Rule Based System for Medicine Inventory Control Using Radio Frequency Identification (RFID)

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Abstract. *Rule based system* is very efficient to ensure stock of drug to remain available by utilizing Radio Frequency Identification (RFID) as input means automatically. This method can ensure the stock of drugs to remain available by analyzing the needs of drug users. The research data was the amount of drug usage in hospital for 1 year. The data was processed by using ABC classification to determine the drug with fast, medium and slow movement. In each classification result, rule based algorithm was given for determination of safety stock and Reorder Point (ROP). This research yielded safety stock and ROP values that vary depending on the class of each drug. Validation is done by comparing the calculation of safety stock and reorder point both manually and by system, then, it was found that the mean deviation value at safety stock was 0,03 and and ROP was 0,08.

1 Introduction

Rule based system uses explicit knowledge and provide certain flexibility in terms of altering knowledge taken [1]. It was once used in ship design research and was able to create principles for machine layout architecture by concerning the relationship among equipment and ship-owner needs, insight, design, etc. In addition, rule based system that has been developed become more common and can be applied to a wider product [1], [2].

Rule based system is highly efficient and achieves an accuracy of up to 94.29% in research aiming at estimating tomato ripeness based on the color. The set of rules is generated automatically from a set of derived features using a decision tree. Expert knowledge is quickly converted into computer programs in the form of if-then-rules. Moreover, expert knowledge also reduces the search space while optimizing the system [3].

The use of instructions is needed in the pharmaceutical world, for example in the field of drug supply, which is the most important factor in the process of health care. Poor management of drugs will result in stagnant drug stocks (excess supply of medicines) and stockout (deficiency or void of drug supply). Stagnant drug supplies have risks in expiration and damage if they are not stored properly. The stagnant and stockout drugs will have an impact on health cares [4].

In inventory systems, the use of RFID technology is believed to have a major impact on revenue increase [5], such as in clothing retail industries, health industries, education, etc. The application of RFID technology used in healthcare apparel management research can also save

up to 30% of total cloth spending. In addition, RFID has also been used in research to ensure that patients' beds and mattresses can be cleaned properly with efficient time and cost, and can shorten work time [5], [6].

Hospital is a health service institution that provides inpatient, outpatient and emergency care services. Hospitals together with their sub-organizations must be managed as well as possible in order to provide health services as much as possible. Pharmacy service is a supporting service and also a main revenue center. This is because more than 90% of health services in hospitals use pharmaceutical supplies, such as medicines, chemicals, medical devices, medical devices and medical gases [7].

The management of drugs in hospitals is routine, urgent and periodic activities which means they must always be available and should not be void. In other words, stockout can disrupt the operational activities of the hospital. In addition, the drug stockout may result in a loss of having to order and immediately deliver medication with higher price than buying from a supplier [7].

Some previously unknown information or knowledge can be found from the data. The data has the potential as supporting evidence to reflect some important patterns by using modeling techniques. Moreover, the model can be revised automatically because the database can be updated in real time when modeling techniques are used. Data can be represented as a rule. Basic rules can be used to manage regulations effectively and efficiently by noticing storage and retrieval. The most commonly used method for representing rules is the *rule based system*

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[8]. Always Better Control (ABC) analysis is one way of controlling inventory by sorting and classifying the type of goods. Research in India used ABC analysis and Vital Esensial Non-esensial (VEN) analysis for efficient drug management. The results obtained from ABC-VEN matrix analysis showed that only 21% of 1536 stock items of drugs belonging to class A require maximum attention [9].

From the above explanation, the *rule-based system* is very efficient and can help in the process of controlling the inventory system by combining ABC analysis in it. In addition, RFID is capable of performing the process of reading data automatically that can be used for the identification process of drug data. Therefore this research will apply *rule-based system* method to know safety stock of drug supplies using RFID input system.

2 Methods

Research has several stages to obtain maximum results, including use-value analysis using ABC classification, Safety Stock (SS) and Reorder Point (ROP) calculations, drug supply system analysis and drug supply system implementation.

2.1 Analysis of use-value by ABC classification

The ABC classification is performed by the analysis of drug use-value. The drug use-value is obtained from the amount of usage in one period, then sorted from the highest usage amount to the lowest usage amount. After the item data is sorted, the percentage of usage, then, is calculated with the following calculation [7].

$$\text{Percentage of usage} : \left(\frac{x}{\Sigma x}\right) \times 100\% \quad (1)$$

From the above formula, it is known that x is the amount of usage per item of drug and Σx is the total amount of drug usage. After the percentage of usage is calculated, the categories of preparations are made in accordance with the cumulative percentage of 70%, 20%, and 10% [20]. The steps used in the ABC classification are:
   a. Counting the number of monthly usage in 2016 for each item.
   b. Sorting usage values, ranging from the largest to the smallest, then a percentage of the value of usage is made.
   c. Finding the cumulative value of usage by summing the value of the percentage of usage that has been ranked. Group A with a percentage of 70%, group B with a percentage of 20% and group C with a percentage of 10%.

2.2 Calculation of Safety Stock (SS) and Reorder Point (ROP)

The importance of calculating safety stocks due to frequent new orders after the lead time is too late (e.g. late travel due to traffic jams or hit by a disaster) and the

frequent increase in production demand. This situation will result in the stock out which will further decrease the level of service at hospitals. Due to the amount of investment for safety stock inventory especially for the most frequently used drugs (class A) then safety stock is prioritized to vital medicines. The way to calculate the amount of safety stock by using VEN system guidance is shown in Table 2.1. [7]

Tabel 2.1 Determination of safety stock using VEN guideline

| Groups of VEN	Safety Stock
Vital	20% of last usage
Essential	10% of last usage
Non essential	5% of last usage

Factors affecting ROP are lead time, average usage and safety stock, can be calculated by the formula [10]:

$$\text{ROP} = (LT \times d) + SS \quad (2)$$

With ROP as the reorder point, LT is the lead time which is the time required when the drug is ordered until the drug arrives at hospital. Then d is the average usage in a given period of time. And SS is safety stock which is an additional supply to protect and preserve the possibility of material deficiency [10].

2.3 Analysis of drug supply system

A shortage and excess supply of drugs commonly happen in hospitals. This is caused by supply planning that does not suit the patients' needs. By applying *rule-based system* method, drug supply planning is made based on the needs of patients.
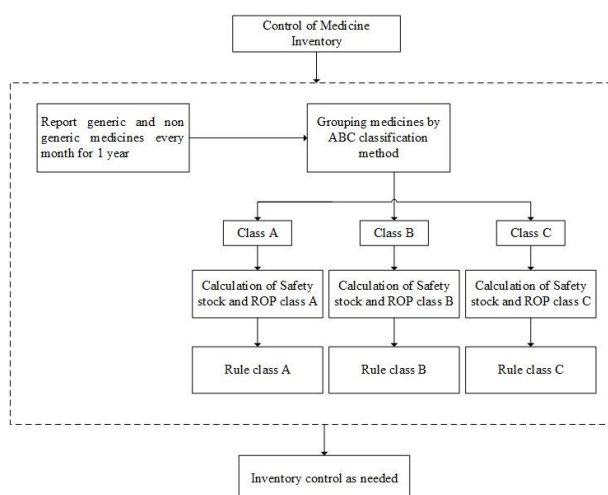
Fig. 1. Theoretical framework

The data used are reports of drug use which will be processed using ABC classification and *rule based system* method. RFID technology serves to accelerate the process of *input* and *output* data and avoid errors. RFID is used to *scan* every incoming and used drug, so the

officers do not need to enter the drug data to accelerate the process of drug entry. There are two users involved in the system, in the warehouse and hospital pharmacy. The description of the research flow lies in the theoretical framework as shown in Figure 1.

2.4 Implementation of drug supply system

The result of data analysis using ABC classification is fast, moderate and slow moving drugs. After classification is done, next is to apply *rule based system* method to know safety stock and ROP from each type of drug based on fast moving, moderate and slow moving drug classification. The procedures for performing decision tree analysis are:

1. Identifying all decision points and other possibilities that will occur
2. Identifying decision alternatives for each decision point
3. Identifying what might happen from every decision
4. Creating a tree diagram showing the order of decisions and events that may occur

And the rule based will be shown with the decision tree in Figure 2.
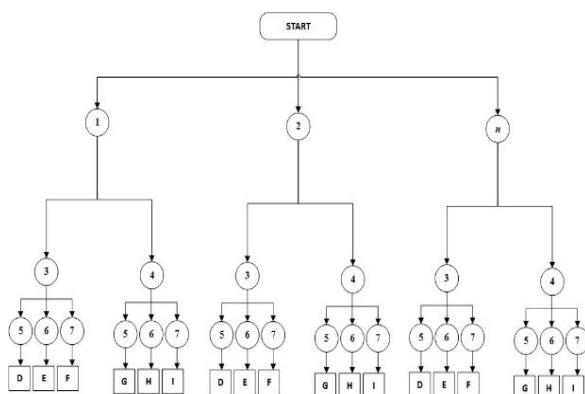
Fig. 2. Decision Tree

In the decision tree, it shows number 1, number 2 to n, where n = 12 which is the number of months of the year. Then number 3 is a generic drug and number 4 is a non generic drug. Then number 5 is the classification of fast moving drugs, number 6 is the classification of moderate drugs and number 7 is the classification of slow moving drugs. And D is the rule for fast moving drug classification, E is the rule for moderate drug classification and F is the rule for the classification of slow moving drugs. The rule description of the decision tree will be shown in Table 1.

Table 1. Explanation of rule of decision tree

Alphabet	Rule
D	**IF** Medicine out of January **AND** generic medicine **AND** fast moving **THEN** safety stock 20% of last usage
E	**IF** Medicine out of January **AND** generic medicine **AND** moderate **THEN** safety stock 10% of last usage
F	**IF** Medicine out of January **AND** generic medicine **AND** slow moving **THEN** safety stock 5% of last usage
G	**IF** Medicine out of January **AND** non-generic medicine **AND** fast moving **THEN** safety stock 20% of last usage
H	**IF** Medicine out of January **AND** non-generic medicine **AND** fast moving **THEN** safety stock 10% of last usage
I	**IF** Medicine out of January **AND** non-generic medicine **AND** fast moving **THEN** safety stock 5% of last usage

3 Results and Discussion

3.1 Calculation process of ABC classification

To calculate ABC classification based on use-value, the steps are as follows:

a. Calculating the monthly usage amount in 2016 for each drug item by using formula (1) as shown in Table 2.

Table 2. The calculation of the amount of usage

NO	MEDICINE NAME	VALUE	AMOUNT USAGE	AMOUNT USAGE (%)
1	ASAM MEFENAMAT TAB 500 MG	TABLET	2370	6,34%
2	METFORMIN TAB 500 MG	TABLET	2283	6,11%
3	PARACETAMOL TAB 500 MG	TABLET	2071	5,54%
4	RINGER LAKTAT LAR INF 500 ML	PLABOT	1913	5,12%
5	VITAMIN B COMPLEX	TABLET	1299	3,48%
6	OMEPRAZOL KAP 20 MG	CAPSULE	1102	2,95%
7	RANITIDIN TAB 150 MG	TABLET	1031	2,76%
8	CEFADROXIL KAP 500 MG	CAPSULE	943	2,52%
9	VITAMIN C 50 MG TAB	TABLET	834	2,23%
10	CIPROFLOXACIN TAB 500 MG	TABLET	795	2,13%
			...	
196	SALEP KULIT BASITRASIN 500 IU/G	TUBE	1	0,00%
	TOTAL		**37353**	

b. Sorting usage values, ranging from the largest to the smallest, then a percentage of usage values is made as shown in Table 3.
c. Finding the cumulative value of usage by summing the value of the percentage of usage that has been ranked. Class A with a percentage of 70%, class B with a percentage of 20% and class C with a percentage of 10%.

So from the classification of ABC, the drugs in class A include the vital group with the calculation of safety stock of 20% of the past use, class B includes the essential group with the calculation of safety stock of 10% of past use and class C includes non-essential group with the calculation Safety stock of 5% of the usage then shown in Table 3. For ROP calculation has been determined by the formula according to the average monthly usage and safety stock in each class, as shown in Table 4.

Table 3. Result of safety stock calculation in each class

NO	MEDICINE NAME	VALUE	AMOUNT USAGE	AMOUNT USAGE (%)	CLASS	SS
1	ASAM MEFENAMAT TAB 500 MG	TABLET	2370	6,34%	A	474
2	METFORMIN TAB 500 MG	TABLET	2283	6,11%	A	457
3	PARACETAMOL TAB 500 MG	TABLET	2071	5,54%	A	414
4	RINGER LAKTAT LAR INF 500 ML	PLABOT	1913	5,12%	A	383
5	DIAZEPAM 2 MG TABLET	TABLET	310	0,83%	B	31
6	CEFTRIAXON 1 GR INJEKSI	VIAL	308	0,82%	B	31
7	ONDANSETRON INJ 4 MG/2 ML	AMPUL	297	0,80%	B	30
8	LOPERAMID TAB 2 MG	TABLET	94	0,25%	C	5
9	LISINOPRIL TAB 10 MG	TABLET	90	0,24%	C	5
10	PAPAVERIN TAB	TABLET	90	0,24%	C	5

Table 4. Result of ROP calculation in each class

NO	MEDICINE NAME	VALUE	AMOUNT USAGE	AMOUNT USAGE (%)	CLASS	SS	d	ROP
1	ASAM MEFENAMAT TAB 500 MG	TABLET	2370	6,34%	A	474	79	632
2	METFORMIN TAB 500 MG	TABLET	2283	6,11%	A	457	76	609
3	PARACETAMOL TAB 500 MG	TABLET	2071	5,54%	A	414	69	552
4	RINGER LAKTAT LAR INF 500 ML	PLABOT	1913	5,12%	A	383	64	510
5	DIAZEPAM 2 MG TABLET	TABLET	310	0,83%	B	31	10	52
6	CEFTRIAXON 1 GR INJEKSI	VIAL	308	0,82%	B	31	10	51
7	ONDANSETRON INJ 4 MG/2 ML	AMPUL	297	0,80%	B	30	10	50
8	LOPERAMID TAB 2 MG	TABLET	94	0,25%	C	5	3	11
9	LISINOPRIL TAB 10 MG	TABLET	90	0,24%	C	5	3	11
10	PAPAVERIN TAB	TABLET	90	0,24%	C	5	3	11

3.2 Evaluation and validation of calculation result

Verification is done by comparing manual calculations to perform ABC classification with calculation result using system. The data used for verification are 20 random data of generic drug types taken from each class, as shown in Table 5.

Table 5. Verification result of ABC classification

No	MEDICINE NAME	Calculation Result of ABC Manual Classification			Calculation Result of ABC Classification Using System			Conformity
		Fast Moving	Moderate	Slow Moving	Fast Moving	Moderate	Slow Moving	
1	2	3	4	5	6	7	8	9
1	AMOXICILLIN TAB 500 MG	√			√			CORRESPONDING
2	RINGER LAKTAT LAR INF 500 ML	√			√			CORRESPONDING
3	RANITIDIN TAB 150 MG	√			√			CORRESPONDING
4	FUROSEMID TAB 40 MG		√			√		CORRESPONDING
5	RAMIPRIL TAB 10 MG			√			√	CORRESPONDING
6	AMLODIPIN TAB 5 MG	√			√			CORRESPONDING
7	IBUPROFEN TAB 400 MG	√			√			CORRESPONDING
8	ASAM TRANEKSAMAT TAB 500 mg		√			√		CORRESPONDING
9	COTRIMOXAZOLE TAB 480 MG		√			√		CORRESPONDING
10	ASAM FOLAT 1 MG TAB		√			√		CORRESPONDING
11	ANTASIDA DOEN TAB		√			√		CORRESPONDING
12	CIPROFLOXACIN INF 2 MG/ML			√			√	CORRESPONDING
13	PROPANOLOL TAB 40 MG			√			√	CORRESPONDING
14	CO-AMOXICLAV 625 MG			√			√	CORRESPONDING
15	BETAHISTIN TAB	√			√			CORRESPONDING
16	CEFIXIME KAP 100 MG	√			√			CORRESPONDING
17	AMITRIPTILIN TAB 25 MG			√			√	CORRESPONDING
18	OMEPRAZOL INJ 40 MG / VIAL			√			√	CORRESPONDING
19	FLUNARIZIN TAB 5 MG			√			√	CORRESPONDING
20	CIPROFLOXACIN TAB 500 MG	√			√			CORRESPONDING

Next, verification for safety stock and ROP calculation is performed. The verification is done by using the mean deviation formula by calculating the difference between system calculation and manual calculation, then searching for the average of data difference and dividing the amount of data used to perform the verification. The verification results show that the average deviation generated for the safety stock is 0.03 and for the ROP is 0.08 as shown in Table 6.

Table 6. Verification of safety stock and ROP calculation

No	MEDICINE NAME	Manual ABC Classification Calculation Result		Calculation Result of ABC Classification Using System		Difference	
		Safety Stock	ROP	Safety Stock	ROP	Safety Stok	ROP
1	2	3	4	5	6	7	8
1	AMOXICILLIN TAB 500 MG	106	142	107	143	1	1
2	RINGER LAKTAT LAR INF 500 ML	383	510	383	511	0	1
3	RANITIDIN TAB 150 MG	206	275	207	277	1	2
4	FUROSEMID TAB 40 MG	15	26	16	28	1	2
5	RAMIPRIL TAB 10 MG	2	4	2	4	1	1
6	AMLODIPIN TAB 5 MG	101	134	101	135	0	1
7	IBUPROFEN TAB 400 MG	92	123	93	125	1	2
8	ASAM TRANEKSAMAT TAB 500 m	23	39	24	40	1	1
9	COTRIMOXAZOLE TAB 480 MG	16	26	16	28	0	2
10	ASAM FOLAT 1 MG TAB	15	26	16	28	1	3
11	ANTASIDA DOEN TAB	13	22	13	23	0	1
12	CIPROFLOXACIN INF 2 MG/ML	5	11	4	10	1	1
13	PROPANOLOL TAB 40 MG	5	11	4	10	1	1
14	CO-AMOXICLAV 625 MG	4	10	4	10	0	0
15	BETAHISTIN TAB	71	95	72	96	1	1
16	CEFIXIME KAP 100 MG	85	113	85	115	0	2
17	AMITRIPTILIN TAB 25 MG	4	9	4	10	0	1
18	OMEPRAZOL INJ 40 MG / VIAL	4	8	4	10	0	2
19	FLUNARIZIN TAB 5 MG	3	7	4	10	1	3
20	CIPROFLOXACIN TAB 500 MG	159	212	159	213	0	1
				AVERAGE DEVIATION		0,03	0,08

4 Conclusions

The supply control system can identify drugs with fast, moderate and slow movements by applying the ABC classification method. From the results of experiments in this study, ABC classification generated from the system has been in accordance with the results of manual ABC classification calculation. The rule-based system method can be applied to know safety stock and ROP on each drug based on its class. This is evident from the test results indicating that the average deviation produced is relatively small, i.e. for safety stock with an average deviation of 0.03 and for ROP with an average deviation of 0.08.

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