Drug Supplies Planning in Hospital for Epidemic Attack using SEIR Model

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Drug Supplies Planning in Hospital for Epidemic Attack using SEIR Model

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Abstract. Denguehaemorrhagic fever is one of the epidemic diseases that often occurs in Indonesia. The incidence of dengue outbreaks in Indonesia territory shows an increasing trend from year to year. People infected dengue virus, if not treated immediately can cause death and can quickly spread on a wider scale. The hospital as one of the health care facilities must be able to handle patients who are indicated and infected with dengue quickly and precisely. One important resource is the fulfilment of drug supplies for the treatment of DHF patients. Lack of drugs during a dengue epidemic should not occur because it will seriously endanger patient safety. To avoid shortages of drugs, hospital management is required to be able to manage and determine the enough amount of drug supplies in the hospital. This study aims to predict the amount of drug supplies in hospitals during the outbreak of dengue fever. SEIR model is used to predict the number of drug needs that must be provided by the hospital in the event of an dengue fever outbreak.

1. Introduction

Dengue fever is a type of epidemic disease that is quite a health problem in Indonesia. The number of cases of dengue fever in Indonesia has been quite volatile in recent years. Based on data from the Indonesian Health report in 2015, the number of DHF patients reported was 129.650 cases with a total of 1.071 deaths (morbidity = 50,75 per 100,000 population and mortality = 0.83%). Compared to 2014, there were 100,347 cases and 39.80 morbidity rates increased in 2015[1].

Hospitals as health care providers are required to be able to overcome and meet the problem of medication needs during an epidemic attack. Therefore, inventory management in hospitals plays an important role in efforts to handle the control of epidemic attack. Planning the right amount of drugs in the hospital will be able to overcome the problem of drugs shortages in the event of a disaster[2]. By looking at the importance of drug supplies in the hospital, it can be said that a study that can model drugs need in dealing for natural disaster situations still needs to be done. Some natural disasters have stochastic patterns, for example: epidemic outbreaks related to climate change (dengue fever, diarrhea, respiratory infections, etc.). Some ofdiseases incidencewhich influenced by climate could be predicted using historical data in a certain period of time. According to[3]many parameters and variables of epidemics logistics response systems are of stochastic. In this paper through a stochastic problem

approach that considers epidemic incident data in an area, it is expected to be able to model a planned inventory of drugs in a hospital during an epidemic attack. Mathematical model of epidemic will use to over come determining amount of drugs supply in handling epidemic incidence.

2. Inventory Managementin Hospital

Inventory in a hospital is an important supply chain component in health care activities. Inventories in the hospital include medical equipment, drugs, treatment facilities and others. Availability of equipment and medical needs in health services are demands that must be met. The unavailability and lack of medical needs (medicines) in the provision of health services will affect the quality of health services for patients. According to [4]the hospital pharmacy management team needs to adopt inventory management because it can have a positive impact on hospital performance. Effectiveness and efficiency in managing medical supplies in a hospital will improve the balance between inventory supply and demand.

The need for emergency disaster medical logistics is a very important material in health service activities. [5]say that in emergency medical logistics operations will encounter three complex and complex problems, namely: first, limited information on the number of disaster victims; second, the rapid increase in the number of victims affected by disasters (for example: due to widespread epidemics); third, substitution of medical relif is not perfect, unlike other relifs such as food. Specific drugs cannot be completely replaced with other drugs [6]. Accuracy in decision making relating to the supply of medical logistics supplies will affect the health supply chain performance. Studies in the field of inventory management that integrate Healthcare Supply Chain and Disaster Supply Chain will be an interesting issue to discuss[7].

3. Dengue Hemorrhagic Fever (DHF)

DHF is one of the most common infectious diseases in humans in recent years, making it a world health problem. According to the World Health Organization (WHO) report, more than 2.5 billion people worldwide are estimated to be at risk of getting dengue.The DHF is transmitted by mosquito-borne infection with one of four dengue virus serotypes[8]. DHF disease can affect infants, children and adults with symptoms appearing 3-14 days after the bite of a dengue virus mosquito. DHF is a disease transmitted by Aedesaegypty and Aedesalbopictus.

Dengue is not transmitted directly from person to person but through the bite of mosquitoes infected with dengue virus. The initial symptoms of DHF disease are starting with a mild fever and can progress to high fever, severe headaches, pain behind the eyes, muscle and joint pain. There is no vaccine or special medicine to treat dengue fever.People who suffer from DHF have to rest, have minimal fluid and consume paracetamol to reduce or reduce fever. Severe dengue is characterized by fever, abdominal pain, persistent vomiting, bleeding and difficulty breathing and can result in potentially deadly complications. Dengue disease most often affects children. Early clinical diagnosis and careful clinical management by trained doctors and nurses can improve patient survival.

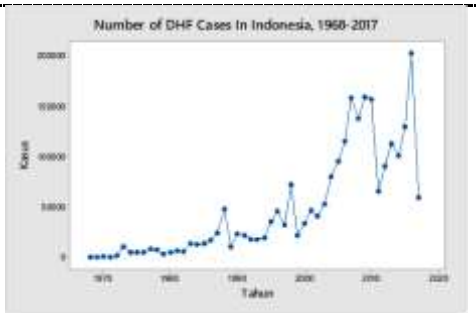

Figure 1. Number of DHF Cases In Indonesia (1968 – 2017) (http://www.depkes.go.id/)

In Indonesia dengue hemorrhagic fever is still an important public health problem. Dengue infection occurs endemic in Indonesia over the past few years from mild and severe symptoms. The number and distribution of DHF cases shows an increasing trend in decades (Figure 1).

4. Epidemic Model and Drugs Forecasting

Epidemiology is the study of the distribution and determinants of the prevalence of chronic and infectious diseases in humans [9]. Epidemiology has developed very rapidly in various aspects of life. The science of epidemics includes not only infectious diseases but also aspects of social, genetic and molecular biology. Through mathematical models, disease behavior can be learned and prevented from spreading when the epidemic emerges.Model of *SEIR* (Susceptible-Exposed-Infectious-Removed) is an extended of the SIR (Susceptible-Infectious-Removed) epidemic model proposed by [10]in 1927. The SEIR model describes four classes: classes of susceptibles, classes of individuals suspected of being infected by exposed, the class of the number of individuals who have been infected by the disease (infectious), and the class of the number of individuals who are free from recovery. The SEIR model is a mathematical model for disease outbreaks that have latency. In [11]define the latent period (incubation period) as the period of an individual who has been infected by the disease but the individual has not been able to transmit the disease to other individuals. The SIER standard model is shown as in equation (1).

$$\begin{aligned} \frac{dS}{dt} &= \mu N - \frac{\beta IS}{N} - \mu S \\ \frac{dE}{dt} &= \frac{\beta IS}{N} - \alpha E - \mu E \\ \frac{dI}{dt} &= \alpha E - \mu I - \gamma I \\ \frac{dR}{dt} &= \gamma I - \mu R \end{aligned} \tag{1}$$

where, N population, S number of susceptible, E number of exposed, I number of infectious, R number of recovered, β transmission rate class S to E, γ recovery rate, μ natural death and α transmission rate from class E to I. S, E, I, and R respectively indicate the number of individuals who are vulnerable, affected, infected, and cured in their respective regions. S represents those who are vulnerable to infection. E shows the people affected during the incubation period (latent period). The incubation period is the time interval between exposure to the disease and the appearance of early signs or symptoms of disease. An individual in this period has been infected but has not transmitted himself. I represent an infectious individual. R shows those who are cured and have permanent immunity. In the above SEIR model, the population is assumed to be constant $N = S + E + I + R$, so that the rate of birth and death is assumed to be constant. In this model it is assumed that individuals who contract the disease get treatment.The number of requests for drugs in the time period t is $\int_{t_0}^{t_0+L}[S(t)+E(t)]\,dt$ and the number of treatment requests in period t is $\int_{t_0}^{t_0+L} I_j(t)\,dt$, where t_0 refers to the beginning of the period t and the period of the period L. In[5]the demand forecast of drugsas equation (2).

$$D = \begin{cases} \theta^p \int_{t_0}^{t_0+L} \left[S(t)+E(t)+(1-\sigma) I_j(t) \right] dt, & p \in M_p \\ \theta^p \int_{t_0}^{t_0+L} \sigma I(t)\,dt, & p \in M_t \end{cases} \tag{2}$$

Where θ is number of types of drugs p, t_o is the beginning of a period of time t ; L is the length of time period.

5. Materials and Methods.

5.1. Study Area

This study looked at one type of epidemic disease, namely dengue fever or called DHF. In this study, we will see historical data of medical patients in hospitals that indicated dengue fever. Based on the treatment by the hospital, dengue fever patients are categorized into two types, namely inpatients and outpatients. The hospital that became the object of research was a regional hospital in Gresik regency, namely Muhammadiyah hospital.

5.2. Method

The SEIR model is used for forecasting with continuous time intervals and distribution decisions are made with discrete time periods. Therefore, in this study, the drugs demandare an aggregate the proportion of the number of individuals infected with epidemic diseases on certain periods. As sampling for epidemic cases is DHF. Estimates of the number of infected individuals are based on historical data of DHF sufferers in the area over the past few years (2014-2016). The forecasting time period with the SEIR model is used with a time interval of three months (90 days). Estimated number of DHF sufferers usean integral number of infected individuals *(I)* (equation 2). There are two types of emergency medical assistance that are considered, namely individuals who are susceptible to infection (denoted as *Mp*) and medical assistance for people who can transmit the disease (symbolized as *Mt*). The number of drugs needed and must be provided by the hospital correlates with the number of individuals who are infected and can transmit dengue virus.

5.3. Data Collection

Data of dengue fever patients were obtained from the number of patients handled by Muhammadiyah Gresik hospital for three years (2014 – 2016). Patients with dengue fever were grouped into 2 groups, namely outpatients and inpatients. In this study, the prediction of the amount of drugs needed are only focused on inpatients.

6. Result

Data of DHF patients at Muhammadiyah Hospital of Gresik per 3 months in three years (2014-2016) are shown as Figure 2.The number of DHF patients in the last three years (2014-2016) tends to increase in the second quarter (Apr-Jun) and 3rd quarter (Jul-Sept). But it experienced a decline at the end of the period in the first quarter (March) and the fourth quarter (December). The significant increase in the second quarter and the third quarter is estimated because the period is the best time for aides aegypti mosquitoes to develop. So that during this period, caution must be taken in anticipating the soaring number of incidents of dengue disease.

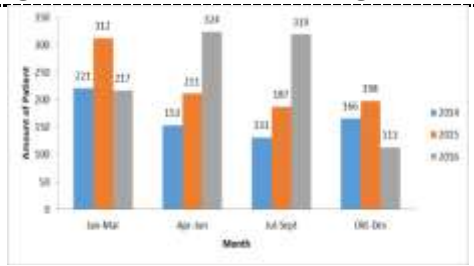

Figure 2. DHF patients per 3 months (2014-2016)

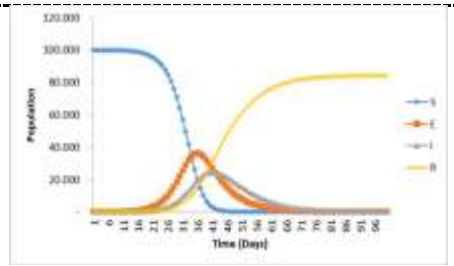

Figure 3. Graph of SEIR model

In this study.Parametersμ, β and αare use the values from[12].Parameter values are N =86,934;μ = 0.0000421;S_0= 86.306; E_0= 500; I_0=128; R_0=0;β = 1,428; α = 0,125; γ= 0,1428571. Demand ofdrugs are based on the prediction of individuals amount which are infected with DHF. Graph of the SEIR model as shown in Figure 3. Equilibrium point occurs when the values of *S*, *E*and *I*reach zero. Equilibrium pointshow that there is no disease in the population or is known as a disease-free point. Number of infectious individuals (*I*) is used as a basis for predicting the number of DHF patients. Based on the calculation results obtained the peak point *I* occurred at the number 20.844. The

prediction of individuals number that potentially infected with dengue are proportional to the maximum value *I*. The estimated number of infected individuals can be used to predict the number of drugs needed to treat DHF patients. The number of patients that can be handled by the hospital depend on the capacity of the hospital beds. Based on this capacity, it can be obtained the number of patients that are potentially served by every hospital in the district of Gresik. The number of potential patients that can be handled by hospitals in Gresik district are as shown in table 1.

Tabel 1. Bed capacity and proportion allocation patients in hospital

Name of hospital	Bed capacity (BC)	%BCx Tot. I	Name of hospital	BC	%BC x Tot. I
Ibnu Sina	239	3910	Walisongo I	53	867
Muhammadiyah Gresik	101	1652	Wates Husada	53	867
Nyai Ageng Pinatih	51	834	Surya Medika	50	818
Graha Husada	46	753	Petrokimia Driyorejo Gresik	66	1080
Petrokimia Gresik	128	2094	Mabarot MWC NU Bungah	43	785
Denisa	50	818	PKU Muhammadiyah Sekapuk	50	818
Semen Gresik	140	2291	Cahaya Giri	48	785
Fatma Medika	55	900	PUSKESMAS	96	1571
Total				1.274	20.844

Based on the predictions of potential DHF patients that can be treated by hospitals (see table 1), Muhammadiyah Gresik hospital will get a proportion of 1.652 patients. This number prediction is quite far, when compared with the prediction trend of patients using the Moving Average (MA), regression and Exponential Smoothing (ES) forecasting methods for the next periods (Figure 4). Sequentially obtained the prediction of patientsnumber with a regression, MA and ES approach are 1.002, 1472 and 1028 people. The difference is quite far because the SEIR method is a prediction of the incidence of regional dengue.

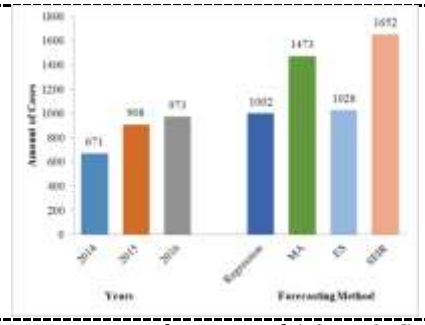

Figure 4. Number of DHF cases in the Hospital (2014-2016) and forecasting result

The SEIR method only predicts the rate of spread of disease in the region based on the findings of dengue cases in the region. So the amount obtained are the number of occurrences in the area which are the point of spread of epidemic diseases. The area of disease spread and number of population could be influencedfor the greater of infection case. Estimates of the number of individuals infected using the SEIR model are still possible to be used as a consideration for hospital inventory management.

Tabel 2. Demand of drugs for next periods

Name of drugs	Unit	Total amount of drugs demand forecasting			
		Regression	MA	ES	SEIR
RL	fls	9.018	13.257	9.252	14.868
Paracetamol	tab	9.018	13.257	9.252	14.868
Ranitidin	ampul	6.012	8.838	6.168	9.912
Ceftriaxone 1g	vial	6.012	8.838	6.168	9.912
Methilprednissone 125 mg	ampul	6.012	8.838	6.168	9.912

Decision planning for the amount of drug supply is not only based on forecasting using conventional methods (regression, MA and ES), but also using the SEIR method. Based on the prediction results of the number of patients which are handled by the hospital, the amount of drugs supplies for DHF cases as in table 2. The amount of drugs supplies needed for dengue cases are aggregate needs for a period of one year. Hospital inventory management can estimate the number of drug requirements when cases of epidemic disease use a conventional forecasting approach or SEIR method.

7. Conclusion

DHF is an epidemic that can endanger public health if it is not addressed immediately. Disease spread quickly and can extend to other areas. Thus problem can be avoided if immediately get treatment quickly and accurately. The hospital is one of the main health services in handling cases of dengue disease. In order hospital can serve and handle cases of DHF epidemic, the availability of drugs must be guaranteed. To avoid shortages of drugs, it is necessary to anticipate by forecasting of drug needs. One of forecasting approach that can be used is using SEIR method. This method, although based on regional forecasting, but can still be used as one of the considerations in determining the planning of drugsamount that must be provided by the hospital to deal DHF cases.

8. References

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