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Analysis And Improvement Of Drug Supply Chain Risk Management Using House Of Risk (HOR) And Analytical Hierarchy Process (AHP) Approaches

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Abstract. Risk management is required because there is always a chance that problems will develop in supply chain activities. In industries engaged in health services, such as PT. Rukun Putera Bersama, in supply chain activities for the procurement of drugs, there is an opportunity for risks to arise. Therefore, it is necessary to carry out a risk analysis and design mitigation actions to mitigate the risks that are likely to arise in the drug procurement supply chain. This research was conducted using the House of Risk (HOR) model and the Analytical Hierarchy Process (AHP). After conducting the research, it was found that there were 23 risk events and 15 risk agents. There are 10 risk mitigation actions in the drug procurement supply chain. Furthermore, from the 10 mitigation actions, it is reprocessed using AHP. The results of AHP weighting obtained the best alternative strategy, namely the use of digital pharmacy management information system software to regulate and monitor pharmacy management performance.

1 Introduction

Risks associated with supply chain management operations can have an impact on how smoothly a company's supply chain operates. The possibility of an event disrupting the company's supply chain operations is known as supply chain risk [1]. In order to take precautions against these risks, supply chain risk management is required [2]. There is an effort to control risk, often known as risk management, with regard to the potential for risk to arise in supply chain activities. In order to maintain the integrity of the supply chain system, risk management is crucial. Because one can never predict the future, risk management is crucial in supply chain operations [3].

PT Rukun Putera Bersama is a company engaged in the health industry, selling services for medical devices, pharmacy stores (pharmacies), and laboratories. In carrying out its business, of course, PT Rukun Putera Bersama is inseparable from the supply chain management (SCM) process, such as in the drug procurement process. Supply chain activities for drug procurement are, of course, related to drug suppliers or suppliers in this condition; these suppliers are known as Pharmaceutical Wholesalers (PBF). In the drug procurement process, there are often obstacles in the supply chain activities. Such as supply uncertainty due to soaring demand and drug delivery lead times from suppliers. This will certainly be detrimental to the company, both in terms of time and cost. Therefore, it is necessary to carry out a risk analysis and design a risk mitigation strategy to minimize risks or disruptions that may arise in the supply chain.

This information will be used to identify risks, risk agents that can cause risks to occur, and suggested handling strategies that can be used to reduce the likelihood that risk agents will appear in a supply chain for the purchase of drugs using the House of Risk (HOR) method to determine priority management strategies [4]. In the meantime, strategic priorities are chosen using the Analytical Hierarchy Process (AHP), which takes into account expert views based on a number of factors.

2 Research Method

2.1 House Of Risk (HOR)

The House of Risk (HOR) method combines the FMEA (Failure Mode and Effect Analysis) strategy with the HOQ (House of Quality) method. With the goal of reducing the source of risk from already present risks in the supply chain process, this strategy is used to establish risk priorities that must be carried out successfully [5]. The House of Risk (HOR) concept is as follows [6]: (1) The House of Risk (HOR) 1 is used to decide which risk agent needs to be addressed first in order to take preventive action. (2) In an effort to develop a mitigation method for categorizing priority risk agents, House of Risk (HOR) 2 is applied.

2.1.1 Phase 1 of House of Risk

The steps for completing HOR 1 are as follows [7]:

- a. Identify risks that occur in each supply chain, which includes plan, source, make, deliver, return, and enable.
- b. Estimating the impact of each existing risk, using a scale of 1 to 10, to determine the impact caused. Extreme impacts are indicated by the

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- number 10. The severity level is placed on the right of the table and is expressed as S_j .
- c. Doing weighting on each risk source with a scale of 1 to 10, a scale of 10, indicates that the risk agent occurs frequently. The risk agent is placed on the top row of the table with a notation connected to the bottom line of the table O_j .
 - d. Developing a relationship matrix, linking each risk source and each risk event by assigning a value (0, 1, 3, 9) to each risk event R_{ij} , where a value of 0 indicates low, 1 indicates low, 3 indicates middle, and 9 indicates high.
 - e. Calculates the potential pool of risk by calculating values ARP (*Aggregate Risk Potential Of Risk Agent* $j = ARP_j$).

$$ARP_j = O_j \sum S_j R_j \quad (1)$$

ARP_j : *Aggregate Risk Potential*
 O_j : *Occurrence*
 S_j : *Severity*
 R_j : *Relationship*

- f. Make a ranking of each existing risk source based on potential sources of risk using a pareto diagram.

2.1.2 Phase 2 of House of Risk

House of Risk Phase 2 will provide high-priority proactive action suggestions (full assistance) to save costs and prevent harm. The second stage of the house of risk contains the following stages [8]:

- a. Determine the priority causes of risk using pareto analysis with the 80/20 concept.
- b. Identification of forms of mitigation measures for the relevant prevention efforts. Mitigation measures and explained with signs PA_k .
- c. E_{jk} marks with a scale of 0, 1, 3, or 9 are used to assess the relationship between each mitigation and each risk agent, where a value of 1, 3, or 9 indicates a low, medium, or high value, and a value of 0 indicates no relationship.
- d. The following formula is used to determine the overall effectiveness score for each mitigation action:

$$TE_k = \sum i ARP_j E_{jk} \quad (2)$$

- e. Estimated degree of difficulty of each action. A scale weight of 3 indicates that mitigation activities are easy to practice; a scale weight of 4 indicates that mitigation actions are a bit more challenging to practice; and a scale weight of 5 indicates that mitigation actions are difficult to practice. Financial requirements and the amount of resources required should be considered when determining the degree of difficulty in implementing mitigation measures.

- f. The method for calculating the overall value of the success of mitigation actions against the level of difficulty is as follows:

$$ETD_k = TE_k / D_k \quad (3)$$

- g. Prioritizing mitigation actions, the mitigation action with the largest ETD_k value is at the top.

2.2 Analytical Hierarchy Process (AHP)

This study looks at one way to choose the priority strategy to be used, the AHP method. The benefit of AHP is that it combines qualitative and quantitative criteria while conducting parallel analysis [9]. The following is a description of the finishing process used in this approach:

1. Data collection is based on the problems encountered, such as determining criteria, sub-criteria, and alternatives.
2. Decomposition, namely identifying problems and modeling the AHP structure.
3. Perform pairwise comparisons of alternatives, sub-alternatives, and criteria. By comparing the relative significance of various factors, comparisons are made. The ranking between one option and another is then determined using a comparison value.
4. Priority synthesis involves ranking criteria, sub-criteria, and alternatives according to their relative relevance.
5. Each pairwise comparison matrix is subjected to a consistency test. This formula is used to determine CI and CR values in the consistency test.

$$CI = \frac{(\lambda_{maks} - n)}{(n-1)} \quad (4)$$

$$CR = \frac{CI}{RI} \quad (5)$$

The random consistency index is called the RI. The matrix is said to be consistent if the CR value is 10%. Pairwise comparisons are repeated if the matrices used for pairwise comparisons are inconsistent.

3 Results and Discussion

3.1 House of Risk (HOR) Mapping Phase 1

The identification of risk events and risk agents is the initial stage in HOR phase 1 [10]. Field observations, interviews with firm management, questionnaire results, and group brainstorming with relevant managers are used to identify risk events and risk agents or causes of risk. The SCOR model, which is broken down into the business plan, source, make, deliver, return, and enable sub-processes, is used to identify the company's business processes and supply chain activities [11, 12]. This business process' section seeks to identify potential risk areas. The responsible component of each business process is also recognized,

and the risk parameters for each business process are listed as well. Table 1 displays all of the outcomes.

Table 1. Mapping Supply Chain Activities For Drug Procurement In The SCOR Model

Business Processes (SCORE)	Sub Processes	Risk Event	Code	
<i>Plan</i>	Drug Procurement Planning	Miscalculations in planning	E1	
		Change order planning	E2	
		Discrepancy between stock and record keeping	E3	
	Purchasing Execution	Incorrectly wrote the type and amount of medicine requested in the order letter	E4	
	Drug Supply Monitoring	Uncertainty orders from consumers	E5	
		Sudden changes in drug stock	E6	
		Unsold/expired product	E7	
<i>Source</i>	Purchase drugs from suppliers	There is broken or destroyed medicine	E8	
		Discrepancies in the number of drugs ordered and the drugs that come	E9	
		Slow service response from Pharmaceutical Wholesalers	E10	
		Drugs are not available when there is a purchase from consumers	E11	
		Increase in drug prices from Pharmaceutical Wholesalers	E12	
		Drug storage	Warehouses are unable to store drug supplies	E13
		Delivery of drugs by suppliers	Lack of standard delivery operations	E14
	Delay in getting the drug to the pharmacy		E15	
	Drug product inspection	The quality of the drug product is not as requested	E16	
		Incomplete shipping documents	E17	
<i>Return</i>	Send the wrong item for exchange	Return of drugs to pharmaceutical wholesalers because the expiration date is too close	E18	
		Drug return claims are not accepted by pharmaceutical wholesalers	E19	

		Drugs sent by pharmaceutical wholesalers are exchanged	E20
<i>Enable</i>	Information, resources, and contracts for supply chain operations	Poor coordination of dispensary workers	E21
		Drug regulatory and recall issues	E22
		Weakness in contract agreements between pharmacies and pharmaceutical wholesalers	E23

Determine and quantify risk occurrences and risk agents using Table 1's mapping process results using the SCOR model. This measurement is done to ascertain the risk event identification results' severity scale and the risk agent's occurrence scale. Distribution of questionnaires is used to collect this data. The tables 2 and 3 present the findings of these measurements.

Table 2. Result of Risk Event Measurement

Business Processes (SCORE)	Code	Risk Event	Severity
<i>Plan</i>	E1	Miscalculations in planning	6
	E2	Change order planning	4
	E3	Discrepancy between stock and record keeping	4
	E4	Incorrectly wrote the type and amount of medicine requested in the order letter	9
	E5	Uncertainty orders from consumers	8
	E6	Sudden changes in drug stock	7
	E7	Unsold/expired product	9
<i>Source</i>	E8	There is broken or destroyed medicine	5
	E9	Discrepancies in the number of drugs ordered and the drugs that come	4
	E10	Slow service response from Pharmaceutical Wholesalers	6
	E11	Drugs are not available when there is a purchase from consumers	9
	E12	Increase in drug prices from Pharmaceutical Wholesalers	5
	E13	Warehouses are unable to store drug supplies	5
	E14	Lack of standard delivery operations	6
	E15	Delay in getting the drug to the pharmacy	6
	E16	The quality of the drug product is not as requested	8
	E17	Incomplete shipping documents	8
<i>Return</i>	E18	Return of drugs to	5

		pharmaceutical wholesalers because the expiration date is too close	
	E19	Drug return claims are not accepted by pharmaceutical wholesalers	9
	E20	Drugs sent by pharmaceutical wholesalers are exchanged	5
Enable	E21	Poor coordination of dispensary workers	5
	E22	Drug regulatory and recall issues	7
	E23	Weakness in contract agreements between pharmacies and pharmaceutical wholesalers	8

Table 3. Result of Risk Agent Measurement

Code	Risk Agent	Occurrence
A1	Medication planning error	8
A2	Negligence of labor and procurement staff	2
A3	Unstable demand	2
A4	Supplier negligence	8
A5	There are no substitute suppliers	5
A6	There is a shortage of medicines	8
A7	There is an increase in drug prices from the factory	5
A8	Capacity limitations	2
A9	There is no Standard Operating Procedure for shipping goods from suppliers	2
A10	Uncertainty about the timing of drug distribution from pharmaceutical wholesalers	5
A11	The employee does not comply with Standard Operating Procedures	5
A12	There is no Standard Operational Procedure for evaluating expiration dates	2
A13	Delivery errors due to inaccuracy among pharmaceutical wholesalers	5
A14	There is no computerized system	5
A15	Unclear regulations with stakeholders	2

The mapping process in this model involves entering measurement results for the frequency of risk agents and the severity level of risk events (see tables 2 and 3), and then calculating the correlation. To determine the Aggregate Risk Potential (ARP) value, this mapping was created. The severity value, occurrence value, and correlation value of the risk event and the risk agent are multiplied to produce the ARP value. Table 4 displays the results of ranking the priority ARP values from those with the highest ARP values to those with the lowest ARP values. After compiling the priority ARP values, a Pareto diagram of ARP is made for all risk sources, as shown in Figure 1.

Table 4. Summary of The Ranking of Aggregate Risk Potential Values

Rank of Priority	Risk Agent	ARP
1	A4	2376
2	A1	2320
3	A6	1872
4	A11	1760
5	A14	1450
6	A15	1296
7	A2	818
8	A3	732
9	A13	660
10	A5	585
11	A10	560
12	A7	515
13	A12	408
14	A9	338
15	A8	134

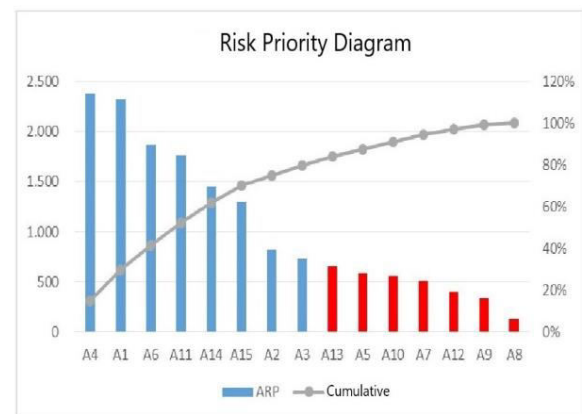


Fig. 1. Pareto Diagram of Risk Agent Priorities

Selected risk agents will be considered in developing risk mitigation activities based on Figure 1 and the Pareto 80/20 rule. According to the Pareto chart's findings, eight of the 15 risk agents have been prioritized for mitigation measures. Phase 2 of the HOR model will then include these risk agents for the purpose of designing mitigation measures. The intended mitigation measure is a step taken to lessen a risk agent's impact prior to the risk happening. Brainstorming produces more mitigation measures. The eight chosen risk agents are the main focus of this mitigation effort. Table 5 lists the additional mitigation measures that could be taken.

Table 5. Risk Agents and Mitigation Actions

No	Code	Risk Agent	Mitigation Actions	Code
1	A4	Supplier negligence	Control of delivery flow with pharmaceutical wholesalers	PA1
2	A1	Medication planning error	Provide product inventories with adjustments between needs	PA2
3	A6	There is a shortage of medicines	Looking for alternative drugs with similar functions	PA3
			Determine additional alternative suppliers	PA4
4	A11	The employee does not comply with Standard Operating Procedures	Conduct regular training and appeal to all employees	PA5
5	A14	There is no computerized system	Conduct periodic drug data collection	PA6
6	A15	Unclear regulations with stakeholders	Sharing and updating information with suppliers	PA7
			Establish Standard Operational Procedures for drug storage	PA8
7	A2	Negligence of labor and procurement staff	Providing rewards, punishments, and work motivation to employees	PA9
8	A3	Unstable demand	Perform forecasts based on historical demand data	PA10

3.2 House of Risk (HOR) Mapping Phase 2

The purpose of mitigation action mapping is to observe the impact of mitigation interventions on risk agents, by associating the potential mitigation actions with particular risk agents. Measuring the association between the chosen risk agents and the mitigation activities is the first step that needs to be conducted [13].

Measuring the level of difficulty (D_k) is the next stage. This rating is used to gauge how challenging it will be to put mitigation measures in place.

The next step is to multiply the correlation value between the risk agent (j) and the preventative action (k) to determine the overall effectiveness. The next step is to calculate the effectiveness to difficulty ratio, which is calculated by dividing the overall value of effectiveness (TE_k) by the level of difficulty involved in performing the activity. The efficacy of the degree of difficulty calculation aims to establish the order of importance for each action. Tables 6 and 7 display the outcomes of the risk mitigation action mapping in HOR Phase 2.

Table 6. Effectiveness To Difficulty Ratio

Code	Mitigation Actions	ETDk
PA1	Control of delivery flow with pharmaceutical wholesalers	8205
PA2	Provide product inventories with adjustments between needs	8874
PA3	Looking for alternative drugs with similar functions	8453
PA4	Determine additional alternative suppliers	9373
PA5	Conduct regular training and appeal to all employees	11901
PA6	Conduct periodic drug data collection	10679
PA7	Sharing and updating information with suppliers	8963
PA8	Establish Standard Operational Procedures for drug storage	9325
PA9	Providing rewards, punishments, and work motivation to employees	6095
PA10	Perform forecasts based on historical demand data	7978

Table 7. Rating of Proposed Mitigation

Rank of Priority	Mitigation Actions	ETD	Percentage	Cumulative
1	PA5	11901	13%	13%
2	PA6	10679	12%	25%
3	PA4	9373	10%	36%
4	PA8	9325	10%	46%
5	PA7	8963	10%	56%
6	PA2	8874	10%	66%
7	PA3	8453	9%	75%
8	PA1	8205	9%	84%
9	PA10	7978	9%	93%
10	PA9	6095	7%	100%

The results of Table 7 show that the priority mitigation action ranking results are PA5, namely conducting regular training and appealing to all employees.

3.3 Weighting of Mitigation Actions Using the AHP Method

According to the theory by [14], the AHP method can be used to solve problems where the criteria taken are quite large, with the main input being human perception. House Of Risk Phase 2 obtained the results for the selected mitigation actions, namely conducting regular training and advising all employees. Furthermore, from the selected mitigation actions, the researcher prioritized improvements using the analytical hierarchy process method. These criteria and alternatives are considered by the expert in accordance with the conditions of the company. The criteria in the analytical hierarchy process method refer to research conducted by [15].

The criteria considered by experts include the following:

1. The length of time required to realize preventive measures (time)
2. The amount of costs incurred during the realization of preventive measures
3. Effectiveness is defined as a measure of success in achieving the objective of preventive action (effectiveness).

Meanwhile, several alternative forms of training that may be carried out by companies based on the recommendations provided and discussed with experts are as follows:

1. Use of digital pharmacy management information system software to regulate and monitor pharmacy management performance.
2. Establish supplier selection policies using the Supplier Relationship Management approach by sharing and updating information to determine product quality and track record analysis.
3. Applying the HR Development method by conducting regular business SOP training.

The next step is to arrange a hierarchy (Figure 2) to make it easier for researchers to get views regarding the calculation steps of the AHP method. Hierarchy preparation is done by compiling a hierarchy starting with general objectives, followed by criteria for selecting training activities, and finally, at the bottom of the hierarchy, alternative choices in the form of realization of mitigation actions. The results of AHP are shown in Table 8.

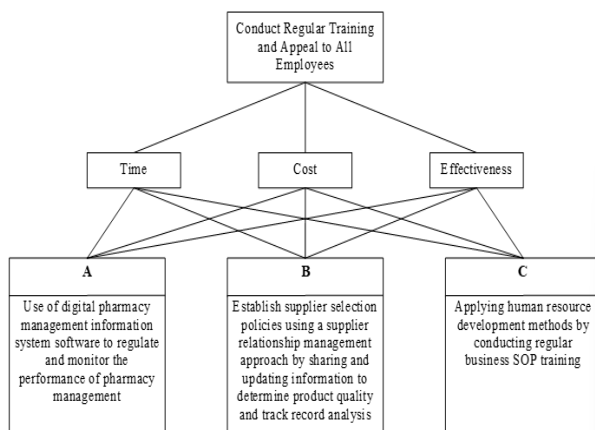


Fig. 2. AHP Hierarchy

Table 8. Selection of The Best Alternative

Alternative	Eigen Vector			Alternative Weight Evaluation
	Time	Cost	Effectiveness	
	0,284	0,619	0,096	
A	0,284	0,600	0,333	0,485
B	0,619	0,200	0,333	0,332
C	0,096	0,200	0,333	0,183
				1

From table 8, it can be seen that the highest AWE value is in alternative A, namely the use of digital pharmacy management information system software to

regulate and monitor the performance of pharmacy management. with a weight of 0.485. So this type of training is the recommended one to be implemented.

4 Conclusion

From the results of risk identification using the House of Risk 1 approach, there were 23 risk events from 15 risk agents identified at all stages of the drug procurement supply chain activity process using the SCOR model, which consists of six business processes (Source, plan, make, deliver, return, and enable). From HOR 1, it is known that a risk agent can also cause various risk events with a certain correlation weight value.

The output results from HOR 1 are input to HOR 2, which is a mitigation action framework for risk sources (risk agents). In HOR 2, 10 mitigation actions are prioritized to be realized based on ranking. Furthermore, from the selected mitigation actions, improvement priorities are determined using the analytical hierarchy process (AHP) method. The results of this study show that there are three priority recommendations for mitigation actions that can be carried out to handle the drug procurement supply chain process. The first action recommendation is the use of digital pharmacy management information system software to regulate and monitor the performance of pharmacy management, establish supplier selection policies using a supplier relationship management approach by sharing and updating information to determine product quality and track record analysis, and apply HR development methods by conducting regular business SOP training.

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