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Forecasting Demand in Blood Supply Chain (Case Study on Blood Transfusion Unit)

Fitra Lestari, Ulfah Anwar, Ngestu Nugraha, Budi Azwar

***Abstract*—Blood Transfusion Unit is an institution under the supervision of the government that tasked to provide blood components for the community. Furthermore, this agency serves the community for the provision of information on the availability of blood, blood filtration of infectious diseases and blood storage. Problem of this case showed that there was out of stock of blood components that was caused by the blood components have low viability when long-time stored. Purpose of this study is to forecast demand of blood components for decision making process in supporting the activities of Blood Transfusion Unit. There were four methods of foresting involving moving average, weighted moving average, exponential smoothing, exponential smoothing with trend which these methods were analyzed using POM-QM software. Finding showed that there were two patterns of forecasting results of blood components that categorized into time series of stationary and trend. Implication in this study is able to select the appropriate forecasting method for anticipate the uncertainty demand of blood components. Further research is recommended to consider the safety stock for calculating the minimum inventory at Blood Transfusion Unit. This calculation can be continued to determine the ordering using method Re-Order Point (ROP) to fulfil the demand.**

***Index Terms*—Blood component, supply chain, forecasting, Blood Transfusion Unit**

I. Introduction

Blood is an essential component in the human body that carries nutrients and oxygen to organs such as the heart, lungs, brain, liver and kidneys,. Bonjour (2013) found in his research that the lack of blood in the body caused the body balance (*homeostasis*) is disturbed. To prevent this condition, it need suppling the blood from outside of the human body through blood transfusion. Furthermore, process of blood transfusion aims to replace lost blood in patients due to bleeding, burns, overcoming shock, maintaining the body's resistance to infection (Keyhanian et al., 2010). Aritonang et al. (2016) also found that there were several blood components composed of *whole blood, packed red cell, washed erythrocyte, fresh frozen plasma, plasma liquid, thrombocyte concentrate, cryoprecipitate* and *apheresis*.

Blood Transfusion Unit is an institution under the supervision of the government tasked to provide blood for the community. Furthermore, this agency serves the community for the provision of information on the availability of blood, blood filtration of infectious diseases and blood storage. Obviously, *Blood Transfusion Unit* seeks to provide the best service for the community by distributing the blood to those in need. Thus, people can feel directly participate in humanitarian activities of blood donation.

Aritonang et al. (2012) reported that there was problem in managing blood donation. They concluded that the blood components have low viability when long-time stored. It was a challenge for the management of the *Blood Transfusion Unit* because occurring out of stock or shortage product due to the expiry on blood components. Nowadays, the management overcome the expired blood components by putting in place the blood of storage. Nevertheless, there was not guarantee that the quality of blood whenever stored for a long time in the freezer will be better. Implication for this condition caused there was imbalance between the amount of blood stock demand and blood availability.

Forecasting method is able to prevent imbalance between supply and demand. Therefore, it can predict the demand of products and facilitate the manager in decision making process. Essences of forecasting method is to estimate the tendency of data. In addition, the beneficial of forecasting method able to obtain the results will be closer to actual condition (Nenni et al., 2013). Most of forecasting methods were widely used in production activities because this method determined the amount of demand for product. Then, it was also the first step of the process of production planning and control (Daniel et al., 2011).

Indeed, purpose of this study is to provide forecasting techniques for decision making process in supporting the activities of *Blood Transfusion Unit*. The data in this study used demand of blood components in *Blood Transfusion Unit* on January - December 2015.

II. Forecasting

Forecasting is a technique in business process that seeks estimate demand to produce finished product with the right quantity. In addition, forecasting function predicts future demand based on several variables and parameters of

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F. Lestari is Head of Supply Chain Management Research Group and Researcher of Industrial Engineering Department at Sultan Syarif Kasim State Islamic University and Pelalawan School of Technology (corresponding author e-mail: fitra_lestari@yahoo.com)

U. Anwar is Medical Doctor, Lecture of Pahlawan Tuanku Tambusai University and Director of AlMadinah Health Consulting in Indonesia (e-mail: ul_pha7@yahoo.com).

N. Nugraha is researcher at Sultan Syarif Kasim State Islamic University, Industrial Engineering Department in Indonesia (e-mail: ngestu.nugraha@yahoo.com).

B. Azwar is a researcher at Sultan Syarif Kasim State Islamic University, Islamic Economic Department in Indonesia (e-mail: budiazwar79@yahoo.com).

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historical time series data. Nenni et al., (2013) revealed that the optimal result of forecasting was obtained whenever the result contains low value of errors. In addition, forecasting method was done based on certain time horizon such as daily, monthly, quarter and others.

Most of research that employed forecasting method categorized into two approaches involving qualitative forecasting and quantitative forecasting (Caniato et al., 2011; Shao and Wang, 2010). These approaches were used for decision making process in predicting the amount of demand. Moreover, qualitative forecasting also which was called judgment method. This approach does not require manipulation or calculation of the historical data. Nevertheless, decision making process on forecasting technique was adopted based on experience, knowledge and other information. Although the actual judgment method was taken from the expert, it also considered historical data from their experience. Then, quantitative forecasting was used whenever the historical data was available and represent to predict demand in the future. This approach assumed that the demand in the past can be extended for requirement in the future.

Furthermore, there were several methods of quantitative forecasting involving *moving average, weighted moving average, exponential smoothing, exponential smoothing with trend.*

A. *Moving Average*

Moving average is implemented using the amount of actual data or request for new sale to generate value forecasting for future demand. Safi and Dawoud (2013) revealed This method is effectively implemented whenever it assumes that the demand of the product remains stable over time. A common problem with this method is how to choose the n-period estimated to obtain appropriate result.

B. *Weighted Moving Average*

Weighted moving average is more responsive to changes due to new data from the period is usually given greater weight. Nevertheless, the limitation of this method depend on the length of the period that is set. The longer the period stipulated so the greater the weighting given to the latest data (Shih et al., 2008).

C. *Exponential Smoothing*

Exponential smoothing model works with matching the value of forecasting to the actual demand. Ravinder (2013) implemented this method and revealed that the actual value of the demand is higher than the forecast value so this model automatically increases the value of the forecast.

D. *Exponential Smoothing with Trend*

The procedure of *exponential smoothing with trend* requires two constants including α for average and β for trend. Ravinder (2013) concluded that this method able to use on the problem is seasonal.

III. Methodology

Data collection in this study in the form of information related with blood donation process and classification of blood components at *Blood Transfusion Unit*. This data was collected using qualitative research in the form of observation, interviews and documentation (Kiridena and Fitzgerald, 2006). The observations were done by looking at the blood transfusion process and its storage. Furthermore, the interview was done in the form of open-ended interviews with person in charge in *Blood Transfusion Unit* and volunteer of blood donor. Interviews were conducted to obtain the required secondary data research. While the documentation was done to gather some supporting documents both historical and current conditions.

IV. Case Study

This case study described the business process of managing the blood components that involves several entities include suppliers, manufacturers, distributors and consumers. Blood components were collected through the events that held to the public. Furthermore, *Blood Transfusion Unit* recorded people who want to become permanent blood donors, volunteers and blood donors substitute. Thus, *Blood Transfusion Unit* had a list of donors that was used as a reference in managing blood components. *Blood Transfusion Unit* had events scheduled in founding the donors and resolve stock availability of blood components.

Furthermore, *Blood Transfusion Unit* had several tasks included consultation related blood issues to the public. Then, it proceeded to the processing of blood transfusion that had standard quality. In addition, the blood components were screened, stored and distributed to communities.

Blood that obtained by *Blood Transfusion Unit* dispensed in accordance integrity. There were two groups of distributor of blood components involving Hospital Blood Bank (BDRS) and other institutions (non-BDRS) such as clinics. Finally, the users of blood components were patients.

Obviously, it was concluded that the above activities related of blood donation can be assessed on blood supply chain strategy. Therefore, in managing blood components, it required many entities involved to provide the best service for the community. Figure 1 described the business process of blood supply chain.

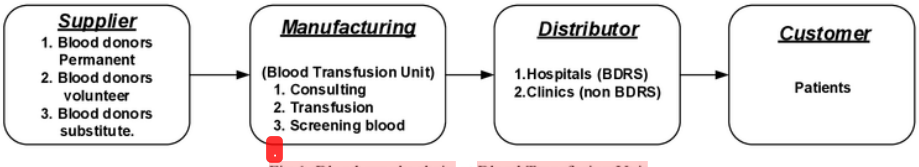

Fig 1. Blood supply chain at Blood Transfusion Unit

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V. Result

Forecasting analysis of blood components was done using POM-QM Software. Furthermore, the actual data was collected at *Blood Transfusion Unit* that were taken from the period January – December 2015. Moreover, forecasting methods in this study used a time horizon in the form of monthly. POM-QM software supported on analysis of data by choosing the method with the smallest number of errors of forecasting results using four methods: *moving average, weighted moving average, exponential smoothing, exponential smoothing with trend*. Figure 2 is forecasting of blood components in form of *whole blood* use POM-QM software.

The entire of blood components in *Blood Transfusion Unit* was calculated to get the results of forecasting with the selected method. Recapitulation of the forecasting for the entire blood components can be seen in Table 1.

TABLE I
FORECASTING BASED ON SELECTED METHOD

No	Blood Component	Selected Method	Forecasting
1	*Whole Blood*	exponential smoothing ($\alpha = 0,5$)	953 Unit
2	*Packed Red Cell*	exponential smoothing ($\alpha = 0,4$)	2274 Unit
3	*Washed Erythrocyte*	weighted moving average (weight = 4)	24 Unit
4	*Fresh Frozen Plasma*	exponential smoothing with trend ($\alpha = 0,1$ and $\beta = 0,1$)	201 Unit
5	*Thrombocyte Concentrate*	exponential smoothing with trend ($\alpha = 0,1$ and $\beta = 0,4$)	801 Unit
6	*Cryoprecipitate*	exponential smoothing ($\alpha = 0,1$)	24 Unit
7	*Apheresis*	moving average (period = 3)	34 Unit

VI. Discussion

Historical data were analyzed by calculating the demand for blood demand of 12 periods for each component. Data was processed using POM-QM software revealed there were two patterns of forecasting result of blood components. The first pattern concluded that blood components of *whole blood, packed red cells, washed erythrocyte, fresh frozen plasma* and *apheresis* categorized into *stationary* pattern. Therefore, the data forecasting results obtained fluctuate around the mean value that occur constantly. For blood components *thrombocyte concentrate* and *cryoprecipitate* categorized into trend pattern that have a tendency up or down continuously.

Furthermore, forecasting results was continued to determine the accuracy of forecasting error by comparing the predicted values with the actual value. This study used the *mean absolute deviation* (MAD), *mean absolute percentage error* (MAPE) and *standard error* (SE). The accuracy of the smallest forecasting error was taken to consider in determining the selected method of forecasting.

VII. Conclusion

This study proven that the case of blood components requiring to adopt forecasting method to anticipate blood shortage in blood supply chain. There were many methods of forecasting with different parameters. This study indicated that the trend data was represented by the demand of blood components can be predicted using the forecasting. Thus, management of *Blood Transfusion Unit* able to make decision making to fulfil requirement of blood.

Moreover, results of this study provides information for decision-makers in the form of predictive blood requirement by *Blood Transfusion Unit*. Nevertheless, the management are still needed preparation for buffer stock which serves to anticipate the demand uncertainty. Further research is recommended to consider the safety stock for calculating the minimum inventory at *Blood Transfusion Unit*. This calculation can be continued to determine the ordering using method Re-Order Point (ROP) to fulfil the demand.

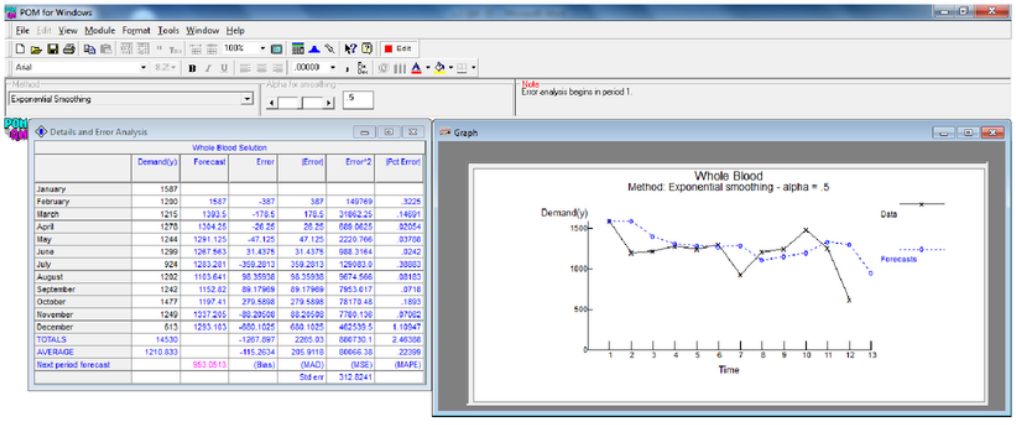

Fig 2. Forecasting of blood component in form of *whole blood* use POM-QM software

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