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Cost analysis of transcranial magnetic stimulation for stroke using time driven activity-based costing method

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A B S T R A C T

Objective: Transcranial Magnetic Stimulation (TMS) is widely used in health centers in Indonesia because its non-invasive and increase patient stroke preferences in choosing therapy. However, TMS service has not been studied based on unit cost. Therefore, in this study we will analyze unit costs based on the Time Driven Activity Based Cost (TDABC) method of TMS services to find out the difference with the TMS current rates in Sri Husada Clinic and the difference with Indonesia's Case Based Group (INA-CBG's) for be more accurate cost calculations. Method: Qualitative research type, a case study research, calculating the Unit Cost of TMS and a prospective observational research design. The study uses primary data and secondary financial data in Sri Husada Clinic between March 2022 to February 2023 to calculate the cost of TMS using TDABC. Result: Unit cost for TMS using the TDABC method is IDR. 224,446.00. TMS service current rate in Sri Husada Clinic is IDR. 250,000 .00 and INACBGs is IDR 238,724 .00. The difference with the current rates is IDR 25,554 .00 (10.2%) and the difference with INACBG is IDR14,258.,00 (5.9%). Conclusion: Unit cost calculations using the TDABC method for TMS is lower than current rate and INACBG. TDABC method can produce more accurate cost estimates. The result will differences and the need further analysis dependent activity and availability to other service.

INTRODUCTION

Stroke is one of the diseases that causes most neurological disorders compared to all other neurological conditions. Worldwide it accounts for approximately 5.5 million deaths each year, with 44 million years of life adjusted for the impact of disability [(1)]. Advances in stroke therapy technology are growing rapidly in the era of globalization. This progress was obtained both from preventive, curative and rehabilitative therapy [(2)]. One of the modern stroke rehabilitation therapy tools is Transcranial Magnetic Stimulation (TMS) [(3)]. TMS is a for diagnosis and therapy using magnetic waves in the cerebral cortex and peripheral nervous system [(4)].

Various options for stroke rehabilitative therapy are interesting things to discuss in terms of cost-effectiveness analysis of an intervention. Cost determination using unit cost is the price issued by the company obtained from the measurement of production or service volume [(5)]. The unit cost is the total amount of resources consumed per episode of care. These resources include time, money and other scarce resources that could be used elsewhere [(6)].

Time Driven Activity Based Cost (TDABC) developed by Kaplan and Anderson at Harvard Business School (7), is a costing methodology that estimates activity-based costs at the unit cost of supply capacity and time needed to perform services (8). TDABC is expected to provide more accurate and transparent cost estimates that allow for efficiency and cost control and are evaluated in more detail than traditional costing methods (9).

TMS is widely used in several health centers in Indonesia because its non-invasive actions will increase patient preference in choosing therapy. However, TMS service has not been studied based on unit cost. Therefore, in this study we will analyze unit costs. Therefore, in this study we will analyze unit costs based on the TDABC method for TMS service and to find the difference to current rate in Sri Husada Clinic and INACBG's. Current rate in Sri Husada Clinic use fee for service method and INACBG's or *Indonesia's Case Based Group* is

payment method for patient care based on relatively similar diagnoses or cases for government insurance financing.

METHOD

The research is a qualitative research type, a case study research design, calculating the unit cost of TMS and a prospective observational research design. The study uses primary data and secondary *financial data* from the Sri Husada Clinic (SHC). This study aims to describe the unit cost associated to TMS service at the SHC using the TDABC method. Research data collection was carried out at SHC from March 2022 to February 2023.

Subjects in this study were the head of finance, neurologists, physiotherapists, pharmacists, administrative officers such as registration officers, medical records. To obtain comprehensive data at the SHC. The object of this research is the time required for each activity that occurs in the TMS procedure at the SHC.

The data that has been collected will be selected and summarized to suit the purposes of this study. After that, the data will be analyzed according to the TDABC method, based on the seven steps of Kaplan et al.

1. Determine cases of stroke patients who are intervened using TMS
2. Determine the care delivery value chain (CDVC) in TMS services
3. Develop each activity process / TMS service activity map
4. Estimating the time required for each TMS service activity
5. Estimating the total cost provided for each TMS service
6. Estimating the practical capacity of each resource and calculating the Capacity Cost Rate (CCR) of TMS services
7. Calculating the total cost of TMS services

After determining the unit cost of TMS services using the TDABC method, we determine the difference with the current rates at SHC and the difference with I *INA-CBG's*.

RESULTS AND DISCUSSION

The calculation of the TMS unit cost at SHC uses TDABC based on predicted revenue targets and building construction costs which are then divided by the number of patients in one year, from March 2022 to February 2023. The total is 2062 patients.

1. Determine cases of stroke patients who are intervened using TMS

   Characteristics based on SHC annual report data, the majority of patients are ischemic stroke patients 1439 (69.8%) compared to hemorrhagic stroke 623 (30.2%). The age group of patients was dominated by the age of more than equal to 55 years, namely as much as 1,685 (81.7%) and age less than 55 years only 377 (18.3%). The gender is dominated by male sex 1267 (62.9%) than female 765 (37.1%).

2. Determine the care delivery value chain (CDVC) in TMS services

   This CDVC can be divided into four steps namely patient registration, clinical examination, intervention (TMS) and administration. Creating a value chain of care delivery based on clinical pathways and interviews with Neurologists then confirmed by direct observation. Figure 1 describe CDVC for TMS.

3. Provide every process of TMS service activity

   The third step is to make a map of the service activity process. Therefore, Figure 1 shows a map of the TMS activity process, which is divided into four steps, namely patient registration, clinical examination, intervention (TMS) and administration.

4. Assess the time required for each TMS service activity

   The fourth step is determining the time for each activity. We assessed the time for each activity in 335 patients who were given TMS services using a stopwatch. Table 1 the average time needed for each activity based on the room and staff used in the TMS process. The patients spends most of their time in the treatment room, which is 20.5 minutes. The most time spent on Treatment Room is for Physiotherapists, around 20.5 minutes.

5. Estimating the total cost provided for each TMS service

   The fifth step is to estimate total cost charged to each TMS. Data processing was taken from the annual financial report of the SHC. Estimated total costs are obtained from staff costs, building costs, electricity, water, equipment, indirect costs and consumable costs.

6. Estimating the practical capacity of each resource and calculating the CCR of TMS services

   After the annual financial data is collected, the CCR is calculated for the resource. Determine the staff CCR as shown in table 2. The total staff cost for TMS services is IDR 48,302,994. Neurologist doctors are the highest source of costs, amounting to IDR 37,812,050 or 77% of the total labor costs.

   Infrastructure's CCR is the cost of space and equipment used in TMS services in rupiah per minute. Space costs include space depreciation, electricity, water, and cleaning costs. The total cost of infrastructure and equipment shown in table 2 is IDR 82,990,443. The treatment room has the highest CCR, IDR. 81,116.370 per minute.

   Indirect costs that cannot be integrated with the TMS service activity process map, in this study indirect costs are charged based on the number of patients from March 2022 to February 2023. The total indirect costs is IDR 169,294,000 with a total of 2062 patients. The indirect cost per patient is IDR 82,102 which will be charged directly at the end of the calculation. The indirect cost allocation is explained as shown in Table 3.

   There are costs that are charged directly, namely the cost of consumable materials. The consumable materials fee for the TMS action is IDR. 11,071 which is described in table 4.

7. Calculating the total cost of TMS services

   The last step is to calculate the total cost of TMS services. Described in table 5, explaining that the total cost is the sum of the total activity costs which are calculated based on the process map using the TDABC method and added to the indirect costs charged to all patients from March 2022 to February 2023. Based on the calculations, the total cost of TMS services is IDR 224,266.00.

DISCUSSION

Stroke patients who were given TMS treatment at SHC were dominated by ischemic stroke by 69.8% compared to hemorrhagic stroke patients. In a previous study by Mukherjee et al (2011) the results showed that the most common cause of stroke was ischemic rather than hemorrhagic [(1)]. Ischemic strokes are caused by blockages due to plaque clots, emboli and/or thrombus which cause the brain's oxygen supply to decrease and cause brain cell death (10). There are degenerative factors that cause the structure of blood vessels in the brain to change (11). Other factors that cause stroke are unhealthy lifestyles and smoking is the main cause of stroke in men (12). The consequences of other diseases such as atrial fibrillation are the most common causes of stroke in women (13). In this study, there were 62.9% male subjects and 37.1% female subjects with a predominance of the age range more than 55 years of 81.7%.

Treatment TMS requires a different time needed and amplitude for each diagnosis [(4)]. In this study, neurologists advise stroke patients who are treated using TMS with a maximum amplitude is 50% and an average duration of 20.5 minutes. This was also found in a study by Keser et al (2022) stroke therapy using TMS therapy with an average amplitude of 50% and a duration of 15-20 minutes for one therapy (14). In contrast to the study by Goirgiou et al (2022) using an average amplitude of 40% with a duration of 30-35 minutes for one therapy(15).

Calculation of the unit cost using TDABC shows in detail by calculating the CCR (16). The results of the total CCR staff in this study was IDR 48,302,994. Neurology doctors are the highest source of costs, amounting to IDR 37,812,050 or 77% of the total staff costs. The cost of specialist doctors is also the largest staff cost in the study by Epifanov et al (2017)(10). Specialists have expertise and knowledge and are the determinants of therapy so that they generate more costs than other staff (17). The TDABC method can determine the resources that are most needed or can eliminate resources that are not used with the aim of simplifying costs (18). The TDABC method can help find opportunities to save costs, increase the efficiency of clinical service actions, and can help find unused clinical capacity of personnel (19).

The results of the space and infrastructure CCR showed that the most cost was from the action room, which was IDR 81,116.370 per minute (97%). The high cost is due to the SHC having a new TMS equipment infrastructure of IDR. 4,000,000,000.00 with depreciation for 4 years or a CCR of IDR 3632.82. The cost of electricity and water in the treatment room also generates costs with the highest percentage compared to other rooms or CCR of IDR. 324.07. This was also influenced by the time spent in the treatment room, which was 20.5 minutes. In the previous study by Puumalainen et al (2020) it was also shown that the results of the space cost of the action produced the most costs(20). Stroke patients with rehabilitation, physiotherapy and neurorestoration interventions require a long time and relatively large equipment infrastructure costs compared to other space infrastructure (21). These results cause the intervention process to be the process with the highest cost, it was IDR. 91,245,052. The intervention process is the source of the highest cost because it involves a lot of time and the high cost of infrastructure and consumables. The TDABC method can produce more accurate cost estimates of the resources needed for a service or action (19).

The total unit cost calculation results using the TDABC method in this study amounted to Rp. 224,446 .00. Most of the costs were generated from infrastructure costs of Rp. 82,990.00 (36.9%) and indirect costs of Rp. 82,102.00 (36.5%). The TDABC method calculates infrastructure costs based on space depreciation, electricity, water requirements and equipment depreciation (17). Calculation of depreciation of space based on the square area used is proportional to the total cost of the square area of the building (18). The TDABC method does not take into account the many indirect costs incurred (22). Indirect fees are charged based on the number of patients from February 2022 to March 2023. This means that TMS service fees can change depending on the number of patients. Detailed cost calculations are useful for the profitability of health service providers in determining the rates of a service (23).

Based on the results of the interview data obtained, it can be analyzed that the tariff for the TMS procedure at the SHC is IDR. 250,000 .00.. SHC has not calculated the unit cost which has the potential for errors in the real calculation. Current rates consist of equipment rental costs, medical services for neurologists and physiotherapists. Current rate has not taken into account the building depreciation costs, electricity, water and indirect costs in detail and has not analyzed the amount of CCR costs for each staff and all TMS activities. Meanwhile, after being analyzed using the TDABC method, the unit cost incurred was IDR 224,446.00. These results show that there is a positive difference of IDR. 25,554 .00 or a 10% margin of costs calculated using the TDABC method compared to current rates. Whereas the INACBG's tariff for TMS measures is IDR. 238,724.00. The difference in INACBG's and TDABC shows that there is a positive difference of IDR. 14,258.00 or a margin of 5.9%.

Using the TDABC method requires detailed data about each service process and the resources needed (16). The TDABC method requires primary data using the time component as the main cost driver. Thus, with the same estimated time for a service, the TDABC method can analyze complex processes into simpler ones without reducing the accuracy of the analysis (24). However, the estimated cost and time needed to analyze each service activity varies in different places. Because these activities are highly dependent on staff performance and the availability of tools and infrastructure. This will affect the consumption of time and costs, so that the calculation results will be different and further analysis is needed in accordance with the availability at each service location (17).

CONCLUSIONS AND SUGGESTIONS

Unit cost analysis for TMS at SHC using the TDABC method is IDR. 224,446.00. The current rates of the TMS at the SHC is IDR. 250,000 .00. The unit cost value with the TDABC method is smaller than the current rates. The difference is IDR. 25,554 .00 or a 10% margin of costs calculated using the TDABC method compared to current rate. The INACBG's rate for TMS measures is IDR 238,724.00. The unit cost value using the TDABC method is lower than the INACBG's rate. The difference in INACBG and TDABC rates is calculated, it shows that there is a positive difference of IDR. 14,258.00 or a margin of 5.9%. The TDABC method was chosen because it can be a transparent comparison, prevent the risk of loss, know the details of waste so that more efficient services can occur.

Unit cost calculations using the TDABC method for TMS procedures at SHC produce lower costs than current rate and INACBG's. Even though the TMS treatment is not the highest income group at SHC, the cost assignment must be analyzed appropriately. TDABC analyzes each highly dependent action

activity based on staff performance and availability of tools and infrastructure. This will result in differences and the need for further analysis in accordance with the availability in other service areas.

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Conflict of interest

The authors declare that there are no conflicts of interest.

Ethical approval

This Study had no ethical approval because there is no ethical issue.

Authors contributions

HA. conceived and designed the study, conducted research, provided research materials, and collected and organized data. F.P analyzed and interpreted data. HA. wrote initial and final draft of article, and provided logistic support. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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Appendix

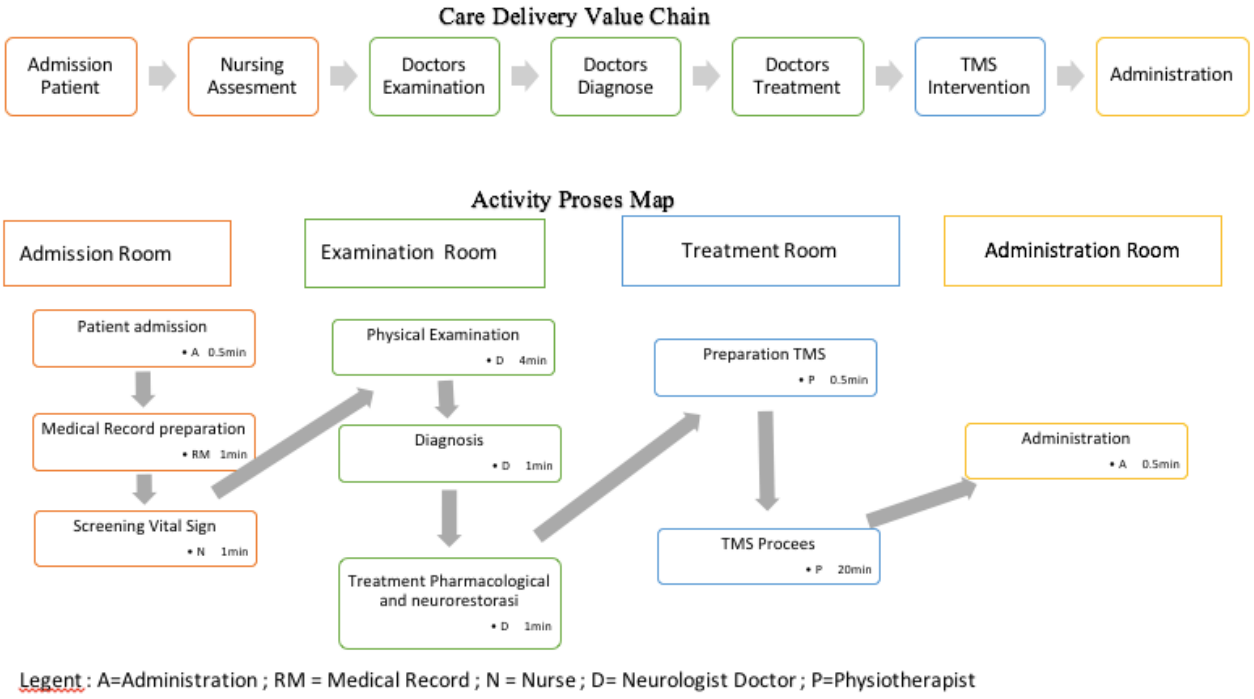

Figure 1

Table 1. Average Time Needed of Each Activity

	Activity (Minutes)						Activity (Minutes)				
Room	**Admission**	**Examination**	**Intervention**	**Administration**	**Total**	**Person**	**Admission**	**Examination**	**Intervention**	**Administration**	**Total**
Admission Room	2.5				2.5	**Administration Staff**	0.5			0.5	1
Doctors Room		6			6	**Medical Record**	1				1
Treatment Room			20.5		20.6	**Nurse**	1				1
Administration Room				0.5	0.5	**Neurologist**		6			6
						Physiotherapist			20.5		20.5

Table 2. Capacity cost rate (CCR)

Person	CCR (IDR/Minute)	Admission		Examination		Intervention		Administration		Total (IDR)
		Time (Minutes)	Cost Allocated (IDR)	Time (Minutes)	Cost Allocated (IDR)	Time (Minutes)	Cost Allocated (IDR)	Time (Minutes)	Cost Allocated (IDR)	
Administration Staff	IDR. 104,116	0.5	IDR. 52,083	0	-	0	-	0.5	IDR. 52,083	IDR. 104,166
Medical Record	IDR. 104,116	1	IDR. 104,166	0	-	0	-	0	-	IDR. 104,166
Nurse	IDR. 144.927	1	IDR. 144,927	0	-	0	-	0	-	IDR. 144,927
Neurologist	IDR. 6.303,508	0	-	6	IDR 37.812,050	0	-	0	-	IDR. 37.812,050
Physiotherapist	IDR. 494,082	0	-	0	-	20,5	IDR. 10.128,682	0	-	IDR. 10.128,682
Total Cost			IDR. 301,176		IDR 37.812,050		IDR. 10.128,682		IDR. 52,083	IDR. 48.302,994

Room	CCR (IDR/Minute)	Admission		Examination		Intervention		Administration		Total
		Time (Minutes)	Cost Allocated (IDR)	Time (Minutes)	Cost Allocated (IDR)	Time (Minutes)	Cost Allocated (IDR)	Time (Minutes)	Cost Allocated (IDR)	
Admission Room	IDR. 197,201	2,5	IDR 493,004	0	-	0	-	0	-	IDR. 493,004
Doctors Room	IDR. 219,727	0	-	6	IDR. 1.318,366	0	-	0	-	IDR. 1.318,366
Treatment Room	IDR. 3.956,896	0	-	0	-	20.5	IDR 81.116,370	0	-	IDR 81.116,370
Administration Room	IDR 125,405	0	-	0	-	0	-	0,5	IDR 62,702	IDR. 62,702
Total Cost			IDR 493,004		IDR 1.318,366		IDR. 81.116,370		IDR. 62,702	IDR. 82.990,443

Tabel 3 Indirect Cost

KEY	Cost
Service Operational Costs	IDR 11.900.000
Office Administration Fee	IDR 9.194.000
Office Operational Costs	IDR 36.800.000
Environmental Health Costs	IDR 10.200.000
Service Support Salary Fees	IDR 101.200.000
Total Annual Indirect Cost	IDR 169.294.000
Number of Patients	2062 Patients
Total Indirect Cost Per Patient	IDR 82.102

Tabel 4. Consumable Cost

Key		Cost
Spray alcohol	IDR	100
Alcohol Swabs	IDR	121
Gloves	IDR	2.450
Headcap	IDR	1.200
Methilxantin gel	IDR	3.000
Underpad	IDR	3.200
Drinking water	IDR	1.000
Total	IDR	11.071

Table 5 Total Cost

No	Key		Cost
1	Consumable Cost	IDR	11.071
2	Indirect Cost	IDR	82.102
3	Staff Cost	IDR	48.303
4	Infrastructure Cost	IDR	82.990
TOTAL COST TMS		**IDR**	**224.466**

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