospitals empanelled under Central Government Health Scheme (CGHS) and other reliable sources.

In the public health care system in India, there were around 4,833 Community Health Centres (CHCs), 987 sub-divisional hospitals and 722 district hospitals in 2013 that can be termed as First Referral Units (FRUs). These are equipped to provide round-the-clock services for emergency obstetric and newborn care, in addition to all emergencies that any hospital is required to provide (GOI 2013). Besides, there were 381 medical colleges in the country (GOI 2014). The private health sector in India constitutes the majority of the health facilities (around 70%), ranging from individual owned clinics, and small nursing homes to very large multi-specialty corporate hospitals (Hooda 2015).

Sample size estimation: Based on a pilot carried out at 6 health care facilities in Karnataka state of India, the demand per bed was estimated to be 9.6 units (SD:6) in a year. There are three strata which are primary, secondary and tertiary facilities. As the variation in demand

[2] Sample Registration System, (2011), Government of India

[3] Sample Registration system, (2010-12), Government of India

was expected to be very high between stratum and within a stratum, it was decided to estimate the sample size with very narrow precision (allowable error) which would provide a large number to be studied. As the facility is the cluster, the design effect 2 was considered. The sample size was calculated as overall number and then the same was replicated in each stratum to provide narrow precision in the stratum wise analyses. Therefore, in order to estimate the demand at a precision of 0.1 with 95 CI, it was required to study 13,830 units in a year per stratum which was rounded off to 15,000 units per stratum which sum up to 45,000 units (Table 2). Accounting a design effect of 2, it was required to study 90,000 units of blood per region.

Table 2 - Sample size estimation for region– Different precisions

Demand per year per bed [Mean (SD)]	Expected absolute precision 0.075	Expected absolute precision .1	Expected absolute precision .125
9.6 (6.0) per year	24,586	**13,830**	8,851
Approximately per stratum	25,000	**15,000**	9,000
For three stratums	75,000	**45,000**	27,000
Design effect of 2 (Facility as cluster)	150,000	**90,000**	55,000

In order to study 90,000 units in a region, around 9,000 beds need to be studied, considering 9.6 units per bed per annum as the estimated demand. The required number of beds in primary, secondary, tertiary and public and private facilities was decided based on probability proportionate to size method (PPS). The expert consensus on the ratio of transfusion in primary, secondary and tertiary care facilities was 10%, 25% and 65% respectively (1:2:6.5). In view of this ratio and the average number of beds in primary (35), secondary (120) and tertiary care facilities (1,000), around six tertiary, 20 secondary and 24 primary facilities were to be included in the study which would sum up to 9,000 beds and 90,000 units.

According to National Family Health Survey (NFHS) III, the private medical sector remains the primary source of health care for the majority of households in urban (70 percent) as well as rural areas (63 percent) (IIPS 2007). Considering this, further stratification was done for public and private facilities at the ratio of 60:40. Table-3 provides the breakdown of the total number of facilities required from each region from private and public; and primary, secondary and tertiary facilities.

Table 3 - Required sample in each region

Type of facilities	Proportion of transfusion (%)	No. of beds to be sampled based on % transfusion	Average number of beds	Sampling unit (cluster) Rounded	Sampling unit (cluster) Public (40%)	Sampling unit (cluster) Private (60%)
Primary	10	900	35	24	10	14
Secondary	25	2,250	120	20	8	12
Tertiary	65	5,850	1,000	6	3	3
Total	**100**	**9,000**	**-**	**50**	**21**	**29**

The required number facilities were randomly selected from the list of primary, secondary and tertiary levels of facilities, using the table of random numbers. In case of a facility refusing to participate in the study, the closest available facility under the specific type of facility was selected.

4.3 Data handling and analysis

4.3.1 Data processing and management

Database for this study was developed and maintained by Clinical Data Management Centre (CDMC) at Christian Medical College (CMC), Vellore. Study data were collected in the standard paper questionnaire and double data entry was carried out with inbuilt data validation checks. Identification number (ID) was assigned to each record as an identifier which contains code for,

Table 4 - Coding of data

State	(2 Text Digits)	MH or UP
Public/Private	(2 Text Digits)	G or P
Primary/Secondary/ Tertiary	(1 Text Digit)	P/S/T
Number	(3 Digit Number)	Unique for site

Study data were entered and managed in REDCap (Research Electronic Data Capture) tool hosted at Department of Biostatistics, Christian Medical College Hospital, Clinical Data Management Centre (CDMC), Vellore, India. REDCap was developed by an informatics core at Vanderbilt University with ongoing support from National Center for Research Resources (NCRR) and National Institute of Health (NIH) grants. The data were downloaded as SPSS file for further analysis.

4.3.2 Statistical methods

The data were screened for outliers and extreme values using histograms, frequency distribution and Box-Cox plots. The qualitative (categorical) data were screened through bar charts and frequency distributions. The data analysis was done in SPSS 22.

Delphi data: The Delphi data such as the percentage of people requiring transfusion and the average number of units required (whole blood/red cells and other components for each disease condition was obtained from Delphi.

Descriptive statistics from the bootstrap data, such as mean, median, standard deviation, and interquartile ranges (IQR) were computed for each disease condition. As the number of observations based on Delphi was smaller in size, the 95% confidence interval was calculated using the bootsrtap method.

Estimation of population need (calculations):

In order to estimate the total population need, the following steps were done.

For each disease, the following were calculated:

Step 1:

$$\text{Number of people with a disease} = \frac{\text{Population at risk X Prevalence}}{100} \quad \text{or}$$

$$\text{Number of people with a disease} = \frac{\text{Population at risk X Incidence}}{100}$$

Step 2:

$$\text{Number of people requiring transfusion} = \frac{\text{No of people with disease X Percentage of people requiring transfusion}}{100}$$

Step 3:

Population need =

No of people requiring transfusion x No of units of components required (mean /median)

This was determined for each disease condition in each group: medicine, surgery, obstetrics and gynaecology and paediatrics.

Step 4:

The total need for diseases in each group was calculated as the sum of the above

$$\text{Total Population Need for Medical conditions } PN_{\text{Total Medical}} = PN_{\text{Disease1}} + PN_{\text{Disease2}} \ldots + PN_{\text{Disease n}}$$

$$\text{Total Population Need for Surgical conditions } PN_{\text{Total Surgical}} = PN_{\text{Disease1}} + PN_{\text{Disease2}} \ldots + PN_{\text{Disease n}}$$

$$\text{Total Population Need for Obst \& Gyn conditions } PN_{\text{ObstGyn}} = PN_{\text{Disease1}} + PN_{\text{Disease2}} \ldots + PN_{\text{Disease n}}$$

$$\text{Total Population Need for Paediatric conditions } PN_{\text{Total Paed}} = PN_{\text{Disease1}} + PN_{\text{Disease2}} \ldots + PN_{\text{Disease n}}$$

Step 5:

$$\text{Total Population Need } \mathrm{PN}_{\text{Population}} = \mathrm{PN}_{\text{Total Medical}} + \mathrm{PN}_{\text{Total Surgical}} + \mathrm{PN}_{\text{Total ObstGyn}} + \mathrm{PN}_{\text{Total Paed}}$$

Clinical demand calculation by region/country:

In order to calculate the overall demand, disease-specific demand for each institution was computed by adding the demand for whole blood and the highest component among red cells (RBC), plasma (FFP), platelets and cryoprecipitate. This was followed by computing the institution wise demand which is the total of demand for all the diseases that were treated by the institution. The institutional demand for each section i.e. medicine, surgical, obstetrics and gynaecology and paediatrics, was computed by adding all the disease-specific demand for an institution.

Step 1: Calculation of demand of whole blood and most frequently used component for each speciality in each institution WB = Number of units of whole blood used; HC = Highest count of the most frequently used component

$$\text{Total institutional demand for Medicine } \mathrm{DM}_{\text{Inst}} = \text{Disease1}_{(\text{WB+HC})} + \text{Disease2}_{(\text{WB+HC})} + \cdots + \text{Disease n}_{(\text{WB+HC})}$$

$$\text{Total institutional demand for Surgery } \mathrm{DS}_{\text{Inst}} = \text{Disease1}_{(\text{WB+HC})} + \text{Disease2}_{(\text{WB+HC})} + \cdots + \text{Disease n}_{(\text{WB+HC})}$$

$$\text{Total institutional demand for Obst \& Gyn } \mathrm{DOBG}_{\text{Inst}} = \text{Disease1}_{(\text{WB+HC})} + \text{Disease2}_{(\text{WB+HC})} + \cdots + \text{Disease n}_{(\text{WB+HC})}$$

$$\text{Total institutional demand for Paediatrics } \mathrm{DP}_{\text{Inst}} = \text{Disease1}_{(\text{WB+HC})} + \text{Disease2}_{(\text{WB+HC})} + \cdots + \text{Disease n}_{(\text{WB+HC})}$$

Step 2: Calculation of demand for each speciality in each region

$$\text{Total medical demand for region } \mathrm{DM}_{\mathrm{Region}} = \mathrm{DM}_{\mathrm{Inst1}} + \mathrm{DM}_{\mathrm{Inst2}} + \cdots + \mathrm{DM}_{\mathrm{Inst\_n}}$$

$$\text{Total surgical demand for region } \mathrm{DS}_{\mathrm{Region}} = \mathrm{DS}_{\mathrm{Inst1}} + \mathrm{DS}_{\mathrm{Inst2}} + \cdots + \mathrm{DS}_{\mathrm{Inst\_n}}$$

$$\text{Total obstetric \& gynaecology demand for region } \mathrm{DOBG}_{\mathrm{Region}} = \mathrm{DOBG}_{\mathrm{Inst1}} + \mathrm{DOBG}_{\mathrm{Inst2}} + \cdots + \mathrm{DOBG}_{\mathrm{Inst\_n}}$$

$$\text{Total paediatric demand for region } \mathrm{DS}_{\mathrm{Region}} = \mathrm{DP}_{\mathrm{Inst1}} + \mathrm{DP}_{\mathrm{Inst2}} + \cdots + \mathrm{DP}_{\mathrm{Inst\_n}}$$

Step 3: Calculation of demand for each speciality for the country (Summation of the demand for all regions)

$$\text{Total medical demand for country } \mathrm{DM}_{\mathrm{Country}} = \mathrm{DM}_{Region1} + \mathrm{DM}_{Region2} + \cdots + \mathrm{DM}_{\mathrm{Region\ 5}}$$

$$\text{Total surgical demand for country } \mathrm{DS}_{\mathrm{Country}} = \mathrm{DS}_{Region1} + \mathrm{DS}_{Region2} + \cdots + \mathrm{DS}_{\mathrm{Region\ 5}}$$

$$\text{Total obstetric \& gynaecology demand for country } \mathrm{DOGB}_{\mathrm{Country}} = \mathrm{DOBG}_{Region1} + \cdots + \mathrm{DOBG}_{\mathrm{Region\ 5}}$$

$$\text{Total paediatric demand for country } \mathrm{DP}_{\mathrm{Country}} = \mathrm{DP}_{Region1} + \mathrm{DP}_{Region2} + \cdots + \mathrm{DP}_{\mathrm{Region\ 5}}$$

Step 4: Calculation of total demand for the whole country

$$\text{Total demand for country } \mathrm{DT}_{\mathrm{Country}} = \mathrm{DM}_{\mathrm{Country}} + \mathrm{DS}_{\mathrm{Country}} + \mathrm{DOBG}_{\mathrm{Country}} + \mathrm{DP}_{\mathrm{Country}}$$

Overall component-wise demand for country/region

In order to calculate the total component demand, the institutional wise demand for each component (WB, RBC, FFP, Plasma, Platelets) was calculated.

Step 1: Calculation of demand of each component for each speciality in each institution

$$\text{Institutional whole blood demand } \mathrm{WBD_{Inst}} = \mathrm{Disease1_{(WB\ demand)}} + \cdots + \mathrm{Disease\ n_{(WB\ demand)}}$$

$$\text{Institutional red cell concentrate demand } \mathrm{RBCD_{Inst}} = \mathrm{Disease1_{(RBC\ demand)}} + \cdots + \mathrm{Disease\ n_{(RBC\ demand)}}$$

$$\text{Institutional FFP demand } \mathrm{FFPD_{Inst}} = \mathrm{Disease1_{(FFP\ demand)}} + \cdots + \mathrm{Disease\ n_{(FFP\ demand)}}$$

$$\text{Institutional platelets demand } \mathrm{PLTD_{Inst}} = \mathrm{Disease1_{(PLT\ demand)}} + \cdots + \mathrm{Disease\ n_{(PLT\ demand)}}$$

$$\text{Institutional cryoprecipitate demand } \mathrm{CRYOD_{Inst}} = \mathrm{Disease1_{(CRYO\ demand)}} + \cdots + \mathrm{Disease\ n_{(CRYO\ demand)}}$$

Step 2: Calculation of demand of component for each region was obtained by summation of individual institutional demand for each component.

$$\text{Regional whole blood demand } \mathrm{WBD_{Region}} = \mathrm{WBD_{(Inst1)}} + \cdots + \mathrm{WBD_{(Inst\_n)}}$$

$$\text{Regional red cell concentrate demand } \mathrm{RBCD_{Region}} = \mathrm{RBCD_{(Inst1)}} + \cdots + \mathrm{RBCD_{(Inst\_n)}}$$

$$\text{Regional FFP demand } \mathrm{FFPD_{Region}} = \mathrm{FFPD_{(Inst1)}} + \cdots + \mathrm{FFPD_{(Inst\_n)}}$$

$$\text{Regional platelets demand } \mathrm{PLTD_{Region}} = \mathrm{PLTD_{(Inst1)}} + \cdots + \mathrm{PLTD_{(Inst\_n)}}$$

$$\text{Regional cryoprecipitate demand } \mathrm{CRYOD_{Region}} = \mathrm{CRYOD_{(Inst1)}} + \cdots + \mathrm{CRYOD_{(Inst\_n)}}$$

Step 3: Calculation of demand of component for the country was obtained by summation of demand of each component for each region.

$$\text{Whole blood demand (Country) } \mathrm{WBD}_{\mathrm{Country}} = \mathrm{WBD}_{(\mathrm{Region1})} + \cdots + \mathrm{WBD}_{(\mathrm{Region5})}$$

$$\text{Red cell concentrate demand (Country) } \mathrm{RBCD}_{\mathrm{Country}} = \mathrm{RBCD}_{(\mathrm{Region1})} + \cdots + \mathrm{RBCD}_{(\mathrm{Region5})}$$

$$\text{FFP demand (Country)} \mathrm{FFPD}_{\mathrm{Country}} = \mathrm{FFPD}_{(\mathrm{Region1})} + \cdots + \mathrm{FFPD}_{(\mathrm{Region5})}$$

$$\text{Platelets demand (Country) } \mathrm{PLTD}_{\mathrm{Country}} = \mathrm{PLTD}_{(\mathrm{Region1})} + \cdots + \mathrm{PLTD}_{(\mathrm{Region5})}$$

$$\text{Cryoprecipitate demand (Country) } \mathrm{CRYOD}_{\mathrm{Country}} = \mathrm{CRYOD}_{(\mathrm{Region1})} + \cdots + \mathrm{CRYOD}_{(\mathrm{Region5})}$$

Supply and utilization calculations

The percentage of supply against the demand and percentage of utilization against supply of whole blood and components were obtained from all the institutions. The percentage of supply and utilization were converted into absolute numbers, using the actual demand data from all the institutions. These absolute numbers were used for data analysis to compute the speciality, region, ownership, and level of care wise supply and utilization of whole blood and components.

4.4 Modeling for prediction of demand based on beds for the institution

As the variable-demand per bed per annum did not follow a normal distribution, the log transformation was done which follows a normal distribution. The probability density function for the normal distribution is as follows,

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

Where, x – log demand, μ – mean log demand, and σ – standard deviation of the log demand.

In order to predict the demand per bed in a facility, a multilinear regression model with log-transformed demand was used as the dependent variable. The potential variables and their weight that influence the demand were decided either based on the statistical significance of the variable or based on the epidemiological and programmatic importance. The following was the equation used for estimating the weights for various predictors,

$$P(X_1, X_2, \mathrm{K}, X_n; \mu, \sigma^2) = \prod_i \tfrac{1}{\sqrt{2\pi}\sigma} e^{-(X_i-\mu)^2/2\sigma^2}$$

$$L(\mu, \sigma^2; \mathbf{X}) = \sigma^{-n} e^{-\frac{1}{2\sigma^2}\sum_i -(X_i-\mu)^2}$$

$$\lambda(\mu, \sigma^2; \mathbf{X}) = -n \log \sigma - \tfrac{n}{2\sigma^2}\left[X^2 - 2\mu\overline{X} + \mu^2\right]$$

In order to verify whether the model fits the data, scatter plots and R2 statistics were done for predicted values vs. errors (residuals) and predicted vs observed.

Validation of the model: Splitting method was adopted to validate the model. The model was built using 75% of the randomly selected data. The established model was validated using 25% of remaining data. Scatter plot of observed values and predicted values, bias index, and intraclass correlation coefficients, mean of observed and predicted values were computed as part of validation.

4.5 Modeling for prediction of demand based on population in a geographical area

The regional data on demand per 1000 population was modelled to calculate the demand for the states that represent the region. This demand per 1000 population is a count data, which followed a negative binomial distribution which is a combination of Poisson and gamma distribution. Therefore, a generalized negative binomial regression model was used.

The potential variables and their weights were decided either based on the statistical significance of the variable or based on the epidemiological and programmatic importance. The regression coefficients were used as weights for prediction. Different models were done based on the consensus. Model selection was done using Akaike Information Criteria

(AIC) and Bayesian Information Criteria (BIC) statistics. The generalized negative binomial regression model is given below,

$$\log(Y_i) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n$$

The weights were estimated using the following function.

$$l(\beta, a) = \sum_{i=1}^{n} \sum_{j=0}^{y_i^*} \log(1 + aj) + y_i \log \mu_i - (y_i + a^{-1}) \log(1 + a\,\mu_i)$$

Validation of the model: The model was validated using scatter plots of observed and predicted values for demand for a specific population**.** Further, bootstrap validation was done using 1000 resampling from the study data. That is, for each resampled data, the weights were applied and the predicted value was calculated. Intra Class Correlation (ICC) was calculated for the observed and predicted demand per bed per year for each resampled data. Similarly, the bias between observed and predicted values of demand for each facility was calculated. Then mean and (SD) bias was calculated for each resample. Thus we have obtained 1000 mean (SD) for bias and ICC. As these statistics (ICC and Bias) followed normal distribution the mean and 95% CI were computed using the bootstrap sample.

4.5.1 Definitions and data used for the calculations/estimations of different indicators

i. **Level of care:** For this study, the primary, secondary and tertiary care facilities are defined as below,

   Primary health care facilities: The primary care facilities in the public sector include, Upgraded Primary Health Centres (UPHC), Community Health Centres (CHC), Urban Primary Health Centres (UPHC) and Urban Community Health Centres (UCHC), irrespective of the number of beds. In private sector, the facilities providing basic/primary medical, surgical, obstetrics & gynaecology and paediatrics services with less than 50 beds were categorised as primary health care facilities.

Secondary healthcare facilities: In the public sector, this includes sub-district/divisional (SDH), and district hospitals (DH) that provide secondary care services. In private sector, it includes facilities that provide secondary care (basic and speciality services (with more than 50 beds)

Tertiary health care facilities: In the public sector, this includes medical college hospital and other tertiary care facilities with a minimum of 200 beds. In private sector, it includes private medical college hospitals and multispecialty hospitals providing super speciality services with a minimum of 200 beds.

ii. **The total population of the country:** The total population of the country taken for this study is the projected population of 1,319,566,420 in July 2017[4].

iii. **Adult population**: It is 61.01% of the total population which is (805,067,473) according to the 2011 census[5].

a. **Age-specific population:** The other required age-specific population were also calculated using the proportion of the age-specific population in 2011[6].

b. **Adult male and female population**: The percentage of the adult male population was 50.87% and the Female population was 49.13% in 2011, which were used to calculate the male and female population[7].

iv. **Crude Birth Rate (CBR):** The crude birth rate is 20.4% in 2017[8].

v. **Stillbirth:** The stillbirth rate is 4 per 1000 live births[9].

vi. **Total Pregnancy in a year: Live births+ Abortions+ stillbirth**

i. **Live births** = Total population*CBR/1000

= 1,319,566,420*20.4/1,000 = 26,919,155

[4] State-wise Aadhaar Saturation, (2017), Government of India
[5] Census, (2011), Government of India
[6] Age specific data, Census (2011), Government of India
[7] Census, (2011), Government of India
[8] Sample Registration System, (2017), Government of India
[9] Sample Registration System, (2017), Government of India

ii. **Stillbirths:** It is estimated as the number of stillbirths per one thousand live births (LB). Estimated considering 4/1000 live births as the stillbirth rate (SRS Bulletin 2017)

= 26,919,155 * 4/1000 = 107,677

iii. **Abortion**: The currently available data indicates 701,415 abortions in a year.[10]

vii. **The population at risk for different diseases and conditions**

- **Nutritional anaemia**: It is excluding the number of pregnant women from the adult population (above 18 years) in the year 2017, as anaemia among pregnant women is considered under obstetrics and Gynaecology section.
- **Fibroids-myomectomy and AUB: Excluding** the population of pregnant women from the adult females in the age group of 18-54 years.
- **AUB/Prolapse/Adenomyosis/endometriosis:** Excluding population of pregnant women from the adult female population
- **Cancer cervix:** Females above 30 years of age.
- **Cancer endometrium:** Females above 40 years of age. According to the census 2011 data, the percentage of women above 40 years of age.
- **Cancer ovary:** Adult female population.

viii. **Number of people with a disease or condition:** It is either the absolute number of people with the disease or condition or computed based on the prevalence/incidence rate (%) multiplied by the population at risk.

ix. **Percentage of persons requiring transfusion and an average number of units required**: Percentage of people with the disease who requires transfusion of blood and the average number of units of blood required per patient were derived from the Delphi exercise.

x. **Number of persons requiring transfusion:** The percentage of persons who require transfusion was calculated using the percentage requiring transfusion multiplied by the number of persons with a specific disease or condition

[10] Health and Family Welfare Statistics, (2015), Government

4.6 Adherence to ethical standards

The Institutional Review Board of Christian Medical College and Hospital, Vellore, India, had reviewed and cleared the proposal with exemption from Ethical clearance for this proposal. Besides, this proposal was cleared by Technical Resource Group (TRG), Research and Development, National AIDS Control Organization followed by the Center-level Associate Director for Science (CDC) and Associate Administrator for Science (ATSDR), the Centers for Disease Control and Prevention (CDC).

4.7 Pilot study

A pilot study was carried out to examine the feasibility of conducting the study, assess the implementation methods, test the data collection tools and database creation. The pilot study was conducted in Karnataka state from the southern region of India which is not part of the main study. For the estimation of population need, a Delphi exercise was conducted at Christian Medical College Hospital, Vellore. Fifteen subject experts participated in the Delphi exercise.

In terms of estimation of current clinical demand, supply and use, one health care facility each from the public and private sector representing the primary, secondary and tertiary level of care were randomly selected from Karnataka. In total, six health care institutions were included in the pilot study.

All the tools were administrated to test the tools, check the feasibility of implementation approach, and the database structures. Few changes were done in the tools based on the learning from a pilot study.

5. Results and findings

5.1 Population need

As mentioned earlier, the study focused on the key technical aspects that are, population need, current clinical demand, current supply and utilization of blood and blood components. In order to estimate the total population need for blood, the disease and condition specific population need under each speciality were estimated. Enlisting of the diseases or conditions that require transfusion was done through Delphi exercise. The prevalence or incidence of the diseases that require transfusion was computed primarily through literature review. In the absence of data related to prevalence and incidence any diseases/condition, Delphi was used to arrive at prevalence or incidence based on consensus. Besides, the Delphi exercises focussed on estimating the percentage of people require transfusion, and the quantum of blood or components required (average units). The participant details of Delphi exercises are given in Table-5.

Table 5 - Delphi participants

Description	Medicine (n=16)	Surgery (n=16)	Obst & Gyn (n=14)	Paediatrics (n=14)
Gender				
Male	12 (75%)	14 (87.5%)	7 (50%)	8 (57.1%)
Female	4 (25%)	2 (12.5%)	7 (50%)	6 (42.9%)
Place of Practice				
Rural	3 (18.8%)	4 (25%)	3 (21.4%)	2 (14.3%)
Urban	13 (81.3%)	12 (75%)	11 (78.6%)	12 (85.7%)
Type of care				
Primary	2 (12.5%)	1 (6.25%)	2 (14.3%)	1 (7.1%)
Secondary	1 (6.3%)	3 (18.75%)	2 (14.3%)	2 (14.3%)
Tertiary	13 (81.3%)	12 (75%)	10 (71.4%)	11 (78.6%)
Zone				
North	5 (31.3%)	2 (12.5%)	1 (7.1%)	4 (28.6%)
East	3 (18.8%)	2 (12.5%)	1 (7.1%)	2 (14.3%)
West	1 (6.3%)	2 (12.5%)	5 (35.7%)	1 (7.1%)
South	7 (43.8%)	9 (56.3%)	6 (42.9%)	6 (42.9%)
North East	0	1 (6.3%)	1 (7.1%)	1 (7.1%)

5.1.1 Population need – Medicine

5.1.1.1 Diseases and conditions that require transfusion - Medicine

The medical diseases and conditions that require transfusion are listed below. Based on discussion with the experts, related diseases and conditions were categorised together for ease of computation.

Nutritional Anaemia: Anaemia that results from inadequate intake or assimilation of materials essential for the production of red blood cells and haemoglobin is called as nutritional anaemia (WHO 2011b). According to ICMR, anaemia is classified as, Severe Anaemia (Hb <7 g%); Moderate (between 7 and 9 g%); and Mild (9.1-12 g%) (ICMR 2003-04, Gupta et al. 2014). The prevalence of severe nutritional anaemia in India among rural population is 1.3% (Malhotra et al. 2004) and a country-wise study indicated a prevalence of severe nutritional anaemia as 1.4% (Bharati et al. 2008a). According to NFHS-4, 1% of adult women and 1.1% of adult men have severe anaemia with variation between rural and urban population. For the estimation, the NFHS-4 data was to arrive at the number of people with severe anaemia(IIPS and ORC-Macro 2017).

Bone marrow failure: Bone marrow failure syndromes (BMFS) are a cluster of inherited or acquired disorders characterized by peripheral cytopenia due to a dysregulated haematopoiesis(Zhang 2016). It includes aplastic anaemia and myelodysplastic syndromes. According to a study, the incidence of aplastic anaemia varies from 1.4 to 14 cases per million populations and is higher in the Asian countries than West(Malhotra et al. 2016). The Delphi consensus on the burden of bone marrow failure was 1 per 1,00,000 population.

Leukaemia: It is characterized by widespread, rapid and disorderly proliferation of leukocytes and their precursor and by the presence of immature leukocytes in the blood often in very large numbers (Singla, Bodal et al. 2016). The annual incidence of Chronic Myeloid leukaemia was reported to be 0.8 to 2.2 per 100,000 populations (Ganesan and Kumar 2017). As per GLOBOCON – the International Agency for Research on Cancer, the five-year prevalence of Leukaemia was 24,042 in the year 2012 (GLOBOCON

2012, Mallath, Taylor et al. 2014) which is equivalent to 3 per 100,000 that was used for population need estimation.

Myeloma & Lymphoma: The age-adjusted incidence rates for Non-Hodgkin's Lymphoma in men and women in India are 2.9/100,000 and 1.5/100,000 population (Nair, Arora, and Mallath 2016). The reported incidence of multiple myeloma in India ranges from 0.5 to 1.2 per 100,000 (Nair et al. 1993). The reported 5-year prevalence of lymphoma including non-Hodgkin's lymphoma (NHL) and multiple myeloma is 52,615 cases which were used for population need estimation (GLOBOCON 2012b).

Haemolytic Anaemia: Haemolytic anaemia results from an increased rate of red cell destruction due to defects in the RBCs. These could be in the haemoglobin molecule (e.g., thalassemia, sickle cell anaemia), in the red cell membrane (e.g., hereditary spherocytosis, hereditary elliptocytosis) or in the red cell enzymes (e.g., G6PD deficiency and pyruvate kinase deficiency (Venkataswamy and Devi 2017). The average prevalence of β thalassemia carriers is 3–4% which translates to 35 to 45 million carriers and another study reports a prevalence of 2.8% β-thalassemia carriers (Mohanty et al. 2013). The estimated patients with a β thalassemia syndrome and sickle cell anaemia in India are around 100,000 and 150,000 respectively which amounts to 250,000 patients (Colah, Italia, and Gorakshakar 2018) and were used for population need estimation.

Autoimmune haemolytic anaemia: Autoimmune Haemolytic Anaemia (AIHA) is characterized by the production of autoantibodies directed against red blood cells (Chaudhary and Das 2014). The incidence is 1-3 per 10,00,000 per year and its prevalence is 17/100,000 (Prabhu et al. 2016) which was considered for the estimation of population need.

Haemophilia: Haemophilia is an inherited single gene disorder with an incidence of 1 per 10,000 births. The estimated prevalence of haemophilia A was reported to be around 50,000 patients (Kar et al. 2014). Another study indicated an incidence of nearly 1 in 10,000 males and haemophilia A accounts for 80-85% of total cases. It is also estimated that there are at least 50,000 severe haemophilia patients and only 15% of estimated numbers have been diagnosed to have haemophilia in our country (Kashyap and Choudhry 2001) which was used for estimation of population need.

Idiopathic Thrombocytopenic Purpura (ITP): It is defined as a hematologic disorder, characterized by isolated thrombocytopenia without a clinically apparent cause. According to literature, the incidence of ITP is reported as 50-100 per million per year (Kayal, Jayachandran, and Singh 2014). However, literature in India indicates an incidence of up to 3.3 per 100,000 adults per year (Anoop 2012) which was considered for estimation.

End Stage Renal Disease (ESRD): It is the last stage (stage five) of chronic kidney disease (CKD) (Varma 2015). The average crude and age-adjusted incidence rates of ESRD were 151 and 232 per million population respectively (Modi and Jha 2006). Considering the present scenario, the Delphi consensus on the incidence of ESRD was 40 per 1,00,000 population.

Other Oncological conditions: The estimated number of people living with any oncological conditions was around 2.5 million(NICPR 2018). As few conditions, such as, Leukaemia, Myeloma, Lymphoma, gynaecological malignancies etc. were considered separately under respective sections, these numbers were deducted from the overall estimated number of people which amounts to 1.3 million patients which was considered for estimation.

Gastro-Intestinal Bleed: Gastrointestinal (GI) bleed involves any bleeding in the GI tract from the mouth, oesophagus, stomach, small intestines, large intestines, to the anus. Microscopic levels of bleeding can lead to anaemia over time, and more massive amounts of bleeding can lead to death (El-Tawil 2012). The incidence of upper gastrointestinal bleed (UGIB) is approximately 100/100,000 population per year and bleeding from the upper gastrointestinal tract (GIT) is approximately 4 times as common as bleeding from the lower GIT and is a major cause of morbidity and mortality (Jain et al. 2015). The Delphi consensus of both Upper and Lower GI bleed was 100 per 1,00 ,000 persons.

Plasmapheresis: Therapeutic apheresis encompasses a variety of blood processing techniques, which improves the outcome of susceptible clinical disorders. It also includes therapeutic plasma exchange (Kumar et al. 2015). The Delphi consensus of plasmapheresis requirement was 1 per 1,00,000 in a year which was used for population need estimation.

Disseminated Intravascular Coagulation (DIC): It is an acquired syndrome characterised by the intravascular activation of coagulation with loss of localisation arising from different causes (Venugopal 2014). The Delphi consensus on DIC was 100 per 1,00,000 population of all hospitalised patients in a year.

Severe Malaria: Of the 1.4 billion people living in 11 countries (6% of global area), 1.2 billion are susceptible and are exposed to the risk of malaria, most of whom live in India (Kumar et al. 2007). As per literature, severe malaria accounts for approximately 5% of imported malaria cases with a range of 1–38% (Trampuz et al. 2003). In view of this, the Delphi consensus for severe malaria was 5% of all malaria cases. In 2016, the total number of the malaria cases was 10,59,437(NHP 2017a) and 61.01% being the proportion of adult population above 18 years, the estimated number of cases was 6,46,363; of this 5% (Severe Malaria) amounts to 32,318.

Dengue: Patients with dengue fever can potentially experience haemorrhagic complications due to plasma leaking, fluid accumulation, respiratory distress, severe bleeding, or organ impairment (WHO 2018b). The reported number of dengue cases in 2017 was 1,11,896(NHP 2017a). Considering 61.01% of adult population, the number of adult dengue cases was estimated to be 68,268 which was used for population need estimation.

Bone Marrow Transplant: A bone marrow transplant is a procedure which involves separating stem cells from the bone marrow and giving them back either to the same patient (autologous transplant) or to another person(allogeneic transplant) (JohnHopkinsMedicine 2017). According to literature, 30% Leukaemia and 10% haemolytic anaemia patients might require bone marrow transplant (BMR 2017). Considering this, the total population requiring bone marrow transplant was estimated to be around 17,710 patients which was used for population need estimation.

5.1.1.2 Estimated population need for Medicine

The quantum of blood to cater to the medical needs of the population was estimated at 10.6 million units (95% CI: 8.4-14.3). This implies that the country needs to collect 10.6 million whole blood to address the need for whole blood and components in the country. This is based on assumption that there is rational use (appropriate components) of blood across the country.

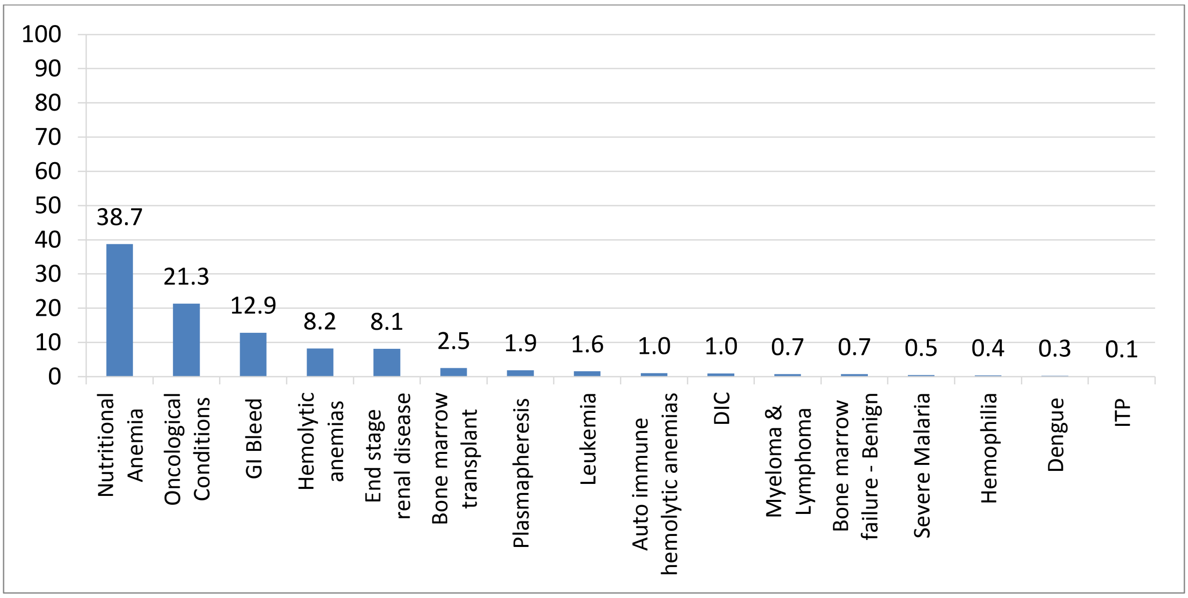
The disease-specific need is mentioned in Table-6. In addition to the prevalence or incidence or the actual number of people with a specific disease or condition, the proportion of people requiring transfusion and the average number units of blood requirement for each condition are mentioned in the table.

Table 6 - Population need for specific diseases and conditions under Medicine

Medical Conditions							
S. No	**Clinical condition**	**Population at risk (In Lakhs)**	**Prevalence or Incidence (%)**	**No of people with condition**	**% requiring transfusion (95% CI)***	**Average number of Units per patient***	**Total Need (x1000 units) (95% CI)**
1	Nutritional Anaemia	7,773	Male=1.1 Female=1.0	81,82,930	25.0 (25.0-30.0)	2 (2.0-2.0)	4,091 (4,091-4,910)
2	Bone marrow failure - Benign	8,051	0.001	8,051	73.0 (68.8-77.2)	13.2 (10.1-16.3)	78 (56-101)
3	Leukaemia	8,051		24,042	60.7 (57.4-64.0)	11.3 (9.3-13.3)	165 (129-204)
4	Myeloma & Lymphoma	8,051		52,615	30.0 (27.5-30.0)	5.0 (4.0-5.0)	79 (58-79)
5	Haemolytic anaemia	8,051	0.03	2,41,520	50.2 (48.6-51.8)	7.2 (6.2-8.2)	871 (728-1,025)
6	Auto immune haemolytic anaemia	8,051	0.017	1,36,861	20.0 (20.0-20.0)	4.0 (2.0-4.0)	109 (54-109)
7	Haemophilia	4,095		50,000	25.6 (22.6-28.6)	3.4 (2.2-4.6)	44 (25-66)
8	Idiopathic Thrombocytopenic Purpura (ITP)	8,051	0.0033	26,567	8.4 (6.2-10.7)	4.2 (3.1-5.4)	9 (5-15)
9	End stage renal disease	8,051	0.04	3,22,027	51.6 (40.3-62.9)	5.2 (3.2-8.8)	859 (415-1,781)

10	Oncological Conditions	8,051		13,85,906	30.0 (21.9-38.1)	5.4 (4.3-6.5)	2,255 (1,305-3,433)
11	Gastrointestinal Bleeding	8,051	0.1	8,05,067	41.2 (36.8-45.6)	4.1 (3.4-4.8)	1,359 (1,006-1,762)
12	Plasmapheresis group	8,051	0.001	8,051	97.5(90.0-100)	25.0 (22.5-28.0)	196 (163-225)
13	Disseminated Intravascular Coagulation (DIC)	8,051	0.01	80,507	22.8 (14.7-30.9)	5.6 (4.9-6.2)	102 (57-155)
14	Severe Malaria	8,051		32,318	40.0 (30.0-40.0)	4.0 (4.0-5.0)	52 (39-65)
15	Dengue	8,051		68,268	8.6 (6.7-10.4)	5.6 (4.9-6.3)	33 (22-45)
16	Bone marrow transplant	8,051		17,710	100.0(100.0-100.0)	15.0 (12.0-19.0)	266 (213-336)
	Total population need				**1,05,69,176** (83,67,716-1,43,12,052)		

Figure 2 - Population need: Proportion of need for specific diseases and conditions – Medicine



Nutritional anemia contributed around 39% of the population need (Figure-2) followed by oncological conditions (21.3%), GI bleed (12.9%), haemolytic anemia (8.2%), end-stage renal disease with 8.1%, bone marrow transplant(2.5%), plasmapheresis (1.9%) and leukemia (1.6%). ITP (0.1%), dengue (0.3%), hemophilia (0.4%) and severe malaria (0.5%) contributes the least to the total population need.

5.1.2 Population need – Surgery

5.1.2.1 Diseases and conditions that require transfusion – Surgery

The surgical diseases and conditions that require transfusion are listed below. Based on discussion with the experts, related diseases and conditions were categorised together for ease of computation.

Head and neck surgeries-Emergency: This includes, otorhinolaryngology which is the surgical speciality of the head and neck including ear, nose and throat (ENT) (Crumley 1982, RL 1982), maxillofacial surgeries, and other general surgeries related to the same anatomical region. As this is a broad area, there is inadequate literature indicating the incidence. The Delphi experts arrived at the consensus of 5 per 100,000 population requiring emergency head and neck surgeries in a year.

Head and neck surgeries-Elective: The Delphi consensus was 30 per 100,000 populations.

Neurosurgical procedures-Emergency: The conditions requiring emergency neurosurgical procedure include traumatic injuries like skull fracture, intracranial injury and non-traumatic pathological conditions like infections, subdural haemorrhage, neoplasms, and aneurysms(Kulkarni 2017). The Delphi consensus was 20 per 100,000 population.

Neurosurgical procedures-Elective: The Delphi consensus on elective neurosurgical procedures was 10 per 100,000 population.

Adult cardiac surgery: Adult Cardiac Surgery is surgery on the heart and the large blood vessels in the chest in patients above 18 years which includes Coronary Artery Bypass Graft (CABG), valve surgery, aneurysm surgery, heart rhythm disorders and a few congenital conditions(SCTS 2018). An Indian study places the burden of Coronary Artery Disease (CAD) in rural areas as 3-5% and urban population as 7-10%(Kaul and Bhatia 2010). Another study indicates a prevalence of CAD in the rural and urban population as 1.5% and 3% respectively(Gupta, Mohan, and Narula 2016) which sums up to 1,58,38,897 cases when extrapolated for the rural and urban population in India. Delphi experts arrived at a consensus that 4% of those with CAD undergo cardiac surgeries. Based on this, the number of patients who require cardiac surgeries in a year is computed as 6,33,556 which was used for population need estimation.

Paediatric cardiac surgery: According to literature, the prevalence of congenital heart disease (CHD) varies from 2.25 to 5.2 per 1000 live births (Saxena et al. 2016) and in India, around 48,000 to 1,28,000 children are born with congenital heart diseases each year (Girinath 2001). A large-scale study in India quotes the prevalence of CHD in children as 19.4 per 1000 population and around 2% of these cases undergo cardiac surgery that amounts to 1,99,626 patients (Bhardwaj et al. 2015) which was used to estimate the population need.

Abdominal surgery-Emergency: It includes surgeries for conditions such as incarcerated and strangulated inguinal hernias, appendicitis, intestinal obstructions caused by adhesions, volvulus, worm infection, or intussusception, peptic ulcer complications and bowel perforation etc.(McCord et al. 2015). The number of patients who require emergency abdominal surgery in a year as per Delphi consensus was 20 per 100,000 which is used for estimation.

Abdominal surgery-Upper GI: Surgery (Upper GI) refers to the surgical treatment of diseases in the oesophagus, stomach and duodenum (first part of the small intestine) (NottinghamUniversityHospitals 2018). The Delphi consensus on the total number of persons requiring upper GI surgeries was 20 per 1, 00,000 population per year.

Abdominal surgery-Lower GI: This procedure includes surgical treatment of diseases pertaining to small bowel, colon, and rectum(Welch, Ottinger, and Welch 1980). The Delphi consensus for the number of patients requiring abdominal surgery (Lower GI) was 40 per 1, 00,000 population per year.

Abdominal surgery- Hepato-pancreatic-biliary (HPB): Abdominal surgery-HPB is the surgical treatment of diseases related to the gallbladder, liver and pancreas (hepatobiliary system) (WashingtonUniversitySchoolofMedicineinSt.Louis 2018). The Delphi consensus for the number of patients requiring abdominal surgery-HPB was 20 per 1, 00,000 population per year.

Thoracic surgery: It includes the surgery for complications of pulmonary tuberculosis, carcinoma lung and other chest conditions. All types of major chest surgeries like lung resections, decortication, thoracoplasty, video-assisted thoracic surgery and tracheal surgery are included(JohnsHopkinsMedicine 2018a). The Delphi consensus for the number of patients requiring thoracic surgery was 15 per 1,00,000 population per year.

Oncology surgery: Surgical oncology is a specialized area of oncology that requires surgery to remove a tumour which may be curative by itself or adjunct to any other type of treatment such as radiotherapy and chemotherapy (Peake 2011). The Delphi consensus for the number of patients requiring oncology surgery was 50 per 1,00,000 populations per year.

Orthopaedic surgery-Emergency: An orthopaedic emergency includes a range of conditions such as Fractures, Concussions, Dislocations, Tendon ruptures, and those causing neurovascular compromise etc. (Marco, Humphries, and Mozeleski 2017). The Delphi consensus for the number of patients requiring emergency orthopaedic surgery was 50 per 100,000 population per year.

Orthopaedic surgery-Elective: It includes most common hip and knee procedures, including arthroscopic hip and knee surgery and total hip and knee replacement, amputations etc. (Dwyer et al. 2015). The Delphi consensus for the number of patients requiring elective orthopaedic surgery was 100 per 1,00,000 population per year.

Polytrauma: Polytrauma (multi-trauma) refers to severely injured patients usually associated with two or more severe injuries in at least two areas of the body. (Kroupa 1990a, b). This includes road traffic accidents and injuries related to any other accidents. The Delphi consensus for the number of patients requiring surgery for polytrauma was 10 per 1,00,000 population in a year.

Transplant: Transplant is defined as grafting of any human organ from any living or deceased person to some other living person for therapeutic purposes (GOI 1994). The transplant need in the country are 2,00,000 kidney, 50,000 liver, 50,000 heart transplants (Organ-India 2013). Based on this, the Delphi consensus on the estimated number of persons requiring transplants is 2,50,000 which was used for population need estimation.

Urology: It includes radical prostatectomy, urologic reconstruction, laparoscopy, treatment of rare stone disease, urinary incontinence, benign prostate hypertrophy, erectile dysfunction, nephrectomy, bladder reconstruction etc. (JohnsHopkinsMedicine 2018b). The Delphi consensus for the number of patients requiring surgery for urology conditions was 30 per 1,00,000 population per year.

Skin and soft tissue: It includes treating skin or subcutaneous infections, such as necrotizing fasciitis, skin grafts to cover defects in the skin from burns, trauma, or infections (UniversityofUtah 2018). The Delphi consensus for the number of patients requiring surgery for skin and soft tissue related conditions is 100 per 100,000 population per year.

Burns: The estimated annual burns incidence in India is approximately 6-7 million per year. (Gupta, Makhija, and Bajaj 2010). According to WHO, over 10,00,000 people in India are moderately or severely burnt every year (WHO 2018a). The Delphi consensus for the number of patients requiring surgery for severe burns was 10 per 100,000 population per year.

5.1.2.2 Estimated population need for Surgery

The quantum of blood to cater to the surgical needs of the population was estimated at 6.6 million units (95% CI; 3.8-10.0). This implies that the country needs to collect 6.6 million units of whole blood to address the surgical need for whole blood and components in the country.

This is based on assumption that there is rational use (appropriate components) of blood across the country. The disease-specific need is mentioned in Table-7. In addition to the prevalence or incidence or the actual number of people with a specific disease or condition, the proportion of people requiring transfusion and the average number units of blood requirement for each condition are mentioned in the table.

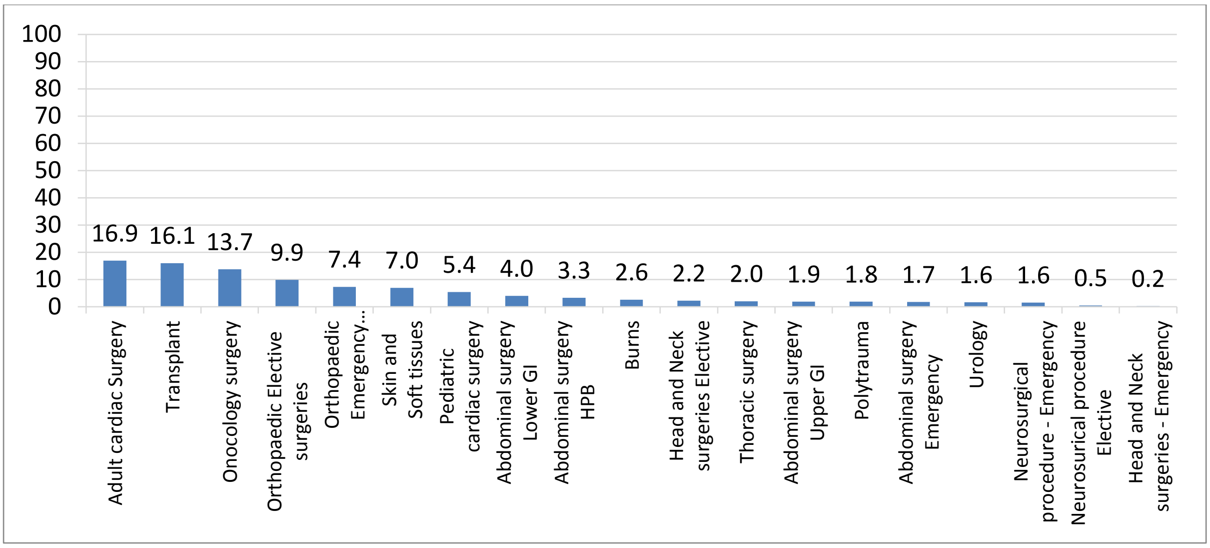
Table 7 - Population need for specific diseases and conditions under Surgery

Surgical Conditions							
S. No.	**Clinical condition**	**Population at risk (in Lakhs)**	**Prevalence or Incidence (%)**	**No of people with condition**	**% requiring Transfusion (95% CI)**	**Average number of Units per patient**	**Total Need** (x1000 units) **(95% CI)**
1	Head and Neck Surgeries - Emergency	13,196	0.005	65,978	17.1 (11.9-22.2)	1.4 (1.2-1.7)	16 (9-25)
2	Head and Neck surgeries - Elective	13,196	0.03	3,95,870	25.0 (17.9-32.1)	1.5 (1.1-1.9)	148 (79-239)
3	Neurosurgical procedure Emergency	13,196	0.02	2,63,913	26.2 (19.1-33.3)	1.5 (1.1-1.9)	104 (56-165)
4	Neurosurgical procedure - Elective	13,196	0.01	1,31,957	20.2(16-25)	1.3 (1- 1.6)	35 (21-53)
5	Adult cardiac Surgery	8,051	0.08	6,33,556	77.0 (71.3-82.7)	2.3 (1.7-2.9)	1,122 (773-1,514)
6	Paediatric cardiac surgery	5,145	0.04	1,99,626	90.0 (90-100)	2.0 (1.0-2.0)	359 (180-399)
7	Abdominal surgery Emergency	13,196	0.02	2,63,913	22.5 (18.7-25.7)	1.9 (1.7-2.2)	115 (85-146)
8	Abdominal surgery - Upper GI	13,196	0.02	2,63,913	27.1 (20.1-34.2)	1.7 (1.3-2.2)	124 (68-196)
9	Abdominal surgery - Lower GI	13,196	0.04	5,27,827	27.5 (21.5-33.8)	1.8 (1.4-2.2)	264 (161-396)
10	Abdominal surgery - HPB	13,196	0.02	2,63,913	33.5 (23.4-43.5)	2.5 (2.1-2.9)	221 (130-333)
11	Thoracic surgery	13,196	0.015	1,97,935	38.1 (29.6-46.6)	1.8 (1.1-2.5)	136 (67-227)
12	Oncology surgery	13,196	0.05	6,59,783	53.1 (46.1-60.1)	2.6 (1.0-4.0)	911 (304-1,586)
13	Orthopaedic surgeries - Emergency	13,196	0.05	6,59,783	41.2 (35.4-46.2)	1.8 (1.4-2.2)	489 (327-671)
14	Orthopaedic surgeries - Elective	13,196	0.1	13,19,566	33.1 (27.4-38.8)	1.5 (1.2-1.8)	655 (433-922)
15	Polytrauma	13,196	0.01	1,31,957	44.2 (36.3-52.2)	2.1 (2.0-2.4)	123 (96-165)
16	Transplant	13,196		2,50,000	82.9 (79.9-89.8)	5.1 (3.0-8.0)	1,065 (599-1,796)

17	Urology	13,196	0.03	3,95,870	20.5 (13.7-27.3)	1.3 (1.0-1.7)	108 (54-184)
18	Skin and Soft tissues	13,196	0.1	13,19,566	23.5 (17.8-29.2)	1.5 (1.2-1.8)	464 (281-693)
19	Burns	13,196	0.01	1,31,957	35.2 (22.1-48.4)	3.8 (2.2-5.2)	174 (64-332)
	Total population need				**66,32,019 (37,87,602-1,00,40,722)**		

Adult cardiac surgery contributes the highest which accounts for 17% of the total population need (Figure-3), is followed by transplant (16.1%) and oncology surgeries (13.7%). The least contributing condition is head and neck elective surgeries (0.2%) preceded by neurological condition elective (0.5%), neurosurgical procedures emergency and urology with 1.6%.

Figure 3 - Population need: Proportion of need for specific diseases and conditions - Surgery



5.1.3 Population need – Obstetrics and Gynaecology

5.1.3.1 Diseases or conditions that require transfusion - Obstetrics and Gynaecology

The diseases or conditions under Obstetrics and Gynaecology that require transfusion are listed below. Based on discussion with the experts, related diseases and conditions were categorised together for ease of computation.

Anemia in pregnancy: According to WHO, hemoglobin level below 11gm/dl in pregnant women indicates anemia and hemoglobin below 7gm/dl is severe anemia. The Center for Disease Control and Prevention (1990) defines anemia as less than 11gm/dl in the first and third trimester and less than 10.5gm/dl in the second trimester (Sharma and Shankar 2010). The World Bank reported a prevalence of 50.1% in 2016 and the NFHS-4 reported 50.3% among pregnant women in India which is less than 11.0 g/dl which is considered for estimating the population need (IIPS and ORC-Macro 2017)

Abortions: It is defined as a fetus or embryo removed or expelled from the uterus during the first half of gestation - 20 weeks or less, or in the absence of accurate dating criteria, born weighing < 500 g (Schorge et al. 2012). In India, 7,01,415 abortions were reported in 2014-15; (GOI 2015, Singh et al. 2018) which was considered for analysis.

Molar pregnancy: Molar pregnancy (hydatidiform mole) is known as the pre-malignant form of gestational trophoblastic neoplasia. There is a wide variation in incidence reported worldwide which has been contributed by genetic, demographic, environmental and host-related factors. The incidence of molar pregnancy in most of the hospital-based study was 4/1000 deliveries (Jagtap et al. 2017). Moreover, an Indian study reported an incidence of 4.5 per 1000 deliveries (Dineshkumar et al. 2016) which was considered for estimation.

Ectopic pregnancies: Ectopic pregnancy is defined as any intra/extra-uterine pregnancy in which the fertilized ovum implants at an aberrant site which is not conducive to its growth and development. The incidence of ectopic pregnancy is around 1-2% in most of the hospital-based studies (GOI 2018). According to a study conducted in India, the reported incidence of ectopic pregnancy was 9.1/1,000 pregnancies (Tahmina, Daniel et al. 2016) which was used for population need estimation.

Hepatic disorders: Liver disease during pregnancy is rare, but it can complicate up to 3% of all pregnancies (Shekhar and Diddi 2015). Clinical conditions that are seen only in pregnant women and involve the liver are hyperemesis gravidarum that happens in 1/200 pregnancies and intrahepatic cholestasis of pregnancy (0.5-1.5/100), acute fatty liver of pregnancy (1/7270 to 13,000 deliveries) and few other conditions (Lata 2013). The Delphi consensus for the number of patients with hepatic disorders was 1/100 deliveries per year.

HELLP (Haemolysis, Elevated Liver enzymes, and Low Platelets): HELLP syndrome is a life-threatening pregnancy complication which may be a variant of preeclampsia. According to a study, the incidence of HELLP is reported as 0.73% (Ara et al. 2015), whereas most of the studies reported an incidence of 0.5% to 0.9% of all pregnancies (Lata 2013);(George and Thankachi 2017). The Delphi consensus for the number of patients having HELLP syndrome was 0.5% which was used for the estimation.

Antepartum hemorrhage (APH)-Placenta praevia: It is defined as bleeding from the genital tract in the second half of pregnancy (Giordano et al. 2010). The incidence of placenta praevia has been rising in parallel with the increasing rate of cesarean delivery. Studies indicate an incidence ranging from 2 to 5% (Jejani and Kawthalkar 2015). Literature indicates that around 60% to 70% of APH are due to placenta praevia (Majumder et al. 2015) (Wasnik and Naiknaware 2015). Indian study reported an incidence of APH due to Placenta praevia at 1.9% (Fan et al. 2017) which was considered for population need estimation.

Antepartum hemorrhage (APH) – Abruption: Abruption is the premature separation of a normally placed placenta before delivery of the fetus, with blood collecting between the placenta and the uterus. This accounts for 30% of all cases of antepartum hemorrhage (GOI 2018). Abruptio placentae occurs in about 1-2% of all pregnancies throughout the world(Deering 2017). The Delphi consensus was 1/100 deliveries.

Placenta accreta: It is an abnormal adherence of the placenta to the uterine wall and is an uncommon but a potentially life-threatening obstetric condition that requires a multidisciplinary approach to management. There are three main entities: accreta, increta, and percent. The incidence of placenta accreta has increased over the past century from 1/7000 deliveries to 1/2500 deliveries due to an increased rate of cesarean deliveries (Khan et al. 2013). According to a study, the reported incidence of placenta accreta was 1 in 533 pregnancies (Chaudhary and Antil 2016) which was considered for population need estimation.

Postpartum Haemorrhage (PPH) associated with the caesarean section, atonic uterus, retained placenta, and traumatic PPH: It is commonly defined as a blood loss of 500 ml or more within 24 hours after birth, while severe PPH is defined as a blood loss of 1000 ml or more within the same timeframe. PPH affects approximately 2% of all women who give birth (WHO 2012). Literature indicates that the incidence of PPH after vaginal delivery is between 2%-4% and 6% after cesarean section with uterine atony being the cause in about 50% cases (NHP 2017b) (Amy 1998). The Delphi consensus on PPH was 3% which was used for population need estimation.

Haematology-Factor deficiency, all thrombocytopenias and anticoagulation: Thrombocytopenia, defined as platelet count less than 150,000 μl^{-1}, which is the second most common hematological finding in pregnancy after anemia. It affects 7-10% of all pregnant women. Different types of thrombocytopenia occurring in pregnancy are gestational thrombocytopenia which occurs in approximately 8% of all pregnancies and immune thrombocytopenia which occurs in 1 in 1000-10,000 pregnancies, accounting for 3% of all thrombocytopenic gravidas(Perepu and Rosenstein 2013). Literature indicates an estimated incidence of ITP at 0.1–1 case per 1000 pregnancies (Sankaran and Robinson 2011). The Delphi consensus for the number of patients for this group of conditions was 1 per 1000 deliveries per year.

Fibroid uterus: A fibroid tumor, also known as leiomyoma or myoma, is a mass of compacted muscle and fibrous tissue that grows on the wall (or sometimes on the outside) of the uterus. A study in India reported a prevalence of uterine fibroids at 11.6% (Srilatha and Malathi 2017). According to reports, at any given point in time, nearly 15-25 million Indian women have fibroid uterus (GOI 2018). The Delphi consensus on myomectomy requirement out of the total fibroid uterus cases was 5%, amounting to 1 million cases was considered as the population of women requiring myomectomy.

Hysterectomy for Abnormal Uterine Bleeding (AUB), prolapse, adenomyosis, endometriosis-fibroids, Pelvic Inflammatory Disease (PID): Hysterectomy is the surgical removal of the uterus. It may also involve removal of the cervix, ovaries, fallopian tubes and other surrounding structures. This is a curative procedure for a variety of conditions; the common ones are specified above. The estimated need for hysterectomy was 20.7/1000 women (Desai et al. 2016).

Abnormal Uterine Bleeding (AUB): This is a common problem among women in the reproductive age group which includes oligomenorrhoea, polymenorrhoea, hypomenorrhoea, menorrhagia, metrorrhagia and dysfunctional uterine bleeding. According to the Indian literature available, the reported prevalence of abnormal uterine bleeding ranges from 9 to 17% (Murthy et al. 2009);(Saheta, Sharma, and C.Hariharan 2014);(Fraser, Langham, and Uhl-Hochgraeber 2014). The Delphi consensus for the number of patients for severe AUB was 2% which was used for the population need estimation.

Cancer cervix: Every year in India, 1,22,844 women are diagnosed with cervical cancer. Based on the data of the population-based cancer registries, the estimated number of new cancers cases during 2007 in India was 90,708.1 (GOI 2018) As per the same data, the age-adjusted incidence rate of cervical cancer in India varies from 12.3 – 25.4 per 1,00,000 persons in various parts of the country (Globocon 2012a) . The Delphi consensus for the number of patients with cancer cervix was 3,08,901 (Globocon 2012a) which was considered for population need estimation.

Carcinoma endometrium: Endometrial cancer is the commonest gynecological cancer mostly affecting women in the post-menopausal age group. Rates vary worldwide and are highest in white women in Western populations, however in India, the rates are as low as 4.3 per 100,000 (Balasubramaniam et al. 2013).

Carcinoma ovary: Ovarian cancer has emerged as one of the commonest malignancy affecting women in India. During the period 2001-06, the age-standardized incidence rates (ASR) for ovarian cancer varied from 0.9 to 8.4 per 1,00,000 person-years amongst various registries (Murthy et al. 2009). The GLOBOCON reported a 5-year prevalence of carcinoma ovary as 55,231 for India(Globocon 2012a).

5.1.3.2 Estimated population need for Obstetrics and Gynaecology

The quantum of blood to cater to the obstetrics and gynecology needs of the population is estimated at 3.6 million units (95% CI; 1.9-6.2). This implies that the country needs to collect 3.6 million units of whole blood to address the obstetrics and gynecology need for whole blood and components in the country. This is based on assumption that there is rational use (appropriate components) of blood across the country.

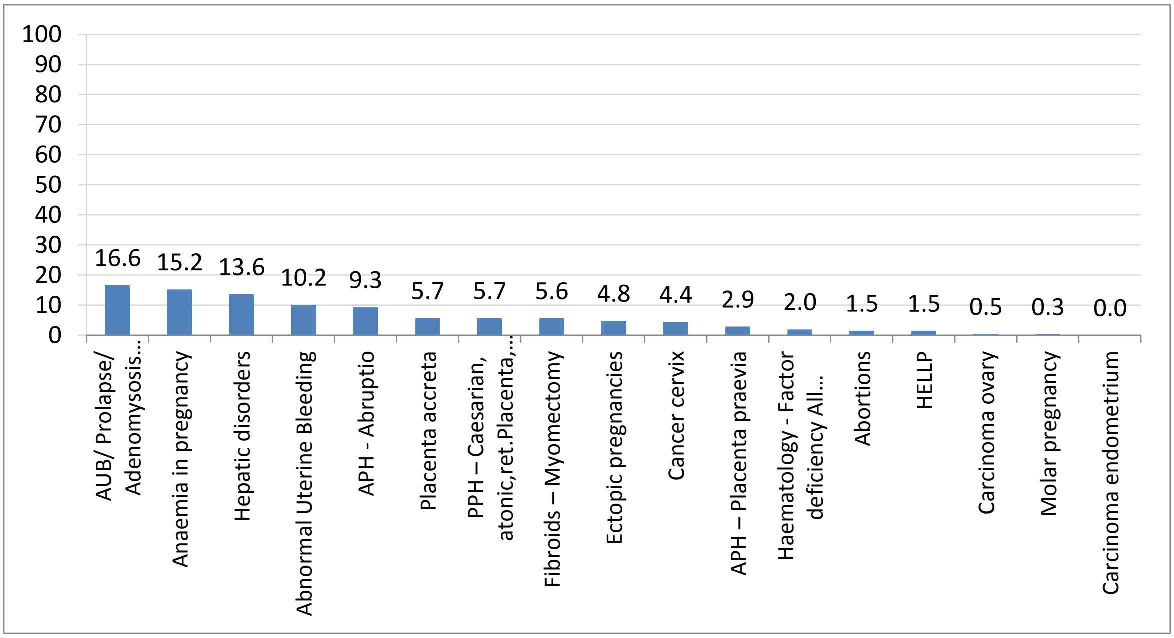
The disease-specific need is mentioned in Table-8. In addition to the prevalence or incidence or the actual number of people with a specific disease or condition, the proportion of people requiring transfusion and the average number units of blood requirement for each condition are mentioned in the table.

Table 8 - Population need for specific diseases and conditions under Obstetrics & Gynaecology

Obstetrics and Gynaecology							
S. No	**Clinical condition**	**Population at risk (In Lakhs)**	**Prevalence or Incidence (%)**	**No of people with condition**	**% requiring Transfusion (95% CI)**	**Average number of Units per patient**	**Total Need** (x1000 units) **(95% CI)**
1	Anaemia in pregnancy	277	50.3	1,39,47,308	2 (1.0-2.7)	2 (1.4-2.2)	558 (202-863)
2	Abortions	277		7,01,415	4 (2.5-5)	2 (1.4-2.0)	56 (24-70)
3	Molar pregnancy	277	0.46	1,26,441	5 (2-10)	2 (1.4-1.9)	13 (3-24)
4	Ectopic pregnancies	277	0.91	2,52,327	35 (20-42.5)	2 (1.7-2.4)	177 (85-257)
5	Hepatic disorders	277	1.0	2,77,282	22.5 (11.3-30)	8 (5-16)	499 (156-1331)
6	Haemolysis Elevated Liver Low Platelets Syndrome(HELLP)	277	0.5	1,38,641	8.8 (6.8-10.8)	4.5 (3.0-9.0)	55 (28-135)
7	APH – Placenta praevia	277	1.90	5,26,837	10 (6.6-14.9)	2 (1.6-2.5)	105 (57-196)
8	APH - Abruption	277	1.0	2,77,282	16.2 (12.3-20.0)	7.6 (4.0-10.0)	342 (136-555)
9	Placenta accrete	277	0.19	52,023	100 (100-100)	4 (3.2-4.9)	208 (164-258)
10	PPH – Caesarean, atonic, ret. Placenta, Traumatic PPH	277	3.0	8,31,847	10 (10-15)	2.5 (2.0-4.0)	208 (166-499)

11	Haematology Factor deficiency, All thrombocytopenias, Anticoagulation	277	0.1	27,728	26.7 (23.8-29.2)	9.9 (4.0-14.0)	73 (26-113)
12	Fibroids – Myomectomy	1,750	0.6	10,15,576	10.4 (8.2-12.5)	2.0 (1.6-2.3)	206 (132-296)
13	Hysterectomy - AUB/ Prolapse/ Fibroids Adenomysosis/ Endometriosis/ PID	3,638		76,13,489	5.08 (3.9-6.2)	1.6 (1.3-1.9)	609 (394-873)
14	Abnormal Uterine Bleeding	1,750	2.0	35,01,987	5.5 (4.6-6.5)	1.9 (1.5-2.3)	372 (247-521)
15	Cancer cervix	1,676		3,08,901	23.2 (21.3-25.1)	2.3 (1.9-2.5)	161 (129-196)
16	Carcinoma endometrium	1,096	0.004	4,715	3.9 (2.9-5.0)	1.8 (1.4-2.2)	0.342 (0.196-0.525)
17	Carcinoma ovary	3,955		55,231	13.8 (6.5-20.0)	2.2 (2.0-2.6)	17 (7-928)
	Total population need				**36,60,818 (19,59,801-62,18,013)**		

Figure 4 - Population need: Proportion of need for specific diseases and conditions – Obst & Gyn



Hysterectomy for AUB, prolapse, adenomyosis, endometriosis-fibroids, and PID contributes around 16.6% of the population need under Obstetrics and Gynaecology (Figure-4) followed by anaemia in pregnancy (15.2%), Hepatic disorders (13.6%) and AUB (10.2%). Carcinoma endometrium (0.01%) preceded by molar pregnancy (0.3%) and carcinoma ovary (0.5%) contributes the least in population need for obstetrics and gynecological conditions.

5.1.4 Population need - Paediatrics

5.1.4.1 Diseases or conditions that require transfusion - Paediatrics

The diseases or conditions under paediatrics that require transfusion are listed below. Based on discussion with the experts, related diseases and conditions were categorized together for ease of computation.

Severe nutritional anaemia: Nutritional anemia includes all pathological conditions in which the blood hemoglobin concentration falls to an abnormally low level, due to deficiency of one or several nutrients (Kotecha 2011). Anemia is categorized into mild, moderate and severe, on the basis of hemoglobin level. Severe anemia is defined as hemoglobin level less than 7 g/dl; for moderate anemia, the hemoglobin level is between 7 g/dl and 9 g/dl and mild anemia between 9 g/dl to11 g/dl for children below 18 years of age (ICMR 2004).

According to literature, the prevalence of severe anemia for children between 6 months to fifty-nine months was 2.9% (Kotecha 2011). A study in 2008, reported a countrywide prevalence of 1.4% as severe anemia (Bharati et al. 2008b). According to NFHS-4, the proportion of children having severe anemia is 1.5% (IIPS and ORC-Macro 2017) which was used for population need estimation.

Bone marrow failure-Benign: Aplastic anemia is a rare hematological disorder which is characterized by pancytopenia with a hypocellular bone marrow (Gupta et al. 2013). Inherited Bone Marrow Failure Syndromes (IBMFS) are more frequent in the pediatric population and comprise roughly 25% to 30% cases of bone marrow aplasia in children. A study in 2013, reported an incidence of acquired aplastic anemia at 2 per 1 million children per year in North America and Europe and 2 to 3 fold higher in Asia (Hartung, Olson, and Bessler 2013). Another study conducted in India indicates that the incidence of aplastic anemia is 0.6 to 6.1 cases per million population (Gupta and Bala 2013). The Delphi consensus for the number of patients with bone marrow failure was 0.6/1,00,000 population per year.

Leukemia: It is characterized by widespread, rapid and disorderly proliferation of leukocytes and their precursor and by the presence of immature leukocytes in the blood often in very large numbers (Singla, Bodal et al. 2016). According to literature, there are nearly 25,000 children diagnosed with cancer in India every year and around 9000 of these have leukemia (Arora and Arora 2016). Literature indicates that age-adjusted incidence of leukemia among boys and girls below the age group of 14 years are 6.1 per one lakh and 4.0 per one lakh respectively (Satyanarayana, Asthana et al. 2014). Based on this, the Delphi consensus on the prevalence of leukemia among children is 4/1,00,000 which was used for population need estimation.

Hemolytic anemias including Thalassemia: Thalassemia is a common genetic disorder in India. It is a severe phenotype which requires lifelong blood transfusions and the only curative option is bone marrow transplantation (Panigrahi and Marwaha 2007). Autoimmune hemolytic anemia (AIHA) has a prevalence of 1 per 100,000. In children, it often presents as an acute, self-limited illness, with good response to short-term steroid therapy in nearly 80% of patients (Naithani et al. 2007).

According to literature, there are approximately 1,00,000 children born with Thalassemia Major worldwide every year out of which 10,000 are born in India (Thacker 2007a, Shah, Choudhury, and Dubey 1999). Another study suggests that there would be 32,400 babies with serious hemoglobin disorder who are born in India, out of which 10,000 to 12,000 children born each year are thalassemic (Colah, Italia, and Gorakshakar 2017).

A study estimated that there were about 65,000 to 67,000 thalassemia patients in India with around 10,000 cases being added every year (Thacker 2007b). The mortality rate of Thalassemia was reported as 2.9% in 2007, 2.3% in 2008, 2.9% in 2009, 2.6% in 2010, and 0.7% in 2011 (Wu et al. 2016). Another study indicated the mortality rate of beta-thalassemia patients as 1.5%(Mokhtar et al. 2013). Considering 67,000 cases in 2007, the addition of 10,000 new cases every year and a mortality rate of 5% (as per Delphi), the thalassemia cases in 2017 was estimated as 1,16,355 which was rounded off to 1,00,000 cases.

Chronic renal disease (CRF): CRF is an insidious and irreversible condition that eventually progresses to end-stage renal failure. The disease process is better termed as chronic kidney disease (CKD), in order to encompass the entire spectrum and severity of renal diseases (Kanitkar 2009).

A population-based data from Italy have reported a mean incidence of pre-terminal CKD of 12.1 cases per million of the age-related population (pmarp) per year, with a point prevalence of 74.7 per pmarp in children younger than 20 years of age (Warady and Chadha 2007). Another study indicates that in most developed countries the incidence varies between 4-10 per million children below 18 years of age (Hari et al. 2003). In South East Asia, the incidence and prevalence of pediatric kidney disease is 11 pmarp and 51 pmarp respectively (Harambat et al. 2012). The Delphi experts came to a consensus of 40 per million population for the prevalence of chronic renal disease which was used for population need estimation.

Oncological conditions: It was reported that 1.6% to 4.8% of all cancer in India is seen in children below 15 years of age. However, the reported age of the standardized incidence rate for India ranges from 38 to 124 per million children per year (Arora, Eden, and Kapoor3 2009). Literature also indicates that more than 80% of all childhood cancer cases occur in low and middle-income countries. It is estimated that about 1,48,000 cancers occurred during 2008 in children aged 0–14 years was in less-developed regions (Bashar and Thakur 2017).

The Delphi consensus on the prevalence of oncological conditions was 1/1,00,000 population up to 18 years, which is 15% of the overall cancer patients of the country.

Gastrointestinal bleeding (GIB): It is a condition which affects hospitalized children and can occur in any area of the gastrointestinal tract, from the mouth to the anus. Lower GI Bleed is a more common problem in the pediatric population than the Upper GI Bleed which is an uncommon but potentially serious, life-threatening clinical condition (Romano et al. 2017).

A population-based survey indicates the incidence of upper gastrointestinal bleeding as 1 to 2 per 10,000 children per year(Tintinalli et al. 2018). Another study reported that 1% of all the children admitted to the pediatric hospital is affected by gastrointestinal bleeding (Gul Javid et al. 2010). The Delphi experts arrived at a consensus of incidence of 2/1000 population which was used for population need estimation.

Sepsis and Disseminated Intravascular Coagulation (DIC): The term sepsis, is usually referred to an infection that overwhelms the host causing a capillary leak, hypotension, and/or respiratory failure. Relatively stable children admitted to the hospital with complicated pneumonia, pyelonephritis, invasive cellulitis, or bronchiolitis are given these descriptive discharge diagnoses even though most could be given the diagnosis of sepsis (Randolph and McCulloh 2014). Disseminated Intravascular Coagulation (DIC) is a complex pathophysiological disorder where there is an unregulated thrombin explosion leading to release of free thrombin in the circulation resulting in widespread microvascular thrombosis (Bakhshi and Arya 2003). A study indicates an incidence of 1 per 1000 patients among hospitalized children(Nair 2008). The Delphi consensus was 800/1,00,000 population which is used for population need estimation.

Severe malaria: There are approximately 2.48 million malaria cases reported annually from South Asia of which 75% cases are contributed by India alone (Kundu et al. 2005). According to NHP (2017), the total reported cases of malaria in the country was 10,59,437 (GOI 2017), of which 4,13,074 (38.9%) was below 18 years of age. According to literature, 5% of the total malaria cases are severe malaria (Trampuz et al. 2003), thus the total number of pediatric patients suffering from severe malaria was calculated as 20,654 which was used for population need estimation.

Severe dengue: Dengue is a mosquito-borne disease where nearly two-thirds of the global population is at risk to this infection (Gupta and Ballani 2014). While most patients recover following a self-limiting non-severe clinical course, a small proportion progress to severe dengue which is mostly characterized by plasma leakage with or without severe hemorrhage and sometimes leading to organ impairment (WHO 2009a).

According to a study, 10.57% of the people suffering from dengue are severe cases (Soo et al. 2016). Another study indicates that 5% to 20% of the all the dengue cases are severe (Das et al. 2017). The Delphi experts arrived at a consensus of 15% as severe dengue. Considering this the number of dengue cases is estimated to be 6,544 which was used for population need.

Hemolytic uremic syndrome (HUS): It is a relatively rare disease that includes the triad of microangiopathic hemolytic anemia (MAHA), thrombocytopenia and renal failure. In children, diarrhea-related typical HUS (tHUS) is commonest (80-90%), occurs sporadically or in epidemics, rarely recurs, and has a relatively better prognosis (Banerjee 2009).

The overall incidence of Shiga toxin-associated hemolytic-uremic syndrome (Stx-HUS) is estimated to be 2.1 cases per one lakh population per year, with a peak incidence in children who are younger than 5 years (6.1/100,000 per year), and the lowest rate in adults who are 50 to 59 year of age (0.5 per 100,000 per year) (Noris and Remuzzi 2005). Another study reported an average annual crude incidence rate of 0.78 per 100 000 pediatric HUS cases among children below 18 years (Ong et al. 2012). The Delphi experts arrived at a consensus of 1/1,00,000 HUS cases among paediatric population.

Neonatal sepsis: It is defined as a clinical syndrome in an infant who is of 28 days of life or younger, manifested by systemic signs of infection and isolation of a bacterial pathogen from the bloodstream (El-Din et al. 2015). Sepsis is one of the major causes of morbidity and mortality in neonates, in spite of recent advances in healthcare units. More than 40% of under-five deaths globally occur in the neonatal period, resulting in 3.1 million newborn deaths each year.

According to literature, the incidence of neonatal sepsis varies from 7.1 to 38 per 1000 live births in Asia. In India alone, neonatal septicemia occurs in 10.97 to 27 per 1000 live births (De, Rathi, and Mathur 2013), which was used for population need estimation.

Very Low Birth Weight (VLBW) among neonates: Low Birth Weight (LBW) refers to a birth weight below 2,500 grams. It is one of the major determinants of perinatal survival, infant morbidity, and mortality as well as the risk of developmental disabilities and illnesses in future (Gebregzabiherher et al. 2017). Very Low Birth Weight (VLBW) infants weigh less than 1500 grams (Hussein et al. 2014).

According to NFHS-4, the percentage of children aged between 0 to 35 months with low birth weight (LBW) was 18.2% (IIPS and ORC-Macro 2017). According to Rapid Survey on Children in India (2014), the percentage of children aged between 0 to 59 months with very low birth weight (VLBW) was 9.4% (GOI 2014). Literature indicates that VLBW neonates comprise approximately 4 to 7% of all live births (Gera and Ramji 2000);(Basu, Rathore, and Bhatia 2008);(Hussein et al. 2014). According to Delphi experts, 7% of all births were estimated to be very low birth weight.

Haemorrhagic Disease of the New-Born (HDN): It is one of the most common causes of acquired hemostatic disorder in early infancy. It is categorized as early, classical or late depending on the time of onset. Late HDN usually occurs between 2 to 8 weeks but can occur anytime in the first year. As per the study, the incidence of Late-HDN in the eastern world is 25 to 80 per 100,000 births which is higher than that in the western world (Pooni et al. 2003). Another study reported an incidence of late HDN as 1 in 14,000 infants when no vitamin K prophylaxis is used at birth (Shendurnikar, Rana, and Gandhi 2001). Reports from Asia and Europe indicate the rate of late HDN ranging from 4.4 to 7.2 cases per 100,000 (D'Souza and Rao 2003);(Gondhali et al. 2012). The Delphi experts arrived at a consensus of 1/100,000 HDN cases among neonates.

Birth asphyxia/trauma: Asphyxia is insufficient oxygen supply that can lead to severe hypoxic-ischaemic organ damage in new-borns followed by a fatal outcome or severe life-long pathologies (Golubnitschaja et al. 2011). A study indicates that the incidence of birth asphyxia is reported to be much higher in developing countries, and presents a formidable challenge to health professionals from the point of view of preventative as well as therapeutic interventions (Sabrine, Singh, and Sinha 1999).

In resource-rich countries, severe perinatal asphyxia is 1/1000 live births and in resource-poor countries, studies suggest an incidence of 5–10/1000 live births (McGuire 2007). Another study has reported that the international incidence of perinatal asphyxia or neonatal hypoxia-ischemia as 2–6/1,000 term births, reaching higher rates in developing countries (Morales et al. 2011). The Delphi consensus on the incidence of birth asphyxia/trauma was 1/1000 per live births.

Hemolytic disease among newborn: Haemolytic disease of the fetus and newborn (HDFN) is a condition in which trans-placental passage of maternal antibodies results in immune hemolysis of fetal or neonatal red cells. The hemolytic process may result in anemia or hyperbilirubinemia or both; thereby affecting fetal/neonatal morbidity and mortality. The prevalence of Neonatal transfusions of Haemolytic disease was 0.1% (Basu, Kaur, and Kaur 2011), which was used for population need estimation.

5.1.4.2 Estimated population need for pediatrics

The quantum of blood to cater to the pediatric need of the population is estimated at 5.6 million units (95% CI; 3.9-7.8). This implies that the country needs to collect 5.6 million units of whole blood to address the pediatric need for whole blood and components in the country. This is based on assumption that there is rational use (appropriate components) of blood across the country.

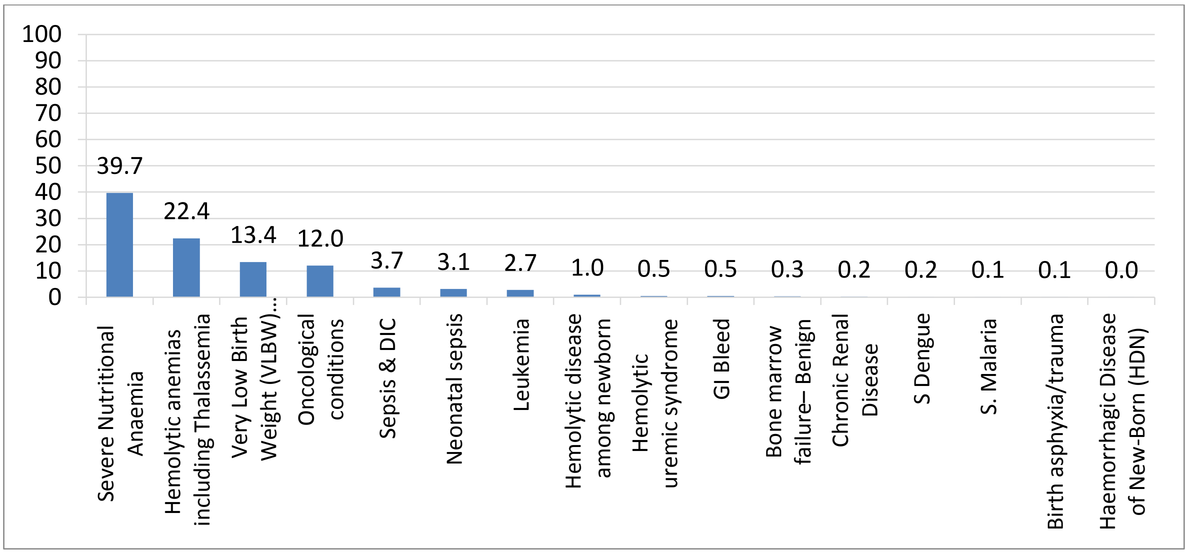
The disease-specific need is mentioned in Table-9. In addition to the prevalence or incidence or the actual number of people with a specific disease or condition, the proportion of people requiring transfusion and the average number units of blood requirement for each condition are mentioned in the table.

Table 9 - Population need for specific diseases and conditions under Paediatrics

Paediatric Conditions							
S. No.	**Clinical condition**	**Population at risk (In Lakhs)**	**Prevalence or Incidence (%)**	**No of people with condition**	**% requiring Transfusion (95% CI)**	**Average number of Units per patient**	**Total Need (x1000 units) (95% CI)**
1	Severe Nutritional Anaemia	5,145	1.5	77,17,484	18.1 (13.7-23.6)	1.6 (1.3-1.9)	2,232 (1,371-3,466)
2	Bone marrow failure Benign	5,145	0.0006	3,087	87.7 (81.8-93.2)	7.1 (4.2-10.4)	19 (10-29)
3	Leukaemia	5,145	0.004	20,580	97.3 (94.2-99.2)	7.7 (4.1-12.6)	155 (79-257)
4	Haemolytic anaemias - Thalassemia	5,145		1,00,000	100.0 (100-100)	12.6 (11.1-14.1)	1264 (1,112-11,408)
5	Chronic renal disease	5,145	0.004	20,580	22.3 (18.5-26.1)	2.4 (1.8-2.9)	11 (7-16)
6	Oncological conditions	5,145	0.001	3,80,000	55.9 (46.8-65.0)	3.2 (2.6-3.7)	676 (469-922)
7	Gastrointestinal bleeding	258	0.2	51,450	30.0 (22.2-37.8)	1.8 (1.6-2.0)	28 (18-40)
8	Sepsis & Disseminated intravascular coagulation	258	0.8	2,05,800	53.2 (48.4-58.0)	1.9 (1.4-2.5)	208 (140-298)
9	Severe Malaria	5,145		20,654	25.5 (17.3-33.6)	1.6 (1.2-2.1)	8 (4-15)
10	Severe Dengue	5,145		6544	44.5 (36.9-52.7)	3.2 (2.5-3.9)	9 (6-13)
11	Hemolytic uremic syndrome (HUS)	5,145	0.001	5,145	63.2 (51.4-74.2)	9.4 (6.1-12.3)	30 (16-46)
12	Neonatal sepsis	269	1.1	2,95,303	34.5 (26.9-42.1)	1.7 (1.4-2.1)	176 (108-260)
13	Very Low Birth Weight (VLBW) among neonates	269		18,84,341	23.2 (19.1-27.2)	1.7 (1.5-2)	755 (523-1,026)
14	Haemorrhagic Disease of the New-Born (HDN)	269	0.001	6,730	10.0 (5.0-12.5)	1.0 (1.0-1.5)	0.673 (0.336-1.262)
15	Birth asphyxia/trauma	269	0.1	26,919	12.2 (8.4-16.0)	1.1 (1.0-1.2)	4 (2-5)
16	Hemolytic disease among new-born	269	0.1	26,919	100 (100-100)	2 (1.4-2.6)	54 (38-69)
	Total population need				**56,29,587 (39,05,484-78,73,796)**		

Severe nutritional anaemia contributed the highest which is around 39.7% of the population need (Figure-5) followed by haemolytic anemia - thalassemia (22.4%), very low birth weight (13.4%) and oncology (12.0%). Hemorrhagic disease of the new-born (0.01%) preceded by birth asphyxia/trauma (0.1%) and severe malaria (0.1%) contributes the least in population need for pediatric conditions.

Figure 5 - Population need: Proportion of need for specific diseases and conditions-Paediatrics



5.1.5 Total population need in India

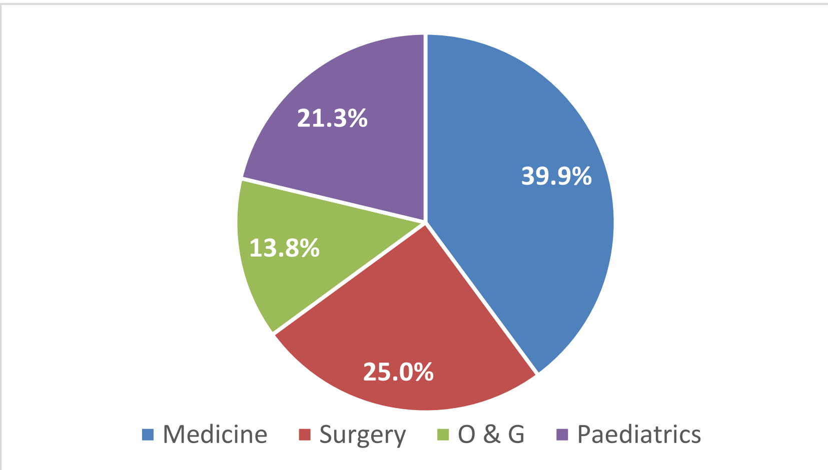
The quantum of blood needed to cater to the entire population encompassing all specialties is estimated at 26.5 million units (95% CI; 18.0-38.4), of which medicine accounts for 39.9% of all the need followed by surgery (25%), obstetrics and gynaecology (O&G) (13.8%) and pediatrics (21.3%) (Table -10). Hence the blood transfusion services of the country need to collect 26.5 million units of whole blood in order to address the national need for whole blood and components. This is based on assumption that there is rational use of blood (appropriate components and appropriate indications) across the country.

The higher need in medical specialties is primarily due to the high prevalence of anemia in the country and the trend of increasing prevalence of non-communicable diseases and oncological conditions. Although there is a public perception that the need for obstetric and gynecological conditions is high, the study indicates the quantum to be only 13.8% of the total need. This can be ascribed to the relatively lower proportion of the population at risk.

Table 10 - Estimated population need

Specialty	Estimated population need	Lower	Upper	Percentage
Medicine	105,69,176	83,67,716	143,12,052	39.9
Surgery	66,32,019	37,87,602	100,40,722	25.0
Obst & Gyn	36,60,818	19,59,801	62,18,013	13.8
Paediatrics	56,29,587	39,05,484	78,73,796	21.3
Total	**2,64,91,600**	**1,80,20,604**	**3,84,44,583**	**100.0**

Figure 6 - Population need



5.2 Clinical demand, supply, and utilization

In total, 251 healthcare facilities representing primary, secondary and tertiary care from five regions of the country were included in the study. The details of the healthcare facilities included in the study are mentioned in Table- 11.

Location: The majority (76.5%) of the healthcare facilities were located in the urban area with a slight variation between regions. The Northeast region indicated a higher percentage of urban facilities (81.5%), followed by North region (80.8%), East (75.0%), West (72.9%) and South Region (71.4%).

Table 11 - Details of the healthcare facilities

Components	Total	North Region	East Region	West Region	South Region	North East Region
Location	(n=251)	(n=52)	(n=48)	(n=48)	(n=49)	(n=54)
Rural	59 (23.5%)	10 (19.2%)	12 (25.0%)	13 (27.1%)	14 (28.6%)	10 (18.5%)
Urban	192 (76.5%)	42 (80.8%)	36 (75.0%)	35 (72.9%)	35 (71.4%)	44 (81.5%)
Ownership						
Private	144 (57.4%)	28 (53.8%)	28 (58.3%)	29 (60.4%)	28 (57.1%)	31 (57.4%)
Public	107 (42.6%)	24 (46.2%)	20 (41.7%)	19 (39.6%)	21 (42.9%)	23 (42.6%)
Level of Care						
Primary	107 (42.6%)	23 (44.2%)	21 (43.8%)	17 (35.4%)	24 (49.0%)	22 (40.7%)
Secondary	113 (45.0%)	23 (44.2%)	21 (43.8%)	24 (50.0%)	19 (38.8%)	26 (48.1%)
Tertiary	31 (12.4%)	6 (11.5%)	6 (12.5%)	7 (14.6%)	6 (12.2%)	6 (11.1%)
Type of Facilities (Govt)						
CHC	45 (42.1%)	10 (41.7%)	9 (45.0%)	5 (26.3%)	10 (47.6%)	11 (47.8%)
SDH/DH	47 (43.9%)	11 (44.9%)	8 (40.0%)	11 (57.9%)	8 (38.1%)	9 (39.1%)
MC	15 (14.0%)	3 (12.5%)	3 (15.0%)	3 (15.8%)	3 (14.3%)	3 (13.0%)
Type of Facilities (Private)						
Profit	96 (66.7%)	14 (50.0%)	23 (82.1%)	18 (62.1%)	20 (71.4%)	21 (67.7%)
Not for profit	48 (33.3%)	14 (50.0%)	5 (17.9%)	11 (37.9%)	8 (28.6%)	10 (32.3%)
Geographical coverage						
Less than 10 Km	13 (5.2%)	4(7.7%)	3 (6.3%)	0	1 (2.0%)	5 (9.3%)
10 Km to 50 Km	173 (68.9%)	33 (63.5%)	35 (72.9%)	29 (60.4%)	39 (79.6%)	37 (68.5%)
More than 50 Km	65 (25.9%)	15 (28.8%)	10 (20.8%)	19 (39.6%)	9 (18.4%)	12 (22.2%)

Population Coverage						
Less than 1 lakh	107 (42.6%)	22 (42.3%)	21 (43.8%)	19 (39.6%)	21 (42.9%)	24 (44.4%)
1 lakh to 10 lakh	118 (47.0%)	26 (50%)	25 (52.1%)	20 (41.7%)	23 (46.9%)	24 (44.4%)
> 10 lakhs	26 (10.4%)	4 (7.7%)	2 (4.2%)	9 (18.8%)	5 (10.2%)	6 (11.1%)
Total number of Staff						
Less than equal to 20	27 (10.8%)	7 (13.5%)	5 (10.4%)	7 (14.6%)	6 (12.2%)	2 (3.7%)
21 to 50	57 (22.7%)	10 (19.2%)	14 (29.2%)	13 (27.1%)	12 (24.5%)	8 (14.8%)
More than 50	167 (66.5%)	35 (67.3%)	29 (60.4%)	28 (58.3%)	31 (63.3%)	44 (81.5%)
Total Number of Beds						
<=30 beds	75 (29.9%)	19 (36.5%)	15 (31.3%)	12 (25.0%)	18 (36.7%)	11 (20.4%)
31 Beds to 200 Beds	36 (14.3%)	4 (7.7%)	7 (14.6%)	8 (16.7%)	6 (12.2%)	11 (20.4%)
More than 200 beds	140 (55.8%)	29 (55.8%)	26 (54.2%)	28 (58.3%)	25 (51.0%)	32 (59.3%)
Bed Occupancy Rate						
Less than 25%	15 (6%)	3 (5.8%)	4 (8.3%)	0	7 (14.3%)	1 (1.9%)
More than 25% to 75%	132 (52.6%)	29 (55.8%)	23 (47.9%)	27 (56.3%)	22 (44.9%)	31 (57.4%)
More than 75%	104 (41.4%)	20 (38.5%)	21 (43.8%)	21 (43.8%)	20 (40.8%)	22 (40.7%)
Out-patients per day						
Less than 50	49 (19.5%)	9 (17.3%)	13 (20.5%)	7 (14.6%)	12 (24.5%)	8 (14.8%)
50 to 300	126 (50.2%)	22 (42.3%)	21 (47.7%)	24 (50%)	22 (44.9%)	37 (68.5%)
More than 300	76 (30.3%)	21 (40.4%)	14 (31.8%)	17 (35.4%)	15 (30.6%)	9 (16.7%)
Average Length of stay						
Up to 3 days	112 (44.6%)	32 (61.5%)	22 (45.8%)	16 (33.3%)	20 (40.8%)	22 (40.7%)
Above 3 days to 5 days	107 (42.6%)	17 (32.7%)	18 (37.5%)	24 (50%)	22 (44.9%)	26 (48.1%)
More than 5 days	32 (12.7%)	3 (5.8%)	8 (16.7%)	8 (16.7%)	7 (14.3%)	6 (11.1%)
Attached blood bank						
Yes	86 (34.3%)	20 (38.5%)	14 (29.2%)	16 (33.3%)	18 (36.7%)	18 (33.3%)
No	165 (65.7%)	32 (61.5%)	34 (70.8%)	32 (66.7%)	31 (63.3%)	36 (66.7%)

Ownership: More than half of the facilities (57%) were owned by the private sector and the remaining were owned by the public sector. Around two-thirds (67%) of the facilities owned by the private sector were for-profit facilities and the remaining (33%) were not-for-profit facilities. The eastern region had the maximum number of for-profit facilities (82.1%), followed by south (71.4%), north-east (67.7%), west (62.1%) and northern region (50%).

Regarding public facilities, 43.9% of the facilities were either District Hospital (DH) or Sub District Hospital (SDH) followed by 42.1% of Community Health Centers (CHC) and 14% of Medical Colleges.

Level of care: Around 45% (113) of the facilities were providing secondary care services, 42.6% (107) primary care, and 12.4% (31) offered tertiary care services. Out of the total private primary facilities (n=62), around 84% were for profit and the remaining were not-for-profit/non-profit/NGO/Charitable organizations. Most of the private secondary care facilities (57.6%; n=66) were for-profit whereas, 62.5% of the total private tertiary care facilities (n=16) were not for profit.

Geographic coverage: Majority of the facilities (68.9%) offered services that covered a geographic area of 10 kms to 50 Kms, whereas 25.9% of the facilities covered more than 50 Kms and only 5.2% of the facilities had a geographical coverage less than 10 km.

Population coverage: Around 47% of the facilities had a reported population coverage of 1 lakh to 10 lakhs, followed by 42.6% covering less than 1 lakh and 10.4% having a population coverage of more than 10 lakhs (one million).

Human resources: The categories of staff include doctor, nurses, paramedical and support staff. Two third of the facilities (66.5%) had more than 50 staff and around 34% had less than 50 staff. The average number of staff in tertiary care facilities is 1052(SD: 602), followed by secondary 201(SD: 170) and primary 37 (SD: 21).

Bed strength: Around 56% of the facilities had more than 200 beds, 30% had less than or equal to 30 beds and 14.3% had 31 to 200 Beds. The average bed strength of tertiary care facilities was 980 (SD: 642) followed by secondary care (158; SD:119) and primary care (31; SD: 10). The average bed strength was higher in public tertiary facilities (1250; SD: 670) and secondary care (195; SD: 140) than private tertiary (727; SD: 513) and secondary care (132; SD: 93).

Bed Occupancy Rate (BOR): The BOR provides the average number of beds occupied out of the total beds available in the facility. More than half of the facilities (52.6%) had BOR between 25% to 75%, around 41% had more than 75% and the remaining reported less than or equal to 25%. The average BOR was the highest in tertiary care facilities (83.9%; SD:17.3), followed by secondary care (72.9%; SD:24.7) and primary care (60.4%; SD:25.9). The average BOR in the public facilities was higher than the private.

Average out-patients per day (OP): Around 50% and 30% of the facilities had an average of 50 to 300 and more than 300 out-patients per day respectively. This is highest for tertiary care (2074; SD: 1643), followed by secondary (420; SD: 555) and primary care (138; SD: 120).

The average length of stay (ALOS): The majority of the facilities (44.6%) had an ALOS up to 3 days. Around 43% and 13% of the facilities had 3 to 5 days and more than 5 days respectively. The mean ALOS was higher in tertiary care (5.9; SD: 1.2) without much variations between public and private facilities. The secondary care facilities (4.2; SD:1.6) owned by private sector indicated a higher mean (4.3; SD:1.3) than the public (3.9; SD:1.9).

Availability of blood banks within the facility: Around 34% of the facilities had an attached blood bank whereas, more than half (65.7%) did not. All the tertiary care facilities followed by 54 (47.8%) secondary care and one upgraded primary care center had an attached blood bank.

5.2.1 Clinical demand

Similar to the estimation of population need, disease or condition-specific clinical demand under each specialty was computed (Refer Annexure-1,2,3&4). In addition to the basic information about the healthcare facility, annual data on the total number of cases requiring transfusion (whole blood or components) for a specific disease or condition was collected. In addition, the total number of units of whole blood/components for the specific disease or condition demanded by the clinicians was also collected. These parameters were used to compute the total demand (whole blood and components) for each specialty and the demand at the national level.

5.2.1.1 Region wise clinical demand by specialty

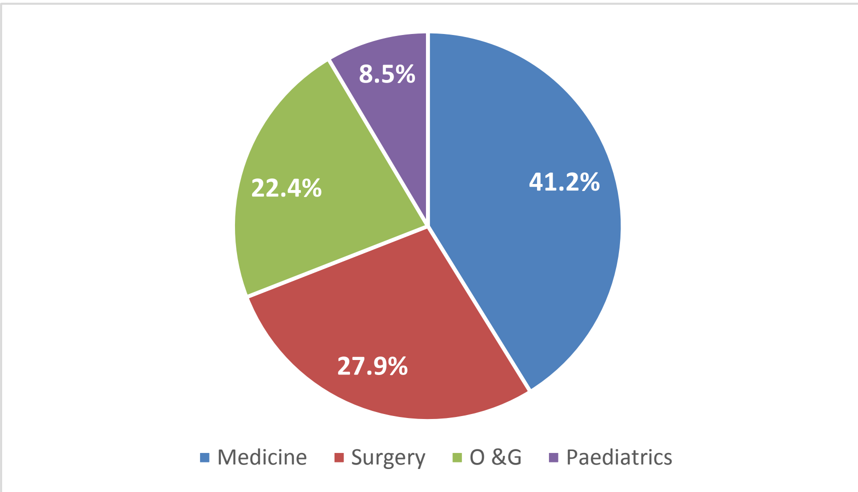
As mentioned in Table-12, a larger proportion of the clinical demand is found to be for medicine (41.2%), followed by surgery (27.9%), obstetrics & gynecology (22.4%) and pediatrics (8.5%). The proportion of demand for medical conditions was the highest in the eastern region (53.8%) followed by northern region (43.7%), compared to other specialties. The proportion of demand for the surgical specialty is the highest in the southern region (34.6%) and the lowest in the eastern region (19.8%). The proportion of demand for obstetrics & gynecology is highest in the northeast (28.3%) and the lowest in the eastern region (15.6%) and for pediatrics it is highest in the eastern region (10.9%) and the lowest in northeast (15.6.8%).

Table 12 - Current clinical demand*

Region	Medicine	Surgery	Obst & Gyn	Paediatrics	Total Demand
North	39,010 (43.7)	24,289 (23.2)	17,627 (19.8)	8,276 (9.3)	89,201 (100)
East	48,053 (53.8)	17,700 (19.8)	13,904 (15.6)	9,700 (10.9)	89,357 (100)
West	38,549 (39.0)	32,421 (32.8)	19,822 (20.1)	7,969 (8.1)	98,762 (100)
South	30,753 (30.4)	35,006 (34.6)	27,814 (27.5)	7,709 (7.6)	1,01,282 (100)
North East	39,068 (40.7)	22,953 (23.9)	27,145 (28.3)	6,857 (7.1)	96,024 (100)
Total	**1,95,434 (41.2)** (1,94,769-1,96,098)	**1,32,370 (27.9)** (13,1764 - 132,976)	**1,06,312 (22.4)** (1,05,749-1,06,875	**40,511 (8.5)** (40,134-40,888)	**4,74,626 (100)** (4,72,417-4,76,837)

** % given in parenthesis*

Figure 7 - Clinical demand



5.2.1.2 Demand for components

The demand for whole blood and blood components for the 251 healthcare facilities studied is mentioned in Table-13. The red cell concentrates demand was the highest (38%), followed by whole blood (36.5%), plasma (12.7%), platelets (11.5%) and cryoprecipitate (1.3%). The demand for whole blood was higher than red cell concentrates in east, south and north-east regions. The demand for cryoprecipitate is the lowest as it is used specifically for replacement of coagulation factor VIII, von Willebrand antigen and fibrinogen in inherited and acquired conditions which are uncommon and require specialized laboratory tests for diagnosis and monitoring of therapy.

The possible reasons for continued demand for whole blood could be due to archaic clinical practices, the lack of availability of blood component separation units, and sub-optimal component separation.

Table 13 - Demand for components*

Region	Whole Blood	Red Cells	Plasma	Platelets	Cryo precipitate
North	16,376	61,225	22,767	18,339	-
East	35,423	33,105	16,617	21,370	131
West	41,123	47,865	11,766	11,606	1,347
South	51,876	41,920	14,935	9,678	5,552
North East	61,629	30,714	5,656	3,907	144
Total	**2,06,427** (2,05,718-2,07,136)	**2,14,829** (2,14,114-2,15,544)	**71,741** (71,250-72,231)	**64,900** (64,430-65,370)	**7,173** (7,008-7,337)

** % given in parenthesis*

5.2.1.3 Major contributors to clinical demand– Medicine

The study recorded a comprehensive list of clinical diagnoses (refer Annexure-1) for which blood transfusions were done in the healthcare facilities across the country. As the list of diagnosis is very exhaustive, some of them were combined together under broad categories for ease of computation and understanding. Besides, diagnoses that were either reported infrequently or demanded significantly low volume were categorized under "others". The diseases or conditions that demanded more than 1% of the total demand under medicine are mentioned in Table-14.

The majority of the demand is for nutritional anemia (32.8%) followed by end-stage renal diseases (9.7%), gastrointestinal bleed (5.8%), dengue (5.6%), chronic liver disorder (5.2%) and leukemia (5%).

Table 14 - Major contributors to clinical demand – Medicine

Diseases/Conditions	Demand(units)	%
Nutritional Anaemia	64,143	32.8
End-stage renal disease (ESRD)	19,053	9.7
Gastro-Intestinal Bleed	11,255	5.8
Dengue	10,851	5.6
Chronic Liver Disorder	10,219	5.2
Leukemia	9,810	5.0
Oncological conditions	7,196	3.7
Others	6,489	3.3
Idiopathic Thrombocytopenic Purpura	5,522	2.8
Chronic Kidney Disease	4,587	2.3
Hemolytic anemias	3,883	2.0
Malaria	3,688	1.9
Myeloma & Lymphoma	3,255	1.7
Autoimmune hemolytic anemias	3,076	1.6
Haemophilia	2,009	1.0
Rheumatic Heart Disease	1,957	1.0
Disseminated Intravascular Coagulation	1,937	1.0
Sepsis	1,911	1.0

5.2.1.4 Major contributors to clinical demand– Surgery

The healthcare facilities across the country recorded a comprehensive list of surgical diseases and conditions, for which blood transfusion was done. The elective and emergency conditions were categorized based on literature and discussion with experts. The diseases or conditions that demanded more than 1% of the total demand under surgery are mentioned in Table-15.

The relatively higher demand is for orthopedic surgeries (25%) followed by abdominal surgeries (13.6%), trauma (9.9%), oncology (8.4%), head and neck (6.8%) and adult cardiac surgeries (4.9%).

Table 15 - Major contributors to clinical demand – Surgery

Disease/Condition	Demand	%
Orthopaedic Surgeries	32,995	24.9
Abdominal surgeries	18,040	13.6
Trauma	13,104	9.9
Oncology surgeries	11,073	8.4
Head and Neck surgeries	8,960	6.8
Adult cardiac surgeries	6,524	4.9
General surgeries	5,930	4.5
Neurosurgical Procedures	5,004	3.8
Burns	4,604	3.5
Urology	3,262	2.5
Thoracic surgeries	2,761	2.1
Others	2,056	1.6
Coronary artery bypass graft (CABG)	1,862	1.4
Road Traffic Accident (RTA)	1,717	1.3
Pediatric cardiac surgeries	1,355	1
Fracture	1,268	1

5.2.1.5 Major contributors to clinical demand - Obstetrics & Gynaecology

An exhaustive list of obstetric and gynecological diseases and conditions, for which blood transfusion was performed by the healthcare facilities was recorded in the study. The diseases or conditions that demanded more than 1% of the total demand under obstetrics and gynecology are mentioned in Table-16.

Anemia is the leading contributor (34.2%) for demand under this section, followed by PPH due to caesarean, atonic, retained placenta, traumatic PPH (14.8%), abnormal uterine bleeding (5.8%), LSCS (4.7%) and abortions (4.5%).

Table 16 - Major contributors to clinical demand - Obstetrics & Gynaecology

Diseases/Conditions	Demand	%
Anemia in pregnancy	36,398	34.2
PPH - Caesarean, atonic, ret. Placenta, Traumatic PPH	15,727	14.8
Abnormal Uterine Bleeding	6,177	5.8
LSCS	4,972	4.7
Abortions	4,824	4.5
Hysterectomy - AUB/ Prolapse/Adenomysosis/ Endometriosis-Fibroids/ PID	4,017	3.8
APH - Placenta praevia	3,122	2.9
Ectopic pregnancies	2,908	2.7
ANC	2,897	2.7
Fibroids - Myomectomy	2,888	2.7
Placenta praevia accreta/accreta	2,649	2.5
APH - Abruptio	2,433	2.3
Carcinoma ovary	2,330	2.2
Cancer cervix	2,019	1.9
PNC with Anaemia	1,911	1.8
Hematology - Factor deficiency, All thrombocytopenia, Anticoagulation,	1,426	1.3

5.2.1.6 Major contributors to clinical demand - Paediatrics

The study recorded a comprehensive list of pediatric diseases and conditions, for which blood transfusion was done in the healthcare facilities across the country. The diseases or conditions that demanded more than 1% of the total demand under pediatrics are mentioned in Table-17.

Hemolytic anemia, (predominantly thalassemia) is the leading contributor of demand under pediatrics (23.6%), followed by severe nutritional anemia (14%) and leukemia (8.2%).

Table 17 - Major contributors to clinical demand – Paediatrics

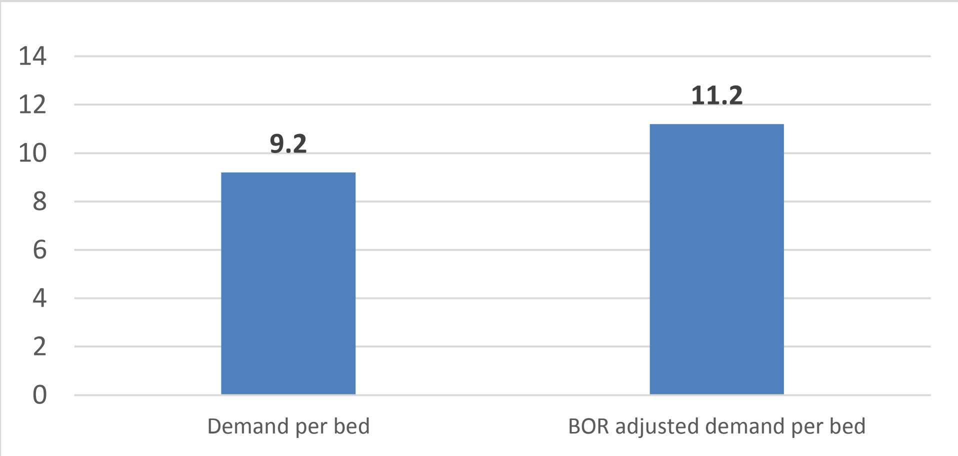
Diseases/Conditions	Demand	%
Hemolytic anemias - Thalassemia	9,563	23.6
Severe Nutritional Anaemia	5,714	14.1
Leukemia	3,319	8.2
Other	2,775	6.8
Sepsis & DIC (of all hospital admissions)	1,876	4.6
Dengue	1,772	4.4
Neonatal transfusions -LBW	1,708	4.2
Neonatal transfusions - Sepsis	1,440	3.6
Malaria	1,208	3.0
Aplastic Anaemia	1,100	2.7
GI Bleed (of all hospital admissions)	1,036	2.6
Chronic renal disease	955	2.4
Neonatal transfusions - birth asphyxia/ trauma	860	2.1
Neonatal Jaundice	788	1.9
Thrombocytopenia	678	1.7
Hemophilia - severe	624	1.5
Sickle Cell Anaemia	578	1.4
Congenital Heart Disease	413	1.0

5.2.1.7 Clinical demand per bed and Bed Occupancy Rate (BOR) adjusted demand per bed

The demand per bed is computed by dividing the total clinical demand with the total number of beds in the facilities. The BOR adjusted demand per bed is computed using the actual number of occupied beds using the bed occupancy rate obtained from all the health facilities, as the denominator.

The overall clinical demand per bed was found to be 9.2 (95% CI: 7.5-9.5) units in a year for the country. However, the BOR adjusted clinical demand per bed was higher at 11.2 (10.7-13.2) units per annum. The BOR adjusted demand per bed is a more useful indicator as this reflects the actual demand for blood for utilized beds.

Figure 8 - Overall demand per bed and BOR adjusted demand per bed



5.2.1.8 Demand per bed and BOR adjusted demand per bed by region

The BOR adjusted demand per bed was highest in the western region at (12.1; 95% CI: 9.5-14.5) units per bed per annum followed by northeast (11.7; 95% CI: 9.9-15.2), east (11.3; 95% CI: 10.5-15.9), south (10.7; 95% CI: 9.9-15.8) and the lowest in the northern region (10.3 95% CI: 7.9-12.5) (Table -18).

Table 18 - Demand per bed – By region

Region	No of Beds	BOR adjusted beds	Demand	Demand per bed	BOR adjusted demand per bed (95% CI)
North	10,914	8,689	89,201	**8.2** (6.2-12.4)	**10.3** (7.9-12.5)
East	9,559	7,920	89,357	**9.4** (7.2-11.3)	**11.3** (10.5-15.9)
West	10,157	8,198	98,762	**9.7** (6.9-10.3)	**12.1** (9.5-14.5)
South	11,809	9,483	1,01,282	**8.6** (5.8-9.7)	**10.7** (9.9-15.8)
North East	9,123	8,185	96,024	**10.5** (7.3-10.8)	**11.7** (9.9-15.2)
Total	**51,562**	**42,474**	**4,74,626**	**9.2** (7.5-9.5)	**11.2** (10.7-13.2)

5.2.1.9 Demand per bed and BOR adjusted demand per bed by location

The BOR adjusted demand per bed was higher in urban areas at 11.4 units (95% CI; 11.1-14.0), as compared to rural areas at 9.1 units (95% CI; 6.4-11.8) which may be a reflection of availability of and access to healthcare facilities.

Table 19 - Demand per bed – By location

Location	Demand	No of beds	BOR adjusted beds	Demand per bed	BOR adjusted demand per bed
Rural	31,266	4,816	3,444	6.5 (4.0-7.8)	9.1 (6.4-11.8)
Urban	4,43,360	46,746	39,030	9.5 (7.8-9.9)	11.4 (11.1-14.0)
Total	**4,74,626**	**51,562**	**42,474**	**9.2** (7.5-9.5)	**11.2 (10.7-13.2)**

5.2.1.10 Demand per bed and BOR adjusted demand per bed by ownership

As indicated in Table -20, the BOR adjusted demand per bed was higher in private sector (12.7 units; 95% CI: 12.0 -15.3) compared to the public sector (10.3 units; 95% CI: 7.7-10.5). The possible reasons for the higher BOR adjusted demand for blood could be due to the higher level of services that demand higher volume of blood transfusions such as dialysis and specialized surgeries. Besides, the relative ease of availability of blood to the private sector, affordability and non-adherence to guidelines could be the other contributing factors.

Table 20 - Demand per bed – By ownership

Ownership	Private			Public		
Region	**Demand**	**Demand per bed**	**BOR adjusted demand per bed**	**Demand**	**Demand per bed**	**BOR adjusted demand per bed**
North	36,264	7.7	12.2	52,937	8.5	9.3
East	33,984	8.3	12.0	55,374	10.1	10.9
West	46,779	8.6	11.7	51,983	11.0	12.4
South	51,585	10.0	13.3	49,697	7.5	8.9
North East	29,193	10.0	15.2	66,831	10.8	10.7
Total	**1,97,805**	**8.9** (8.0-10.6)	**12.7** (12.0 -15.3)	**2,76,822**	**9.5** (7.4-9.9)	**10.3** (7.7-10.5)

Among public facilities, the BOR adjusted demand per bed was the highest in the western region (12.4 units) and the lowest in the southern region (8.9 units).

Without adjusting for occupancy rate, the demand per bed was higher in public sector (9.5 units; 95% CI: 7.4-9.9) compared to private (8.9 units; 95% CI: 8.0-10.6). The difference could be due to the higher bed occupancy rate in public sector facilities.

5.2.1.11 BOR adjusted demand per bed by the level of care

The BOR adjusted demand per bed was higher (12.3 units; 95% CI: 10.9-13.8) in secondary care facilities followed by tertiary care facilities (10.9 units; 95% CI: 8.8-12.5) and primary care facilities (7.6 units; 95% CI: 7.3-9.6).

The relatively higher BOR adjusted demand per bed in secondary care facilities could be due to the proximity of secondary care facilities leading to ease of access to patients, availability of all specialty and super specialty services, and rational use of blood in tertiary care facilities as most are academic institutions.

Table 21 - Demand per bed – By level of care

Level of care	Primary		Secondary		Tertiary	
Regions	Demand	BOR adjusted demand per bed	Demand	BOR adjusted demand per bed	Demand	BOR adjusted demand per bed
North	2,778	7.6	30,779	12.0	55,644	9.7
East	1,971	4.6	34,239	11.8	53,148	11.6
West	3,503	10.0	37,929	12.5	57,330	12.0
South	3,682	9.5	33,980	12.8	63,620	9.9
North East	3,166	6.7	30,968	12.3	61,890	11.9
Total	**15,100**	**7.6** (7.3-9.6)	**1,67,894**	**12.3** (10.9-13.8)	**2,91,632**	**10.9** (8.8-12.5)

5.2.1.12 BOR adjusted demand per bed by the average length of stay (ALOS)

The BOR adjusted demand per bed was higher (11.5 units) in facilities where the average length of stay (ALOS) was more than 5 days, followed by 11.4 units in facilities that recorded 3 to 5 days ALOS and 8.7 units in facilities with up to 3 days of average length of stay.

Table 22 - Demand per bed – By average length of stay (ALOS)

ALOS	Up to 3	Above 3 to 5	Above 5
Regions	BOR adjusted demand per bed	BOR adjusted demand per bed	BOR adjusted demand per bed
North	7.0	11.7	9.7
East	11.9	8.8	12.9
West	10.1	12.9	11.5
South	9.3	11.3	10.3
North East	8.3	12.0	12.4
Total	**8.9**	**11.4**	**11.5**

5.2.1.13 BOR adjusted demand per bed by availability of blood banks

The BOR adjusted demand per bed was higher (11.3 units) in facilities where blood bank was present and it was 10.5 units per bed in facilities without a blood bank. The same pattern was observed in all the regions except the southern region where the BOR adjusted demand per bed was higher (16 units) in facilities that do not have blood banks attached to it. This could be due to the higher number of stand-alone blood banks in proximity to healthcare facilities.

Table 23 - Demand per bed – By availability of blood banks

BBs	Facility with blood bank		Facility without blood banks	
Regions	Demand	BOR adjusted demand per bed	Demand	BOR adjusted demand per bed
North	81,942	10.7	7,259	7.1
East	74,916	11.3	14,442	11.3
West	84,999	12.2	13,764	11.0
South	87,406	10.1	13,876	16.0
North East	85,425	12.3	10,598	8.4
Total	**4,14,688**	**11.3**	**59,939**	**10.5**

5.2.2 Current supply of whole blood and components

The current supply is the percentage of supply against the demand for whole blood and components in each facility.

5.2.2.1 Supply of whole blood and components by specialty

The specialty wise supply of whole blood and components in percentage is mentioned in Table -24. According to the study, around 93% of whole blood, 92%, 86% and 78% and 92% of the red cells, plasma, platelets and cryoprecipitate respectively were supplied against the demand. The low percentage supply of plasma and platelets may be a reflection of sub-optimal component production leading to a constrained supply of components, injudicious demand etc. The continued programmatic focus on maternal health could be one of the reasons for the relatively higher supply of components for obstetrics and gynecological conditions.

Table 24 - Supply - Whole blood and components (%)

Specialty	Whole Blood	Red Cells	Plasma	Platelets	Cryoprecipitate
Medicine	91.8	91.8	84.4	78.3	91.0
Surgery	93.1	90.9	86.6	79.0	89.8
Obst & Gyn	92.2	92.1	94.0	83.0	96.4
Paediatrics	96.5	93.0	83.0	71.5	80.3
Total supply	**92.6** (92.4-92.7)	**91.7** (91.6- 91.8)	**86.0** (85.8-86.3)	**77.5** (77.1-77.8)	**92.1** (91.5-92.7)

5.2.2.2 Supply of whole blood and components by region

The region-wise supply of whole blood and components in percentage is presented in Table-25. Though the overall supply is around 93%, the eastern region reported the lowest level of whole blood supply compared to other regions. The eastern region reported the lowest supply in terms of red cells and platelets as well. The demand and supply gap in the eastern region could be due the sub-optimal component production, constrained supply of whole blood and components, injudicious demand and archaic practices.

Table 25 - Supply of whole blood and components (%)

	Whole blood	Red cells	Plasma	Platelets	Cryoprecipitate
North	97.4	95.6	92.2	90.3	0
East	81.6	78.6	76.1	57.5	94.1
West	97.4	97.4	98.5	95.3	98.5
South	93.1	87.3	73.8	78.9	90.3
North East	93.9	95.2	97.2	82.8	100

5.2.2.3 Supply of whole blood and components by ownership

The percentage of supply against the demand of whole blood, red cells and platelets were found to be higher in the private sector. The plasma and cryoprecipitate supply were higher in public sector.

Table 26 - Supply of whole blood and components (%) by ownership

Ownership	Whole blood	Red cells	Plasma	Platelets	Cryoprecipitate
Public	86.4	92.4	86.5	71.4	100.0
Private	95.0	91.0	85.6	84.4	89.4

5.2.2.4 Supply of whole blood and components by level of care

The percentage of supply of whole blood, red cells and plasma was found to be around 95% in primary care facilities and it was 90% for platelets. The secondary care facilities reported a supply of around 93 to 94% for whole blood, red cells, plasma. Thee platelets supply was around 92% and cryoprecipitate around 97%. However, the tertiary care facilities recorded a relatively lower percentage of supply for whole blood and components. (Refer Table- 27).

Table 27 - Supply of whole blood and components (%) by level of care

Level of care	Whole blood	Red cells	Plasma	Platelets	Cryoprecipitate
Primary	95.5	94.5	95.5	90.0	0.0
Secondary	93.3	93.7	93.1	92.1	96.5
Tertiary	91.5	90.9	82.9	73.7	91.6

5.2.3 Current utilization of whole blood and components

The current utilization is the percentage of utilization of whole blood and components against the supply in healthcare facilities.

5.2.3.1 Utilization of whole blood and components by specialty

The specialty-wise utilization (%) of whole blood and components is given in Table-28. According to the study, around 99% of whole blood and red cell concentrates that were supplied were utilized. However, the utilization rate of plasma, platelets and cryoprecipitate was found to be around 97%.

It was observed that blood banks do not accept back the components once issued since there was no mechanism for traceability of cold chain. Although the supply-utilization gap is small, the potential reasons need to be explored further.

Table 28 - Utilization of whole blood and components (%)

Specialty	Whole Blood	Red cells	Plasma	Platelets	Cryo precipitate
Medicine	96.9	99.6	97.3	98.3	94.2
Surgery	99.6	99.2	95	94.3	83.4
Obst & Gyn	99.7	99.2	98.7	98.1	100
Paediatrics	98.5	97.4	97	97.6	100
Total utilization	**98.7** (98.6-98.8)	**99.2** (99.1-99.2)	**96.8** (96.6-96.9)	**97.6** (97.4-97.7)	**94.4** (94.1-95.2)

5.2.3.2 Utilization of whole blood and components by region

The region wise utilization of whole blood and components is mentioned in Table-29. In general, the percentage of utilization was found to be more than 98% in all the regions for the whole blood and the components, except the western region that reported a utilization rate of 86%, 92% and 73% for plasma, platelets and cryoprecipitate respectively.

Table 29 - Utilization of whole blood and components (%) by region

Component	Whole Blood	Red Cells	Plasma	Platelets	Cryo precipitate
North	99	99.2	98.3	98.1	-
East	98.7	100	100	100	100
West	98.7	98	85.9	91.9	73.1
South	99.8	99.6	100	100	100
North East	97.7	99.8	99.8	100	100

5.2.3.3 Utilization of whole blood and components by ownership

The utilization rate in public health facilities was found to be more than 98% for whole blood and components. Private health facilities reported relatively lower utilization rate of plasma (94.8%) and platelets (96.4%) and cryoprecipitate (92.5%).

Table 30 - Utilization of whole blood and components (%) by ownership

Ownership	Whole blood	Red Cells	Plasma	Platelets	Cryo precipitate
Public	98.4	99.9	98.8	98.8	100.0
Private	99.3	99.0	94.8	96.4	92.5

5.2.3.4 Utilization of whole blood and components by level of care

The utilization rates whole blood and components were more than 98% and 99% in primary and tertiary care facilities respectively. The secondary care facilities reported a low utilization of plasma (92%), platelets (92%) and cryoprecipitate (54%).

Table 31 - Utilization of whole blood and components (%) by level of care

Level of care	Whole blood	Red Cells	Plasma	Platelets	Cryo precipitate
Primary	98.0	99.8	100	100	0
Secondary	97.9	98.1	91.8	91.7	53.6
Tertiary	99.6	99.6	99.1	99.3	100.0

6. National estimation of population need, clinical demand, supply, and utilization

6.1 Estimated clinical demand

As mentioned earlier, the population need for blood was estimated to be 26.4 million per annum. The clinical demand for each specialty was extrapolated using the total number of beds in the sampled health care facilities and the estimated number of beds in the country. The total number of beds in the sampled health care facilities was 51,562 and the clinical demand was 4,74,626 units per annum.

As per National Health Profile (2017), India has 6,34,879 beds in public sector which is approximately 40% of the total beds in the country. Considering this, the remaining 60% was computed which would be around 9,52,319 beds in the private sector. Therefore, the total number of beds available in the country was estimated to be 15,87,198 which was used for extrapolation.

According to this study, 40.3% of the beds were in the medical specialty followed by surgery (30%), obstetrics and gynecology (17.1%) and pediatrics (12.6%). The same proportion was applied to estimate the number of beds available in the country under the four specialties. The data on clinical demand and number of beds (sample beds and country beds) were used to estimate the clinical demand for all the specialties and total clinical demand in India.

Table 32 - Estimated clinical demand

Specialty	Clinical demand (Study)	Beds (Study)	Country beds	Estimated demand (95% CI)
Medicine	1,95,434	20,779	6,39,641	**60,15,910** (60,12,223-60,19,597)
Surgery	1,32,370	15,469	4,76,159	**40,74,654** (40,71,294-40,78,014)
Obst & Gyn	1,06,312	8,817	2,71,411	**32,72,529** (32,69,405-32,75,652)
Pediatrics	40,511	6,497	1,99,987	**12,47,022** (12,44,929-12,49,115)
Total	**4,74,627**	**51,562**	**15,87,198**	**146,10,116** 145,97,852-146,22,378)

Based on the above, the clinical demand for the country was estimated to be 14.6 million units which would address the whole blood and component demand. Of the total demand, the demand for medicine was 6.0 million (41.2%), followed by surgery 4.1 million (27.9%), obstetrics and gynecology 3.3 million (22.4%) and pediatrics 1.2 million (8.5%).

It is essential to consider the possibility of disasters, epidemics and pandemics that would create additional demand for blood in a specific geographic region of a country. The blood transfusion services of the country must determine whether such scenarios lead to a demand for more blood in the affected region. In Spain, the requirement was estimated to be 4.7 blood units and 2.3 components per casualty. In Israel, it was estimated to be 3 blood units and 3 components per casualty (MDA 2008). As the demand for blood during these situations vary and depends on the number of casualties and the severity of it, the estimation needs to be based on a comprehensive assessment of the situation.

6.2 Estimated demand for components

The exclusive demand for specific components was estimated using the same method of extrapolation. Considering the estimated beds available in the country (15,87,198), the whole blood demand was estimated to be 6.3 million (95% CI: 63,50,366 - 63,58,237) , red cell concentrates 6.6 million (95% CI: 66,08,967 - 66,16,903), plasma - 2.2 million (95% CI: 22,05,632 - 22,11,074), platelets-1.9 million (95% CI: 19,95,167 - 20,00,3801) and 0.2 million (95% CI: 2,19,887 - 2,21,716) cryoprecipitates (Table – 33).

Table 33 - Estimated demand for components

	Whole blood	Red cells	Plasma	Platelets	Cryo precipitate
Sample Demand	2,06,427	2,14,829	71,741	64,900	7,173
Estimated demand for the country	**63,54,302** (63,50,366-63,58,237)	**66,12,935** (66,08,967-66,16,903)	**22,08,354** (22,05,632-22,11,074)	**19,97,773** (19,95,167-20,00,380)	**2,20,802** (2,19,887-2,21,716)

6.3 Population need vs Clinical demand

The overall conversion of the estimated population need to demand was found to be 55.1%. The percentage of the population need converting into demand in obstetrics and gynecological conditions (89.4%) was the highest. This may be due to the health-seeking behavior for maternal health conditions, availability and accessibility to services for women and the impact of specific maternal health programmes in the country.

Table 34 - Population need vs Clinical demand

Specialty	Estimated need	%	Estimated demand	%	Need to demand
Medicine	105,69,176	39.9	60,15,910	41.2	56.9
Surgery	66,32,019	25.0	40,74,654	27.9	61.4
Obst & Gyn	36,60,818	13.8	32,72,529	22.4	89.4
Paediatrics	56,29,587	21.3	12,47,022	8.5	22.2
Total	**2,64,91,600**	**100.0**	**1,46,10,116**	**100.0**	**55.1**

6.4 Donation required per 1,000 population

The blood donation required per 1,000 population was computed for both total population and eligible population. The computation of donation required per 1,000 population using the general population as the denominator seems to be inappropriate as it does not provide a clear picture to those working within the program. It is well known that the entire general population is not directly eligible to donate blood. There are various constraints that are enforced by technical and regulatory standards that finally reduce the eligible population significantly. The criteria are intended to reduce the health risk of the donor as well as to safeguard the recipient. These criteria include age limits (>18 years to <65 years), haemoglobIn > 12.5 g/dL and exclusion for most morbidities and high-risk behaviour. Therefore, this study estimated the truly eligible population after conservative exclusions for age, disease burden and other possible conditions that hinder the donation of blood. This will provide a better framework and a well-defined eligible target population to those who are working in the blood transfusion services at large, organizations working in the voluntary blood donor motivation and recruitment and other stakeholders involved in improving the blood transfusion services across the country.

The eligible population is computed based on the following inclusion and exclusion criteria, The total population of the country was 1,31,95,66,420 in 2017.

Inclusion Criteria

- Adult population between the age group of 18 to 65 years – 58.56% as per Census 2011.

Exclusion Criteria

- Pregnant Women – Estimated at 2,77,28,247
- Anemic population – Hemoglobin level- A minimum of 12.5 g/dL
    - As per NFHS-4, Anaemia among adult women is 53% (less than 12 g/dl) and adult men 23.3% (less than 13 g/dl). As the cut off for blood donation is 12.5 g/dl for men, the anemia prevalence of 20% was considered for men.
    - An estimated 2.5 million cancer patients in India
    - Communicable and non-communicable diseases - a conservative assumption of 10% of the adult population having any communicable and non-communicable diseases making them ineligible for blood donation.

Based on this, the population eligible for blood donation was estimated to be 42,54,48,160 (425 million population- 42.5 cores) which is 32.2% of the total population in India. In the United States, according to the American Redcross, an estimated 38% of American population is eligible to donate(ARC 2018).

In order to meet the population need for blood, **62.3 per 1,000 eligible population (6.23% of the eligible population)** should donate once in a year. The need is converted into a demand, only when the person seeks health care services in a health facility. The conversion of the need to demand depends on geographic, socio-economic, and cultural factors which affect the access to health services. However, it is essential to reduce the gap between need and demand which may not be just the health system's responsibility but, requires a multisectoral approach.

According to this study, **34.3 per 1,000 eligible population (3.43% of eligible population)** must donate blood once in a year to address the estimated clinical demand. The proportion can be reduced in the event of promotion of repeat voluntary non-remunerated blood donation. Addressing the clinical demand is the most critical aspect, as it reflects the current demand that is experienced in the health facilities. Failure to meet the current clinical demand indicates that the blood transfusion services in the country experience shortages.

Table 35 - Requirement of blood donation per 1,000 population

	Blood units	Population	Eligible Population	All population	Eligible population
Population need	2,64,91,600	1,31,95,66,420	42,54,48,160	20.1	**62.3**
Clinical demand	1,46,10,116	1,31,95,66,420	42,54,48,160	11.2	**34.3**
Supply	1,35,87,392	1,31,95,66,420	42,54,48,160	10.2	**31.9**
Annual collection in 2017	1,10,94,145	1,31,95,66,420	42,54,48,160	8.4	**26.1**

According to this study, the country was able to supply around 93% of whole blood and 92% of red cell concentrates requirement. Assuming, 93% of the demand was supplied, **supply per 1000 population was 31.9 per 1,000 eligible population (3.19% of eligible population)** which indicates a gap between demand and supply. An additional 3 per 1000 population, donating blood may address the actual clinical demand of the country. In 2017, the annual collection of blood in India was 11,094,145 (11 million). If this data is assumed as supply, then the **actual supply per 1,000 was 26.1 per 1,000 eligible population (2.61% of eligible**

population) which indicates a significant gap between demand and supply. The possibilities of under-reporting and unbanked direct blood transfusions (UDBT) need to be factored if the actual reported collection is to be assumed as supply.

It is crucial to understand that it is the overall situation in the country but the equity in distribution is to be further studied. The country may be facing a situation of non-availability blood in places where it is actually required, though, in total, it seems adequate.

According to WHO (2017), the whole blood donation rate is an indicator of the general availability of blood in a country (WHO 2017). It reported that in low-middle income countries of the SEARO, the annual blood collection ranged from 1.8 to 30.8 per 1000 population (median 7.9) (WHO 2016). The WHO in 2013 indicated that India reported less than 9.9 donations per 1000 population. The denominator seems to be the entire population, not just eligible population. This seems to have improved in 2017 to 10.2 donations per 1000 population as indicated in our study. However, if the reported annual collection in India is assumed as supply, it is 8.4 donations per 1,000 population. The current clinical demand, according to the study is 11.2 per 1,000 population and the population need is 20.1 per 1,000 which indicate a gap between need and demand, demand and supply.

The shortage of blood donation and supply is documented across the world. A recent study reported declining trends of blood donation in the United States (Ellingson et al. 2017) and certain European regions(Schonborn et al. 2017). Switzerland has also projected a shortage of blood donations over the next two decades with their trend models suggested that RBC demand could equal supply by 2018 and could eventually cause an increasing shortfall of up to 77,000 RBC units by 2035 (Volken et al. 2018). In South Asia region, Singapore blood services reported a declining trend of blood donors that could potentially cause challenges to face demand that was growing at 3-5% (Wong 2017). However, in many countries, this was paralleled by reduced clinical demand through modern technologies and blood-less procedures.

6.5 Modeling for prediction

6.5.1 Modeling for prediction of demand based on beds for institutions

The objective of this exercise is to predict the demand for blood in a health facility using the number of beds available in the facility. The existing clinical demand data collected from 251 health facilities that included primary, secondary and tertiary care representing public and private facilities across the country were used in the modeling exercise. This provided a formula (model) with required variables that determine the demand for blood in a healthcare facility. The demand for blood can be predicted if the institutions have all the required variables that serve as inputs for the model.

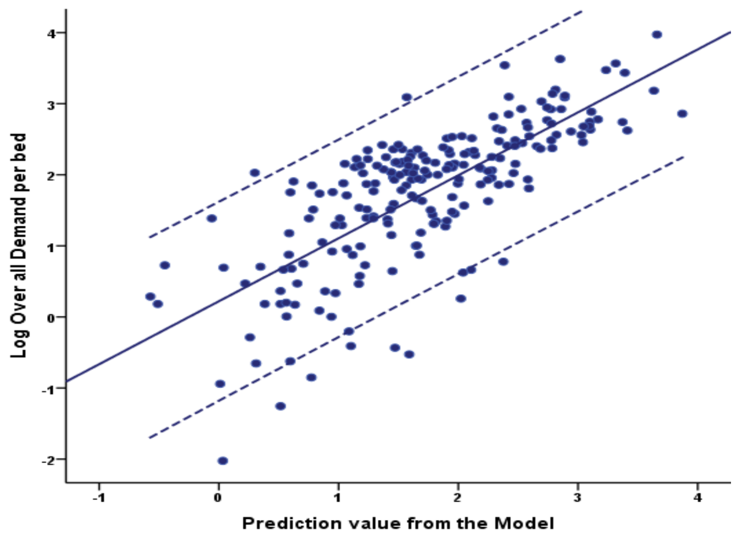
The variables that were included in the model are, location, type of care, region (North, East, West, South, North East), ownership (private, public), local vs non-local, availability of blood bank, total number of beds, specialty services requiring high volume blood (consistently), and average bed occupancy rate (%).

Table 36 - Weights for the predictors based on modeling

Variables	Coefficients β0	95.0% Confidence Interval for β		P value
		Lower Limit	Upper Limit	
Constant	-1.57029	-2.70561	-0.43497	0.0070
Location	0.22869	-0.09167	0.54904	0.1606
Type of care	-0.04020	-0.28411	0.20371	0.7453
Region (North, East, West ,South, NE)	0.09857	0.02441	0.17273	0.0095
Ownership (Private, Public)	0.47272	0.19436	0.75107	0.0009
Non-local % (Patients)	0.01302	0.00577	0.02027	0.0005
Availability of blood bank	-0.17227	-0.47367	0.12913	0.2608
Total number of beds	0.00015	-0.00018	0.00047	0.3823
Speciality services requiring high volume blood (Consistently)	1.29941	1.05526	1.54356	<0.0001
Average bed occupancy rate (%)	0.02166	0.01645	0.02686	<0.0001

The validation of the model indicated 0.73 as the correlation between observed and predicted values (Refer Fig -9). This indicates that there is 73% accuracy in prediction.

Figure 9 - Correlation between observed and predicted values for institution



6.5.1.1 Model for predicting demand per bed in a health facility

Regression coefficients based on the above model weights have to multiply by input data such as the type of care, total number of beds, location etc., along with the constant term. The summated score will be transformed back to predict the demand per bed per annum. The following is the formula to estimate the demand per bed in a health facility.

$$Y = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 x_1} + \boldsymbol{\beta_2 x_2} + \ldots\ldots\ldots\ldots + \boldsymbol{\beta_n x_n}$$

Y = $\boldsymbol{\beta_0}$ Constant+ $\boldsymbol{\beta_1}$Location+ $\boldsymbol{\beta_2}$Type of care+ $\boldsymbol{\beta_3}$Region+ $\boldsymbol{\beta_4}$ Ownership+ $\boldsymbol{\beta_5}$Non-Local+ $\boldsymbol{\beta_6}$blood bank+ $\boldsymbol{\beta_7}$Total number of Beds+ $\boldsymbol{\beta_8}$Speciality Services requiring high volume blood+ $\boldsymbol{\beta_9}$ Average bed occupancy rate

6.5.1.2 The description of inputs variables and the relevant codes to be used in the model

The following are the information required to estimate the demand for blood for a healthcare facility.

i. **Location:** It indicates whether the health care facility is located at the urban or rural area. If the facility is located in a panchayat or below, it is designated as rural. An institution located in a municipality or above is designated as urban.

ii. **Level of care:** It indicates the level of care provided by the health facility that are, primary, secondary and tertiary**.** The facilities providing basic medical, surgical, obstetrics and gynecology and pediatrics services are considered as primary; the facilities providing the basic and the specialty services are considered as secondary; the facilities that are medical college hospitals or providing super specialty services are considered as tertiary.

iii. **Region:** It indicates the region of the health facility.

- **North:** Delhi, Haryana, Punjab, Jammu & Kashmir, Himachal Pradesh, Chandigarh, Uttarakhand, Uttar Pradesh
- **East:** Bihar, West Bengal, Jharkhand, Odisha, Chhattisgarh
- **West**: Maharashtra, Madhya Pradesh, Goa, Gujarat, Daman and Diu, Rajasthan, Dadar & Nagar Haveli
- **North East:** Nagaland, Assam, Sikkim, Meghalaya, Mizoram, Manipur, Tripura, Arunachal Pradesh
- **South:** Andhra Pradesh, Telangana, Karnataka, Kerala, Tamil Nadu, Puducherry, Andaman & Nicobar, Lakshadweep

iv. **Ownership:** It indicates whether the facility is owned by public or private sector.

v. **Percentage of population covered (non-local):** It indicates the proportion of patients availing services from the facility. The percentage of patients from other districts, states and/or countries will qualify under "non-local patients". This needs to be expressed in percentage.

vi. **Availability of blood bank in a hospital:** It indicates whether the health facility is attached to a blood bank or not.

vii. **Total number of Beds:** The total number of running beds in the hospital

viii. **Provision of specialty services requiring high volume blood (consistently):** It indicates the facilities that consistently cater to any one of the diseases and conditions that require a high volume of blood. The diseases and conditions under specialties are,

Medicine: End-stage renal disease, GI bleed, leukemia, and hemophilia

Surgery: Orthopedic surgeries, trauma, adult cardiac surgery, CABG, RTA and Transplant

Obstetrics & Gynaecology: Postpartum hemorrhage, APH-placenta praevia, APH-abruption placenta, and ruptured uterus

Pediatrics: Haemolytic anaemia-Thalassemia, leukemia, hemophilia

ix. **Average bed occupancy rate (%):** It indicates the average bed occupancy in a year.

Table 37 - Codes to be used in the model

S No.	Variables	Coding description
1.	Location	Rural - 1 Urban - 2
2.	Level of care	Primary - 1 Secondary - 2 Tertiary - 3
3.	Region	North East - 1 West - 2 South - 3 North - 4 East - 5
4.	Ownership	Government - 1 Private - 2
5.	Non-local patients	Percentage
6.	Availability of blood bank in a hospital	No - 0 Yes - 1
7.	Number of beds	The actual number of beds
8.	Provision of specialty services requiring high volume blood(Consistently)	No - 0 Yes - 1
9.	Average bed occupancy rate	Percentage

6.5.2 Modeling for prediction of demand based on population in a geographical area

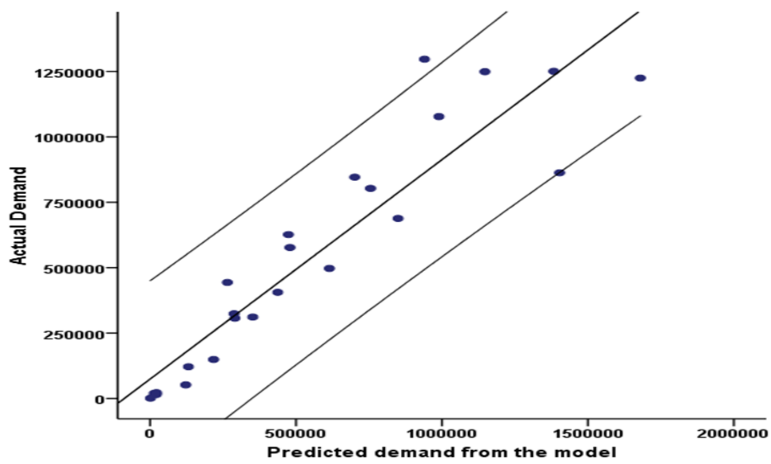
The demand for blood of a specific geographical region depends on several factors such as physical, socio-economic access to the facility, availability of human resources, the infrastructure of the facility, health status etc. The potential variables such as number of blood banks, distance from CHC, CHC per 1000 Rural Population, total number of Beds (state), doctors per 1000 population, Population (state), Nurses per 1000 population, Maternal Mortality rate (MMR), Nutritional Anaemia, and Human Development Index (HDI) were considered for the modeling.

Table 38- Weights for the predictors based on modeling

Variables	Coefficient	95% CI for β		P value
	β	LL	UL	
Number of blood banks	-0.294371300	-0.354726300	-0.234016300	0.000
Average radial distance covered by CHC	-0.018111800	-0.041132700	0.004909100	0.123
CHC per 1000 rural Pop.	-0.128531700	-0.172983800	-0.084079600	0.000
Total number of beds *(state)*	0.000005500	-0.000000060	0.000011100	0.053
Doctors per 1000 pop.	0.152327600	-0.263001200	0.567656500	0.472
Population (state)	0.000000005	0.00000000029	0.0000000101	0.038
Nurses per 1000 population	0.076932100	-0.023804000	0.177668100	0.134
MMR	-0.005952500	-0.009197700	-0.002707200	0.000
Nutritional Anaemia	-0.005735500	-0.030653800	0.019182900	0.652
HDI	-6.227404000	-10.752040000	-1.702766000	0.007
Constant	17.760900000	13.724950000	21.796860000	0.000

The validation of the model indicated 0.919 as the correlation between observed and predicted values (Refer Fig -10) which indicates around 92% accuracy in prediction.

Figure 10 - Correlation between observed and predicted values for population



Model for predicting the demand based on population: Regression coefficients based on the above model weights need to be multiplied by input data such as number of blood banks, distance from CHC, CHC Per 1000 rural population, total number of beds (state), doctors per 1000 population, population (state) etc., along with the constant term. The summate score will be transformed to demand per 1000 population.

$$\log (Y_i) = \boldsymbol{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_n x_n}$$

log(Yi) = $\boldsymbol{\beta_0}$ Constant+ $\boldsymbol{\beta_1}$Number of Blood Banks + $\boldsymbol{\beta_2}$ Distance from CHC + $\boldsymbol{\beta_3}$Total number of Beds+ $\boldsymbol{\beta_4}$ CHC Per 1000 Rural Population +$\boldsymbol{\beta_5}$ Doctors per 1000 population+ $\boldsymbol{\beta_6}$ Population + $\boldsymbol{\beta_7}$ Nurses per 1000 population + $\boldsymbol{\beta_8}$ MMR **+** $\boldsymbol{\beta_9}$ Nutritional Anaemia + $\boldsymbol{\beta_{10}}$ HDI

6.5.2.1 The description of inputs variable and the relevant codes for prediction of demand

The following are the information required to estimate the demand for blood in a specific region (district, state, region or country).

i. **Number of blood banks:** It indicates the total number of blood banks in the specific geographic region.
ii. **Average radial distance covered by CHC:** It indicates the average distance covered by the CHCs in kilometers in the particular region.

iii. **CHC per 100,000 rural population:** It indicates the ratio of the total number of CHCs in any given geographic region and the population in the region

iv. **Total number of beds: It indicates the** total number of hospital beds both in the private and public hospitals in the region.

v. **Doctors per 1000 population:** It indicates the doctors available per 1000 population in the region.

vi. **Nurses per 1000 population:** It indicates the nurses available per 1000 population in the region.

vii. **Population:** The total population of the region.

viii. **MMR:** The Maternal Mortality Rate (MMR) per 100,000 live births in the region

ix. **Nutritional anemia:** The prevalence of nutritional anaemia in the region.

x. **HDI:** It indicates the Human Development Index (HDI) of the region.

7. Conclusion

Ensuring universal access to safe and sufficient blood transfusion is the responsibility of a country's health system. It is essential that the policy makers, programme managers and providers of blood are aware of the quantum of blood required to address the population need and clinical demand besides, the actual supply and utilization. As the demand for blood depends on several factors, the regional, state, district and institutional level information is critical for better planning and implementation of programmes. Accurate estimation of blood requirements is crucial as annual plans and budgetary outlays for blood transfusion services are decided based on available estimates.

In this context, this study aimed at understanding the technical and management aspects of blood requirements as well as the gaps and challenges associated with it. The study has provided a toolbox for future studies including standardized definitions, robust methodology, and data collection tools for assessment of need, demand, supply and utilization that can be applied at different levels.

The study reported the estimated requirement of need, demand, supply and utilization in-terms of per bed and per 1000 population with disaggregated information for regions, ownership, level of care, etc. In addition, the study brings out a model (formula/equation) to predict the demand for blood based on a number of beds or population in a specific geographical region.

The study estimated a population need of 26.4 million units of blood which implies that the country needs to collect 26.4 million units of whole blood to address the need for whole blood and components in the country. The clinical demand was estimated to be 14.6 million units of blood which is required to address the demand that arises in healthcare facilities across the country. According to the study, the supply was found to be 13.5 million; however, the annual collection reported by NACO in the country was 11.1 million units in 2017. Hence, although the country might collect an adequate volume of blood in terms of overall country requirement, the distribution of availability and therefore, access, may not be equitable.

The study indicated that there should be 62.3 donations per 1,000 eligible population (6.23% of the eligible population) in a year to address the population need; 34.3 per 1000 eligible population (3.43% of the eligible population) should donate blood to address the clinical demand. The supply (the donations) was 31.9 per 1,000 eligible population (3.19% of the eligible population). However, if the reported annual collection was considered as supply, the actual supply per 1,000 population was 26.2 per 1,000 eligible population which indicates a significant gap between demand and supply. The overall utilization rate was found to be above 96% for whole blood and components which seem to be an acceptable rate of utilization. However, it is essential to understand the reasons for non-utilization and mechanism for return and discard of blood.

Considering available beds as reference, the country needs to collect 20.3 units of whole blood per occupied bed to address the population need and 11.17 units of whole blood per occupied bed to address the clinical demand in a year, which will be sufficient to manage the whole blood and component requirements considering the current rate of component separation.

In total, around 55% of the need is converted into demand which indicates that the need arising in the community is not being completely converted into clinical demand. This also indicates that the population with blood transfusion need are not reaching the healthcare facility. Though it is not solely under the purview of the health system, these gaps need to be addressed to ensure a healthy and productive population. It requires a multi-sectoral approach to address the need and demand gap.

Another aspect of importance is that it is not just the quantum of donors or donation that needs to be considered, but making blood accessible and available at the point of demand is most critical. Unless the system is geared for it in terms of uniform high quality, logistics, cold chain management, common inventory and appropriate regulatory framework, this cannot happen. The recent (2016) notification of the Government of India to permit bulk transfer of blood and component between blood banks may address some of the issues related to access to blood.

The study brings out evidence that stresses the need for concerted efforts to be re-focused on the voluntary blood donor program in a systematic manner. This includes several steps such as sustained national awareness campaigns through a multi-media approach to sensitize the public, recruiting and training of human resources for the purpose of increasing awareness, motivating and recruiting donors, recognition and incentivization of the act of voluntary blood donation and systematically engaging with donors to become repeat donors.

In view of several factors such as the improving socio-economic growth and increased interest in the health sector by both the public and private sector as evidenced by emerging national health care programs, reducing the gap between need and demand remains a vital imperative. In the light of this, the onus on the healthcare sector is two-fold: on the one hand, it is essential to improve blood donor strategies to increase the blood collection and bring in distribution efficiencies. On the other hand, it is imperative to focus on the aspect of patient blood management that encompasses framing and implementing evidence-based guidelines for use of blood and components, promotion of rational clinical practice in collaboration with national professional societies, followed by monitoring the healthcare facilities for compliance.

8. Limitations

The lack of implementation of systematic national standards for medical records and coding of diagnosis are important factors that may contribute to a non-standard grouping of related diagnostic groups.

Unlike public sector, the categorisation of level of care of private healthcare facilities based on beds was a challenging task as, even a 10 to 20 bedded hospitals provide secondary care services across the country. Therefore, the allocation of the private facilities in the primary, secondary and tertiary care was found to be difficult. Hence, the criterion for categorisation of private facilities by level of care was developed based on consensus among experts through the Delphi exercise.

The total number of beds by specialization (medicine, surgery, obstetrics and gynaecology and Paediatrics) in the country was not available. Therefore, the speciality wise extrapolation of the demand in the country was not done and only the overall demand was estimated.

The data related to burden (prevalence/incidence) of diseases and conditions were taken from national/state level reports and publications. There is no mechanism to correct the under-reporting of certain clinical conditions as perceived by experts.

Indian literature is not adequate that specify the requirement of blood in special circumstances like disasters – each of which may have peculiarities based on the nature of the incident, geography and preparedness of local response units.

9. References

Agarwal, S P. *National Voluntary Blood Donation Day- Message of The Secretary General* 2012. Available from http://www.indianredcross.org/sg-message-27-sep-2013.htm.

Aggarwal, Sourabh, and Vishal Sharma. 2012. "Attitudes and problems related to voluntary blood donation in India: A short communication." *Ann Trop Med Public Health* no. 5 (50).

Amy, J. J. 1998. "Severe postpartum haemorrhage: a rational approach." *Natl Med J India* no. 11 (2):86-8.

Anoop, P. 2012. "Immune Thrombocytopenic Purpura: Historical Perspective, Current Status, Recent Advances and Future Directions." *Indian Pediatrics* no. 49:811-818.

Ara, Shaheen, Bhati Balgopal Singh, Nandani Birla, and Jyothi D. 2015. "Incidence of Hellp Syndrome in Preeclampsia and Eclampsia & Maternal and Perinatal Outcome Including Morbidity and Mortality." *PARIPEX - INDIAN JOURNAL OF RESEARCH* no. 4 (7):65-67.

ARC. 2018. *Blood Facts and Statistics*. The American National Red Cross 2018 [cited 10th January 2018 2018]. Available from https://www.redcrossblood.org/learn-about-blood/blood-facts-and-statistics.

Arora, RS, TOB Eden, and G Kapoor3. 2009. "Epidemiology of childhood cancer in India." *Indian Journal of Cancer* no. 46 (4):264-273. doi: 10.4103/0019-509X.55546.

Bagcchi, Sanjeet. 2014. "More blood for India." *BMJ : British Medical Journal* no. 349. doi: 10.1136/bmj.g7166.

Bakhshi, Sameer, and L S Arya. *Diagnosis and Treatment of Disseminated Intravascular Coagulation*. Indian Pediatrics 2003. Available from http://indianpediatrics.net/aug2003/aug-721-730.htm.

Balasubramaniam, Ganesh, Sushama Saoba, Umesh Mahantshetty, and B Rasika. 2013. "Hospital-based study of endometrial cancer survival in Mumbai, India." *Asian Pac J Cancer Prev* no. 14 (2):977-80.

Banerjee, Sushmita. 2009. "Hemolytic Uremic Syndrome." *Indian Pediatrics* no. 46.

Bashar, MD Abu, and JS Thakur. 2017. "Incidence and Pattern of Childhood Cancers in India: Findings from Population-based Cancer Registries." *Indian J Med Paediatr Oncol* no. 38 (2):240-241. doi: 10.4103/ijmpo.ijmpo_163_16.

Basu, S., P. Rathore, and B. D. Bhatia. 2008. "Predictors of mortality in very low birth weight neonates in India." *Singapore Med J* no. 49 (7):556-60.

Basu, Sabita, Ravneet Kaur, and Gagandeep Kaur. 2011. "Hemolytic disease of the fetus and newborn: Current trends and perspectives." *Asian J Transfus Sci* no. 5 (1):3-7. doi: 10.4103/0973-6247.75963.

Bharati, P., S. Som, S. Chakrabarty, S. Bharati, and M. Pal. 2008a. "Prevalence of anemia and its determinants among nonpregnant and pregnant women in India." *Asia Pac J Public Health* no. 20 (4):347-59. doi: 10.1177/1010539508322762.

Bharati, Premananda, Suparna Som, Suman Chakrabarty, Susmita Bharati, and Manoranjan Pal. 2008b. "Prevalence of Anemia and Its Determinants Among Nonpregnant and Pregnant Women in India." *Asia-Pacific Journal of Public Health* no. 20 (4):347-359.

Bhardwaj, Ritu, Sunil Kumar Rai, Abhishek Kumar Yadav, Siddharth Lakhotia, Damyanti Agrawal, Ashok Kumar, and Bhagyalaxmi Mohapatra. 2015. "Epidemiology of Congenital Heart Disease in India." *Congenital Heart Disease* no. 10 (5):437-46. doi: 10.1111/chd.12220.

BMR. 2017. *Bone Marrow Transplant*. Bone Marrow Registry 20172017]. Available from http://www.bonemarrowregistry.co.in/faq.html.

Chaudhary, Aarushi, and Sarvottma Antil. 2016. "Successful management of a rare case of placenta percreta." *International Journal of Reproduction, Contraception, Obstetrics and Gynecology* no. 5 (7):2473-2474. doi: http://dx.doi.org/10.18203/2320-1770.ijrcog20162155.

Chaudhary, R. K., and S. S. Das. 2014. "Autoimmune hemolytic anemia: From lab to bedside." *Asian J Transfus Sci* no. 8 (1):5-12. doi: 10.4103/0973-6247.126681.

Choudhury, N. 2011. "Blood transfusion in borderless South Asia." *Asian J Transfus Sci* no. 5 (2):117-20. doi: 10.4103/0973-6247.83234.

Colah, Roshan, Khushnooma Italia, and Ajit Gorakshakar. 2017. "Burden of thalassemia in India: The road map for control." *Pediatric Hematology Oncology Journal*.

Colah, Roshan, Khushnooma Italia, and Ajit Gorakshakar. 2018. "Burden of thalassemia in India: The road map for control." *Pediatric Hematology Oncology Journal*:1-6.

Crumley, R. L. 1982. "What is otolaryngology--head and neck surgery?" *Prim Care* no. 9 (2):261-8.

D'Souza, I.E., and S.D.Subba Rao. 2003. "Late Hemorrhagic Disease of Newborn." *Indian Pediatrics* no. 40:226-229.

Das, Sushmita, Asim Sarfraz, Nitesh Jaiswal, and Pradeep Das. 2017. "Impediments of reporting dengue cases in India." *Journal of Infection and Public Health* no. 10 (5):494-498. doi: 10.1016/j.jiph.2017.02.004.

De, Anuradha S, Madhuri R Rathi, and Meenakshi M Mathur. 2013. "Mortality audit of neonatal sepsis secondary to acinetobacter." *J Glob Infect Dis* no. 5 (1):3-7. doi: 10.4103/0974-777X.107165.

Deering, Shad H. 2017. "Abruptio Placentae." https://emedicine.medscape.com/article/252810-overview

Desai, Sapna, Oona MR Campbell, Tara Sinha, Ajay Mahal, and Simon Cousens. 2016. "Incidence and determinants of hysterectomy in a low-income setting in Gujarat, India." *Health policy and planning* no. 32 (1):68–78. doi: https://doi.org/10.1093/heapol/czw099.

DHHS, US. 2011. The 2011 national blood collection and utilization survey report. : . Washington, DC: US Department of Health and Human Services, Office of the Assistant Secretary of Health, 2012.

Dineshkumar, Y Ajitkumar Singh, L Somenkumar Singh, L Ranjit Singh, Paya Liyak, and Alvencia Vaz. 2016. "A Study of Molar Pregnancy at Tertiary Centre of India." *IOSR Journal of Dental and Medical Sciences* no. 15 (9): 49-52.

Dwyer, Tim, Michael Drexler, Vincent W. S. Chan, Daniel B. Whelan, and Richard Brull. 2015. "Neurological Complications Related to Elective Orthopedic Surgery: Part 2: Common Hip and Knee Procedures." *Reg Anesth Pain Med* no. 40 (5):443-54. doi: 10.1097/AAP.0000000000000183.

EDQM. 2011. The collection, testing and use of blood and blood components in Europe (2011). FRANCE: European Directorate for the Quality of Medicines & HealthCare (EDQM) of the Council of Europe.

El-Din, Eman M. Rabie Shehab, MohamedM. Adel El-Sokkary, Mohamed Reda Bassiouny, and Ramadan Hassan. 2015. "Epidemiology of Neonatal Sepsis and Implicated Pathogens:A Study from Egypt." *BioMed Research International*. doi: 10.1155/2015/509484.

El-Tawil, A. M. 2012. "Trends on gastrointestinal bleeding and mortality: Where are we standing?" *World J Gastroenterol* no. 18 (11):1154-8. doi: 10.3748/wjg.v18.i11.1154.

Ellingson, K. D., M. R. P. Sapiano, K. A. Haass, A. A. Savinkina, M. L. Baker, K. W. Chung, R. A. Henry, J. J. Berger, M. J. Kuehnert, and S. V. Basavaraju. 2017. "Continued decline in blood collection and transfusion in the United States-2015." *Transfusion* no. 57 Suppl 2:1588-1598. doi: 10.1111/trf.14165.

Erhabor, O., T.C Adias, and A.S Mainasara. 2013. *Provision of Safe Blood Transfusion Services in a Low Income Setting in West Africa: Case Study of Nigeria*. Vol. 59, *Advances in Medicine and Biology*: Department of Medical Laboratory Science, College of Basic Medical Science, Niger Delta University Amassoma Bayelsa State Nigeria.

Fan, Dazhi, Song Wu, Zhengping Liu, Xiaoling Guo, Wen Wang, Tian Guo, and Li Liu. 2017. "Prevalence of antepartum hemorrhage in women with placenta previa: a systematic review and meta-analysis." *Sci Rep* no. 7:40320. doi: 10.1038/srep40320.

Far, R. M., F. S. Rad, Z. Abdolazimi, and M. M. Kohan. 2014. "Determination of rate and causes of wastage of blood and blood products in Iranian hospitals." *Turk J Haematol* no. 31 (2):161-7. doi: 10.4274/tjh.2012.0105.

Fraser, Ian S, Sue Langham, and Kerstin Uhl-Hochgraeber. 2014. "Health-related quality of life and economic burden of abnormal uterine bleeding." *Expert Review of Obstetrics and Gynaecology* no. 4 (2):179-189.

Ganesan, Prasanth, and Lalit Kumar. 2017. "Chronic Myeloid Leukemia in India." *J Glob Oncol* no. 3 (1):64-71. doi: 10.1200/JGO.2015.002667.

Gebregzabiherher, Yisak, Abera Haftu, Solomon Weldemariam, and Haftom Gebrehiwet. 2017. "The Prevalence and Risk Factors for Low Birth Weight among Term Newborns in Adwa General

Hospital, Northern Ethiopia." *Obstetrics and Gynecology International*. doi: 10.1155/2017/2149156.

Geller, S. E., S. S. Goudar, M. G. Adams, V. A. Naik, A. Patel, M. B. Bellad, S. S. Patted, S. A. Edlavitch, N. Moss, B. S. Kodkany, and R. J. Derman. 2008. "Factors associated with acute postpartum hemorrhage in low-risk women delivering in rural India." *Int J Gynaecol Obstet* no. 101 (1):94-9. doi: 10.1016/j.ijgo.2007.08.025.

George, Preetha, and V M Jayasree Thankachi. 2017. "Hellp Syndrome - A Study from a Tertiary Centre in India." *International Journal of Contemporary Medical Research* no. 4 (7).

Gera, Tarun, and S. Ramji. 2000. "Early Predictors of Mortality in Very Low Birth Weight Neonates." *Indian Pediatrics* no. 38:596-602.

Giordano, Rosalba, Alessandra Cacciatore, Pietro Cignini, Roberto Vigna, and Mattea Romano. 2010. "Antepartum Haemorrhage." *Journal of prenatal medicine* no. 4 (1):12–16.

Girinath, M. R. 2001. "The future of cardiothoracic surgery in India." *J Indian Med Assoc* no. 99 (9):497-8.

Globocon. 2012a. *Globocon 2012: Estimated cancer incidence, mortality & prevalence worldwide in 2012*.

GLOBOCON. 2017. *Prevalance of Hodgkin Lymphoma, Non-Hodgkin Lymphoma and Multiple Myeloma*. Globocon 2012: Estimated Cancer ,Mortality and Prevalance Worldwide in 2012 2012b [cited 18th December 2017]. Available from http://globocan.iarc.fr/Pages/fact_sheets_population.aspx.

GOI. 1994. The Transplantation of Human organs and Tissue Act 1994. New Delhi: Government of India.

GOI. 2014. Rapid Survey on Children. In *New Delhi*. Ministry of Women and Child Development, Government of India.

GOI. 2015. Health and Family Welfare Statistics 2015. New Delhi: Ministray of Health and Family Welfare, Government of India.

GOI. 2017. National Health Profile-2017. New Delhi: Ministry of Health and Family welfare,Government of India.

GOI. 2018. STANDARD TREATMENT GUIDELINES OBSTETRICS & GYNAECOLOGY. New Delhi: Ministry of Health and Family Welfare,Government of India.

Golubnitschaja, O., K. Yeghiazaryan, M. Cebioglu, M. Morelli, and M. Herrera-Marschitz. 2011. "Birth asphyxia as the major complication in newborns: moving towards improved individual outcomes by prediction, targeted prevention and tailored medical care." *EPMA J* no. 2 (2):197-210. doi: 10.1007/s13167-011-0087-9.

Gondhali, Shital Bhattad, Suresh H Bhattad, Girish Nanoti, Himanshu Dua, and Bhupendra Asudani. 2012. "Late Hemorrhagic Disease of Newborn in Infants with Hospital Deliveries." *Indian Journal of Trauma and Emergency Pediatrics* no. 4.

Gul Javid, Showkat Ali Zarger, Manzoor Ahmad Wani, Ghulam Mohamad Gulzar, Jaswinder Singh, Mushtaq Ahmad Khan Sodhi, Zeeshan Ahmad Wani, Asif Iqbal Shah, Reyaz-u-Saif, Mohamad Yousuf Bhat, Abid Shoukat, and Mushkoor Ahmed. 2010. "Upper Gastrointestinal Bleeding in Children in Kashmir (India): An Analysis of Causes, Characteristics and Outcome." *Journal of Digestive Endoscopy* no. 1 (3):145-50.

Gupta, B M, and Adarsh Bala. 2013. "Bone Marrow Research in India: A Scientometric Study, 2003-12." *Journal of Bone Research*. doi: 10.4172/2329-8820.1000108.

Gupta, E., and N. Ballani. 2014. "Current perspectives on the spread of dengue in India." *Infect Drug Resist* no. 7:337-42. doi: 10.2147/IDR.S55376.

Gupta, JL, LK Makhija, and SP Bajaj. 2010. "National programme for prevention of burn injuries." *Indian Journal of Plastic Surgery* no. 43 (3):6-10.

Gupta, Rajeev, Indu Mohan, and Jagat Narula. 2016. "Trends in Coronary Heart Disease Epidemiology in India." *Annals of Global Health* no. 82 (2):307-315.

Gupta, Sanjay Kumar, Sanjay S Agarwal, Rituja Kaushal, Ambuj Jain, Vineet Kumar Gupta, and Neeraj Khare. 2014. "Prevalence of Anemia among rural population living in and around of rural health and training center, Ratua Village of Madhya Pradesh." *Muller Journal of Medical Sciences and Research* no. 5 (1):15-18.

Gupta, V., A. Kumar, I. Saini, and A. K. Saxena. 2013. "Cytogenetic profile of aplastic anaemia in Indian children." *Indian J Med Res* no. 137 (3):502-6.

Harambat, Jérôme, Karlijn J. van Stralen, Jon Jin Kim, and E. Jane Tizard. 2012. "Epidemiology of chronic kidney disease in children." *Pediatr Nephrol* no. 27:363–373. doi: 10.1007/s00467-011-1939-1.

Hari, Pankaj, Ish Kumar Singla, Mukta Mantan, Madhuri Kanitkar, Bobby Batra, and Arvind Bagga. 2003. "Chronic Renal Failure in Children." *Indian Pediatrics* no. 40:1035-1042

Hartung, H. D., T. S. Olson, and M. Bessler. 2013. "Acquired aplastic anemia in children." *Pediatr Clin North Am* no. 60 (6):1311-36. doi: 10.1016/j.pcl.2013.08.011.

Hooda,SK. 2015. PRIVATE SECTOR IN HEALTHCARE DELIVERY MARKET IN INDIA: Structure, Growth and Implications, Institute for Studies in Industrial Development, New Delhi, WP-185

Hsu, Chia-Chien, and Brian A. Sandford. 2007. "The Delphi Technique: Making Sense Of Consensus." *Practical Assessment, Research and Evaluation* no. 12 (10).

Hussein, Hafadh J., Nidhal M. Kadhum, Aeshah Muneeb, and Luay M. Salih. 2014. "Relationship between very low birth weight neonates and increased neonatal mortality for age 0 to 7 days." *Al-Kindy College Medical Journa* no. 10 (2):25-28.

ICMR. 2003-04. Studies on nutrition. New Delhi: Regional Medical Research Centre Bhubaneshwar.

ICMR. 2004. Annual Report 2003-2004. Regional Medical Research Center.

IIPS, and ORC-Macro. 2017. National Family Health Survey-2017 (NFHS-4) New Delhi: Ministry of Heallth and Family Welfare,Government of India.

Jagtap, Sunil Vitthalrao, Vidhya Aher, Suchi Gadhiya, and SwatiSunil Jagtap. 2017. "Gestational Trophoblastic Disease - Clinicopathological Study at Tertiary Care Hospital." *J Clin Diagn Res* no. 11 (8):EC27-EC30. doi: 10.7860/JCDR/2017/27232.10458.

Jain, V, PN Agarwal, R Singh, A Mishra, A Chugh, and M Meena. 2015. "Management of Upper Gastrointestinal Bleed." *Maulana Azad Medical College Journal of Medical Sciences* no. 1 (2):69-79.

Jejani, Ayushma, and Anjali Kawthalkar. 2015. "Study of obstetric outcome in antepartum haemorrhage." *Panacea Journal of Medical Science* no. 5 (3):153-157

JohnHopkinsMedicine. 2017. *Bone Marrow Transplantation*. John Hopkins Medicine 2017 [cited 18th December 2017]. Available from https://www.hopkinsmedicine.org/healthlibrary/conditions/hematology_and_blood_disorders/bone_marrow_transplantation_85,P00086.

JohnsHopkinsMedicine. 2018. *Thoracic Surgery* 2018a [cited 15th January 2018]. Available from https://www.hopkinsmedicine.org/surgery/div/Thoracic.html.

JohnsHopkinsMedicine. 2018. *Urology* 2018b [cited 15th January 2018]. Available from https://www.hopkinsmedicine.org/international/excellence/urology.html.

Kanitkar, M. 2009. "Chronic Kidney Disease in Children: An Indian Perspective." *Med J Armed Forces India* no. 65 (1):45-9. doi: 10.1016/S0377-1237(09)80055-5.

Kar, A., S. Phadnis, S. Dharmarajan, and J. Nakade. 2014. "Epidemiology & social costs of haemophilia in India." *Indian J Med Res* no. 140 (1):19-31.

Kashyap, Rajesh, and V.P. Choudhry. 2001. "Management of Hemophilia in Developing Countries." *The Indian Journal of Paediatrics* no. 68 (2):151-157.

Kaul, Upendra, and Vineet Bhatia. 2010. "Perspective on coronary interventions & cardiac surgeries in India." *Indian Journal Of Medical Rsearch* no. 132 (5):543-548.

Kayal, L, S Jayachandran, and Khushboo Singh. 2014. "Idiopathic thrombocytopenic purpura." *Contemporary Clinial Dentistry* no. 5 (3):410-414.

Khan, Muntaha, P. Sachdeva, R. Arora, and S. Bhasin. 2013. "Conservative management of morbidly adherant placenta – A case report and review of literature." no. 34 (10):963–966. doi: https://doi.org/10.1016/j.placenta.2013.04.016.

Kotecha, Prakash V. 2011. "Nutritional Anemia in Young Children with Focus on Asia and India." *Indian Journal of Community Medicine* no. 36 (1):8-16. doi: 10.4103/0970-0218.80786.

Kroupa, J. 1990a. "[Definition of "polytrauma" and "polytraumatism"]." *Acta chirurgiae orthopaedicae et traumatologiae Cechoslovaca* no. 57 (4):347-360.

Kroupa, J. 1990b. "[Definition of "polytrauma" and "polytraumatism"]." *Acta Chir Orthop Traumatol Cech* no. 57 (4):347-60.

Kulkarni, Dilip K. 2017. "Pattern and categorisation of neurosurgical emergencies." *Journal of Neuroanaesthesiology and Critical Care* no. 4 (4):6-8.

Kumar, Ashwani, Neena Valecha, Tanu Jain, and Aditya P. Dash. 2007. "Burden of Malaria in India: Retrospective and Prospective View." *American Journal of Tropical Medicine and Hygiene* no. 77 (6).

Kumar, R., S. P. Birinder, S. Gupta, G. Singh, and A. Kaur. 2015. "Therapeutic plasma exchange in the treatment of myasthenia gravis." *Indian J Crit Care Med* no. 19 (1):9-13. doi: 10.4103/0972-5229.148631.

Kundu, Ritabrata, Nupur Ganguly, Tapan Kr Ghosh, Panna Choudhury, and Raju C Shah. 42. *Diagnosis and Management of malaria in Children* 2005 [cited 1101-1114 42]. Available from http://www.indianpediatrics.net/nov2005/nov-1101-1114.htm.

Kurup, Rajini, Audrey Anderson, Cecil Boston, Lynn Burns, Marian George, and Marana Frank. 2016. "A study on blood product usage and wastage at the public hospital, Guyana." *BMC Research Notes* no. 9:307. doi: 10.1186/s13104-016-2112-5.

Lata, Indu. 2013. "Hepatobiliary diseases during pregnancy and their management: An update." *Int J Crit Illn Inj Sci* no. 3 (3):175-82. doi: 10.4103/2229-5151.119196.

Lowalekar, Harshal, and N. Ravichandran. 2013. "Blood bank inventory management in India." *OPSEARCH*:1-24. doi: 10.1007/s12597-013-0148-z.

Majumder, Siddhartha, Parul T. Shah, Kruti J. Deliwala, Rina V. Patel, and Anuradha Madiya. 2015. "Study of foetomaternal outcome of antepartum haemorrhage in pregnancy." *International Journal of Reproduction, Contraception, Obstetrics and Gynecology* no. 4 (6):1936-1939.

Malhotra, P., S. Kumari, R. Kumar, and S. Varma. 2004. "Prevalence of anemia in adult rural population of north India." *J Assoc Physicians India* no. 52:18-20.

Malhotra, Pankaj, Vishwanath Gella, Guru Subramanian Murthy, Neelam Varma, and Subhash Varma. 2016. "High incidence of aplastic anemia is linked with lower socioeconomic status of Indian population." *Journal of Public Health* no. 38 (2):223-228.

Marco, Catherine A., Ashley Humphries, and Eric Mozeleski. 2018. *Common Orthopedic Injuries*. RELIAS 2017 [cited 17th January 2018].

McCord, Colin, Doruk Ozgediz, Jessica H Beard, and Haile T Debas. 2015. "General Surgical Emergencies." *Essential Surgery: Disease Control Priorities* no. 1. doi: 10.1596/978-1-4648-0346-8_ch4.

McGuire, William. 2007. "Perinatal asphyxia." *BMJ Clinical Evidence* no. 2007:0320.

MDA. 2008. Use of Blood and Blood Products in Disasters. Paper read at Identifying the Needs of Medical FirstResponder in Disasters, at Israel.

Modi, G. K., and V. Jha. 2006. "The incidence of end-stage renal disease in India: A population-based study." *Kidney Int* no. 70 (12):2131-3. doi: 10.1038/sj.ki.5001958.

Mohanty, D., R. B. Colah, A. C. Gorakshakar, R. Z. Patel, D. C. Master, J. Mahanta, S. K. Sharma, U. Chaudhari, M. Ghosh, S. Das, R. P. Britt, S. Singh, C. Ross, L. Jagannathan, R. Kaul, D. K. Shukla, and V. Muthuswamy. 2013. "Prevalence of beta-thalassemia and other haemoglobinopathies in six cities in India: A multicentre study." *J Community Genet* no. 4 (1):33-42. doi: 10.1007/s12687-012-0114-0.

Mokhtar, Galila Mohamed, Mohsen Abdalhamed Gadallah, Nayera H K El Sherif, and Heba Allah Ali. 2013. "Morbidities and mortality in transfusion-dependent Beta-thalassemia patients (single-center experience)." *Pediatric hematology and oncology* no. 30 (2):93-10. doi: 10.3109/08880018.2012.752054.

Morales, Paola, Diego Bustamante, Pablo Espina-Marchant, Tanya Neira-Peña, Manuel A. Gutiérrez-Hernández, Camilo Allende-Castro, and Edgardo Rojas-Mancilla. 2011. "Pathophysiology of perinatal asphyxia: can we predict and improve individual outcomes?" *The EPMA Journal* no. 2 (2):211-230. doi: 10.1007/s13167-011-0100-3.

Murthy, B. K., M. B. Murthy, and P. M. Prabhu. 2013. "Maternal Mortality in a Tertiary Care Hospital: A 10-year Review." *Int J Prev Med* no. 4 (1):105-9.

Murthy, Nandagudi Srinivasa, Shivalingaiah Shalini, G. Suman, Pruthvish Sreekantaiah, and Aleyamma Mathew. 2009. "Changing trends in incidence of ovarian cancer - the Indian scenario." *Asian Pac J Cancer Prev* no. 10 (6):1025-30.

Nair, M. K., C. Varghese, E. Krishnan, R. Sankaranarayanan, and B. Nair. 1993. "Survival in multiple myeloma in Kerala." *Natl Med J India* no. 6 (1):7-10.

Nair, Reena, Neeraj Arora, and Mohandas K. Mallath. 2016. "Epidemiology of Non-Hodgkin's Lymphoma in India." *Karger Oncology* no. 91 (1):18-25.

Nair, Velu. 2008. *Disseminated Intravascular Coagulation*. Vol. 18: Medical update-2008.

Naithani, Rahul, Neerja Agrawal, M Mahapatra, Rajat Kumar, H P Pati, and V P Choudhry. 2007. "Autoimmune Haemolytic Anaemia in Children." *Pediatric Hematology and Oncology* no. 24 (4).

Nanu, A. 2001. "Blood transfusion services: organization is integral to safety." *Natl Med J India* no. 14 (4):237-40.

NHP. 2018. *National Health Profile,2017*. Central Bureau of Health Intelligence,Ministry of Health and Family Welfare 2017a [cited 25th January 2018]. Available from http://www.cbhidghs.nic.in/index1.asp?linkid=267.

NHP. 2017b. Postpartum Hemorrhage. New Delhi: Ministry of Health and Family welfare,Government of India,New Delhi.

NICPR. 2018. *Cancer Statistics*. National Institute of Cancer Prevention and Research 2018 [cited 15th January 2018]. Available from http://cancerindia.org.in/statistics/

Noris, Marina, and Giuseppe Remuzzi. 2005. "Hemolytic Uremic Syndrome." *Journal of the American Society of Nephrology* no. 16 (4):1035-1050. doi: 10.1681/ASN.2004100861.

NottinghamUniversityHospitals. 2018. *Upper GI Surgery*. 1st February 20182018]. Available from https://www.nuh.nhs.uk/our-services/services/upper-gi-surgery/.

Ong, Kanyin L., Mirasol Apostal, Nicole Comstock, Sharon Hurd, Tameka Hayes Webb, Stephanie Mickelson, Joni Scheftel, Glenda Smith, Beletshachew Shiferaw, Effie Boothe, and L. Hannah Gould. 2012. "Strategies for surveillance of pediatric hemolytic uremic syndrome: Foodborne Diseases Active Surveillance Network (FoodNet), 2000-2007." *Clinical Infectious Diseases* no. 54 (5):S424–S431. doi: 10.1093/cid/cis208.

Organ-India. *A study of the Deceased Organ Donation Environment in Delhi/NCR* 2013. Available from http://organindia.org/wp-content/uploads/2014/11/ORGAN-Research-Report.pdf.

Osaro, E., and A. T. Charles. 2011. "The challenges of meeting the blood transfusion requirements in Sub-Saharan Africa: the need for the development of alternatives to allogenic blood." *J Blood Med* no. 2:7-21. doi: 10.2147/JBM.S17194.

Panigrahi, I., and R. K. Marwaha. 2007. "Mutational spectrum of thalassemias in India." *Indian J Hum Genet* no. 13 (1):36-7. doi: 10.4103/0971-6866.32034.

Patil, Parikshit, Arvind Bhake, and Kishor Hiwale. 2016. "Analysis of discard of whole blood and its components with suggested possible strategies to reduce it." *2016* no. 4 (2):5. doi: 10.18203/2320-6012.ijrms20160299.

Peake, Mick. *Exploring variations in rates of surgery for cancer patients in England* 2011. Available from http://scienceblog.cancerresearchuk.org/2011/03/18/exploring-variations-in-rates-of-surgery-for-cancer-patients-in-england/.

Perepu, Usha, and Lori Rosenstein. 2013. "Maternal thrombocytopenia in pregnancy." *Proceedings in Obstetrics and Gynecology,* no. 3 (1):6.

Pooni, Puneet A, Daljit Singh, Harmesh Singh, and B.K. Jain. *Intracranial Hemorrheage in Late Hemorrhagic Disease of the Newborn*. Indian Pediatrics 2003. Available from http://indianpediatrics.net/mar2003/mar-243-240.htm.

Prabhu, Raghuveer, Renjitha Bhaskaran, Veena Shenoy, Rema G, and Neeraj Sidharthan. 2016. "Clinical characteristics and treatment outcomes of primary autoimmune hemolytic anemia: A single center study from South India." *Blood Res* no. 51 (2):88-94. doi: 10.5045/br.2016.51.2.88.

Ramani, K. V., D. V. Mavalankar, and D. Govil. 2009. "Study of blood-transfusion services in Maharashtra and Gujarat States, India." *J Health Popul Nutr* no. 27 (2):259-70.

Randolph, A. G., and R. J. McCulloh. 2014. "Pediatric sepsis: important considerations for diagnosing and managing severe infections in infants, children, and adolescents." *Virulence* no. 5 (1):179-89. doi: 10.4161/viru.27045.

RL, Crumley. 1982. "What is otolaryngology--head and neck surgery?" *Prim Care* no. 9 (2):261-8.

Romano, C., S. Oliva, S. Martellossi, E. Miele, S. Arrigo, M. G. Graziani, S. Cardile, F. Gaiani, G. L. de'Angelis, and F. Torroni. 2017. "Pediatric gastrointestinal bleeding: Perspectives from the Italian Society of Pediatric Gastroenterology." *World J Gastroenterol* no. 23 (8):1328-1337. doi: 10.3748/wjg.v23.i8.1328.

Sa, Kora, and Keshav Kulkarni. 2011. "An Analysis of Donor Blood Wastage in a Blood Bank in Rural Karnataka." *Journal of Clinical and Diagnostic Research* no. 5 (5).

Sabrine, N., J Singh, and S K Sinha. *Medical Management of Birth Asphyxia*. Indian Pediatrics 1999. Available from http://www.indianpediatrics.net/apr1999/apr-369-376.htm.

Saheta, Astha, Urvashi Sharma, and C.Hariharan. 2014. "Abnormal uterine bleeding." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)* no. 13 (11):63-67.

Saxena, Anita, Anurag Mehta, Mamta Sharma, Sudha Salhan, Mani Kalaivani, Sivasubramanian Ramakrishnan, and Rajnish Juneja. 2016. "Birth prevalence of congenital heart disease: A cross-sectional observational study from North India." *Annals of Pediatric Cardiology* no. 9 (3):205-209.

Schonborn, L., K. Weitmann, N. Greger, V. Kiefel, W. Hoffmann, and A. Greinacher. 2017. "Longitudinal Changes in the Blood Supply and Demand in North-East-Germany 2005-2015." *Transfus Med Hemother* no. 44 (4):224-231. doi: 10.1159/000479538.

Schorge, John O., Lisa M. Halvorson, Joseph I. Schaffer, and Karen D Bradshaw. 2012. *Williams Gynecology*. Edited by 2nd. Dallas, Texas: McGraw-Hill eBooks.

SCTS. 2018. *Adult Cardiac Surgery*. Society for Cardiothoracic Surgery 2018 [cited 16th January 2018]. Available from https://scts.org/patients/adult-cardiac-surgery/.

Shah, Dheeraj, Panna Choudhury, and A.P. Dubey. 1999. "Current Trends in Management of the Beta Thalassemias." *Indian Pediatrics* no. 36:1229-1242.

Sharma, J.B, and Meenakshi Shankar. 2010. "Anemia in Pregnancy." *JIMSA* no. 23 (4):253-260.

Shekhar, Shashank, and Gaurav Diddi. 2015. "Liver disease in pregnancy." *Taiwanese Journal of Obstetrics and Gynecology* no. 54 (5):475-482. doi: https://doi.org/10.1016/j.tjog.2015.01.004.

Shendurnikar, Niranjan, Hiralal Rana, and D.J. Gandhi. 2001. "Late Hemorrhagic Disease of the Newborn." *Indian Pediatrics* no. 38:1198-1199.

Shi, L., J. Wang, Z. Liu, L. Stevens, A. Sadler, P. Ness, and H. Shan. 2014. "Blood donor management in china." *Transfus Med Hemother* no. 41 (4):273-82. doi: 10.1159/000365425.

Singh, Susheela, Chander Shekhar, Rajib Acharya, Ann M Moore, Melissa Stillman, Manas R Pradhan, Jennifer J Frost, Harihar Sahoo, Manoj Alagarajan, Rubina Hussain, Aparna Sundaram, Michael Vlassoff, Shveta Kalyanwala, and BA Alyssa Browne. 2018. "The incidence of abortion and unintended pregnancy in India, 2015." *The Lancet global health* no. 6 (1):111-120.

Siromani, Umakanth, Thasian T, Rita Isaac, Dolly Daniel, Selvaraj K G, Joy John Mammen, and Sukesh Chandra Nair. 2013. "Shortage Of Blood! Youths, The Trend Setters, Can They Help To Meet The Needs?" *Natl J Med Res* no. 3 (2):196-197.

Soo, Kuan-Meng, Bahariah Khalid, Siew-Mooi Ching, and Hui-Yee Chee. 2016. "Meta-Analysis of Dengue Severity during Infection by Different Dengue Virus Serotypes in Primary and Secondary Infections." *PLOS ONE*.

Srilatha, Juvvadi, and Verabelly Malathi. 2017. "Prevalence of fibroids: a study in a semiurban area in Telangana, India." *International Journal of Reproduction, Contraception, Obstetrics and Gynecology* no. 6 (12):5247-5250.

Thacker, Naveen. *Prevention of Thalassemia in India*. Indian Pediatrics 2007a. Available from http://www.indianpediatrics.net/sep2007/sep-647-648.htm.

Thacker, Naveen. 2018. *Prevention of Thalassemia in India* 2007b [cited 12 2018]. Available from http://www.indianpediatrics.net/sep2007/sep-647-648.htm.

Thangaratinam, Shakila, and Charles W. E. Redman. 2005. "The Delphi technique." *The Obstetrician & Gynaecologist* no. 7 (2):120-125. doi: 10.1576/toag.7.2.120.27071.

Tintinalli, Judith E, J Stephan Stapczynski, O John Ma, Donald M Yealy, Garth D Meckler, and David M Cline. 2018. *Gastrointestinal Bleeding in Infants and Children*. 8 ed, *TINTINALLI'S EMERGENCY MEDICINE: A Comprehensive Study Guide, Eighth edition*.

Trampuz, Andrej, Matjaz Jereb, Igor Muzlovic, and Rajesh M Prabhu. 2003. "Clinical review: Severe malaria." *Crit Care* no. 7 (4):315-23. doi: 10.1186/cc2183.

UniversityofUtah. 2018. *Treating Skin Conditions with Surgery*. University of Utah 2018 [cited 1st February 2018]. Available from https://healthcare.utah.edu/general-surgery/skin-soft-tissue.php.

Varma, P. P. 2015. "Prevalence of chronic kidney disease in India - Where are we heading?" *Indian J Nephrol* no. 25 (3):133-5.

Venkataswamy, C., and A. S. Devi. 2017. "Clinico-Haematological Profile of Hereditary Haemolytic Anaemias in a Tertiary Health Care Hospital in South India." *J Clin Diagn Res* no. 11 (6):EC17-EC21. doi: 10.7860/JCDR/2017/25366.10023.

Venugopal, A. 2014. "Disseminated intravascular coagulation." *Indian J Anaesth* no. 58 (5):603-8. doi: 10.4103/0019-5049.144666.

Volken, T., A. Buser, D. Castelli, S. Fontana, B. M. Frey, I. Rusges-Wolter, A. Sarraj, J. Sigle, J. Thierbach, T. Weingand, and B. M. Taleghani. 2018. "Red blood cell use in Switzerland: trends and demographic challenges." *Blood Transfus* no. 16 (1):73-82. doi: 10.2450/2016.0079-16.

Warady, Bradley A., and Vimal Chadha. 2007. "Chronic kidney disease in children: the global perspective." no. 22 (12):1999–2009. doi: 10.1007/s00467-006-0410-1.

WashingtonUniversitySchoolofMedicineinSt.Louis. 2018. *HPB-GI Surgery* 2018 [cited 1st February 2018].

Wasnik, Sneha Kishor, and Sachin Vijay Naiknaware. 2015. "Antepartum Haemorrhage: Causes & Its Effects on Mother and Child: An Evaluation." *Obstetrics & Gynecology International Journal* no. 3 (1):1-5.

Welch, Claude E., Leslie W. Ottinger, and John P. Welch. 1980. *Manual of Lower Gastrointestinal Surgery*.

WHO. 2008. GDBS Summary Report 2008. Geneva: World Health Organization.

WHO. 2009a. Dengue: Guidelines for Diagnosis, Treatment and Prevention and Control.

WHO. 2009b. GDBS Summary Report 2009: WHO Global Database on Blood Safety (GDBS) and Blood Safety Indicators. . Geneva: World Health Organization.

WHO. 2009c. WHO Experts' Consultation on Estimation of Blood Requirements – Meeting Report. Geneva: World Health Organization.

WHO. 2009d. WHO Experts' Consultation on Estimation of Blood Requirements – Presentations. Geneva: World Health Organization.

WHO. 2010a. Towards 100% voluntary blood donation: A global framework for action. Geneva: World Health Organization.

WHO. 2010b. WHO Experts' Consultation on Estimation of Blood Requirements 03 - 05 February 2010, WHO-HQ. Geneva: World Health Organization.

WHO. 2011a. Developing a National Blood System. Geneva: World Health Organization.

WHO. 2011b. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Geneva: World Health Organization

WHO. 2012. WHO recommendations for the prevention and treatment of postpartum haemorrhage. Geneva: World Health Organization.

WHO. 2013. The Rome Declaration on Achieving Self-Sufficiency in Safe Blood and Blood Products,based on Voluntary Non-Remunerated Donation.

WHO. 2016. Global Status Report on Blood Safety and Availability 2016. Geneva: World Health Organization 2017.

WHO. 2018. *Blood safety and availability*. World Health Organization 2017 [cited 15th February 2018 2018]. Available from http://www.who.int/mediacentre/factsheets/fs279/en/.

WHO. 2018. *Burns*. World Health Organisation 2018a [cited 15th January 2018]. Available from http://www.who.int/mediacentre/factsheets/fs365/en/.

WHO. 2018. *Dengue and Severe Dengue*. WHO 2018b [cited 17th January 2018]. Available from http://www.who.int/mediacentre/factsheets/fs117/en/.

Wong, Wendy. 2018. *Fewer youths donating blood in Singapore amid growing demand*. Channel News Asia 2017 [cited 15th January 2018 2018]. Available from https://www.channelnewsasia.com/news/singapore/fewer-youths-donating-blood-in-singapore-amid-growing-demand-8935242.

Wu, Han Ping, Cheng Li Lin, Yin Chen Chang, Kang Hsi Wu, Rouh Lih Lei, Ching Tien Peng, Tefu Weng, Yu Man Tai, and Yu Hua Chao. 2016. "Survival and complication rates in patients with thalassemia major in Taiwan." *Pediatr Blood Cancer* no. 64 (1):135-138. doi: 10.1002/pbc.26181.

Yadav K, Namdeo A, and Bhargava M.A. 2013. " Retrospective and prospective study of maternal mortality in a rural tertiary care hospital of Central India." *Indian Journal of Community Health* no. 25 (1):16-21.

Zhang, Ling. 2016. "Inherited and Acquired Bone Marrow Failure Syndromes: In the Era of Deep Gene Sequencing." *Journal of Leukemia* no. 4 (4):1-3.

10. Annexures

1. Disease-specific demand – Medicine

S No	Disease Condition	WB	Red cells	Plasma	Platelets	Cryo	Demand
1	Abdominal Koch's		58	5			59
2	Acute Heart Failure/ Chronic	21	26	44	10	10	65
3	Acute Mitral Regurgitation		10	10			10
4	Advance Atrioventricular (AV) Block		39	4	4		39
5	Angina		52	43	10		52
6	Acid Peptic Disorder (APD) with Irritable Bowel Syndrome	4					4
7	Anti-Phospholipid Antibody (APLA)				79		79
8	Aplastic Anaemia	382	897	150	816	14	1,432
9	Acute Respiratory Distress Syndrome (ARDS)		76	45	76		109
10	Ascites	54	292	41	51	14	348
11	Auto Immune Haemolytic Anaemias	2,044	1,024	24	30		3,076
12	Bleeding Disorder	106	280	381	264	264	546
13	Bone Marrow Failure - Benign	250	408	2	403		775
14	Bronchiectasis		15	4			15
15	Coronary Artery Disease (CAD)	236	1,050	513	242	13	1,419
16	Carcinoma	113	405	18	11	0	518
17	Congestive Cardiac Failure (CCF) Sepsis	44	143	162	53	7	247
18	Cerebral Haemorrhage	12	53	63	60		107
19	Chronic Kidney Disease (CKD)	1,643	2,862	934	327	122	4,587
20	Chronic Liver Disorder (CLD)	2,155	3,472	7,470	884	427	10,219
21	Central Nervous System (CNS) Lupus	6	30				36
22	Coagulation Disorder	4	8	233	4		237

23	Congestive Cardiac Failure	51	637	255	221		759
24	Chronic Obstructive Pulmonary Disease (COPD)	158	1,075	702	296	8	1,234
25	Coronary Syndrome		127	96	2		127
26	Cerebrovascular Accident (CVA)	230	476	435	181	0	951
27	CVF with Alcoholic Hepatitis	48	2	4			52
28	Dengue	664	765	1,216	9,845	76	10,851
29	Diabetic Keto Acidosis	4	30	4	7		33
30	Disseminated Intravascular Coagulation (DIC)	131	565	1,586	342	374	1,937
31	Diabetes Mellitus (DM)	119	490	138	39	0	616
32	DM with Hypertension	14	995	491	94		1,010
33	Empyema		2				2
34	Encephalopathy	18	196	266	100	158	407
35	End stage renal disease	6,248	12,005	2,820	919		19,053
36	Enteric Colitis	0	19	10	1	35	42
37	Enteric Fever	18					18
38	Epistaxis	16	76	36	24		110
39	Erythroid Hyperplasia		4				4
40	Filariasis	4					4
41	Gastrointestinal Bleed	5,767	5,201	1,771	629	81	11,255
42	Graves Disease	24					24
43	Haematuria	70	327	29	36	7	416
44	Haemoptysis	308	38	22			351
45	Haemorrhage	498	238	92	43	7	791
46	Hematemesis	348	305	46	10		677
47	Hemiplegia	25	15	17	10		42
48	Haemolytic anaemias	1,756	2,053	227	218	8	3,883
49	Haemophilia	456	246	1,207	148	192	2,009
50	Hepatic Abscess	44	227	380	41		423
51	Hepatic Encephalopathy	6	46	173	20	14	179
52	Hepatitis	98	151	303	60	12	461
53	Hepatorenal Syndrome			7	29		29
54	Herpes Genitalis			12			12
55	Hodgkin Lymphoma	25	73	32		43	106
56	Hypoplastic Anaemia	4	12		9		16
57	Hypothyroidism	24	7				31

58	Idiopathic Thrombocytopenic Purpura (ITP)	253	953	247	4,916	409	5,522
59	Japanese Encephalitis	26	11	86			112
60	Jaundice	191	126	494	25		791
61	Kala Azar		25		24		49
62	Leishmania	12					12
63	Leptospirosis		12				12
64	Leukaemia	1,564	5,921	1,197	4,614	359	9,810
65	Liver Cirrhosis	166	128	393	127		627
66	Lower Respiratory Tract Infection (LRTI)	142	185	71	12		384
67	Left Ventricular Failure (LVF)	18	4				22
68	Lymphoma	2					2
69	Malaria	974	1,031	546	1,945		3,688
70	Myelodysplastic Syndrome (MDS)		272	47	97		284
71	Meningitis	64	49	7	9	10	120
72	Metabolic Encephalopathy				2		2
73	Myocardial Infarction (MI)	2	27	4	8		29
74	Myasthenia Gravis	2	25	159	23	55	205
75	Myeloma & Lymphoma	423	2483	204	928	37	3,255
76	Myocarditis		47				47
77	Nutritional Anaemia	31,154	32,953	1,924	1,172	177	64,143
78	Onco/Palliative	2,402	4,286	799	1,934	204	7,196
79	Osteoarthritis	32	61	28		25	94
80	Other	1,813	3,819	1,724	739	176	6,489
81	Pancreatitis	81	582	136	59	14	751
82	Pancytopenia	18	393	222	746	26	905
83	Paraplegia		8				8
84	Pedal Oedema	2					2
85	Pemphigus Foliaceus		4				4
86	Plasmapheresis group		14	169	277	13	347
87	Pleural Effusion	2	122	36	27	36	160
88	Progressive Massive Fibrosis (PMF)		12				12
89	Poisoning	28	85	25	23	14	137
90	Polyclonal ImmunoglobinA (IgA) Nephropathy				11		11

91	Pulmonary Tuberculosis (PTB) with HIV		36				36
92	Pulmonary Embolism		15	18	8	7	26
93	Pulmonary Koch's	234	290	115	91		575
94	Pyrexia Of Unknown Origin (PUO)	131	221	230	449	14	601
95	Peripheral Vascular Disease (PVD)		50	32			50
96	Respiratory Failure	10	17	27			45
97	Rheumatic Heart Disease	552	1,379	471	78		1,957
98	Rheumatism	8					8
99	Seizure		1				1
100	Sepsis	252	1,052	1,262	323	19	1,911
101	Sepsis with Rhesus Theta Defisin (RTD)		22	4			22
102	Septic Shock		56	96	32	31	117
103	Severe Metabolic Acidosis		24				24
104	Shock	28	57	10			85
105	Systemic Lupus Erythematosus (SLE)	49	46	7	34		120
106	Snake Bite	47	175	219	222	82	395
107	Splenomegaly	4	137	7	116		210
108	Sexually Transmitted Infection (STI)	24	24	48			72
109	Stroke Infarct with Septicaemia/ Anaemia	36					36
110	Thrombocytopenia	32	426	235	1,608	18	1,719
111	Transient Ischemic Attack (TIA)	4					4
112	Ulcerative Colitis	11	35				46
113	Upper Respiratory Tract Infection (URTI)	104	6				110
114	Urinary Tract Infection (UTI) Sepsis		25	8			33
115	Wound Infection	24	84				108
	Total	**65,172**	**95,418**	**33,826**	**37,319**	**3,615**	**1,95,434**

2. Disease-specific demand – Surgery

S No	Disease/ Condition	WB	Red cells	Plasma	Platelets	Cryo	Demand
1	Abdominal Surgery	10,165	7,551	2,322	527	67	18,040
2	Abscess	332	119	31	24		462
3	Adult cardiac surgery	1,863	3,794	2,300	1,848	12	6,524
4	Amputation	40	83	25	5		127
5	Appendicitis	193	277	28	5		475
6	Arteriovenous Fistula	84	16				100
7	Bed Sores		9	5			9
8	Benign Prostate Hypertrophy	48	184	52			249
9	Breast Cancer	52	173				225
10	BTC with Haemothorax		44				44
11	Burns	1,869	1,823	1,765	118		4,604
12	Carcinoma (CA)	41	354	446	284		525
13	Coronary Artery Bypass Graft (CABG)	545	963	1,086	359	16	1,862
14	Cataract Surgery		88				88
15	Cellulitis	88	344	141	55		493
16	Cholecystectomy	44	49	20			92
17	Cholelithiasis	68	288	195	12		456
18	Cleft Palate		8		25		25
19	Cyst		13				13
20	Cystocoele	12	124	20	13	7	136
21	Epistaxis	104	188	8	72		340
22	Fracture	406	846	52	14	13	1,268
23	Gangrene	149	419	95	20	12	589
24	General Surgery	1,993	3,208	1,722	990	154	5,930
25	Haemorrhoids	123	327	18	6	7	451
26	Head and Neck surgeries - Elective	6,444	2,405	593	163	48	8,960
27	Hemoperitoneum	8	5				13
28	Hernia	193	182	90	12	39	389
29	Hydrocele	12					12
30	Hypochondrial Lump	4					4
31	Hypopharynx/ Supraglottic Cancer	4	8				12
32	Ileostomy	4	48	14	5		51
33	Intestinal Obstruction	97	480	133	10	14	580
34	Intestinal Perforation	196	363	150	172		560
35	Intra Operative	28	12				40

	Haemorrhage						
36	Jejunostomy		239	118			239
37	Large Hematoma	2					2
38	Liver Cirrhosis			128			128
39	Malena	300	8	16			323
40	Mitral Valve Replacement	87	495	359	213	53	582
41	Necrotising Fascitis	66	142	80	24	23	208
42	Neurosurgical procedure - Elective	2,323	2,566	885	220	194	5,004
43	Onco Surgery	5,186	5,667	2,403	785	88	11,073
44	Ortho surgeries - Elective	19,107	13,781	2,192	482	28	32,995
45	Osteomyelitis	4	12				16
46	Other	621	1,257	357	67	86	2,056
47	Pediatric cardiac surgery	417	919	389	370	2	1,355
48	Peptic Ulcer	106					106
49	Prolapse of Intervertebral Disc	4					4
50	Plastic Surgery	392	149	12			541
51	Pneumothorax		69				69
52	Prostatectomy	39	66	16			105
53	Rectal Prolapse	12					12
54	Renal Calculi	149	297	93	2		461
55	Retro Duodenal Abscess/ Polyp	25					25
56	Road Traffic Accident	306	1,171	839	117	31	1,717
57	Ruptured Meningomyelocele				12		12
58	Subacute Intestinal Obstruction	31	399	298			429
59	Skin and Soft Tissues	320	722	102			1,090
60	Splenectomy		327	309	12		341
61	Thoracic surgery	1,221	1,444	870	463	44	2,761
62	Transplant	45	216	231	134		344
63	Trauma	7,175	5,652	1,661	1,061	120	13,104
64	Transurethral Resection of the Prostate (TURP)	20	142	11		12	162
65	Ulcer	16	26	14	8	22	61
66	Urology	1,477	1,762	161	32	26	3,262
67	Vascular Surgery	12	22	5	4		34
	Total	**64,674**	**62,347**	**22,860**	**8,745**	**1,118**	**1,32,370**

3. Disease-specific demand – Obstetrics & Gynaecology

S No	Disease/ Condition	WB	Red cells	Plasma	Platelets	Cryo	Demand
1	Abnormal Uterine Bleeding	3,997	2,069	122	529		6,177
2	Abortions	3,644	1,180	104	12		4,824
3	Adenomyosis	16	14				30
4	Amenorrhoea	8	75	45			83
5	Anaemia in pregnancy	25,148	11,213	647	354	76	36,398
6	Antenatal Care (ANC)	2,209	552	273	95	41	2,897
7	Antepartum Haemorrhage (APH) - Abruptio	1,129	988	993	536	49	2,433
8	Antepartum Haemorrhage (APH) - Placenta praevia	2,015	919	403		108	3,122
9	Hysterectomy for AUB, prolapse, adenomyosis, endometriosis-fibroids, Pelvic Inflammatory Disease (PID)	2,796	1,160	181	215		4,017
10	Breast Mastitis		4	8			8
11	Bulky Uterus	4	23				27
12	Carcinoma Vulva	4	13	4	8		17
13	Cancer cervix	677	1,293	227	181		2,019
14	Carcinoma endometrium	229	677	16	24		922
15	Carcinoma ovary	846	1,453	372		31	2,330
16	Cystocele	2	14				16
17	Disease of Osteo-muscular system and connective tissue (DOS) Puerperium with CCF Sepsis			12			12
18	Dysfunctional Uterine Bleeding (DUB)	303	171	34			493
19	Eclampsia	83	209	99	29	26	292
20	Ectopic pregnancies	1,533	1,243	466			2,908

21	Endometrial Hyperplasia	6	7				13
22	Fibroid Uterus	176	513	152	4		690
23	Fibroids - Myomectomy	1,870	1,011	17		5	2,888
24	Full Term Pregnancy (FTP)with Foetal Distress		2				2
25	FTP with Labour Pain with Anaemia	44	132				176
26	Haematology - Factor deficiency, All thrombocytopenia, Anticoagulation,	597	293	496	552	24	1,426
27	Haemolysis, Elevated Liver enzymes, and Low Platelets (HELLP)	50	124	284	284	133	469
28	Hepatic disorders	175	199	122	38	360	727
29	Human Papillomavirus	4					4
30	Hydatiform Mole	8	42				50
31	Intra Uterine Device	32	328	205	54		395
32	Laparotomy	51	162	76	8		236
33	Lower Segment Caesarean Section (LSCS)	2,998	1,964	527	107	103	4,972
34	Menorrhagia	163	261	61			424
35	Molar pregnancy	451	339	7	2		790
36	Myoma	12	2				14
37	Other	321	340	36	109		725
38	Ovarian Cyst	94	425	14		6	518
39	Ovarian Dermoid Cyst	8	5				13
40	Ovarian Tumour	12					12
41	Per Vaginal Bleeding	50	119	38	64	3	178
42	Pelvic Floor Repair	30	9		2		39
43	Pelvic Space Occupying Lesion	47					47
44	Pregnancy Induced Hypertension (PIH)	533	263		24	120	795
45	Placenta praevia accreta/accreta	1,993	296	90		357	2,649

46	Planned Hysterectomy	37	202	40			238
47	Postnatal care (PNC) with Anaemia	1,637	275		24		1,911
48	Post Caesarean Section with Anaemia	244	4				248
49	Post-Partum Anaemia	6	2				8
50	Postpartum Preeclampsia	4					4
51	Post-Partum Depression (PPD)		134	16			134
52	Postpartum Haemorrhage (PPH) - Caesarean, atonic, ret. Placenta, Traumatic PPH	10,418	4,318	1,836	449	767	15,727
53	Pregnancy with Fever	8		60	12		68
54	Pregnancy with IUD		71	4			71
55	Primi Gravida with per vaginal Leakage		4				4
56	RH -ve Pregnancy/ Routine Surgery	4					4
57	Ruptured Uterus	77	69	24			160
58	Sepsis	26	75	28			102
59	Uterine Bleeding	5	15	2			20
60	Uterine Perforation	5					5
61	Uterine Prolapse	20	27				47
62	Vulval Haematoma	72	24				96
63	Without Diagnosis	38	151				189
	Total	**66,965**	**35,472**	**8,140**	**3,716**	**2,208**	**1,06,312**

4. Disease-specific demand – Paediatrics

S No	Disease/Condition	WB	Red cells	Plasma	Platelets	Cryo	Demand
1	Abdominal Tumour	24	24				48
2	Acute Gastro Enteritis (AGE)		126	80	33		168
3	Acute Lymphoblastic Leukaemia (ALL)		123	22	192		192
4	Aplastic Anaemia	33	255		1,066		1,100
5	Arnold Syndrome		12				12
6	Atrial Septal Defect (ASD)		20	8	16		20
7	Bleeding Disorder		11	44	17	55	108
8	Bleeding from Umbilicus		24				24
9	Bone marrow Failure-Benign	76	74	12	96		186
10	Congenital Central Hypoventilation Syndrome (CCHS)	8			17		25
11	Cerebral Palsy		4				4
12	Congenital Heart Disease (CHD)	8	382	210	231		413
13	Chronic renal disease	268	448	197	142		955
14	Dengue	112	266	179	1,636	36	1,772
15	Duodenal Atresia		7	36			43
16	Encephalopathy		105	97	18		179
17	Epidermolysis Bullosa				10		10
18	Epistaxis		14	2			16
19	Fever	72	93	52	107	1	256
20	Gastrointestinal Bleeding (GIB)	563	428	370	158	1	1,036
21	Haemangioma	4	5				9
22	Haemolytic Anaemia	3	86	5	2	2	89
23	Hemorrhage		21	19	19		21
24	Hemolytic anemias - Thalassemia	1,825	7,713	62	52		9,563
25	Hemophilia - severe	168	156	385	47		624
26	Hepatosplenomegaly	2	18	18	9	2	32
27	Haemolytic Uremic Syndrome (HUS)	18	58	61	18	2	119
28	Hydrocephalus	12	56	48	12		116
29	Hydrostatic		2	2			2

30	Intussusception		20	3			20
31	Idiopathic Thrombocytopenic Purpura (ITP)		9	1			9
32	Intra-Uterine Growth Restrictions (IUGR)		2		2		2
33	Jaundice	38	214	82			253
34	Jejunal Atresia		38		35		38
35	Leukaemia	187	858	204	2,977		3,319
36	Malaria	233	522	132	822		1,208
37	Meningitis		12		47		47
38	Nercotizing Enterocolitis (NEC)	16	171	16	71		188
39	Neonatal Jaundice	666	85	24	27		788
40	Birth asphyxia/trauma	370	142	364	74		860
41	Haemorrhagic Disease of the New-Born (HDN)	224	28	110	4		354
42	Hemolytic disease among newborn	126	176	24	36		314
43	Neonatal sepsis	500	369	659	100	32	1,440
44	Very Low Birth Weight (VLBW) among neonates	537	967	452	175		1,708
45	Nephritic Syndrome		9				9
46	Onco/ palliative	5	171	36	56		176
47	Other	447	1,980	821	444	48	2,775
48	Paediatric Surgery	4					4
49	Pancytopenia	2	21		79		94
50	Pneumonia	5	113	31	29	1	122
51	Respiratory Distress Syndrome (RDS)	20	30	5	8	1	50
52	Retinoblastoma	2	29	51	50		68
53	Seizure		12				12
54	Sepsis & Disseminated Intravascular Coagulation (DIC)	296	883	1,330	1,038	33	1,876
55	Septic Shock		26	19	17	4	32
56	Septicemia	10	34	77	10		127
57	Severe Mitral regurgitation (MR)		16				16
58	Severe Nutritional Anaemia	2,192	3,475	284	179	5	5,714
59	Sickle Cell Anaemia	472	106				578

60	TAGA		18		8		18
61	Tetanus		8		2		8
62	Thrombocytopenia	48	69	188	460		678
63	Tetralogy of Fallot (TOF)		61	38	31	4	61
64	Tuberculosis		120	27	21	5	120
65	Ventricular Septal Defect (VSD)	20	265	27			284
	Total	**9,616**	**21,591**	**6,915**	**10,696**	**232**	**40,511**