**How to Cite**
Prabhadika, I. P. Y., Tastrawati, N. K. T., Harini, L. P. I., & Dewinta, I. A. R. (2023). Optimization of infusion supply using the probabilistic economic order quantity (EOQ) method at Sanglah Center General Hospital. *International Journal of Physics & Mathematics*, *6*(1), 1-6. https://doi.org/10.21744/ijpm.v6n1.2067

# Optimization of Infusion Supply Using the Probabilistic Economic Order Quantity (EOQ) Method at Sanglah Center General Hospital

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***Abstract---****Inventory planning is important to avoid the advantages or lack of goods. Hospitals as health care providers also have a share in the stock of goods, one of which is infusion. This study aims to optimize infusion supply at Sanglah Central General Hospital using Economic Order Quantity (EOQ) method with (q, r) model. The forecasting method used in forecasting infusion requirements at Sanglah Hospital is an Autoregressive Integrated Moving Average (ARIMA) method. The results of this study indicate the amount of infusion of NaCl 0.9% 500 ml and 5% 500 ml glucose infusion which is expected to be ordered by Sanglah Hospital at the beginning of the booking period is 11,921 and 560 units. Sanglah Hospital need to re-order when the stock of infusion of NaCl 0.9% 500 ml touched the number 3,593 and 5% 500 ml glucose infusion stock touched 202 units. To anticipate the spike in demand, Sanglah Hospital is expected to provide infusion as a safety reserve of 190 units for infusion of NaCl type 0.9% 500 ml and 21 units for glucose type 5% 500 ml. The total inventory cost of the infusion to be issued by Sanglah Hospital in the planning of the infusion needs for 6 months is also obtained.*
***Keywords---****ARIMA, economic order quantity, forecasting, infusion supply, operational research.*

## Introduction

One of the optimization problems that can be studied is the inventory problem. Inventory is related to the storage of sufficient supplies of goods (components and raw materials, for example) that will ensure the smooth operation of production systems or business activities (Taha, 1997). Inventory problems can be solved using the inventory model. In general, inventory models can be divided into two, the first is the deterministic model, the model that assumes all variables are known with certainty, and the second is the probabilistic model, the model that assumes variables have uncertain values (Zhang et al., 2014; Mora et al., 2018; Muliarta, 2016).

Hospitals as health service providers also have a stake in the supply of goods such as medicines, especially infusion-type drugs and other injections. Infusion is a medical device that under certain conditions is used to replace lost body fluids and balance the body's electrolytes. Research on inventory models has been carried out several times. Roy & Chaudhuri (2007), has conducted research on the supply model which discusses the EOQ model with a limited time, taking into account inflation and the time value of money. This research area involves situations where the level of demand depends on the level of supply and investigates models for supply systems where the level of demand depends on the level of supply.

ISSN 2632-9417
Submitted: 27 November 2022 |Revised: 18 December 2022 | Accepted: 09 January 2023

Ernawati & Sunarsih (2008), researched a probabilistic model inventory control system with a "back order policy" where a simulation was carried out at PT. Surya Tarra Mandiri is engaged in general manufacturing. The goal of the company is to minimize annual inventory costs with a capacity constraint of 20 m2 area and a purchasing budget of Rp. 125 million. This research resulted in inventory control using a probabilistic inventory model with a "back order policy" for the company showing better results compared to the planning used by the company so far, so the optimization method can be used as a consideration for company management in holding inventories (Nia et al., 2014; Taleizadeh & Pentico, 2013; Chen et al., 2014).

Based on the studies mentioned, the authors are interested in applying other operations research optimization methods to a case. This study aims to apply the probabilistic EOQ method with (q,r) model in optimizing infusion supplies with case studies at the Sanglah Central General Hospital (RSUP) Denpasar (Handaya, 2011; Heizer et al., 2014; Huang et al., 2003; Teng, 2009). So far, in planning for infusion supplies for the next period, Sanglah Hospital does not use a special method. The infusion chosen as the research object was the most widely used infusion, namely 0.9% NaCl 500 ml and 5% glucose 500 ml. Sanglah General Hospital was chosen because it is the largest hospital and largest infusion provider in Bali. Sanglah General Hospital is also the hospital with the highest number of inpatients in Bali. The Standard Operating Procedure (SOP) for ordering infusions at Sanglah General Hospital did not affect the results in this study. To predict the need for infusion supplies for the next period, the Autoregressive Integrated Moving Average (ARIMA) forecasting model will be used, the results of which will be used in the application of the probabilistic EOQ method (Madda & Jaber, 2008; Khan et al., 2011; Lee & Tong, 2011; ArunKumar et al., 2021).

## Research Method

### *Data collection*

The type of data used in this study is quantitative data, which is historical data on the total use of 0.9% 500 ml NaCl infusion and 5% 500 ml glucose infusion at Sanglah General Hospital every month for 30 months (January 2015 - June 2017).

### *Data analytical method*

The analytical method in this study includes two steps of work, which are forecasting the level of infusion needs used at Sanglah General Hospital using the ARIMA method and then the optimization step using the probabilistic Economic Order Quantity (EOQ) method with (q,r) model (Makridakis et al., 2008; Rangkuti, 2013; Wei, 2006; Eroglu & Ozdemir, 2007). The processing steps are as follows:

### *Calculating ARIMA model*

The ARIMA model is a non-stationary model and has gone through a different process. ARIMA model with (p,d,q) order can be written:

$$\phi_p(B)(1-B)^d Z_t = \theta_q(B)a_t \qquad (1)$$

### *Forecasting criteria*

Measuring the accuracy of a forecasting method is needed to show how far the known data is capable of producing a good forecasting method (Satria, 2014; Bahagia, 2006; Gujarati & Porter, 2004; Winston, 1994). The indicator that is generally used in measuring the accuracy of the forecasting method is the Mean Absolute Percentage Error (MAPE) which can be found using the following formula:

$$MAPE = \frac{\sum_{t=1}^{t=m}\frac{|Y_t - W_t|}{Y_t}\times 100\%}{m} \qquad (2)$$

With:

$Y_t$ = data at time ($t$)

$W_t$ = forecasting data at time ($t$)

$m$ = amount of data

*Economic Order Quantity with (q,r) model*

The first step in the Probabilistic EOQ is to find the value of the initial order quantity ($q_1$) with the formula:

$$q_1 = \sqrt{\frac{2K.E(D)}{h}} \quad (3)$$

With:
$K$ = ordering cost
$E(D)$ = expected infusion requirement
$h$ = storage cost

Then find the stockout probability ($\alpha_1$) and reorder point ($r_1$) with the formula:

$$\alpha_1 = \frac{hq_1}{C_B E(D)} \rightarrow z_{\alpha_1} \quad (4)$$

$z_{\alpha_1}$ value can be seen in the *z* distribution table.

$$r_1 = E(X) + z_{\alpha_1} S\sqrt{L} \quad (5)$$

With:
$C_B$ = inventory shortage costs
$E(X)$ = expected demand during lead time
$S$ = standard deviation of data
$L$ = lead time

Then find the value of $q_2$, $\alpha_2$, $r_2$ with the formula:

$$q_2 = \sqrt{\frac{2E(D)\left[K + C_B \int_{r_1}^{\infty}(X-r)f(X)dX\right]}{h}} \quad (6)$$

$$\alpha_2 = \frac{hq_2}{C_B E(D)} \rightarrow z_{\alpha_2} \quad (7)$$

$$r_2 = E(X) + z_{\alpha_2} S\sqrt{L} \quad (8)$$

If the value of $r_1 \cong r_2$, then the iteration is finished and the optimal *r* and *q* are obtained. If not met, then look for the value of $r_3$ again. Then look for the value of the safety reserve ($ss$) and the total cost of inventory ($TC$) with the formula:

$$ss = z_\alpha S_x \quad (9)$$

$$TC(q,r) = E(D).p + K\frac{E(D)}{q} + h\left(\frac{q}{2} - E(X) + r\right) + \frac{C_B.E(B_r).E(D)}{q} \quad (10)$$

**Result**

*Forecasting Needs for NaCl Infusion and Glucose Infusion*

Based on the tests that have been carried out, it is known that the best model for predicting the need for NaCl infusion is ARIMA (4,1,0) and the best model for predicting the need for glucose infusion is ARIMA (2,1,2) with the following results:

Table 1
NaCl infusion forecasting results

| No | Month | Number of Needs |
|---|---|---|
| 1 | July | 24.597 |
| 2 | August | 26.143 |
| 3 | September | 26.850 |
| 4 | October | 25.605 |
| 5 | November | 25.982 |
| 6 | December | 25.654 |
| Total | | 154.831 |

Table 2
Glucose infusion forecasting results

| No | Month | Number of Needs |
|---|---|---|
| 1 | July | 1.280 |
| 2 | August | 1.367 |
| 3 | September | 1.406 |
| 4 | October | 1.406 |
| 5 | November | 1.397 |
| 6 | December | 1.393 |
| Total | | 8.249 |

*Determining the optimal number of orders, reorder points and safety stock*

1) NaCl Infusion
By using known values, we get:
$q_1$= 11.622,378
$r_1$ = 3.593,378
$q_2$= 11.920,3969
$r_2$ = 3.592,276
From the results obtained, it is known that $r_1 \cong r_2$, therefore the iteration is finished and the optimal value of $r$ = 3,593 and $q$ = 11,921 is obtained (values are rounded up).
Next, a safety reserve (ss) will be sought.
$ss = z_\alpha S\sqrt{L}$
= 189,4465
Thus, the safety reserve that needs to be prepared is 190 units (values are rounded up).
2) Glucose Infusion
By using known values, we get:
$q_1$= 557,5492
$r_1$ = 201,8465
$q_2$= 559,2678
$r_2$ = 201,8465
From the results obtained, it is known that $r_1 = r_2$, therefore the iteration is finished and the optimal value of $r$ = 202 and $q$ = 560 is obtained (values are rounded up).
Next, a safety reserve (ss) will be sought.
$ss = z_\alpha S\sqrt{L}$
= 20,6157
Thus, the safety reserve that needs to be prepared is 21 units (values are rounded up).

*Determining total order cost (TC)*

1) NaCl Infusion

$$TC(q,r) = E(D).p + K\frac{E(D)}{q} + h\left(\frac{q}{2} - E(X) + r\right) + \frac{C_B.E(B_r).E(D)}{q}$$

= 1.004.516.195

2) Glucose Infusion

$$TC(q,r) = E(D).p + K\frac{E(D)}{q} + h\left(\frac{q}{2} - E(X) + r\right) + \frac{C_B.E(B_r).E(D)}{q}$$

= 43.460.456,31

**Conclusions**

Based on the previous discussion, it can be concluded that planning for infusion supplies at Sanglah General Hospital is as follows:

1) Sanglah General Hospital is expected to provide infusions by the beginning of July 2017 as many as 11,921 units for 500 ml 0.9% NaCl infusion and 560 units for 5% 500 ml Glucose type infusion. Sanglah Hospital needs to place another order when the 500 ml 0.9% NaCl infusion stock hits 3,593 and the 5% 500 ml Glucose infusion stock hits 202 units. To anticipate a surge in demand, Sanglah General Hospital is expected to provide infusions as a safety reserve of 190 units for 500 ml 0.9% NaCl type infusion and 21 units for 500 ml 5% glucose type.
2) Planning for the total inventory cost of the infusion to be issued by Sanglah General Hospital is Rp. 1,004,516,195 for 500 ml 0.9% NaCl infusion and Rp. 43,460,456.31 for 500 ml 5% glucose type infusion. Therefore, the costs that need to be prepared by the Sanglah General Hospital in planning the needs of the two infusions for 6 months are Rp. 1,047,976,651.31.

*Recommendations*

Because this study takes the case of an unconstrained model (unlimited storage warehouse), further researchers can use an inventory model with constraints, which is the Economic Order Quantity (EOQ) with the (q, r, λ) model.

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