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Designing Inventory Policy for Formula and Enteral Food in Hospital Using Simulation

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ABSTRACT

High number of products which stored in the warehouse will lead to the high inventory value that could harm the business. One of the public hospitals in Bandung city has the similar problem. A certain number of products wasted due to expired items and very high number of inventory level in the warehouse lead to the cash flow problem. In this research, simulation model was developed for inventory system to cope with the increasing complexity by expiration date parameter. The simulation model was applied to Formulas and Enteral Food at Nutrition Department. One of the main objectives was to minimize the inventory level of the products under study. The tool that used in this research was Arena Simulation. The simulation shows that periodic review policy provides the best result compared to the current method and continuous review policy. Besides the inventory policy, hospital has more information about system characteristics to treat and anticipate an issue of expired products.

Keywords: Inventory system, simulation model, formula and enteral food, arena simulation, public hospital

INTRODUCTION

Supply Chain Management is one of the important things in the hospital management. Recent research developments about perishable products, especially food hospital have been emerged. One of which is the Formula and Enteral Food in hospital. Definition of Formula and Enteral Food is a consumed food which already formulize or by enteral nutrition that have been informed from the dietitian in accordance with the needs of each patient. Inventory system is a part of supply chain management and this is very important part of the perishable product and quality of service to the customer (Beshara *et al*., 2012).

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Food is one of perishable products. Perishable product refers to the reduction of value of the product through the accretion of time and it has a major challenge for inventory system. Currently the hospital has a lot of accumulation of goods that will stimulate on the number of expired products and also the high inventory value. This research was expected to facilitate the hospital to be able to resolve this problem. If the product is out of stock, there will have an impact on unfulfilled the needs of patients, which means service levels will decline. Conversely if the product is over stock, it will have an impact on the cash flow and expired products.

The problem that occurs in the inventory system of Nutrition Department lies on Formula and Enteral Food as a perishable product. The number of products that accumulated in the warehouse can impact to the expired product in large quantities, high inventory value and warehouse area will be used widely, which could be avoided. This research will analyze that problem using simulation model, trying to find improvements that can solve inventory system for the product under study. Simulation model is one of the most popular methods for the quantitative techniques to solve problem analytically which considered difficult. This technique has been done by emulating real-world operating system using the appropriate software on computer (Law and Kelton 2000 and Kelton *et al.*, 2002).

Rockwell Corporation made Arena Simulation Model software, which can be used for a wide variety of manufacturing applications for the example supply chain (logistics, warehousing and distribution process). Arena Simulation Model provides the users with objects libraries for modeling system and SIMAN (a domain-specific language simulation). Optquest is a tool for the optimization of data as well as the other three modules (Arena Input Analyzer, Arena Output Analyzer, and Arena Process Analyzer). The animation is also available for users to run the program (Cimino *et al.,* 2010). Routroy and Kodali (2006) conducted a research using Arena Simulation Model for inventory system planning.

The system will be easier for a non-perishable product while it is more difficult for a perishable product because there are several variables that have a major role when applied to perishable products. Simulation created for perishable products especially for Formula and Enteral Food to evaluate the performance of Nutrition Department. The situation developed to compare existing method and propose method (Continuous and Periodic review policy) to show the process that occurs in the inventory system for Nutrition Department. So that, this research can provides suggestion through proposed method for inventory system in order to become more effective and efficient.

LITERATURE REVIEW

Inventory System

The current development in the organization can be seen from the increasing usage of inventory system theory. One important area is supply system for demand in such emergency conditions, for the example in the hospital. The employees who concerned in this system should establish efficient policies for the provision of normal conditions and also ensure the ability of hospital to fulfill demand in an emergency condition (Duclos, 1993). There are several reasons for doing research on the inventory system. Inventory system can protect the production supply and demand fluctuations. The better inventory system can protect the distribution system, minimizing forecasting error, enabling effective use of resources in the event of demand fluctuations. The other benefit are to fulfill the demand (distribution), set the production process (production), and sometimes as a protective value in case of unexpected price increases or lack of products on the market (supply) (Farsad and LeBruto, 1993).

Inventory system is an extension of product planning process, organizing and controlling process of products that has aim to minimize inventory investment and to maintain the balance between demand and supply. On the other hand, this process has aim to reduce procurement and make an effective stock. Inventory system that was not managed properly will lead to an increase in the scale of product in the warehouse and increase inventory costs simultaneously (Ali, 2011).

The model of the inventory system in general has a strict assumption. Most of the inventory system seems to allow simplification and inventory systems based assumption policy will result in satisfaction. In some cases, simplification of inventory system has a little different fundamentally between actual conditions and particle. Research of Matheus and Gelders (2000) considered the subject of their research in probabilistic demand, and made suggestion of inventory system policy using Q (Continuous Review Policy) method. This method was more suitable to be applied on the large scale product demand.

Another research tried to see if a reorder point can improve the efficiency of inventory system at the Ramathibodi hospital (Thailand), using inventory performance data. There were six parts activities which considered in this inventory system, those were purchasing, dispensing, receiving, checking stock levels, expensive and Narcotic drug nearly expired drug checking and checking. The final conclusion was found that when applying the Q method, then the efficiency of drug inventory system will increase (Laeiddee, 2010).

Simulation Model

The definition of simulation model is a depiction of mathematical model of the problem under study. From the system, there are some descriptions of alternatives and also solutions. Decision makers can compare the results based on those data and test the hypothesis until make a conclusion (Manuj, 2009). The most important thing in simulation model is the mapping of complex system (Shim and Kumar, 2010).

Chunju and Yihong (2007) stated in their research the definition of the simulation model. Simulation model is a reference to a real system process design. They conducted experiments on the model to be able to understand the behavior of the system and be ready with a strategy that will be implemented. The simulation model was created with the aim of studying the dynamics system and its characteristics. Numerical simulation more widely applied to simulation model because of developments in computer technology.

The explanation of Abo-Hamad and Arisha (2011) in their research, decision-modeling system was the case of the real system. On the other hand, the simulation model was the relationship between inputs and outputs in a complex system, there was an objective function. The simulation model cannot provide for the optimal result. Simulation model will give a decision on the best result.

One of the examples, a research from Agresti (1976) conducted a study in a hospital on the dietary management using simulation model on the inventory system with dynamic simulation. The simulation was designed to solve problems using the GASP IV at tray distribution. The model was designed include purchase and inventory of food supplies, food preparation, manpower, tray assembly and distribution. There were less explanation of the variables that were used but mapped of the hospital system was very clearly delineated. There was no similar research or further research based on that research, especially in Formula and Enteral Food.

Based on some explanations in the previous subchapter, SCM system is one of complex system which involves of multiple activities and multiple parties. In the SCM, inventory system is a complex system as well, because there is a data calculation of the product in the warehouse, even more complex if it recorded the perishable product. Thus, the more appropriate solution to this problem will be done by using a simulation model.

Arena Simulation Model

Arena simulation is generally used to simulate business process improvement. Some typical scenarios were conducted using this simulation based Rockwell (2002) includes:

1. Documentation, visualization and shows the dynamics of the process through animation.
2. Predicting the performance of the system based on key metrics such as costs, throughput, cycle times, and utilizations.
3. Identify process bottlenecks such as queue resources and over utilization of resources.
4. Planning staff, equipment, or material requirements.

Arena simulation was used in several studies of inventory system. One of the studies was by Tee and Rossetti (2001). That research used simulation model to analyze the performance of the analytical models that violate the fundamental modeling assumptions. This study aimed to examine the analytical models for a two-echelon warehouse and several retailers using the system (R, Q) inventory policies.

Ekren and Heragu (2008) made a research using simulation model with arena simulation model to optimized stocking location to store the items from single-item two-echelon inventory system. This study aimed to minimize the total inventory, backorder, and transshipments costs, based on charging and transshipment number. Meanwhile, in another study which conducted in a factory, an arena simulation model was a tool that can address the problems in the workflow bottleneck and also for the best selection of staffing issues for achieving operational efficiency. It also can make the improvement for the problem of raw material inventory to support manufacturing activities to manage the quantity and time of ordering policy (Zhang and Tom, 2009).

The use of arena simulation model in the research of Routroy and Bhausaheb (2010) was to evaluate the difference in performance of inventory system for perishable products on the retail stage. Calculations performed on duration of product life cycle, ordering cost, holding costs, stock out cost, overstock cost, demand uncertainty, unit price and product availability in the market. The products under study were green vegetable, fruits, milk, flowers, meat and others. The number of perishable products research at hospital still least which make a trigger for development in this area.

RESEARCH METHODOLOGY

This research focused on one of the public hospitals in Bandung city, precisely in the Nutrition Department. There are 4 types of products in the inventory system of this hospital, but this research was concerned in the Formula and Enteral Food because this type of food has the problem in inventory system which being faced by department. The research was conducted during October-November 2012. Data collection was carried out by field survey and interviews with workers or leaders who in charge in this department. This method was classified as a qualitative method. It was also used simulation model as a quantitative method to solve the problem. A set of data collected from 2009-2012 for the calculation of inventory system that used in this research. Arena simulation model was used as a based method to reach the goal of this study.

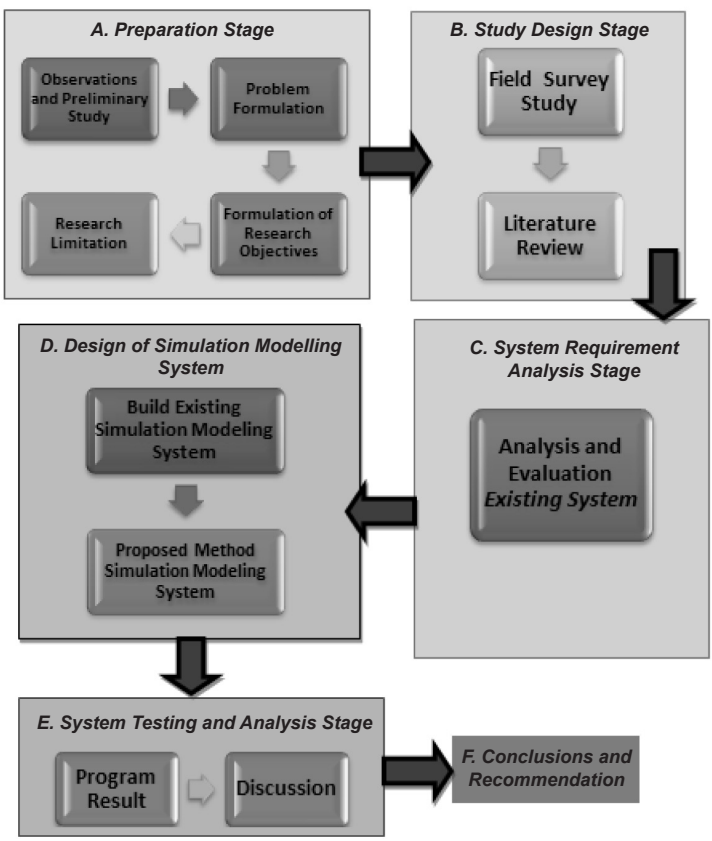

Figure 1 Research methodology flowchart

There are 6 stages in this study as presented in Figure 1. It begins with the preparation stage which defines the problem and sets the objective until system testing and analysis stage and also makes a conclusion and recommendation. This research involves the whole sub installation in the nutrition installation department, those are sub-installation administration, inventory, HR & Training, sub-installation planning, sub-installation planning and food processing, as well as the PIC (Person in Charge) and nutritionists of each room. The whole of the sub-installation has each role of the food products stored in the main food warehouse. Imbalance will occur if one party does not exist. Section C and D are the core of this research. For more details of the design methodology can be seen in Figure 2.

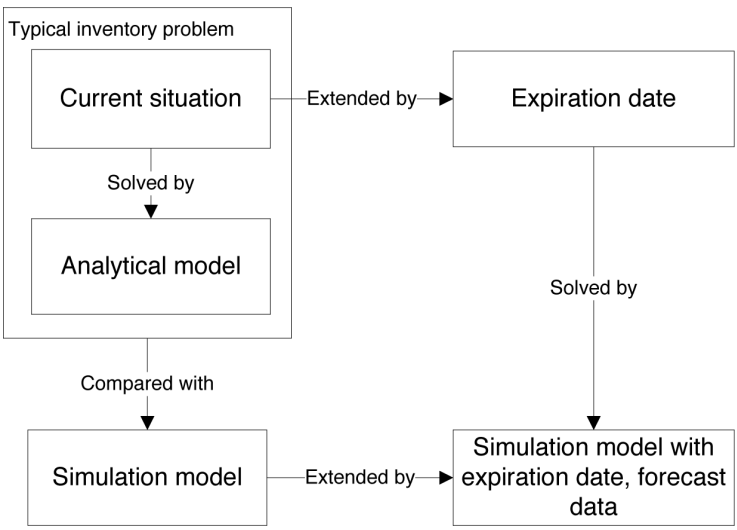

Figure 2 Detail Sections C and D

Starting with the current situation, the problem can be solved by analytical models as typical inventory problem. However, actual problem involved expiration date as an important parameter. Therefore, the problem is extended into inventory with expiration date. To solve the extended problem, with its complexity, simulation model was developed. The new model was developed based on simple simulation model that solve typical inventory problem as validation process. As long as simple simulation model is valid, the extended simulation model can be applied for forecast data.

DATA CALCULATION

The problem of Formula and Enteral Food lies on the products that stored in large quantities, but it used in a low volume. This situation causes loss of damage for those products, high inventory value and a full of products in the warehouse. There were classifications of product categories based on inventory and usage variables. The main concern are the category of product A (usage and inventory high), B (usage and inventory medium) and C (usage low and inventory high) which all of those categories are the products that have a high inventory number. From all products at those categories (A, B and C), 5 products has been chosen and it summarized in Table 1.

Inventory system in the nutrition installation department includes several parties such as sub-installation planning, sub-installation administration, supplies, HR & training, warehouse and also every room that needs Formula and Enteral Food as consumption. Each room has a PIC who always took the products from the main warehouse. When it mapped against the five products, Pediasure and Neosure are the products which needed in the children room, while three other products used for the common room. Both types have a different delivery system and different request, so that the flow chart simulation would be different, but a little bit similar. Figure 3 shows the simulation flowcharts of those types of delivery. Pediasure and Neosure are using ICU Room Flowchart.

Table 1 Formula and enteral food under study

Product type	Product name	Brand	Unit
A	High Calcium Milk	Anlene	boxes
	Enteral Feeding Children Low Lactose	Pediasure	can
B	Special High-Carbohydrate Liver Disorders	Hepatosol	boxes
C	Special Babies Formula BBLR MCT	Neosure	can
	Semi Elemental Peptide	Peptamen	can

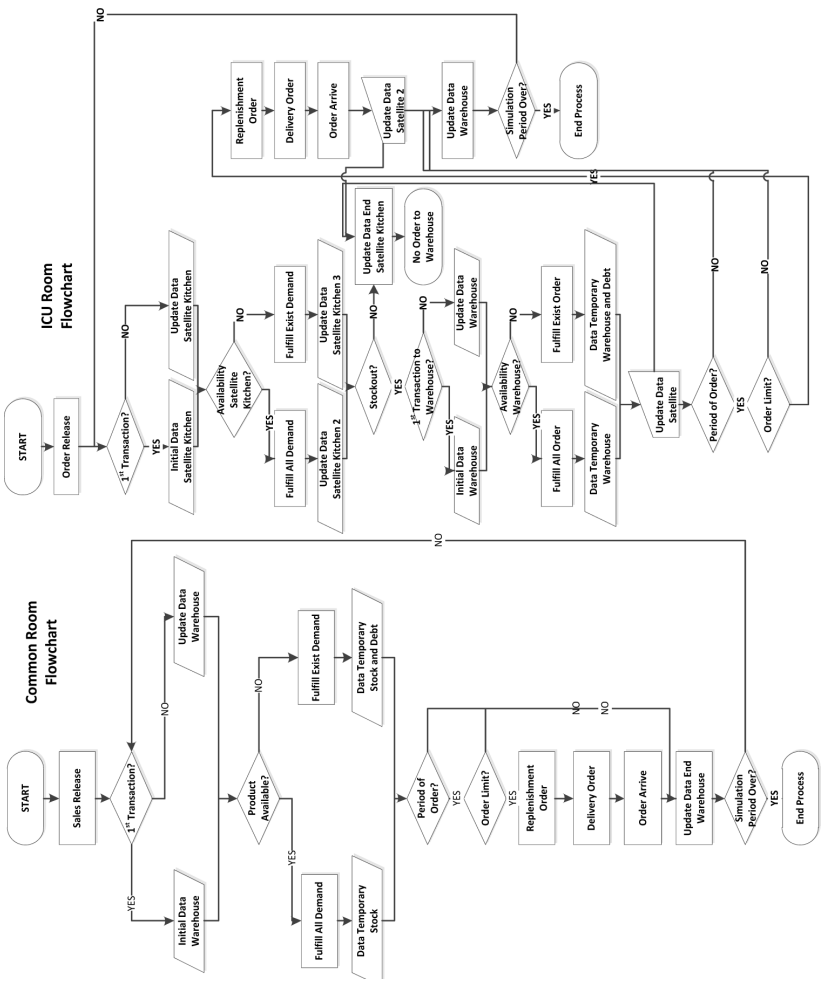

Figure 3 Arena Simulation Model flowcharts

Parameters and performance measures that used in this simulation are presented in Table 2. Table 3 is the set of data used in the simulation on the existing system, periodic and continuous review policy inventory system which use the same cycle service level. It is intend that the comparison between them equivalent. Table 4 shows the result of simulation, which shows about comparison based on average inventory level of warehouse, stock out and average inventory value of satellite kitchen between those 3 experiments through simulation model.

Table 2 Parameters and performance measures

Input Parameter and Performance Measures for the Case Situation	
Order release	The pattern in which demand comes to warehouse nutrition installation. Generally represented by a distribution function.
Initial stock	Amount of inventory owned by warehouse at the commencement of the simulation.
Demand	Request for a number of items in the warehouse needed by the PIC room.
Last stock	The number of products owned by warehouse during simulation.
Counter demand	Numbering on the demand in the simulation model.
Order limit	Limit the number of products in the warehouse before ordering to the supplier.
Check period order	Periodic reviews are conducted to order the products which generally expressed in days or weeks.
Stock out	Unable to fulfill customer orders resulting from the absence of a goods warehouse.
Accumulation stock out	The total number of products which cannot be fulfilled by the hospital.
Order to supplier	Number of products ordered to the supplier.
Simulation duration	This is the duration to do the simulation.

Table 3 Simulation data set based on existing data

Set of data				Existing		Continuous (Q)		Periodic (P)
Brand	**Unit**	**Initial stock**	**Demand**	**Order to supplier**	**Order limit**	**EOQ**	**ROP**	**OUL**
Anlene	boxes	328	EXPO(1.5)	15	7	94	7	28
Pediasure	can	0	EXPO(0.6)	6	7	33	7	10
Hepatosol	boxes	107	EXPO(1.4)	14	18	81	18	54
Neosure	can	103	EXPO(0.2)	2	3	26	3	3
Peptamen	can	102	EXPO(1.2)	12	14	51	14	43

Table 4 Comparison of simulation existing data result

Simulation result		Existing			Periodic (P)			Continuous (Q)		
Brand	**Unit**	**AIL warehouse**	**Stock out**	**AIL satellite kitchen**	**AIL warehouse**	**Stock out**	**AIL satellite kitchen**	**AIL warehouse**	**Stock out**	**AIL satellite kitchen**
Anlene	boxes	84.6	35.6	-	89.4	0.7	-	156.4	0.2	-
Pediasure	can	0.02	7.2	2.4	0.4	6.6	2.3	29	0	4.6
Hepatosol	boxes	17.1	45.6	-	47.8	0	-	137.8	0	-
Neosure	can	65.8	0	1.6	65.8	0	1.6	66.8	0	1.6
Peptamen	can	15.7	37.5	-	38.5	0	-	87.1	0.01	-

Table 5 is the result of simulation and it can compare financially by comparing the average inventory level when multiplied by the unit price of the product. The following table is an average inventory cost and value from each method.

Table 5 Comparison of average inventory and cost value

Brand	Unit	Unit cost (IDR)	AI value current (IDR Tho)	AI value P rev (IDR Tho)	AI value Q rev (IDR Tho)
Anlene	boxes	59,281	5,015	5,300	9,272
Pediasure	can	186,741	452	504	6,274
Hepatosol	boxes	77,796	1,330	3,719	10,720
Neosure	can	109,500	7,380	7,380	7,490
Peptamen	can	159,624	2,506	6,146	13,903

Table 6 Comparison Cycle Service Level (CSL)

Brand	Unit	CSL current method	CSL periodic policy (P)	CSL continuous policy (Q)
Anlene	boxes	93.41%	99.87%	99.96%
Pediasure	can	96.67%	96.94%	100%
Hepatosol	boxes	90.95%	100%	100%
Neosure	can	100%	100%	100%
Peptamen	can	91.32%	100%	100%

From the Table 5 and 6 it can be seen that although the existing system has the lowest average inventory value but in terms of cycle service level is still less than the continuous or periodic review policy. Based on those two tables' results, it is difficult to determine which the best policy to be applied for those five Formula and Enteral Food. For example, the calculation will be made to the Hepatosol product. The difference of average inventory value between the current condition and periodic review policy is equal to IDR 2,389,000. Meanwhile the difference of the CSL is 9.05% which equivalent of 46.2 boxes if we calculated into demand fulfillment and also it is equal to IDR 3,597,715. Judging from the difference between the inventory cost and the lost revenue due to not fulfill the demand, it can be concluded that the periodic review policy is better than the current method. After calculation of the overall product, it shows similar results that periodic review policy is suitable to be applied on the five Formula and Enteral Food under study. Then it designs simulation models by considering the expired date parameters for periodic review policy. Flowchart can be seen in the Figure 3 and Figure 4.

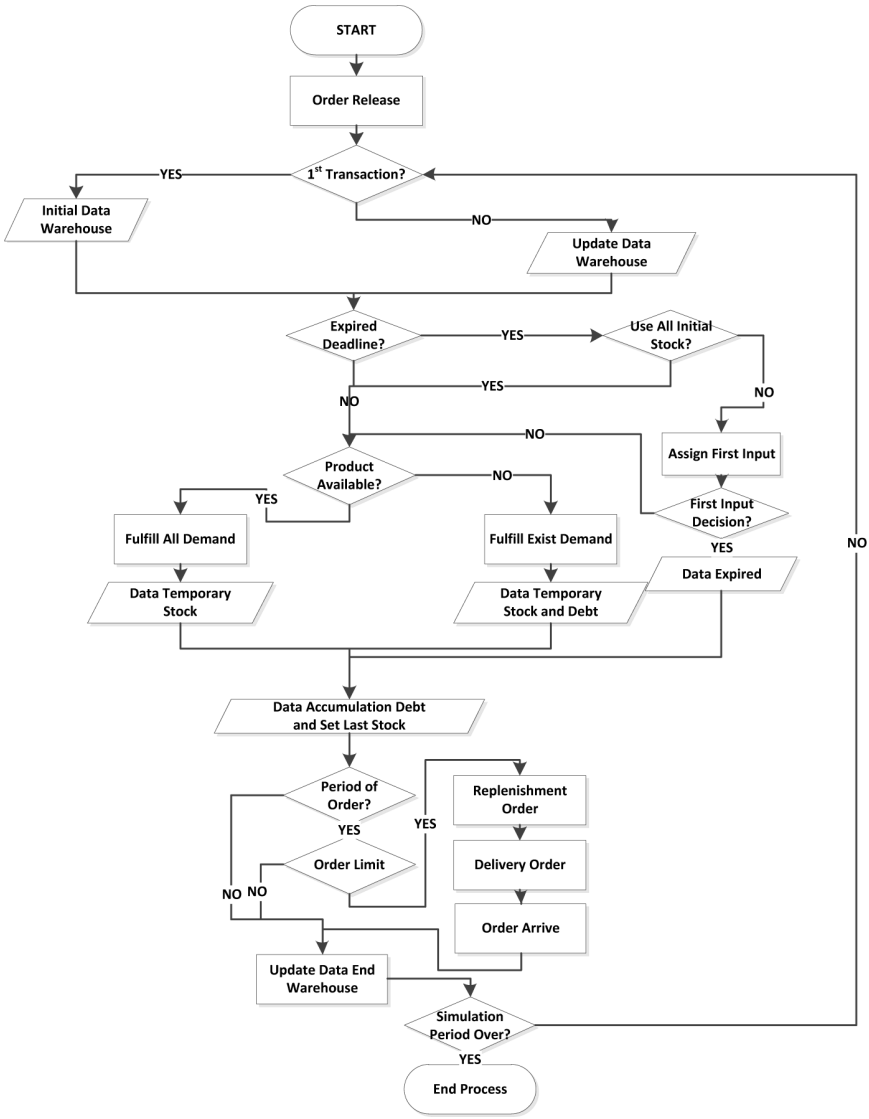

Figure 4 Arena simulation model flowchart using expired date for common room

It performed simulation on the current situation using periodic review policy which is already considering the expiration date parameter so that it will know how many expired products. The results of the simulations can be seen in Table 7.

Table 7 Simulation result of existing data using expired system

Brand	Unit	Periodic Review (P)					Unit cost (IDR)	AI cost and value P Rev (IDR Tho)
		AIL warehouse	AIL satellite kitchen	Stock out	Expired warehouse	Expired satellite		
Anlene	boxes	57.1	–	9.8	191.62	–	59,281	14,744
Pediasure	can	2.7	2.8	3.7	0	0	186,741	1,027
Hepatosol	boxes	47.8	–	0.1	0.5	–	77,796	3,758
Neosure	can	66.5	1.1	0.4	86.3	2	109,500	17,071
Peptamen	can	38.4	–	0.4	1.7	–	159,624	6,401

Table 8 Forecast demand formula and enteral food 2013

Brand	Unit	2013											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anlene	boxes	46	47	47	47	47	47	47	47	47	47	46	46
Pediasure	can	16	15	15	14	17	19	22	20	19	18	17	14
Hepatosol	boxes	56	56	58	63	63	57	57	59	60	58	56	55
Neosure	can	6	7	6	5	5	3	3	4	4	4	3	3
Peptamen	can	14	15	15	18	18	17	16	15	15	14	14	13

From the data it was found that from the existing data then the expired product will be a lot. This is due to miscalculations product needs in the previous period. Then it will do the simulation for demand forecasting data Formula and Enteral Food 2013 by using the same method to look at the cost that would be obtained by hospital and also to find how many products expired using 99.99% of CSL to maximize the service level to the customer and with assuming no initial stock in the warehouse and satellite kitchen.

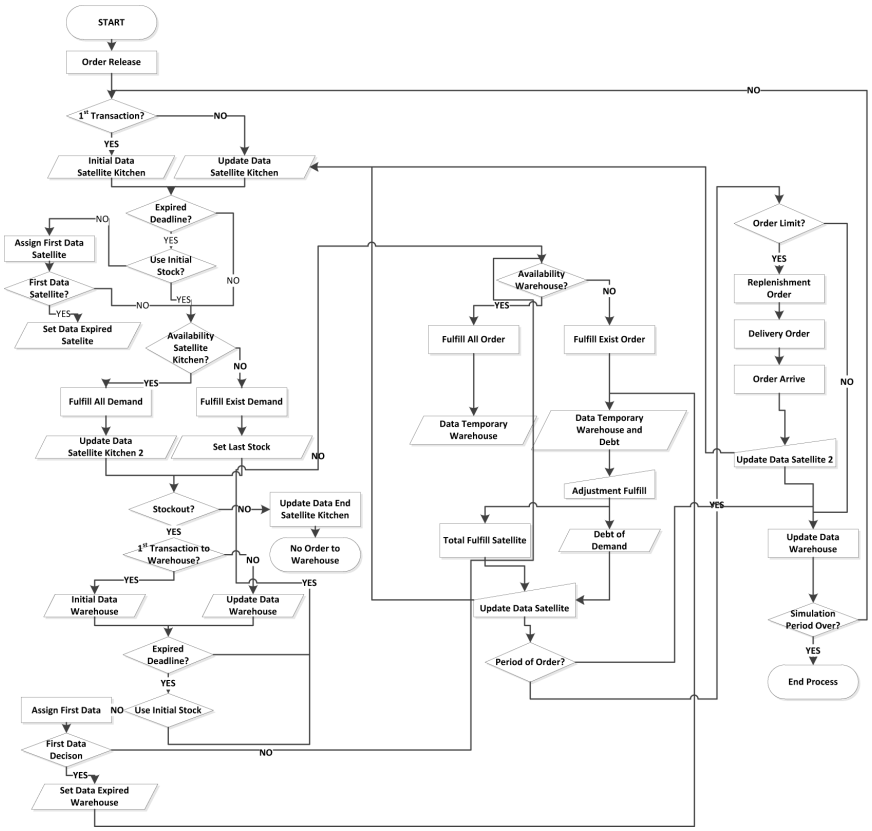

Figure 5 Arena simulation model flowchart using expired date for ICU room

Table 9 Simulation data set based on forecast data

Set of Data Periodic Review (P)			
Brand	Unit	Demand	OUL
Anlene	boxes	EXPO(1.6)	19
Pediasure	can	EXPO(0.6)	9
Hepatosol	boxes	EXPO(1.9)	26
Neosure	can	EXPO(0.1)	3
Peptamen	can	EXPO(0.5)	8

Table 10 Average inventory and cost value based on forecast data

Brand	Unit	Periodic Review (P)					Unit cost (IDR)	AI Value P Rev (IDR Tho)
		AIL warehouse	AIL satellite kitchen	Stock out	Expired warehouse	Expired satellite		
Anlene	boxes	12.2	–	32.4	0	–	59,281	723
Pediasure	can	0.8	3.7	6	0	0	186,741	840
Hepatosol	boxes	19.9	–	25.4	0	–	77,796	1,548
Neosure	can	0.9	0.6	1	0	0	109,500	164
Peptamen	can	7.6	–	1.3	0	–	159,624	1,213

ANALYSIS AND DISCUSSION

The reasons to use simulation model for this research are generally similar to other studies. As expressed by Robinson (2004), there are three reasons, first is the variables owned by the operating system. They can be more than expected, in this study the variables consisting of stock, stock out, expired products and others. The operating system is also interconnected. If there is a change of one thing, it will affect to the other things. Another reason is a complex operating system. Inventory system in the public hospital is one complex system because the items which required by the patient consists of a variety of items and the system should be run effectively and efficiently.

Calculation of the field data from January to September 2012, it has been known that cycle service level of Formula and Enteral Food under study is approximately 98%. Based on that thing, it can be calculated the inventory system to another review policies (continuous and periodic). Previous research has been calculated the analytical method. The result said that periodic review was the most appropriate method to be applied for the five products. By using 75 replications in the simple simulation model, it conducted comparison between the results derived from analytical model and simulation model. The results of simple simulation model stated that periodic review policy is the best method in the implementation of inventory system for historical data. The method which applied by hospitals is not clear, they do periodically review (10 days), but it does not account for other variables, namely order up to level. It was therefore no need to change the method, still reviewing periodically by 10 days, but should establish OUL as the appropriate calculations.

The reason for not using continuous review policy is the significant difference of average inventory value. Generally, food in the hospital reviewed between 5, 7 to 10 days (Suyanto, 2012). But in this case it also did calculations for the review period 15 and 30 days on analytical model. It has been done a comparison between the results of average inventory value the review period 5, 7, 10, 15 and 30 days as well as continuous review policy into a graph. It has known through the graph of period and average inventory value that the review period of 10 days for five products were still far from meeting point average inventory value between those policies.

The effective and efficiency of inventory system can be seen from the average level of inventory in the warehouse. From the results of simulations, it carried out that if only it seen from the average inventory value, existing system still relies better method than the other methods, but it has to be seen also how many stock out that hospital face of and financial lost. After taking several parameters into account

for simulation model, it showed that the total costs incurred by the hospital less when applying periodic review policy. It can be seen in Table 5 and 6, using the periodic review policy Anlene has average inventory value about IDR 5,300,000,- with 99.87% CSL besides Pediasure at IDR 504,000,- with 96.94% CSL, Hepatosol IDR 3,719,000,- with 100% CSL, Neosure IDR 7,380,000,- with 100% CSL and Peptamen IDR 6,146,000,- with 100% CSL.

Proposed improvement of inventory system to the Nutrition Department is to use a periodic review policy. Demand data has been calculated in previous research using time series forecasting method and finally there were 2 methods which suitable to use in forecasting Formula and Enteral Food which were simple exponential smoothing and moving average methods. From these data, it conducted a similar simulation with 99.99% proposed of CSL. It can be seen in Table 10 that using periodic review policy the results of average inventory value for Anlene was IDR 723,000,- , Pediasure IDR 840,000,- , Hepatosol IDR 1,548,000- , Neosure IDR 164,000,- and Peptamen IDR 1,213,000,-. From the table it is also known that when using the simulation model of periodic review policy with assumption of no initial stock and also consider the parameter of expiration date, it will not find any expired products then the stock out data coming from unfulfilled demand in the first period.

The advantage of periodic review policy is the business owner or manager may deduct the time to analyze the amount of inventory in the warehouse. The time can be used for another important thing in their business. The disadvantage is that inaccuracies in determining the number of items required in high demand situation. Assumptions of inventory must be built by the manager or business owner and those assumptions will have an impact on accounting inaccuracies.

CONCLUSION

This research presents simulation model to solve the problem of Formula and Enteral Food in the hospital. This simulation was used because of the complexity of the problem due to expiration date parameter which is difficult to be solved using analytical model. The simulation model was success to solve the problem. By applying the model into five products of Formula and Enteral Food, it was concluded that the periodic review policy was the best method for the problem. Actually, the current method has lower inventory value compared to periodic review. However, its cycle service level is lower than that in periodic review. If the gap of cycle service level is converted into value, then total inventory value for periodic review is the lowest. Further calculation with forecast data shows that inventory value can be reduced as well as number of expired product.

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