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An analysis of convalescent plasma unit cost calculation using time-driven activity-based costing (TDABC) method

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ABSTRACT

Introduction: The viral pneumonia disease covid-19 is currently becoming a pandemic throughout the world due to SARS-CoV-2. With a lack of therapy choices for covid-19, convalescent plasma therapy was considered an emergency intervention in some countries. Convalescent plasma was, by unit cost, the most expensive service at the laboratory of Dolopo Hospital, thus easy, practical, and efficient calculation of unit cost was needed. This research aims to analyze the unit cost of convalescent plasma as calculated using the Time-Driven Activity-Based Costing (TDABC) method and to examine the difference between the unit cost of convalescent plasma calculated using the TDABC with the real cost at Dolopo Hospital.
Methods: This qualitative research used a case study approach. The primary data were obtained through observation of convalescent plasma activity, and the secondary data were obtained through interviews related to the data of convalescent plasma cost.
Results: The convalescent plasma unit cost calculated based on the TDABC method was IDR2,287,675 and on real cost was IDR2,250,000. The result of the calculation using the TDABC method was higher than the real cost calculation by IDR36.765.
Conclusion: The research results showed that cost analysis using the TDABC method resulted in a more detailed and accurate calculation that the calculation was activity and time-based.

Keywords: SARS-CoV-2, Convalescent Plasma, Time-Driven Activity-Based Costing.
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INTRODUCTION

The viral pneumonia disease – coronavirus 2019 (covid-19) is currently becoming a pandemic throughout the world caused by coronavirus 2 (SARS-CoV-2). The number of cases and death increased dramatically from the first case in Wuhan, China, in December 2019.[1] Indonesia announced its first laboratory that confirmed the SARS-CoV-2 case on 2 March 2020 in the capital, DKI Jakarta province.[2] To solve the COVID-19 pandemic, it was important to develop a therapeutic agent and effective vaccine. Given the lack of therapeutic choice for COVID-19, convalescent plasma therapy was considered an emergency intervention in some countries.[3] Each country has feasibility criteria for convalescent plasma donors.[4] On the other hand, convalescent plasma has a theoretical risk of weakening the development of natural immune responses, especially administration for prophylaxis.[5]

Passive antibody therapy involved antibody administration for individuals who were prone to contagious disease. Currently, passive antibody therapy is performed by collecting immunoglobulin covering high-concentration antibody.[6] Anti-SARS CoV-2 antibody-containing plasma obtained from individuals recovering from confirmed COVID-19 had started to be collected using an apheresis device and collected in a blood bank with the expectation of reducing mortality rate and reducing the need for nursing in intensive care room.[1] Convalescent plasma therapy had been used to treat patients with infection using plasma collected from patients who recovered from covid-19. FDA recently agreed on the use of emergency convalescent plasma for patients with severe or life-threatening COVID-19.[7]

Right now, the demand for convalescent plasma increases greatly, with its high price. It is, therefore, necessary to calculate the appropriate unit cost for convalescent plasma, for an actual, real price. Therefore, the unit cost is a crucial cost measure in a company's operational analysis. Identifying and analyzing company's cost per unit is a quick way to examine whether a company produces its products efficiently.[8]

A costing system may give laboratory manager an important part of financial information. Costing system, on the other hand, has the main challenge in inserting indirect cost into products and services, commonly division is used through criteria that the manager believes close to organization's fact.[9] Meanwhile, in the traditional cost model, costing is carried out by allocating overhead cost to products or services based on volume such as number of units (products), direct labor cost, hours of direct labor, or hours of production machine[10] with the steps of implementation.[11] Although it is easy to implement the traditional model, but this method has weaknesses, such as sole volume measure allocation and becoming

inaccurate when overhead is higher than direct cost.[12]

Activity Based Costing (ABC) system means a system to determine the cost for a product, and it was proposed for the first time by Kaplan and Johnson in 1987, also activity Based Costing (ABC) is an alternative of traditional costing method. Unlike traditional cost system, ABC distinguishes indirect cost and determines the cost based on activity driver to reduce indirect cost and determine the cost based on activity driver to reduce the cost and improve asset utilization. There are four measures to implement the ABC method.[11,12] ABC application has its own difficulties which may be due to how people build their ABC model.[13-14] Moreover, trigger rate as estimated based on ABC is commonly higher than real use.[14]

However, this system finds it difficult to apply and maintain a conventional activity based on costing system, preventing this innovation's efficiency, timeliness, and update as a management instrument. The Time Driven Activity Based Costing (TDABC) system may solve the difficulty found by the Activity Based Costing (ABC) system. The TDABC is easier, faster, and more practical in its use. The TDABC system helps strategic decision making and reduces the time for services and goods production. Due to its simplicity and fast implementation, it is easy to update and identify unnecessary activities in cost calculation.[15] Moreover, some of these following research shows that TDABC method as a certain method to compute the cost of hospital services. The TDABC method more make sense in determining SC unit cost.[16] TDABC method able to give the detail of the better cost in computed tomography activities.[17] TDABC model able to explain the percentage consumption of cardiovascular healthcare cost.[18]

The TDABC method is able to explain the RALP computed cost better compared to traditional accounting model.[19] TDABC model being an effective equipment to assessing interventions in the treatment of pediatric appendicitis.[20] TDABC model can be used to calculate more detailed costs in Revision Total Joint Arthroplasties activities.[21] TDABC model is able to determine the difference in managing nurse human resources at the unit level (21). TDABC creates cost transparency.[22] TDABC method is effective to reduce the cost.[23] TDABC method computes a lower cost compared with RCA model.[24] TDABC method is used to reduce processing time up to 16%.[25] TDABC method used activities as a base to lose the cost and determine product cost accurately.[26]

It is still difficult to get Convalescent Plasma and its price is still high by unit cost, it is the most expensive among any services at the laboratory of Dolopo Hospital, thus an easy, practical, and efficient real cost calculation is needed for appropriate real cost, with an expectation that the laboratory will not suffer a loss and convalescent plasma service may continue to help provide services that covid-19 patients currently need. Therefore, this research aimed to calculate the unit cost of convalescent plasma using a Time-Driven Activity Based Costing (TDABC) method at Dolopo Hospital to be the base for making actual, laboratory real costs.

MATERIAL AND METHODS

Research Design

This qualitative research used a case study at Dolopo Hospital – Madiun. This research aimed to calculate the unit cost of convalescent plasma using The Time-Driven Activity Based Costing Method and calculate the difference using the real cost method.

Research Subject and Object

This research's research subjects were Head of the Finance Division, the Head of Laboratory, Head of General Division, for comprehensive data of Dolopo Hospital. The research objects were all activities and time that supported the process of convalescent plasma service at the Laboratory Installation from patient registration for convalescent plasma to obtaining one-unit convalescent plasma.

Inclusion and Exclusion Criteria

The research's inclusion criteria were recovery from covid-19 (as proven with doctor's recovery certification), having no covid-19 symptoms within 14 days before donor, a negative result of contagious disease screening (HIV, syphilis, HCV, HBV), antibody titer 1:160 or 1:80, male or female donor that had not been pregnant or in case of having ever been pregnant with negative result of HLA test, minimum body weight 55 kg and 18-60 years old, having no transfusion history in the last 1 year, having no chronic comorbidity. The exclusion criteria were patient not meeting any of the research's inclusion criteria.

Data Analysis

This research used primary and secondary data. The primary data were obtained directly from the source, through interview with related parties for an overview of convalescent plasma unit cost calculation. The overview of activities related to convalescent plasma taking process was obtained through interview with the head of laboratory, from registration to completed process of convalescent plasma. Observation was also conducted by the researcher directly related to the time needed for convalescent plasma taking process from registration to completed process of convalescent plasma and room observation for data of the size of room and the existing facilities. The secondary data were obtained through collecting information from the existing sources. The secondary data in the research included financial record of Dolopo Hospital in 2021 and the hospital's documents. The observation guidance used was checklist with Standard Operating Procedure (SOP) through direct observation during activities and the time of convalescent plasma taking process. Stopwatch was used to measure the time needed in each activity of convalescent plasma examination.

RESULTS

Figure 1 explains CDVC of convalescent plasma examination activity from patient registration to obtaining 1 bag of convalescent plasma. The convalescent plasma value chain was made based on the standard operation (SOP) and interview with the head of laboratory, and later confirmed with direct observation.

Table 1 presents room, electricity, and water cost analysis. Total room cost in a year = total room cost + room electricity cost + room water cost. Capacity cost rate (CCR) cost of room = total room cost in a year multiplied with available time

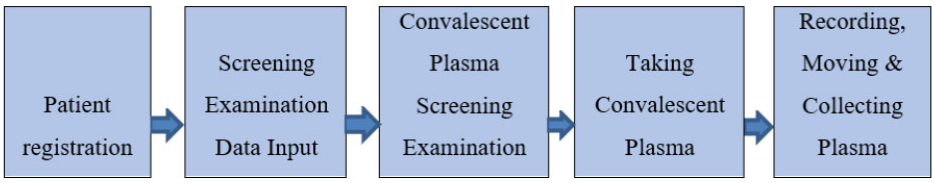

Figure 1. Care Delivery Value Chain (CDVC) of Convalescent Plasma.

in a year. Thus, CCR cost of registration room is IDR11/minute and CCR cost of laboratory room IDR82/minute.

Table 2 presents descriptive analysis of Personal Capacity cost rate (CCR). Total personal is total salary/year divided with total HR capacity/minute, thus total personal CCR of laboratory was IDR2,819/minute; medical record IDR2,757/minute; PK Specialist IDR2,820/minute.

Table 3 presents total personal capacity cost rate (CCR) of all convalescent plasma activities. Personal CCR calculation can be observed in table 2. Time involved is the time obtained in each convalescent plasma activity in minutes. Allocated CCR is obtained from personal CCR multiplied with time involved. Thus, total personal Capacity Cost Rate (CCR) obtained from convalescent plasma taking process, from patient registration to obtaining one bag of convalescent plasma is IDR357.497

Table 4 presents total capacity cost rate (CCR) of room, electricity, and water costs. The calculation of CCR cost/minute for room, electricity and water can be observed in table 1. Allocated CCR is obtained from total CCR multiplied with time involved. Total Capacity Cost Rate of room, electricity and water costs from convalescent plasma taking process from patient registration to obtaining one bag of convalescent plasma is IDR 9.846

Table 5 presents total convalescent plasma cost. Consumables goods laboratory cost is the main cost of convalescent plasma consumables. Indirect cost is from total service operational cost + office administrative cost + office operational cost + environmental health cost + service supporting salary cost that is then divided with number of patients in a year. Human Resource cost of the whole process (see table 3), building, electricity, water costs of the whole process (see table 4).

Table 6 presents the difference of unit cost of TDABC with real cost. Total convalescent plasma cost is IDR2,408,970. Real cost that the hospital determines is IDR2,250,000. Difference in unit cost with TDABC from real cost is IDR36,765.

DISCUSSION

The result of using TDABC method was higher than using real cost applied at Dolopo Hospital of IDR36,765. Calculation of real cost at Dolopo Hospital is guided by the real cost of Soetomo Hospital Surabaya and based on real cost calculated from Dolopo Hospital. So far, the calculation of real cost at Dolopo Hospital have not used unit cost analysis, so they have the potential to cause inaccuracies in determining real cost. The calculation of real cost at Dolopo Hospital had not used the unit cost analysis all this time, which may potentially inaccuracy in real costing. Real costing at Dolopo Hospital to date had not calculated electricity, water, room, indirect costs in detail and had not determine the capacity cost rate of every personal and the whole convalescent plasma activities. Real cost calculation at Dolopo Hospital is different from the calculation model at Private Hospitals, since they were not including fixed costs paid up by the government (such as salary of State Civil Apparatus, building depreciation cost subsidized by the government, depreciation cost of instruments subsidized by the government).

Convalescent plasma therapy also has been used to treat coronavirus diseases such as SARS and MERS. A study in a Hong Kong hospital evaluated the efficacy of convalescent plasma therapy in the treatment of patients with SARS in 2003.[3] Provision of convalescent plasma is still difficult to obtain and expensive. The high price of convalescent plasma is due to the high cost of consumables used to make convalescent plasma. The largest resource usage in convalescent plasma research is the cost of laboratory consumables, which is 77.1%; indirect cost 6.8%; human resources costs 15.6%; the cost of building, electricity, and water from the whole process is 0.4%. The results of this research show that cost analysis using TDABC method produces a more detailed and accurate calculation that its calculation is measured in time unit (minute) based on the existing activities. Calculation using this method can be updated more easily, in case of additional activities into the existing process.

Accurate cost calculation is very important for hospital management, so that real costing will not be far higher or lower, that will then affect hospital's profitability.[27] Using TDABC method the cost analysis will be more transparent, so Social Security Agency of Health (BPJS) and management can use this information to better allocate costs.[28] TDABC based cost estimation is more detailed and useful in practice than calculation using traditional method that is used in hospitals all this time. The TDABC method is implemented as an efficient and accurate method to have an understanding of service provider's actual cost. The TDABC model is most commonly applied at hospital for improved operational efficiency, reducing waste, allowing accurate cost comparison, and reducing the risk of under package payment.[29] On the other hand, The use of TDABC can increase the effectiveness of health services and improve clinical communication systems.[16] The TDABC method can very well analyse costs by service and identify inefficient processes.[30]

The TDABC method is more capable of solving complexity in health service.[31] The variety in applications suggests that more can be done to address the challenges practitioners face.[20] The TDABC method is proposed as an improvement in activity-based costing because it makes an accurate cost analysis faster and easier to update by using two-parameter estimates of (1) the unit cost of resource inputs and (2) the time and quantity of resources needed to perform activities.

Using TDABC requires detailed understanding of the service process and resources consumed. TDABC provides the most accurate health service accounting form, thus actual cost components are known.[32] This method knowing the

calculation of the unit cost of convalescent plasma for government hospitals, so that the required costs are known. In the calculation process the author has limitation on incomplete financial data required in hospital accounting.

TDABC is a cost accounting system can be used to calculate the actual cost of healthcare services. The system is designed for relatively accurate or sufficient information that can accurately estimate the cost of services provided to patients. However, estimating the costs and time required for most hospital activities is subjective and uncertain. As health care costs often vary according to the performance of physicians and other health professionals, there is a high variation in healthcare costs due to uncertainty regarding their capacity and performance. These cases also have a significant impact on the time and cost of services provided to patients, so it is impossible to estimate accurately the costs and time required for most hospital activities.[32]

TDABC facilitates the data collection process by using the time component as the main cost driver. By using the time equation, TDABC can model complex activities and processes into simpler ones. This makes the costing process easier, more accurate, and cheaper. The simplicity of this model results from the fact that it requires only two parameters for a proper estimate: the departmental capacity cost rate and the capacity utilization rate of each activity performed in the department. Each parameter can be estimated simply and objectively.[32]

CONCLUSION

Research results in the following data: a). Unit cost of convalescent plasma examination based on calculation using Time Driven Activity Based Costing (TDABC) method is IDR2,286,675, b). Real cost of convalescent plasma examination at Dolopo Hospital is IDR2.250.000, c). The result of calculation of unit cost of convalescent plasma using Time Driven Activity Based Costing (TDABC) is higher than the real cost applied at Dolopo Hospital, with a difference of IDR36,765.

ETHICAL STATEMENT

This study was conducted based on the protocol, which has been granted ethical approval from the Faculty of Medicine and Health Science Universitas Muhammadiyah Yogyakarta. Review Board (No.119/EC-KEPK FKIK UMY/ IV/2022).

CONFLICT OF INTEREST

We have no conflicts of interns to disclose.

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AUTHOR CONTRIBUTION

All authors contributed equally in this study.

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Table 1. Capacity cost rate (CCR) of room, electricity & water costs.

Name	Size (m2)	Room size (%)	Deprecation	Old building maintenance cost	Total room cost per year	Total electricity cost per year	Room electricity cost	Total water cost per year	Room water cost	Availability (minute)	Total cost, room, electricity, water, per year	CCR
Building						718,372,500		26,166,000				
Old building				139,476,503								
Registration room	42	0.66%			927,341		4,776,262		173,971	24 hours/7 days/week (524,160 minutes)	5,877,573	11
New building			2,273,868,060									
Laboratory room	82	1.43%			32,409,522		10,238,989		372,945	24 hours/7days/ week (524,160 minutes)	43,021,455	82
Old Building size	6,317											
New Building size	5,683											
Total building size	12,000	100%										

Table 2. **Personal Capacity cost rate (IDR/min).**

HR	Total salary (IDR)	HR Capacity (minutes)	Total Personal Capacity Cost Rate (IDR/min)	Total HR	Personal capacity cost rate (IDR/min)
KEY	Total salary in a year	Total HR capacity in minutes	Total HR of CCR in Rupiah	Total HR in clinical setting	CCR per individual
Laboratory (Analyst)	IDR 276,000,000	97,920	IDR 2,819	1	IDR 2,819
Medical Record	IDR 270,000,000	97,920	IDR 2,757	1	IDR 2,757
Clinical Pathologist	IDR 180,000,000	63,840	IDR 2,820	1	IDR 2,820

Table 3. **Total personal capacity cost rate of all convalescent plasma activities.**

No	Name of Step	Personnel	Number of Personnel	CCR of Personnel (IDR/min)	Total CCR	Time Involved (min)	Allocated CCR	Room
1.	Patient comes to laboratory submitting ID for convalescent plasma registration	Analyst	1	IDR2,819	IDR2,819	1	IDR2,819	Laboratory
2.	Laboratory officer (analyst) registers patient with registration counter	Medical Record	1	IDR2,757	IDR2,757	8	IDR22,059	Registration Counter
3.	Laboratory officer (analyst) inputs laboratory examination for convalescent plasma screening at SIMRS	Analyst	1	IDR2,819	IDR2,819	5	IDR14,093	Laboratory
4.	Examination of vital sign, body weight, existence of comorbidity, age	Analyst	1	IDR2,819	IDR2,819	10	IDR28,186	Laboratory
		Clinical Pathologist	1	IDR2,820	IDR2,820	10	IDR28,200	Laboratory
5.	Examination of antibody titer, HIV, HbSAg, Syphilis	Analyst	1	IDR2,819	IDR2,819	15	IDR42,279	Laboratory
6.	Complete blood examination	Analyst	1	IDR2,819	IDR2,819	10	IDR28,186	Laboratory
7.	Apply cuff on donor's arm	Analyst	1	IDR2,819	IDR2,819	1	IDR2,819	Laboratory
8.	Disinfection using alcohol-applied cotton for 2x	Analyst	1	IDR2,819	IDR2,819	1	IDR2,819	Laboratory
9.	Press Cuff on instrument to increase cuff's pressure (100 mmHg)	Analyst	1	IDR2,819	IDR2,819	0.5	IDR1,409	Laboratory
10.	Venipuncture	Analyst	1	IDR2,819	IDR2,819	5	IDR14,093	Laboratory
		Clinical Pathologist	1	IDR2,820	IDR2,820	5	IDR14,100	Laboratory

No	Name of Step	Personnel	Number of Personnel	CCR of Personnel (IDR/min)	Total CCR	Time Involved (min)	Allocated CCR	Room
11.	Press DRAW to start the procedure and do the set of plasma taking process	Analyst	1	IDR2,819	IDR2,819	40	IDR112,745	Laboratory
12.	End the process when procedure complete appears on the screen	Analyst	1	IDR2,819	IDR2,819	1	IDR2,819	Laboratory
13.	Open syringe lock, draw syringe from donor's arm, release plasma product from disposable set	Analyst	1	IDR2,819	IDR2,819	1	IDR2,819	Laboratory
14.	Make a note on plasma bag, worksheet and work report	Analyst	1	IDR2,819	IDR2,819	1	IDR2,819	Laboratory
		Clinical Pathologist	1	IDR2,820	IDR2,820	1	IDR2,820	Laboratory
15.	Removing & storing plasma 200 cc	Analyst	1	IDR2,819	IDR2,819	10	IDR28,186	Laboratory
16.	Plasma bag is given with identity (blood type, serial number, data of taking)	Analyst	1	IDR2,819	IDR2,819	1	IDR2,819	Laboratory
17.	Plasma bag is stored in fridge	Analyst	1	IDR2,819	IDR2,819	0.5	IDR1,409	Laboratory
				TOTAL			**IDR357,497**	

Table 4. **Total capacity cost rate (CCR) of room, electricity, and water costs.**

No	Name of Step	Personnel	Number of Personnel	CCR (IDR/min)	Total CCR	Time Involved (min)	Allocated CCR	Room
1.	Patient comes to laboratory submitting ID for convalescent plasma registration	Analyst	1	IDR82	IDR82	1	IDR82	Laboratory
2.	Laboratory officer (analyst) register patient at registration counter	Medical Record	1	IDR11	IDR11	8	IDR88	Registration counter
3.	Laboratory officer (analyst) inputs laboratory examination for convalescent plasma screening at SIMRS	Analyst	1	IDR82	IDR82	5	IDR410	Laboratory
4.	Examination of vital sign, body weight, existence of comorbidity, age	Analyst	1	IDR82	IDR82	10	IDR820	Laboratory
		Clinical Pathologist	1	IDR82	IDR82	10	IDR820	Laboratory
5.	Examination of antibody titer, HIV, HbSAg, Syphilis	Analyst	1	IDR82	IDR82	15	IDR1,230	Laboratory
6.	Complete blood examination	Analyst	1	IDR82	IDR82	10	IDR820	Laboratory
7.	Apply cuff on donor's arm	Analyst	1	IDR82	IDR82	1	IDR82	Laboratory
8.	Disinfection using alcohol-applied cotton for 2x	Analyst	1	IDR82	IDR82	1	IDR82	Laboratory
9.	Press Cuff on instrument to increase cuff's pressure (100 mmHg)	Analyst	1	IDR82	IDR82	0.5	IDR41	Laboratory
10.	Venipuncture	Analyst	1	IDR82	IDR82	5	IDR410	Laboratory
		Clinical Pathologist	1	IDR82	IDR82	5	IDR410	Laboratory
11.	Press DRAW to start the procedure and do the set of plasma taking process	Analyst	1	IDR82	IDR82	40	IDR3,280	Laboratory
12.	End the process when procedure complete appears on the screen	Analyst	1	IDR82	IDR82	1	IDR82	Laboratory
13.	Open syringe lock, draw syringe from donor's arm, release plasma product from disposable set	Analyst	1	IDR82	IDR82	1	IDR82	Laboratory
14.	Make a note on plasma bag, worksheet, and work report	Analyst	1	IDR82	IDR82	1	IDR82	Laboratory
		Clinical Pathologist	1	IDR82	IDR82	1	IDR82	Laboratory
15.	Removing & storing plasma 200 cc	Analyst	1	IDR82	IDR82	10	IDR820	Laboratory
16.	Plasma bag is given with identity (blood type, serial number, data of taking)	Analyst	1	IDR82	IDR82	1	IDR82	Laboratory

No	Name of Step	Personnel	Number of Personnel	CCR (IDR/min)	Total CCR	Time Involved (min)	Allocated CCR	Room
17.	Plasma bag is stored in fridge	Analyst	1	IDR82	IDR82	0.5	IDR41	Laboratory
			TOTAL				**IDR9,846**	

Table 5. **Total Convalescent Plasma Cost.**

No	Type of Cost	Total Cost
1.	Consumables Goods Laboratory Cost	IDR 1,763,532
2.	Indirect Cost	IDR 155,800
3.	Human Resource Cost of the whole process	IDR 357,497
4.	Building, electricity & water cost of whole process	IDR 9,846
Convalescent Plasma Total Cost		**IDR 2,286,675**

Table 6. **Cost Difference of Unit Cost of TDABC with Real Cost.**

Examination	TDABC Unit cost	Real cost	Difference
Convalescent Plasma	IDR 2,286,675	IDR 2,250,000	IDR 36,765