An Analysis of Lean Service for Brachytherapy in Academic Health Center
A Case Study at Y Department of X Hospital

[*]Hanifah Dina Zain[1], Trisacti Wahyuni[2]

[1] *Faculty of Economics and Business, Universitas Indonesia*
[2] *Faculty of Economics and Business, Universitas Indonesia*
[*]*Corresponding author. Email: hdnzain@gmail.com*

ABSTRACT
An increase in health spending in Indonesia does not simultaneously increase general hospital revenues. To overcome this phenomenon, state-owned hospitals as public health service organizations need to reduce costs and increase revenues without reducing their quality to achieve efficiency and effectiveness. For these two main purposes, lean service is used by hospitals to eliminate activities that do not have added value. In this context, this study analyzes the value stream of the brachytherapy income cycle, creates a hierarchy of activities, and eliminates activities that do not have value-added. The research findings are based on service activities provided at Installation Y Hospital X in 2019 and 2020. The findings show that 77% of activities are activities that have value-added and are essential (Column A), but there are two activities that fall to column B (value-added activity but not essential). Six other activities are included in column C, those are activities that do not have value-added but are essential activities. Elimination and time reduction of 2 activities in the scheduling phase by implementing a computerized scheduling system can reduce costs by ±92 million rupiahs a year. Activities in column C or the patient transfer phase can be improved by implementing monitoring and evaluation for time efficiency. The findings of the current study are based on Department Y of X Hospital's service activity to its patients from 2019 to 2021.

Keywords: *lean service; value stream; revenue cycle; value-added activity; academic health center; brachytherapy*

1. INTRODUCTION

Public Service Organization (Badan Layanan Umum, abbreviated as BLU) is an agency within the Indonesian government. Its primary purpose is to provide services to the public by offering goods and/or services that are sold without prioritizing profit-seeking and conducting their activities based on the principles of efficiency and productivity [1]. The greatest financial threat of Indonesian public hospitals is the cost peak from time to time (Figure 1) and the failure of BPJS Kesehatan to pay its bills. BPJS Kesehatan is a state-owned health insurance enterprise with 3-grade premium options for its customers, which the government has subsidized the 3rd grade. In 2020, BPJS Kesehatan reported their failure to pay hospital claims that reached 6.5 trillion rupiahs even though it was lower than their bad debt in 2019 (15.5 trillion rupiahs) [2]. Other than receiving payment from its service activities to the patient, a public hospital also obtains revenue from the state budget (APBN), grants, or non-health service activities (such as training, leasing, cooperation, etc.) [3]. Figure 2 shows the revenue structure of Hospital X in 2019.

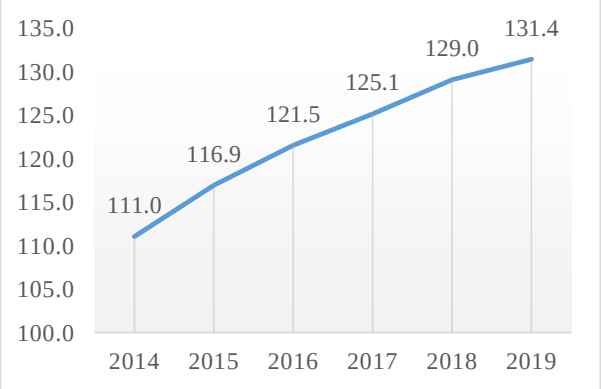

Figure 1. The health service consumer price index of 82 cities in Indonesia from 2014 [4], 2015 [5], 2016 [6], 2017 [7], 2018 [8], 2019 [9]

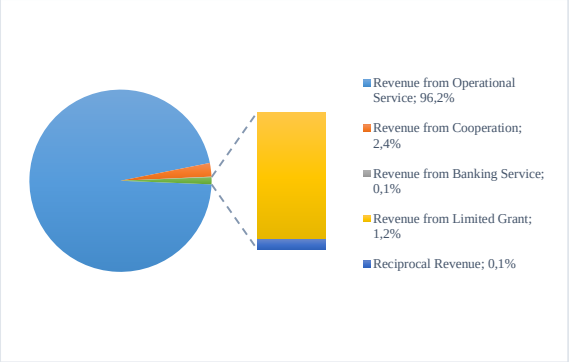

Figure 2. Revenue of Hospital X in 2019

Academic Health Center (AHC) is an integrated health service system for research, education, and excellent patient service [10]. Hospital X is one of 5 AHCs in Indonesia. The main difficulty faced by Hospital X and the Faculty of Medicine at A University in transforming itself into AHC is to synergize the financial and resources owned by the two organizations [11]. The main difference between AHC and non-AHC hospitals in their service activity is the supervision given by the specialists to the residents.

By reviewing the financial performance of 2019 to 2020 in Figure 3, the cost increased 4% higher than the revenue. The cost components of Hospital X (Figure 4) consisted of personnel expenditure (41%), medical equipment capital expenditure (26%), and consumption goods inventory (24%). The other 9% consisted of spending on power and service subscriptions, internal facilities, infrastructure services, building capital expenditures.

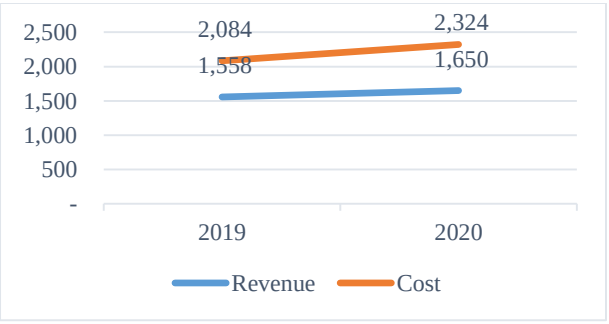

Figure 3. Revenue and Cost of Hospital X (in billion rupiahs) [12]

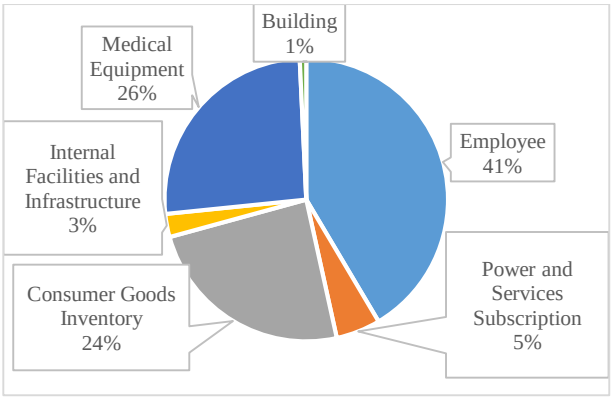

Figure 4. Cost component of Hospital X in 2019 [13]

Department Y's radiation service revenue consists of internal radiation (brachytherapy) and external radiation. Brachytherapy is a type of internal radiation therapy in which seeds, bands, or capsules containing a radiation source are placed in the patient's body, in or near the tumor [14]. External beam radiation therapy comes from a machine that directs radiation to the patient's cancer [15]. Figures 4 and Figure 6 are tools for brachytherapy and external radiation therapy.

Figure 5. High Dose Rate (HDR) Remote Controlled Brachytherapy [16]

Figure 6. Doctors performing brachytherapy session to a patient in Tata Memorial Hospital Photo by S. Shrivastava [17]

Figure 7. External Radiation Therapy Machine [15]

There are two revenue brachytherapy sources: state-owned insurance patients and the VIP patients who paid in cash or company insurance. Furthermore, as Department Y provides two types of brachytherapy procedures (2D and 3D), there are two types of claims to the state-owned insurance company (BPJS Kesehatan). The amount and code of brachytherapy 2D procedure same as external radiation therapy; thereby this study gives an understanding of both external radiation and internal radiation revenue cycle. This study analyzes the implementation of lean service to change the revenue cycle to eliminate non-value-added activities.

2. METHOD

Lean thinking was first developed in the automotive industry to focus on eliminating non-value-added activities from the manufacturing and sales processes so that customers get more benefits. The implementation of lean management will differ between industries [18]. defines There are 2 categories of lean healthcare, namely philosophical lean and activity lean [19]. Lean philosophically consists of the principles of lean and continuous improvement. Lean by activity means activity evaluation and lean enhancement. This study uses lean activity by assessing existing activities and making improvements by eliminating activities that do not have added value.

Value in health care is defined as activities that improve the quality of health care provision and improve patient well-being, thereby leading to improved health outcomes [20]. Added value is the value that exists after a product is further processed [20]. With the aim of continuous improvement, 4 ABCD columns in Figure 7 is composed to illustrate activities that have added value and those that do not, and which are essential activities and that do not [22]. The purpose of this grouping is to move activities from column A to column C or B, and from column C or B to column D, and then eliminate activities in column D.

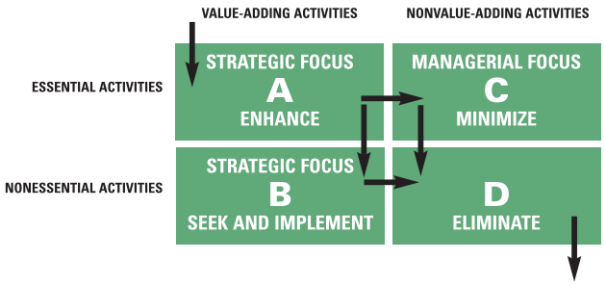

Figure 8. Activity-Based Model for Continues Improvement [22]

Column A consists of activities that have value-added and are essential as the main competencies of the unit. In column A, a unit strategy is needed to improve these key competencies by implementing the latest technology or increasing resource capabilities. Column B is an activity that has value-added but if the activity is eliminated it will not reduce the value-added. The process of eliminating this activity is carried out by redesigning the process. Column C consists of activities that has no value-added but must be carried out for the service to run. Activities in this column are activities that cannot be eliminated but can be minimized. In Column D is activities that should be eliminated immediately. Determining value-added and essential activity will be included in the process to determine the activity performance. Furthermore, the study will measure the impact of reducing non-value-added and non-essential activity on the revenue cycle.

3. DATA COLLECTION

The researcher used primary data collected through interviews, observation, data analysis, and content analysis. The interviews were conducted with several person-in-charge, such as a nurse, medical physic, radiotherapist, and pharmacists to confirm the results of observations and give the researcher a deeper understanding of each profession's role brachytherapy revenue cycle. The observation was performed to understand the interaction between resources and the revenue cycle. Documents and contents analysis was carried out to adjust reality to the standards set by management. The documents consisted of 25 brachytherapy standard operations, 2019 – 2020 budget realization reports, and monthly service reports. The data obtained from the entire process are combined to provide a persuasive essay to answer the existing problem formulation.

Figure 9 visualizes the revenue cycle of brachytherapy and Table 1 are activities consisted in each phase of the cycle obtained from the data collection processes.

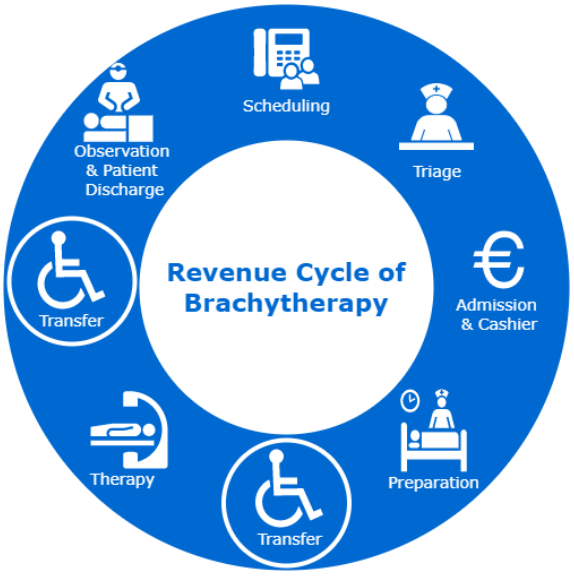

Figure 9. Revenue cycle of brachytherapy service

Table 1. List of Activities

No.	Cycle Phase	Activities	Code
1	**Scheduling**	Checking the requirements for brachytherapy (lab, heart, and chest examination report, also the anesthesia recommendation)	A1
2		Assigning the patient's name to the brachytherapy schedule	A2
3		Confirming the patient's attendance one day before the procedure	A3
4		Sterilizing the clothes and medical equipment	A4
5		Preparing the drugs given after the procedure	A5
6		Issuing INA-CBGs documents	A6
7	**Triage**	Physical examination	B1
8	**Admission & Cashier**	Recording the service code in the Electronic Health Records (EHR) system	C1
9		Billing	C2
10		Printing patient eligibility letter (Surat Eligibilitas Peserta, abbreviated SEP) document for ovoid brachytherapy procedure	C3
11		Recapitulating the total claim value from SEP	C4
12		Checking the completeness of the claim file	C5
13		Submitting the claim file to the Account Payable Team	C6
14	**Planning**	Anesthesia	D1
15		Installing the brachytherapy applicator	D2
16		Taking CT pictures of the patient's pelvis	D3
17		Sending the pelvis CT image to the TPS Oncentra Brachytherapy	D4
18		Determining targets and organs at risk	D5
19		Calculating radiation dose	D6
20		Crosscheck the planning by 2nd medical physics	D7
21		Submit the results of the dose counter to the doctor for the approval process	D8
22		Transferring data to machine	D9
23		Preparing the brachytherapy report	D10
24		Informing the patient about the process, duration of irradiation, and the emergency response	D11
25	**Therapy Session**	Brachytherapy treatment	E1
26	**Observation & Patient Discharge**	Removing attached tools	F1
27		Preparing the patient's lunch	F2
28		Post-action observation	F3
29		Post-action evaluation	F4
30		Informing the patient about the following schedule and drugs consumption	F5
31	**Patient Transfer**	From the short treatment room to the	G1

No.	Cycle Phase	Activities	Code
		brachytherapy treatment room	
32		From the brachytherapy treatment room to the CT Simulator room for pelvic examination	G2
33		From the CT Simulator room to the temporary transit room	G3
34		From the Pelvic CT room to the brachytherapy procedure	G4
35		From the brachytherapy procedure room to the brachytherapy applicator release room	G5
36		From the brachytherapy room to the short treatment room	G6

Due to limited cost of brachytherapy information, it was allocated from the total cost of Hospital X in 2019. Personnel expenses were measured based on the total number of employees and staff involved in brachytherapy services (10 people) compared to the total number of employees and staff of Hospital X which was ±6000 employees. Power and service subscription fees are costs that include electricity, telephone/internet/cable TV, water, outsourcing services (waitresses, runners, etc.), pest control, cleaning services, and building management. The cost of consumer goods inventory is the cost for consumable medical goods (Barang Medis Habis Pakai, abbreviated as BMHP) and pharmaceutical preparations. Ministry of Health Regulation No. 58 in 2014 defines consumable medical goods (BMHP) as medical goods intended for single use, in which listed and regulated by law. Pharmaceutical goods are drugs, medicinal ingredients, traditional medicines, and cosmetics. The amount of use of BMHP and pharmaceutical preparations depends on the number of patients served, for this reason, the cost of power and service subscriptions as well as the cost of supplies of consumer goods are measured based on the bed capacity for brachytherapy (6 beds) compared to the total bed capacity of Hospital X (927 beds). The building and construction costs are calculated by comparing the total area of the service building at Department Y with the building area of Hospital X. The measurement details are described in Table 2.

Table 2. Cost Component and Allocation

Cost	Hospital X	%		Brachytherapy
Cost of Employees	806.155.850.355	$\frac{Employess\ in\ Brachytherapy\ Procedure}{Total\ of\ Hospital\ X\ Employees}$	0,2%	1.343.593.084
Cost of Sources and Services	200.555.348.448	$\frac{Total\ Bed\ of\ Department\ Y}{Bed\ Capacity\ of\ Hospital\ X}$	0,6%	1.298.092.870
Cost of Building & Construction	9.878.969.759	$\frac{Department\ Y\ Service\ Area}{Hospital\ X's\ Width}$	0,8%	78.029.272
Cost of Consumable Inventories	621.005.903.005	$\frac{Total\ Bed\ of\ Department\ Y}{Bed\ Capacity\ of\ Hospital\ X}$	0,6%	4.019.455.683
Cost of Facility and Infrastructure	269.702.738.262	Operational Cooperation with 3rd Party	0%	-
Cost of Medical Equipment	159.111.039.343	Operational Cooperation with 3rd Party	0%	-
Cost of Machine and Devices	17.788.629.520	Operational Cooperation with 3rd Party	0%	-
TOTAL	**2.084.198.478.692**			**6.739.170.909**

Until 2020, the brachytherapy device was in operational cooperation which will become Hospital X's assets only after the Break Even Point. Operational cooperation of equipment is the utilization of public service organization (BLU) assets and/or assets belonging to other parties in the framework of public service organization (BLU) duties and functions, through cooperation between BLU and other parties as outlined in the agreement [23]. Before BEP, Department Y and Hospital X did not bear the maintenance cost nor the cost of the iridium source installment, thereby, there were no costs allocation for facilities and infrastructure services also capital costs for medical equipment.

4. RESULTS

4.1. Activity Analysis

Table 3 distinguish the recorded activities from the unrecorded activities during the service. For those unrecorded activities, the value stream collected by observing the activities and the time spent for those activities. Meanwhile, for the other recorded activities, the author uses monthly activity reports to complete the time-motion study.

Table 3. List of Recorded and Unrecorded Activities

Recorded	Unrecorded	
D1	A1	D11
D2	A2	G1
D3	A3	G2
D4	A4	G3
E1	A5	G4
D5	A6	G5
D6	C1	G6
D7	C2	F2
D8	C3	F4
D9	C4	F5
D10	C5	
F1	C6	
F3	B1	

A time-motion study has been used to measure the performance of each activity at The University of North Carolina Hospitals and Clinics (UNCH) [24]. In addition, it was argued that time-motion studies can help determine the sequence of activities, workflow fragmentation, and identify main activities [25]. Time-motion study is a time recording table used to explain the time spent on each activity. The results of the calculations and field observations are described in Table 4.

Table 4. Time Motion Study

Cycle Phase	Activity	Time Spent for Each Patient (in minute)	Total
Scheduling	A1	5	70
	A2	3	
	A3	10	
	A4	15	
	A5	35	
	A6	2	
Triage	B1	15	15
Admission and Cashier	C1	10	28
	C2	5	
	C3	4	
	C4	2	
	C5	3	
	C6	4	
Planning	D1	24	139
	D2	13	
	D3	10	
	D4	2	
	D5	25	
	D6	40	
	D7	4	
	D8	10	
	D9	3	
	D10	3	
	D11	5	
Therapy Session	E1	15	15
Observation and Patient Discharge	F1	5	176
	F2	3	
	F3	158	
	F4	5	
	F5	5	
Patient Transfer	G1	10	144
	G2	25	
	G3	23	
	G4	76	
	G5	5	
	G6	5	
TOTAL			**587**

A cycle of brachytherapy procedure spent 587 minutes. Observation phase, which was the longest, took 176 minutes (30%). Patient transfer from one procedural room to the other took 144 minutes (24.5%) and the preparation phase spent 139 minutes (23.6%). The shortest phase was therapy session which only took 15 minutes (0.3%).

In a brachytherapy cycle that begin from the scheduling process until the delivery of patient billing documents, is carried out for a minimum of 3 days and a maximum of 6 days. The first day is for the scheduling phase, the second day is D-1 of the therapy session where the nurse contacts the patient and prepares the One Day Care room, drugs, and other pharmaceutical goods. The third day is the day where therapy takes place starting from the triage process until the patient's return and then the billing documents is sent to the payable verification team. Figure 10 describes the revenue stream of Department Y's brachytherapy procedures.

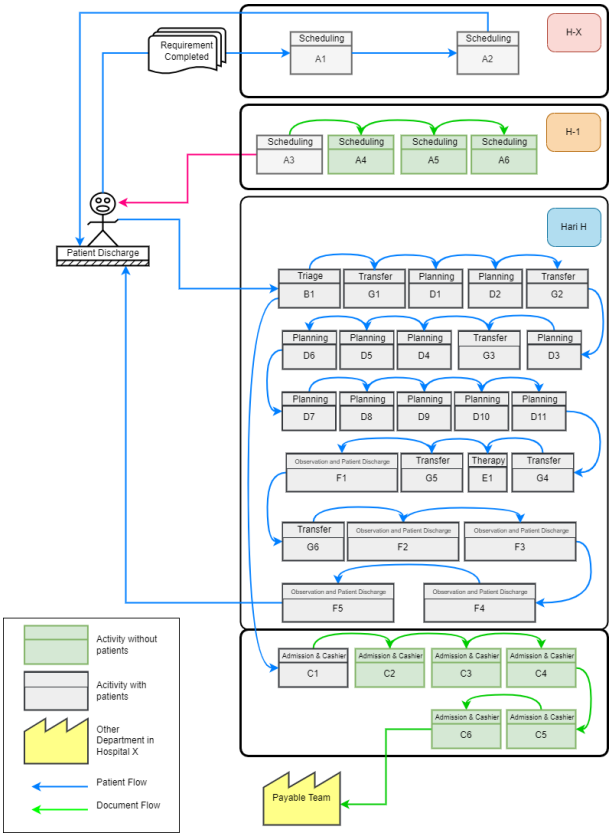

Figure 10. Documents and Patient Stream of Brachytherapy Procedure

4.2. Value-added Activity

In determining value-added and non-value-added activities, the activities carried out by radiographers has been directly used as value-added activities for radiology services at an Academic Health Center [26]. Meanwhile, a recent study the diversification of the two categories is divined by comparing the effect of each activity on patient waiting time to determine value-added and non-value-added activities [20]. This study implements Agrawal's 4-column classification model as in Figure 8 above to eliminate non-value-added and non-essentials activities in column D and improving those in column A. In addition, implementing the model will differentiate this study to the previous study. The four-column hierarchy of activities in Table 5 are:

A. Activities that have value-added and are essential or the main activities of the brachytherapy service.

B. Activities that have value-added but are not essential activities or without these activities, the main activity of the brachytherapy service is not affected.

C. Activities that do not have value-added but are essential activities. Those activities do not add value to the service but must be carried out to keep the brachytherapy service running.

D. Activities that do not have value-added and are not essential, are activities that must and can be directly eliminated because they do not add value nor support the main activity.

Table 5. Hierarchy of Activities

	Value-Added	**Non-Value-Added**
Essentials	**A** A1, A3, A4, A5, A6, B1, C1, C2, C3, C5, C6, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, E1, F1, F2, F3, F4, F5	**C** G1, G2, G3, G4, G5, G6
Non-Essentials	**B** A2, C4	**D**

There is no activity that falls into column D and can be eliminated directly. This condition means all activities are supporting the main activity. Nevertheless, there are two activities falls in column B and six in column C. Activity in column B take up to 1% of the time, need adjustments to be moved to column D and then eliminated.

Value-added but non-essential activities consist of transferring patients from one room to another. This activity occurs because the One Day Care (ODC) ward is located on the 2nd floor, while the brachytherapy treatment room, CT room, and C-Arm room are located on the 1st floor. The transfer of patients from the ODC room to the brachytherapy treatment room will pass through a ±50m long hallway and an elevator.

28 out of 36 activities are value-added and essential activities in column A. Those activities consume 488 minutes or 77% of the total time in a revenue cycle. The planning phase is the most prolonged activity (D1 to D11 took 134 minutes), while the therapy session and triage phases are the shortest (15 minutes).

5. DISCUSSIONS

This study analyzes the lean service of the brachytherapy revenue cycle by reducing time spent or eliminating non-value-added and non-essential activity for improving the activity continuously. Those activities subjected to improvement are A3 from scheduling phase in column A, A2 and C4 in column B and all activities from transfer patients' phase in column C.

The researcher suggesting the use of database because it will simplify the flow of services. The patient database can be used to eliminate patient scheduling activities that were previously done manually by writing names on the schedule book (A2). In addition, information from the database can be used as a reference in contacting patients on H-1 action (A3). As both processes are conducted manually by writing down patient's name to an empty schedule and searching for patients' contact numbers from the medical records, it was extensive and challenging. Some computerized activities, such as sending patient pictures or billing are only take 2-5 minutes. If the time to contact the patient (A3) can be reduced from 10 minutes to 5 minutes and the manual scheduling can be eliminated, the cost of brachytherapy can be reduced by ±92 million rupiah a year or Rp71.033 per patient. This was calculated by multiplying the reduced time % to the cost of brachytherapy in 2019.

$$\frac{8\ minutes}{587\ minutes} \times Rp6.739.170.909 = Rp91.845.600$$

$$\frac{8\ minutes}{587\ minutes \times 1293\ patients} \times Rp6.739.170.909 = Rp71.033$$

As for the transfer patient phase that spent 24% of the total cycle time, eliminating the activities is not possible because the costs of room, machine and building rearrangement would be higher than the benefits. However, monitoring and evaluating patient transfer activity would reduce the time and boost patient satisfaction. Figure describes the service and documents flow if the database was implemented as for Table 6 emphasizes the time before and after lean.

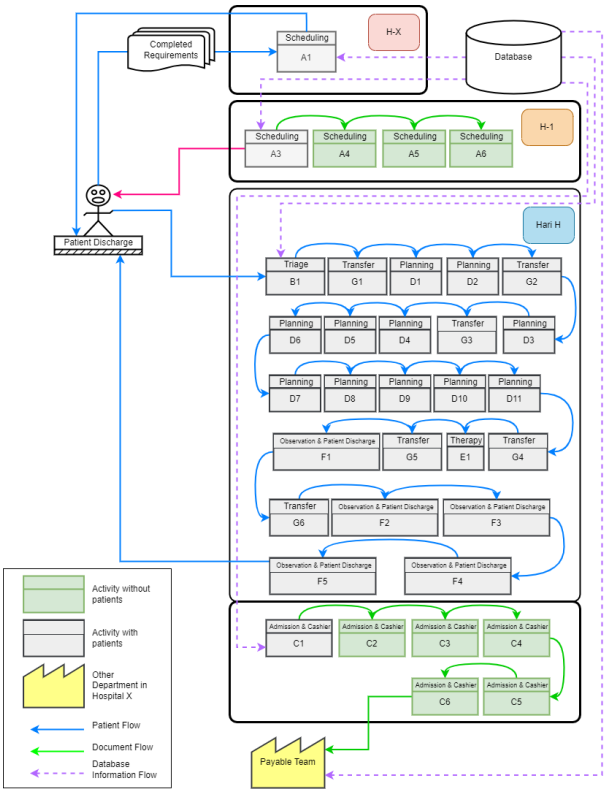

Figure 11. Service and document flow post lean

Table 6. Pre-Lean and Post Lean Cycle Time

CYCLE PHASE	PRE-LEAN	POST LEAN
Scheduling	70	62
Triage	15	15
Admission and Cashier	28	26
Planning	139	139
Therapy Session	15	15
Observation and Patient Discharge	176	176
Transfer Patient	144	144
TOTAL CYCLE TIME	**587**	**577**

By becoming lean, a service cycle can be reduced by 10 minutes or equal to 60 minutes (1 hour) if the maximum capacity of 6 patients per day is met. The scheduling stage can be reduced by 8 minutes which comes from the elimination of A2 activity and improvement of A3 activity. The patient transfer phase can be reduced by 2 minutes because of monitoring and evaluation process.

This research will be resourceful to those seeking to understand the brachytherapy revenue cycle and the lean service analysis for it. Further research could elaborate on several radiation procedures offered in the department. This study is limited because the brachytherapy financial report is not available for research and publication. Further, there could be information bias as the hierarchy of activities was designed only by the researcher. In addition, the nature of the object study as the central hospital in Indonesia made this study challenging to compare to other hospitals' data.

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