# Literature Review: Cost Calculation of Blood Services in Some Countries (Based on HDI Level)

*by* Khisula Riski Andani

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# Literature Review: Cost Calculation of Blood Services in Some Countries (Based on HDI Level)

**Khisula Riski Andani[1]✉, Ernawaty[1]**

[1]Faculty of Public Health, Airlangga University

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## Abstract

*The blood processing replacement costs (BPPD) establishment in Indonesia is an incomprehensive cost calculation for blood services. Several countries have calculated costs for blood services at health care institutions through an activity framework plus generated blood products and components costs as well as blood services fees. This study aims to discuss the cost calculation method for blood services carried out in Zimbabwe, Canada, United Kingdom, Greece, and India. It was a literature review conducted by accessing scientific articles sourced from the Google Scholar database. A total of 11 articles were collected, but only 5 with relevant topics were discussed. Blood service cost calculation provides information of various activities involved in producing a product and service. Also, blood service framework model determination was needed as a cost center for estimation to prevent duplication. Each activity's total output from the cost center was used in calculating the unit cost of the activity or product. The blood products and components include whole blood, red blood cells, platelets, plasma (FFP), and cryoprecipitate. Each of the blood components require a different cost determined by the activity involved in their production.*

## INTRODUCTION

Blood is a body tissue in blood vessels that is composed of two parts, 55% of the total blood volume is part of blood plasma and the rest is a cellular component consists of 45% erythrocytes, leucocytes and <1% platelets (Darmawan et al., 2015). In certain conditions of blood deficiency, a blood transfusion method can be done by giving blood to this deficient patients or recipients, therefore it can improve the quality of their blood through blood circulation (Center for Data & Information of the Indonesian Republic Health Minister, 2018). There is insufficient data on the use of blood products,whereas studies suggests that blood component is often over-prescribed in both high-income and low- and middle-income countries. It is estimated that world-wide over 50% of all medical interventions are prescribed, dispensed, or sold inappropriately (Divkolaye et al., 2019).

According to Constitution of the Indonesian Republic Number 36 Year 2009, definition of blood service is a health care delivery system utilizes human blood as a basic substance for humanitarian effort and not for commercial purposes. Refers to Government7 Year 2011, the price of plasma products is controlled by the government by taking into

✉ Correspondence Address:
Kampus C Universitas Airlangga, Surabaya, Indonesia
E-mail: khisula.riski.andani-2016@fkm.unair.ac.id

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calculate the cost of production and public outreach hence it price becomes rational and conform the principle of equity. Based on Indonesian Republic Health Minister Rule Number 83 year 2014, the government ensure funding for the provision of blood services by means of subsidies for Blood Transfusion Unit (UTD) sourced from the state budget, local government budget and other fundings and the rest is charged to the community. Those rest charged is carried out to maintain that the provision of blood services remains sustainable and produce quality blood transfusions and/or blood components. Those charged called replacement costs for blood processing (BPPD) which include the cost component for administering blood transfusion services and operational costs. Cost component for administering blood transfusion services include costs for non-medical consumables and medical materials/equipment for donor recruitment; donor selection; blood collection; blood safety; blood processing; blood storage; blood distribution; and blood destruction, while the operational cost component includes utilities; personnels, transportation; printed materials; investment costs as well as costs for donors (food, drink and awards).

Blood cost rates are adjusted to the regulation i.e Circular Letter HK/MENKES/31/I/2014 in each region with a maximum rate of IDR 360.000 for each bag. According to Regulation of Probolinggo Regent Number 103 Year 2016, BPPD at Probolinggo district, for each bag is IDR 360.000 which is used for processing and examining blood which includes a service component; administration; maintenance; depreciation; development; and consumables. The service component; administration; maintenance; depreciation; and development is set at IDR 143.581 while the consumables is set at IDR 216.419 Consumables costs include blood bags (IDR 49.470); Rh/Hb blood group (IDR 4.138); crossmatch reagent (IDR 25.000); HbsAg (IDR 18.319); anti-HC (IDR 51.789); vdrl (IDR 34.663); anti-HIV (IDR 29.785); and supporting materials (IDR 3.255).

In the blood bank setting, costing is used to present cost information for the various activities involved in providing products and services. Also provide infromation on the budgets required to produce a product or service. Classification by activiy defines a framework that allows estimation of costs and outputs of specific activity. Alllocation of costs to designated cost centres ensures good capture of data without duplication. Each cost centre can be designed to cover clearly defined areas involved in specific activities, e.g. blood donor recruitment, blood collection, blood processing, etc (World Health Organization, 2010).

WHO had described the costing method for blood services as a guidelines for all countries in the world. In Indonesia, the existing policy has determined the amount of BPPD as price of blood products, but it has not describe a comprehensive calculation of the cost of blood services. There were not topics of research that explains method of calculating costs for blood services in Indonesia hence necessary to discuss research with related and relevant topics that had carried out in several countries. Thus, the aim of this literature sudy is to discus methods of calculating costs for blood services in several countries, e.g. Zimbabwe, Canada, United Kingdom, Greece and India. Those countries were selected based on the Human Development Index (HDI) level. At the very high HDI level, countries from the first rank were Canada, United Kingdom, and Greece. At the medium HDI level there is India, while at the low HDI level there is Zimbabwe (UNDP, 2018).

## METHOD

This study was a review to discusses the calculation of costs for blood services. Research articles to discuss calculating blood service costs were limited, there were 11 articles but only 5 articles had relevant topics. Those articles were accessed from the google scholar database as an open access database for various journals. This study used a qualitative approach by describing the results of the review descriptively. The references used were e-books published in 2010 to 2020; articles from journals published in 2014 to 2020; and Indonesian government policy documents. The keywords were "cost of blood" and "cost of blood service".

This literatur review discussed the calculation of costs for blood services at health care institutions in Zimbabwe, Canada, United Kingdom, Greece, and India. Most researchers used the terms blood production costs and blood components in their research. This review described the framework model of blood service; number of output; included and excluded cost component; & cost calculation method. The results of this research can be used as a reference for health service institutions in Indonesia that provide blood services such as Blood Transfusion Unit (UTD) and Hospital Blood Bank. The results of the literature review are then presented in tabular form.

## RESULTS AND DISCUSION

**Types of Perspectives in Economic Evaluation**

There are two perspective areas for economic measurement, based on provider perspective and societal perspective. Provider perspective has a component of all costs incurred by the provider in providing health services, including the cost of professional salaries, maintenance, equipment, consumables, fixed assets, etc. Societal perspective has a cost component of all costs incurred by the community (including patients and health service providers). Includes all medical and non-medical costs (hospitalization, long-term care, home care, social welfare services, and lost productivity). Another significant perspective to consider is patient's perspective. It has a cost component of all costs that must be charged by patients to take advantege of health care service including out of pocket payments (care, transportation, and lodging), costs for taking time off from work (loss of wages) (Tai et al., 2016).

**Concepts of Costs**

Cost is a representation of resources (factors of production) that must be sacrificed or released to achieve certain organizational goals (Bunga, 2018). Costs categories either based on time frames or involvement in activities. Time frame-based costs are divided into capital and recurrent costs (operational and maintenance). Capital costs are one-time investment costs generally incurred during the first year of the activity. Annualization is calculated based on the fact that capital goods typically needs to be replaced when they have reached their useful life and assumes that an amount of money has to be saved each year to build a "capital fund" to purchase the replacements. This amount needs to be adjusted for inflation and takes into account any interest charged if the amount is to be borrowed. Whereas recurrent costs are thoses associated with operating or maintaining an activity, such as manpower costs, equipment maintenance or management costs (World Health Organization, 2010).

Costs based on involvement in activity are divided into direct (stand-alone) costs and indirect (shared) costs. Direct costs account for the supplies, equipment, manpower, etc. that are fully used in the activity being costed for, such as, blood bags, blood collection nurse in costing for blood collection, etc. Indirect costs are those incurred on supplies, equipment, manpower, which are shared among two or more activities, such as facilities, electricity, etc. The sum of the average annnualized capital cost (direct and indirect) and the recurrent cost (direct and indirect) became a total annual cost of an activity. Therefore, unit cost of an activity is total annual cost divided by the total activity output (WHO, 2010).

**Cost Calculation Approach**

Cost calculations can be done using a tops-down or a bottom-up approach, and combination both of two. A top-down approach is taken after costs in production scale are large and it estimates over a longer period of time, while the bottom-up approach is used when it is intended to assess how much variation in costs is required in production activities. Top-down approach results in more distributed cost variant and less variants of the costs, while bottom-up results individual cost variant and very complex. An example of a top-down approach is Diagnostic Related Group in a National Health Security Program/ Indonesian National Health Insurance (JKN), where individual treatment costs are categorized into diagnostic groupings and these costs are taken from the mean value of all costing data collected in the grouping. This approach is suitable applied to health care service with a small variant, for example health care service which emphasize the use of equipment. An example of a bottom-up approach is Activity-Based Costing which measures activities to produce products in detail thus results costing data individually and rich data variants. This approach is better applied to health services that have a large variant, due to each large cost component can increase the overall cost, for example, childbirth service that has a wide variant (Olsson, 2011; Suprianto & Mutiarin, 2017)

**Calculation of Blood Service Cost**

Production of blood components through by manual collection of whole blood units, or as a specific product using automatic collection device (Devine & Serrano, 2012). An improved collection, testing and processing involve an increased direct product cost. The broader cost of blood needs to accounted, not just the direct costs, but also considered the cost of testing process; administering blood products and associated costs for monitoring and treating adverse events of transfusion (Farmer et al., 2013)

The step of costing blood services involved by following steps (World Health Organization, 2010) : (1). Determine all items contributing to the activity; (2). Determine direct and indirect cost and compute the allocation of indirect cost to the activity; (3). Determine capital and recurrent costs, and the annualizing factor based on the usable shelf-life for capita items; (4). Determine output indicators; and (5). Calculate the total cost of the activity divided by the relevant output indicator.

**Blood Products**

A donor who donate a unit of whole blood can provide a unit of packed red blood cells (PRBC), platelet consentrate (TC), and fresh frozen plasma (FFP). Apheresis tehnology used to separate these components. Fresh whole blood would expired at more than 24 hours. This blood product is used for functional oxygen delivery, rapid expansion of blood volume, simulataneously with intact hemostatic agents

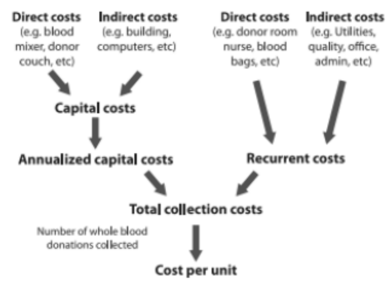


**Figure 1.** *Costing for Blood Collection Activity*
Source: WHO, 2010

and has not affect on hypothermia. *Packed red blood cell* (PRBC) and critaloid or colloid fluids as volume replacement are commonly used for red blood cell transfusions. Apart from whole blood, PRBC is also a blood component with the most red blood cells. The volume of an PRBC unit is between 200-300 ml, and can be stired for up to 42 days. Most of the time, one unit transfused in an adult can increase Hb level by 1 g/dl and depends on the patient's weight, amount of Hb transfused, and age of the cells. PRBC stored at 4-10ºC temperature. Platelets are megakaryocyte fragments that play a role in hemostasis. Each unit contains a minimum of $5{,}5\times10^{10}$ platelets and is stored at 20-24ºC temperature. Fresh frozen plasma component is a portion of liquid that separated from whole blood and then frozen for 8 hours. FFP contains proteins has a function to maintain vascular integrity, anticoagulant proteins, and proteins involved in fibrinolysis. Storage of FFP can last up to 36 months at 25ºC. The volume of a unit varies from 180-300 ml. Cryoprecipitate is obatained by FFP disbursement at 4-6 ºC, contains most of the plasma and removes protein then is suspended again as plasma residue (15-25 ml) and refreeze. Cryoprecipitate contains cryoglobulin which is rich in fibrinogen, von Willebrand factor, factor VII, factor XIII, and fibrinectin. Cryoprecipitate is indicated for the treatment of factor XIII deficiency, dysfibrinogenemia and hypofibrinogenemia (Evangelista et al., 2020).

Table 1 describes framework model of blood service; number of output; included and excluded cost component; & cost calculation method at several health care service institutions

**Table 1.** Framework model of blood service; number of output; included and excluded cost component; & cost calculation method in Zimbabwe, Canada, United Kingdom, Greece and India.

| Country | Aim | Method | Results |
|---|---|---|---|
| Zimbabwe (Mafirakureva et al., 2016) | To assess unit costs using Activity Based Costing method in blood production activities at Zimbabwe. | Method: Descriptive research method and bottom-up approach (*Activity Based Costing).*<br>Location: *National Blood Service Zimbabwe* (NSBZ)<br>Informant: Interview with staff and manager of blood service<br>Instrument: The costing worksheets refers to the WHO's Costing Blood Transfusion Services.<br>Data collection technique: Data source used a secondary data from the NSBZ such as budgets, planning document, ledgers, financial and expenditure reports, and databases. Furthermore, from *Reserve Bank of Zimbabwe,* information on annual interest rates and inflation can be accessed.<br>Data analysis technique: Analyze the sensitivity using discount rate calculation to estimate the annual cost/ depreciation cost of buildings and equipment. | Framework model of blood service<br>Framework model based on nine step process flow model and the focus of analysis on the cost elements associated with the blood collection center which means excluded the cost elements of blood transfusion facilities.<br>Number of output<br>Total number of donor recruitment was 70.834 visits. Total number of donors accepted (selection) was 67.440 visits (95,2%). Total number of usable units of blood was 67.422 units (99,9%). Total number of blood components prepared was 69.242 units. Total amount distributed was 62.303 (90%).<br>Included and excluded cost component<br>Fixed costs included cost of buildings, utilities, equipment, furniture, vehicles, general, and administrative expenses. Variable costs included staff salaries, supplies, and donor incentives.<br>Cost calculation method<br>Mostly, total cost of producing whole blood consists of blood donor recruitment and selection (US$ 15.94); donation collection (US$ 34,62); donation testing (US$ 17.88); storage and distribution (US$ 3.06); finance and administration (US$ 13.27); coordination (US$ 6.21); SHEQ (US$ 3.42); PIR (US$ 7.43); and overheads (US$ 16.59), thus unit cost of whole blood was US$ 118.42. Total cost of producing RBCs consists of blood donor recruitment and selection (US$ 15.94); donation collection (US$ 34,62); donation testing (US$ 17.88); processing (US$ 11,49); storage and distribution (US$ 3.06); finance and administration (US$ 13.47); coordination (US$ 6.31); SHEQ (US$ 3.58); PIR (US$ 7.54); and overheads (US$ 17.06), thus unit cost of RBCs was US$ 130.94. Total cost of producing FFP consists of blood donor recruitment and selection (US$ 11.95); donation collection (US$ 25.96); donation testing (US$ 13.41); processing (US$ 41.43); storage and distribution (US$ 3.06); finance and administration (US$ 21.05); coordination (US$ 9.86); SHEQ (US$ 9.28); PIR (US$ 11.79); and overheads (US$ 34.54), thus unit cost of FFP US$ 199.46. Total cost of PLTs consists of blood donor recruitment and selection (US$ 3.98); donation collection (US$ 8.65); donation testing (US$ 4.47); processing (US$ 5.62); storage and distribution (US$ 3.06); finance and administration (US$ 13.08); coordination (US$ 6.13); SHEQ (US$ 3.28); PIR (US$ 7.33); and overheads (US$ 16.16), thus unit cost of PLTs US$ 76.09. Variable costs contributed 51,2% of the total production cost. The variable cost component mainly includes staff salaries (50.8%), laboratory supplies (27.5%), and clinic supplies (15.4%). |
| Canada (Lagerquist et al., 2017) | To determine costs related to inventory management, storage, testing, publish and administration of a blood product | Method: Descriptive research method, *Activity Based Costing* (ABC) methods and German cost accounting principles. | Framework model of blood service<br>Framework model included eight process steps: (1). receiving/storage/retesting; (2). transport; (3). inventory & storage; (4). testing; (5). investigations; (6). transfusions; (7). collections; and (8). issuing. |

| Country | Aim | Method | Results |
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| | (packed red blood cell/PRBC) per unit in a Canadian Hospital. | Location: University of Alberta Hospital (UAH) and Royal Alexandra Hospital (RAH) in Edmonton, Alberta, Kanada.<br>Informant: Subject matter experts dan pathologists.<br>Instrument: item identification instruments and personnel costs, consumables, and capital equipment; number of PRBC units.<br>Data collection technique: Stations 1 and 2 data were collected at the UAH; Stations 3 until 8 data were collected at the RAH. These captured at several patient care areas, following by emergency medicine; maternity; critical care; pulmonary; orthopaedics; cardiology; general surgery and trauma through interviews, observations, and access to the annual budgets document for each blood bank.<br>Data analysis technique: Determine the cost using activity-based costing methods and German cost accounting principles. | Number of output<br>There are 46.375 units of PRBCs were generated and delivered from Central Blood Service (CBS) to the UAH. Of those number of units, only 10.475 units of PRBCs were transferred from UAH to RAH. Of those transferred, only 10.331 (98,6%) units that were transfused.<br>Included and excluded cost component<br>Consumable cost was the result of dividing the annual individual item cost by annual number of PRBC unit delivered from UAH to RAH. The sum of amortization and maintenance costs became a total capital cost. Personnel salary costs were calculated based on average salaries and benefits paid for each profession. There was a 2,4% disposal of PRBCs that didn't accounted. Also didn't account inter-hospital from UAH to RAH transfers costs that occur. Also not accounted management of long-term complications estimated less than 3% of transfusion costs (immaterial).<br>Cost calculation method<br>(1) Receiving/storage/retesting station consist of personnel cost ($1.74); consumables ($0.22) and capital cost ($0.09), thus total cost per unit ($2.05). (2) Transport stations consist of personnel cost ($1.23); consumables ($0.08) and capital cost ($0.05), thus total cost per unit ($1.35). (3) Inventory & storage station consist of personnel cost ($30.65); consumables ($0.02) and capital cost ($0.13), thus total cost per unit ($30.80). (4) Testing station consist of personnel cost ($63.09); consumables ($20.62) and capital cost ($5.33), thus total cost per unit ($89.04). (5) Investigations stations consist of personnel cost ($39.33); consumables ($9.78) and capital cost ($0.45), thus total cost per unit ($49.57). (6) Transfusions stations consist of personnel cost ($21.28); consumables ($1.57) and capital cost ($0.27), thus total cost per unit ($23.12). (7) Collections stations consist of personnel cost ($13.35) and consumables ($11.11), thus total cost per unit ($24.46). (8) Issuing station consist of personnel cost ($17.84) and consumables ($4.87), thus total cost per unit ($22.70). Total per unit costs is $243,10. The total cost related to the delivery, receipt, storage, testing and transfusion of 10.475-unit PRBC was calculated to be $2.546.485,59. Capital costs, consumables, and personnel costs contributed 2,60%; 19,86%; and 77,54% to this cost. |
| United Kingdom (UK)<br>(Stokes et al., 2018) | To estimates the costs of administering a transfusions at the UK National Health Service. | Method: Descriptive research method and microcosting approach.<br>Location: Oxford University Hospitals; Royal Berkshire Hospital; Guy's & St Thomas NHS Foundation Trust.<br>Informant: Non senior staff, senior biomedical scientists, & transfusion laboratory managers. Nurses in hematology unit, emergency department, & theater.<br>Instrument: Direct input questioner; direct and indirect staff time; capital equipment and laboratory activities; amount of units for each | Framework model of blood service<br>Framework model included transfusion laboratory and nursing inputs. Cost per group and screen, cost per unit RBC and non-RBC issued and transfused were estimated by transfusion laboratory. While the cost for taking blood samples and placing requests for blood and administering transfusions separately for first and subsequent units (same transfusion episode).<br>Number of output<br>Mean units per episode for RBCs (1.7 unit); PLTs (1.2 unit); FFP (4.4 unit); Cryoprecipitate ( 2.0 unit).<br>Included and excluded cost component<br>Staff time per task was an included cost component. Overhead cost of laboratory inputs was included, while in nursing inputs was excluded. Consumables, capital equipment and |

| Country | Aim | Method | Results |
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| | | blood product given to patients during their admission.<br>Data collection technique: Laboratory inputs into transfusion data were collected at Oxford University Hospitals dan Royal Berkshire Hospital (Oxford & Reading). While, nursing inputs into transfusion were collected at Hematologi Unit Oxford University Hospitals dan Guy's and St Thomas NHS Foundation Trust (Oxford dan London). Forms was used and structured interview were conducted.<br>Data analysis technique: The total costs of three elements (laboratory; nursing inputs; and wastage) as a total cost of administering blood, separately for each blood product. Analysis conducted with computer software (Microsoft Excel 2013, Microsoft Corp) | maintenance cost were also calculated. Average wastage cost of each type of blood product was calculated across the two hospitals.<br>Cost calculation method<br>The cost per group and screen, the cost per RBC unit and non-RBC unit issued and transfused calculated separately for each type blood product at *Oxford & Reading,* then calculate average wighted across those two hospital. Cost analysis at transfusion laboratory consist of group and screen ($12.21), RBC cross-match and issue ($11.73), Non-RBC issue ($12.01), RBC unit transfused ($41.51), Non-RBC unit transfused ($39.65). At nursing transfusion, captured personnel cost and consumables. Blood sample and request blood with mean time 17.8 minute ($11.64), administer first unit with mean time 39.2 minute ($25.63) and 14.7 minute ($6.66) for subsequent units.<br>The three elements of the costs of blood administration such as laboratory, nursing inputs and wastage are summarized for first and subsequent units transfused. Mean costs to administering a transfusion for RBCs consist of laboratory inputs for first and subsequent unit (£28.56), nursing inputs for first unit (£25.64) and subsequent unit (£4.58), wastage (£2.99), thus total cost for first unit £57.19 ($83.13) while subsequent unit £36.13 ($52.51). PLTs consist of laboratory inputs for first and subsequent unit (£27.28), nursing inputs for first unit (£25.64) and subsequent unit (£4.58), wastage (£8.45), thus total cost for first unit £61.37 ($89.20) while subsequent unit ($58.59). FFP consist of laboratory inputs for first and subsequent unit (£27.28), nursing inputs for first unit (£25.64) and subsequent unit (£4.58), wastage (£1.34), thus total cost for first unit £54.26 ($78.87) while subsequent unit £33.20 ($48.26). *Cryoprecipitate* consist of laboratory inputs for first and subsequent unit (£27.28), nursing inputs for first unit (£25.64) and subsequent unit (£4.58), wastage (£6.86), thus total cost for first unit £59.78 ($86.69) and subsequent unit £38.72 ($56.28). Mean costs to administering blood per unit transfused per episode for RBCs £82.48, thus mean cost per unit was £48.52 ($70.52). PLTs had mean cost per episode £69.43, thus mean cost per unit was £57.86 ($84.10). FFP had mean cost per episode £167.14, thus mean cost per unit was £37.99 ($55.22). Cryoprecipitate had mean cost per episode £98.50, thus mean cost per unit was £49.25 ($71.58). Based on those cost analyses, blood administering costs increases the costs of blood products. |
| Greece (Fragoulakis et al., 2014) | To analyze cost of producing an unit of blood product based on National Health Service perspective in Greece. | Method: Descriptive research method and quantitative approach.<br>Location: Secondary data were collected by 53 hospitals in the Greece i.e. there are 44 hospitals from the Athens and 9 hospitals from around the country. The sample also included 7 university hospitals & 3 oncology hospitals.<br>Informant: Staff of "Agios Savvas" Regional Cancer Hospital of Athens; medical & | Framework model of blood service<br>9-step process flow model captured only in a blood collection facility: (1) blood collection; (2) blood processing; (3) laboratory testing; (4) blood destruction; and (5) blood inventory and storage.<br>Number of output<br>373.310 units of blood were collected in the country.<br>Included and excluded cost component<br>Costs of productivity loss categorized as indirect cost. The cost of donor recruitment and qualification incredibly low and it has been excluded but still maintaining the accuracy of the presented results. The costs related with pretransfusion preparation; transfusion administration; |

| Country | Aim | Method | Results |
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| | | nursing staff in every blood donation agency; 172 blood donors at KAT Hospotal & "Agios Savvas" Regional Cancer Hospital Athens.<br>Instrument: To collected related to personnel time; number of blood collected yearly; wastage; consumbales; institututional overhead; information technology expenditure; medical equipment; nuclear acid tests, also time spent by donors, its used a questionnaire.<br>Data collection technique: The overhead costs spent by institution were gathered from the Ministry of Health. From data that was gathered from 2 public hospitals in Greece, it can identified indirect cost by the donors as a productivity loss cost. Also, another way that were conducted are interviews and survey.<br>Data analysis technique: Some input parameters were based on assumptions adapted to the local experts' advice. The various types used were estimated on average and assumed to be identical across all the state hospitals. All statisical calculation using Microsoft Excel 2007. | follow-up management of adverse events, & another long-term relevant costs were not taken into consideration. Some transport operations between hospitals was not taken into consideration due to lack of data.<br>Cost calculation method<br>Direct cost per uniy laboratory tests consist of HIV test (€4.25); HBV test (€3.49); HCV test (€4.91); HTLV I/II test (€2.04); syphilis test (€0.3); ABO Rhesus D test (€4.9); C test (€0.6); c test (€0.5); E test (€0.49); e test (€0.71); Kell test (€0.42). Direct cost per unit staff consist of General supervisor (€3200); Directors (€3100); Medical Doctor for Class A (€2600); Medical Doctor for Class B (€2100); Training of Doctors (€1900); Health Visitors from University Education (€1900); Health Visitors from Technical Education (€1700); Health Visitors from Secondary Education (€1400). The cost of blood bag 35 days with ACD were €7; Blood bag 42 days with additive solution were €8; Bag of whole blood 42 days with prestorage leukoreduction of PRBC were €29; Bag of whole blood 42 days with prestorage leukoreduction of 3 components were €73. Cost of centrifuge for blood components preparation (€61,500); refrigerator for blood storage (1-6°C) (€18,450); plasma freezer (€10,000); platelet agitator (€6150); plasma extractor (€615); mixer/monitor volume of blood drawn (€350); centrifuge for test tubes (€10,000); dialectric sealer (€400) with 10 years life cycle.<br>Cost of collected a unit of blood product was a result of unweighted and weighted cost. At unweighted cost consist of €46.86 for personnel cost; €2.88 for overheads; €1.09 for consumables; €0.92 for computerization; €12.30 for blood bag; €39.92 for laboratory tests; €40.38 for nuclear acid tests; 0.04 for equipment, thus total direct cost was €144.37 while indirect cost was €34.00. The mean total indirect cost distributed as cost of transportation/expenses accounts, €2.15; producivity loss, €9.27; the opportunity cost of "days off with compensation", €20.26; and productivity loss of relatives/families, €.2.33. Thus total unweighted cost was €178.37. At weighted cost for collecting 1 unit of blood has the same cost or less than unweighted cost consist of personnel cost (€35.23); overheads (€2.54); consumables (€1.07); computerization (€0.62); blood bag (€12.30); laboratory tests (€39.92); nuclear acid tests (€39.78); equipment (0.02), thus total direct cost was €131.49 while indirect cost was €34.00. Thus total weighted cost was €165.49. Estimated mean weighted direct cost for produce a unit of blood were €131,49. Unweighted direct cost is higher as €144,37. While, estimated unweighted cost for produce a unit of blood in university hospital were €133,36 and €169,05 in oncology hospitals. Estimated average of blood unit was 4,90% or 18.292 units of blood for the entire sample. |
| India (Pokhrel et al., 2019) | To calculate the unit cost of blood refers to activity wise, based on WHO guidelines. | Method: Descriptive research method and quantitative approach.<br>Location: Tertiary Care Hospital Blood Bank.<br>Instrument: MS Excel spreadsheets.<br>Data collection technique: Secondary data related to cost was collected from the | Framework model of blood service<br>Cost of blood at blood collection facility consist of blood collection, processing and storage.<br>Number of output<br>Annual unit of blood that was collected at tertiary care public hospital was 20.748. Approximately 70-80% of the collected whole blood was separated into blood product components. The total number of blood components prepared was 47.069.<br>Included and excluded cost component |

| Country | Aim | Method | Results |
|---|---|---|---|
| | | document records which available in the Blood Bank store and purchase department of the hospital. Staff salaries was taken from the administrative section.<br>Data analysis technique: Unit cost was calculated in the following four ways Activity (A) Unit cost of components was calculated at the present level of functioning of the blood bank; (B) Unit cost was calculated excluding expenses for NAT testing; (C) Unit cost was calculated excluding expenses for voluntary donation camps. Based on those three ways of costing, the total expenses were divided by total components prepared to determine the unit cost (D) Calculate the unit cost at basic minimum level of blood bank function, with component separation (basic ELISA testing) and excluding expenses on component preparation and NAT testing). Total expenses was divided by total number collected. | Both the cost of equipment and cost of maintenance represented as capital cost. The recurring cost included staff salaries, consumables and another items. The cost of building and it maintenance was not included in the capital cost. Other facility activity cost that are provided free of charge (electricity bill and maintenance charge, also office stationery material).<br>Cost calculation method<br>The total annual costs of blood bank was Rs. 86,096,513 consist of equipment cost (Rs 104,39,166); staff salaries (Rs 3,31,24,056); and consumables (Rs 4,25,33,291). Cost of activity that involved at produce a unit of blood varied with the inclusion or exclusion of different activities. The annual costs of blood with component preparation and NAT testing (Activity A) was Rs 86,096,513 thus the unit cost was Rs 1829. The annual costs of blood without NAT testing (Activity B) was Rs 59,078,391 thus the unit cost was Rs 1255. The annual costs of blood if total collection was in house that is excluding expenditure on camps (Activity C) was Rs 81,784,083 thus the unit cost was Rs 1738. The annual costs of whole blood (if no components were prepared) with ELISA testing, done to ascertain cost at basic functioning (Activity D) was Rs 48,486,347 thus the unit cost was Rs 2521.<br>Additional cost on each activity was calculated separately. The additional cost on component preparation activity was Rs 8,216,609 which is 9.54% of total cost. The additional cost on conducting camps activity was Rs 4,312,430 which is 5,01% of total cost. The additional cost on NAT testing activity was Rs 27,018,12 which is 31.38% of total cost. |

such as Ministry of Health, National Blood Service Institutions, Blood Banks, and Hospitals in five countries (Zimbabwe, Canada, United Kingdom, Greece and India).

**Framework model of blood service**

The framework model of blood service is a cost center determinant. Each of the review study on Table 1, calculated the cost of blood services at one of two cost centers. These are blood collection facility cost senter and the transfusion facility. Research which was conducted to calculates costs at blood collection centers as a costs of blood production in Zimbabwe, Greece and India. Meanwhile, studies in Canada and England calculated the cost of blood services at blood transfusion facilities. Cost of Blood Consensus Conference (COBCON) was recommended a nine-step process flow model, that aimed to identifying both direct and indirect cost elements (Mafirakureva et al., 2016). COBCON identified a process flow of eight key steps in calculating the complete societal blood products cost. Steps one through five encompass blood collections facilities as a cost center such as: (1). Donor recruitment; (2). Blood collections; (3). Blood processing and laboratory testing; (4). Blood collections centre inventory; and (5). Storage and transport (Lagerquist et al., 2017). The costs at these facilties are called production costs.

Blood service cost calculations were completed by studies conducted in Canada and United Kingdom (UK) which calculated the cost of blood transfusions. At the blood transfusion facility, the next steps are carried out from the blood collection facilty, those are sixth steps to eight steps. These last steps are often misunderstood or ignored in the canadian Health Care environment (Lagerquist et al., 2017). The Canadian study used an eight-step costing model at the transfusion facility, while the UK study directly stated that the cost center for the transfusion facility included the laboratory input into transfusion and nursing iputs into transfusion.

**Number of Output**

In order to present the calculation of total expenditure become a unit costs, two key information is needed, i.e the total expenditure cost and number of output. Hence, the calculation of the unit cost is obtained by dividing the total cost with the number of output as denomerator (Wulan et al., 2019). The amount of output much depends on the framework model of blood service used in the research study, due to the service framework determines the cost center for which the total cost is calculated as well as the total output. Research that using a blood collection facility framework such as in Zimbabwe has output based on collection activities and results in the number of output from donor recruitment, donors accepted (selection), units of blood that can be used, the number of blood components prepared, and the amount distributed. Similarly with the research study which were conducted in Greece and India. Meanwhile, research study in Canada and England with the framework of blood transfusion facilities should calculating the total output as the number of blood components transfused for each separately blood component (Red Blood Cells; Platelet; Fresh Frozen Plasma; abd Cryoprecipitate). The amount of blood transfused by different hospitals to patients belonging to different payers group to meet the demand of price per unit which hospitals agree to pay to the blood suppliers as a reimbursement. It received by different hospitals from different payers group (Dutta et al, 2019)

**Cost Component**

The calculation of the cost of blood services in the five countries in Table 1 resulsts cost component incurred at each cost center derived from various types of costs. The entire study includes personnel costs, consumables, amortization and maintenance of capital equipment in the cost calculation. The estimated total annual amortization cost is calculated by taking the cost of the individual equipment used at each cost center and dividing it by estimated useful life. Maintenance costs are identified by estimating the direct wages and benefits of maintenance workers per hour multiplied by the estimated number of hours of maintenance during the year (Lagerquist et al., 2017). Research in Zimbabwe and Greece used a social perspective to include incentive costs for donors because of loss productivity as an indirect cost. Only a few studies have included the cost of building, transportation, general expenses and office stationery because an accurate data data was not availabe or there were costs but the amount is small and immaterial. Transportation costs in the processing area are not calculated due to lack of detailed data (Fragoulakis et al., 2014). Research study in India excluded the cost of building and maintenance as capital cost because the blood bank is located in the premises of large public hospital. Other resources that are provided free of charge was also not calculated at recurring cost (Pokhrel et al., 2019).

**Wastage Cost**

Blood supply and blood products that cannot be used (expired) will incur costs that must be incurred. There are two conditions that allow these costs, first if the blood is still in good use but there is no demand, a holding cost will arise. Second, if the blood is more than the expiration date (expired), thus that it cannot be used, the blood must be destroyed, which is considered an overstock cost. Destruction of blood is not only due to expiration date of life, but there are other factors, namely if the process is balanced scale but the blood volume is not significantly up to standard; there was damage to the bag and hose of the blood bag; blood draw time of more than 15minutes; and storage with non-standard paramaters (Fauzi & Bahagia, 2019). According to the UK Blood Stocks Management Scheme 2012-2014 Reports, 2.4% of RBCs released to transfusion laboratories in England and North Wales were wasted and the most common reason was expiration, while 3.8% PLTS and it was being clinically ordered but not used (Stokes et al., 2018). In Canada, disposal of PRBCs was not accounted due to considered immaterial to the overall cost per unit. There was 2-4% disposal rate with rehandling of returned units. Expiry represented approximately 1% of total units handle and are included in the discharge frequency (Lagerquist et al., 2017).

Policies to reduce waste and increase efficiency were implemented by all the Blood Centers around the worldwide. There was a reduction in the RBC inventory and in the blood components there was an increase in supply chain efficiency from the point of blood collection. Among all the blood component products, PLTs had the highest wastage rate, which was mostly due to PLT expiration. PLT components have a very short shelf life and be the main cause of expiration. Certain corrective actions were taken, such as preparing PLT production based on weekly demands and sending excess P1LT units to blood centres in adjacent provinces (Shahshahani & Taghvai, 2017)

**Cost Calculation Method**

One of the importance of calculating costs is determining the organizational units that contribute to the activity and allocating funds for these activities. Fund allocation is conducted directly and indirectly. The allocation of funds for an activity can be done directly if a cost is directly related to the activity. Meanwhile, costs that not directly related to an activity are usually allocated differently from these type. An appropriate cost calculation method is needed, such as a method can calculate the total costs required to produce an output (Lestari, 2015). Research study in Zimbabwe and Canada, it was stated that the researcher used the Activity Based Costing (ABC) method to estimate costs. Acivity Based Costing System can be defined as an approach to calculating costs based on the activities in the organization (Walandouw & Kaunang, 2015).

The research study in United Kingdom aimed to produce a comprehensive estimate of the cost of giving a transfusion per unit of blood product by means of the microcosting study method. In calculating costing, there is no standard approach because each approach has its own advantaged. There are two approches, those are top-down and bottom-up approach. The bottom-up approch requires large resources to implement and has a long period measurement, but the advantage is that it can show variants and show the less efficient cost component. Activity based costing is a form of bottom-up approach (Chapko, 2009). Meanwhile, research study in

Greece and India was not take specific method used to calculate costs.

## CONCLUSION

Cost calculations are required for all steps in the blood service model. Either at blood collection centers or transfusion service facilities to find out the comprehensive cost of blood products and services. The cost center as the center of activities or activities carried out in producing blood products identified the required input components and activities. From the provider perspective, most common, the inputs required for each activity are personnel/labor, equipment, consumables, buildings, and transportation needed in several activities; maintenance and agency support costs. Some of these costs are include and excluded in the calculation. The costs that are not considered are due to lack of available data, lack of robust data, or deliberately not calculated due to their small and immaterial amount. From the calculation results, each blood component procust has a different cost depending on the activities carried out. Several research studies used the activiy based costing system as a method of calculating the cost of blood services, or specific blood component products.

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