International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

The Dynamic Model Approach in Estimating Rabies Death in North Toraja Regency

Sandra DW[a], A. Arsunan Arsin[b],Anwar Mallongi[c]*

[a]*Master Program of Epidemiology, Faculty of Public Health, Hasanuddin University*
[b]*Epidemiology Department, Faculty of Public Health, Hasanuddin University*
[c]*Environmental Health Department, Faculty of Public Health, Hasanuddin University*
[a]Email address: *sandra.pitona@gmail.com*

Abstract

Estimate of deaths from rabies in the future are an important aspect in the planning of public health policies towards Indonesia for rabies. This study aims to estimate the number of deaths from rabies for 20 years (2013-2033) and the most appropriate preventive strategies in reducing the rate of increase in the number of deaths from rabies using a dynamic model approach in North Toraja Regency. The study design was observational analytic with case control study design using secondary data reporting cases of human rabies animal bites, medical treatment provision VAR, deaths from rabies in humans, cases of rabies in animals, the number of the dog population, the number of rabies vaccination in dogs in the District Toraja Utara 2013-2014. Data analysis was performed by building causal loop and flow charts Model Rabies Deaths use Powersim program. The results showed in the 20 years to come estimated deaths from rabies increased by 7x fold per year of 4 people (0.13%) in 2013 to 396 people (12.87%) in 2033 if the risk factors that affect the rabies death not controlled. Increasing the number of deaths from rabies can be prevented by controlling the various risk factors that intervene VAR such as giving 100%, intervention rabies vaccination in dogs by 80%, intervention castration of male dogs as much as 5%, and the combination of increased intervention in all influential variables.

----

* Corresponding author.
E-mail address: sandra.pitona@gmail.com.

The most appropriate strategy to reduce the rate of increase in deaths from rabies is to combine three variables increase interventions that can decrease the number of deaths from 396 deaths to 18 deaths.

Keywords: Estimation; Dynamic Model; Rabies.

1. Introduction

Rabies is an acute infectious disease, zoonotic, attacks the central nervous system in humans and warm-blooded animals caused by this virus. The disease was transmitted by infection material through the saliva of animals rabies because of biting, scratches, or through open wounds [1]. Report of Organization International des Epizooties said that rabies disease in developing countries is the second most feared disease of foreign tourists after malaria [2]. The mortality due to rabies reach almost 100% and attack at all ages and genders. Rabies causes death in humans 30000-70000 per year. The main reservoir cause of rabies in Europe were the fox and the dog, were 47-58% and 18-24%, and more than 90% of cases of human rabies in Asia and Africa are caused by dogs [3].

The cases of rabies in Indonesia continues to increase every year. The incidence of rabies in South Sulawesi province were first reported in 1958 after diagnosed of veterinary laboratory said that dog bite victims was rabies positive. Target free areas which have been implemented since 1998 has not been achieved and it was extended until 2008, but until 2009 it was not achievable, conversely rabies cases tend to be widespread [4]. Rabies in humans ranks 7th among infectious diseases, but human deaths could have been avoided. But in the developing countries including Indonesia have not been able to eradicate rabies, due to the low priority both from the aspect of public health and animal health.

Rabies is not only a dog problem but a human problem. Basically the successful control and eradication of rabies depends on the level of people awareness. There are necessary changing of behavior that allows the community to accept and comply various obligations under the applicable rules as impound and binding their dog, well fed, cared and maintain their dog health and routinely vaccinate dogs. The discipline, ethical and abiding communities will make control officer are easier to overcome the situation [5]. The cultural diversity is an important aspect to understand the dynamics of the spread of rabies in Indonesia, in North Toraja Regency, dog is a pet, beside as a guard in home and garden, dogs are also consumed to meet the needs of animal protein. A number of socio-economic factors such as the number of ownership, system maintenance, the purpose of the maintenance, education level, knowledge of rabies, and the revenue of owners have proven associated with the incidence of rabies [6].

The solutions of prevention, eradication, and the spread of rabies have been carried out and assessed in terms of health. One of the disciplines that can help overcome these problems is mathematics. Mathematical modeling can be used to solve the problem of the spread of rabies by using certain assumptions that the solution can be obtained both analytically and numerically. One way that can be used to determine the estimated number of cases of rabies by using the approach of using dynamic modeling. Dynamic modeling in epidemiology contribute to an understanding of the behavior of infectious diseases, the impact and the possibility of future predictions about its spread. Dynamic modeling is also used in comparing, planning, implementation, evaluate and optimize various detection, prevention, treatment and control program.

The dynamic model is one tool that can help in solving the problems in real life. The problems can be brought into a mathematical model using certain assumptions. Furthermore, we will look for a solution both analytically and numerically. One of the problems in life is about the spread of disease [7]. In the medical world there are diseases that are communicable (infectious diseases) and noninfectious (non infectious diseases) [8]. This research aims to estimate the number of rabies deaths for 20 years (2013-2033) and the most appropriate preventive strategies in reducing the rate of increase in the number of rabies deaths using a dynamic model approach in the regency of North Toraja

2. Material and Method

Location and research design

The research was conducted in the North Toraja regency in South Sulawesi province with judgmental sampling. The type of research are observational analytic using cross sectional design research which aims to determine the estimated number of rabies deaths for 20 years (2014-2033) and the most appropriate prevention strategies in hampering the an increase in the number of rabies deaths with a dynamic model approach.

Population and Sample

The whole population was used as a simulated sample. The samples are all rabies deaths in 2013-2014 were recorded in the Department of Health. The entire dog population and rabies group of dogs who were diagnosed during the years 2013-2014 were recorded in the Department of Animal Husbandry. Intervention scenario variables defined were the provision VAR to the victims of dog bites rabies, vaccination of dogs as rabies reservoir, and castration in male dogs to control the population.

The data collection

The data used were secondary data obtained from the Department of Health and Department of Animal Husbandry of North Toraja Regency. The data collected is the used data as a significant variables and auxiliary variables that influence each other for modeling of system to be simulated. Data rabies cases in North Toraja Regency in the year 2013 - 2014 can be seen in Table 1 (attachment).

The data processing

The initial step in the manufacturing system modeling was conceptual model with described through causal loop diagrams or causal diagram. This causal diagrams are used to visualize the system in general to be simulated by the method of dynamic systems through the visible components. The components were the variables, parameters, and constants and it became interdependent and influence the behavior of the system.

The conceptual model that has been made previously by the causal diagram, translates into a dynamic system models depicted through stock and flow diagram formed by four components, were: the system, the feedback, the level and rate by using software Powersim. Then determining the equation of each variable as in model formulation is done in a way to understand and test the consistency of the model if the model is already in line with the goals and limits of the system that had been made.

Verification is done by checking to the model and units in the model by using the facilities at Powersim. The model validation is done by validating the model structure and performance validation test models. The validation testing model structure aims to look at the suitability of the structure of the model with the behavior of the system in the real world [9]. The performance testing is performed to determine whether the built model was academic viable and also to avoid the wrong model. The common way of testing is to validate the output of the model using statistical test developed by [10] was the statistical test deviation by measuring the average value of the simulation to the actual mean absolute error, AME) and deviation test by measuring value of simulation variation and the actual (absolute variation error, AVE) with a range of values up to 10%.

The formula used is as follows:

$$AME = ((\underline{S_i} - \underline{A_i}) / A_i) \times 100\%$$

$$AVE = ((S_s - S_a) / S_a) \times 100\%$$

$$S_s = ((S_i - \underline{S_i})^2 / N)$$

$$S_a = ((A_i - \underline{A_i})^2 / N)$$

Description :

S_s = Deviation of value simulation

S_a = Deviation of actual value

N = Interval time of observation

3. Result of Research

3.1 The model treatment with scenarios

At this stage the model that has been made given the same treatment by creating scenarios providing recommendations for appropriate prevention strategies in reducing the rate of increase in rabies deaths.

3.2 Causal Diagram

The causal diagram illustrates the relationship between rabies deaths, the bites of rabies dog, giving VAR, population rabid dog, the dog rabies vaccination, the dog population, death and birth of the dog. This diagram shows the cause and effect of the structure of the system. Each arrows indicate the cause or consequence of the relationship between two variables. Sign (+) indicates an increase in the target variable, the sign (-) indicates a decrease on the target variable. Diagram causal variables that cause rabies deaths can be seen in Figure 1 (attachment).

Table 1: The rabies data in North Toraja regency

Year	Animal population	Animal vaccination	Genesis bites	Positive Rabies	*VAR*	Rabies Death
2013	51.863	9.150	309	269	187	4
2014	55.423	9.000	356	339	259	6

Source : Secondary data, 2015

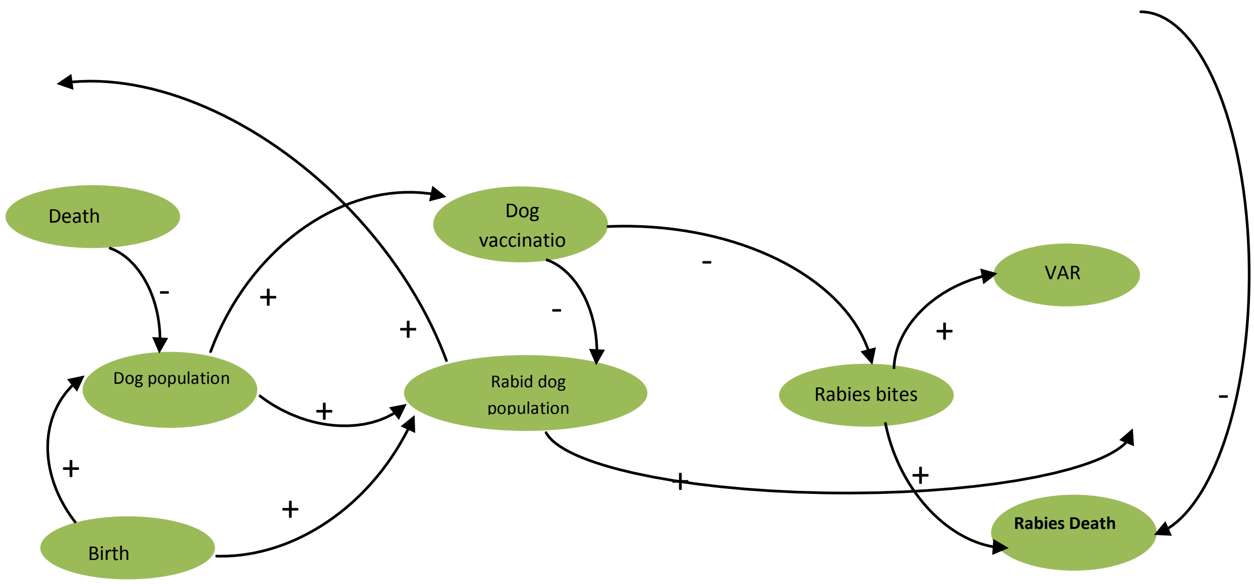
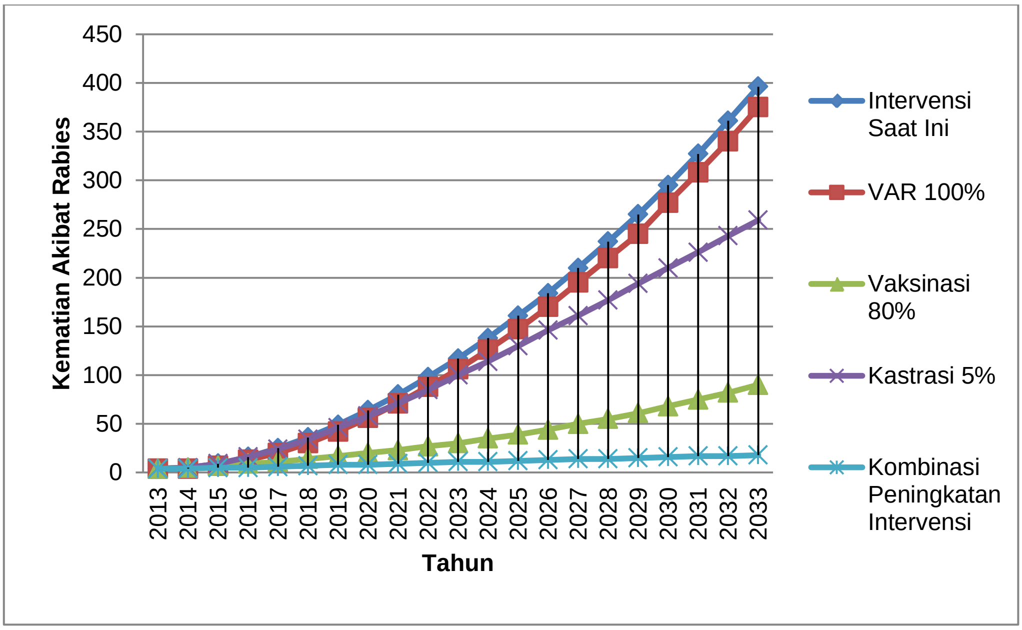


Figure 1: The causal diagram of rabies death

3.3 Analysis and Simulation

Making analysis of simulation results of the initial model development system that has been made, then analyzing the results of the simulation model created by the intervention of the specified scenario.



Picture 2: The Graph of estimation rabies death based on simulation I,II, III, IV and V in North Toraja Regency for 20 Years (2013-20133)

Simulation I

Simulation I is estimated rabies deaths 20 years into the future based on the current situation. Interventions that have been implemented was the provision of 69 % VAR and provision 17 % vaccination of dogs. The estimation of rabies deaths for 20 years, in 2033 showed 396 deaths with the average increase of death number reach 20 people per year.

Simulation II

Simulation II is estimated rabies deaths 20 years into the future with the current conditions and the increase in the intervention scenario 100% VAR provision. The estimation of rabies death for 20 year, in 20133 showed 375 deaths with increased mortality average until 19 people / year

Simulation III

Simulation III is estimated rabies deaths for 20 years into the future with the current conditions and scenarios increase ovaccination interventions dogs until 80%. The estimation of rabies death for 20 years, in 2033 showed the death of 90 people with an average increase in mortality until 4 person / year.

Simulation IV

Simulation IV is estimated rabies deaths for 20 years into the future with the current conditions and scenarios intervention rate control dog populations with 5 % castration or sterilization of male dogs. The estimation of rabies deaths for 20 years, in 2033 showed the number of deaths until 259 deaths with the average increase reach 13 people / year.

Simulation V

Simulation V is the estimated rabies deaths for 20 years into the future with the current conditions and intervention scenarios third combination of variables, were 100 % provision, 80% dog vaccination and 5 % castration. The estimation of rabies deaths for 20 years, in 2033 showed the increase in the death of 18 people with an average of one person every two years.

4. Discussion

The results showed that during the 20 years (2013 – 2033) the rabies death has increased from 4 in 2013 increased to 396 people in 2033 with an average increase in rabies deaths 20 person / years with interventions that have been made on the third variable in North Toraja Regency. The number of rabies deaths by the first model has increased from 4 in 2013 to 375 persons (0.62%) in 2033, with an average increase 20 person / years. The developing process a model requires a deep understanding of the existing actual conditions and complete information so that the model can describe the actual conditions (representing the current situation). In the development of dynamical systems, feedback systems play an important role because each variable affects the other variable.

The spread of rabies is a complex process, one approach to modeling of rabies is to start with a simple epidemiological models to look at the distribution level, after it analyzed the stability of the model. The general assumption of the model is contagion from an infected dog to determine the conditions change in the future epidemics. Some specific assumptions underlying this model adalah virus contained in the saliva of infected dogs, generally transmitted through bites, through direct contact between infected dog to a dog or a person. Rabies is fatal, with almost 100% of CFR . The birth late equal to deadt rate. The contact between infected dog with the dog or human in one population. The short interval and assumption less than one year.

The bites of rabies dog become determinant variables on the incidence of rabies in humans in which along with the medical action of factors such as post-exposure prophylaxis such as VAR determining the onset of illness and rabies death. The vaccination of dog populations associated with rabies disease control determines the level of effectiveness of maintenance management applied. At the management level of dog maintenance will give the different incidence of rabies deaths t when applied to different percentages rabies vaccination or with different levels of population control. The choice of used vaccine will determine the success of the eradication program. For the eradication program, vaccination coverage dogs at least 70%, under this coverage, rabies will tend to be endemic. Considering this things, the accessibility to hold the dog used as criteria for selecting the type of vaccine used [11].

As a reservoir of rabies, canine population dynamics, such as population control and how maintenance were very influential in the spread of rabies. The population density (population density) and how high-maintenance dogs will determine low levels of attack (attack rate). The higher the density of dogs then contact rate also increased so that the level of rabies attacks on sensitive group of animals or humans will be higher [12]. The spread of rabies was closely related to population density and movement of the dog. Dog is good breeding, easy to reproduce when there was enough food, water and shelter. Dogs adaptable to the environment even live abandoned in the streets or in landfills. One way that can be done to control the dog population growth rate is the act of castration in male dogs.

The results of model simulation V with scenarios the addition of interventions on the three variables showed the smallest increase in the estimated death and become the best strategy for controlling rabies deaths. In response to rabies, there are at least five essential components are mutually related were the role of government, the public (dog owners), rabies prevention methods, dog ecobiology and availability of logistics. Many components play a role and each resulted in prevention of rabies become complex [12]. Overall these components are difficult to obtain as a whole and in synergy with each other to support the efforts to eradicate rabies in dogs, as a source of rabies to humans. It was considered that the regency of North Toraja is an area with a fairly high level of incidence of rabies in South Sulawesi province, the eradication of rabies in this area requires the full support of the community and the government.

The number of cases of rabies deaths based on simulations I, II, III, IV and V can be seen in the attachment.

5. Conclusion and Suggestion

Based on the results of data processing, analysis and discussion, then the conclusion can be drawn that the most appropriate strategy to reduce the rate of increase in rabies deaths are on the simulation V (a combination of an increase in the variable VAR intervention until 100%, 80 % rabies vaccination of dogs, and 50 % castration of male dogs). There was a decrease in the number of deaths from 396 cases of death (simulation I) to 18 death cases. It was necessary increased coordination and cooperation among stakeholders and the public in preventing the increase in rabies deaths by improving dog maintenance management and intervention to the influential variable as controlling rabies deaths in North Toraja Regency.

References

[1] WHO.(2014). *Rabies.*www.who.int/mediacentre/factsheets/fs099/en/ diakses tanggal 16 Januari 2015.

[2] OIE.(2011). *Rabies*.OIE Terrestrial Manual 2011. Chapter 2.1.13.

[3] WHO.(2007). Guidance for Research on Oral Rabies Vaccines and Field Application of Oral Vaccination of Dogs Against Rabies. Geneva: World Health Organization.

[4] Utami Sri & Bambang Sumiarto. (2012). *Tingkat dan Faktor Risiko Kekebalan Protektif Terhadap Rabies Pada Anjing di Kota Makassar*.Jurnal Veteriner Maret 2012 Vol. 13 No. 1: 77-85.ISSN : 1411 – 8327.

[5] Depkes R.I. (2008). *Modul Pelatihan Penanggulangan Rabies*. Jakarta: Sub Dit Zoonosis Ditjen PPM & PLP.

[6] Hiswani.(2003). *Pencegahan dan Pemberantasan Rabies*.Skripsi. Medan: Universitas Sumatera Utara.

[7] Simatupang. (1995). *Pemodelan Sistem. 1 ed.* Klaten: Penerbit Nindita.

[8] Rochmatika Labibah dkk.(2013). *Penyelesaian Numerik dan Analisa Kestabilan pada Model EpidemikSEIR dengan Memperhatikan Adanya PenularanPada Periode Laten*. Naskah Publikasi. Surabaya: Jurusan Matematika, Fakultas MIPA, Institut Teknologi Sepuluh Nopember (ITS).

[9] Wikner J. (2005). *Dynamic Analysis of A Production-Inventory Model*. Kybernetes Journal 34, No. 6.

[10] Muhammadi dkk.(2014). *Analisis Sistem Dinamis Lingkungan Hidup, Sosial, Ekonomi, Manajemen*.

[11] Anonim.(2015). *First Aid After a Bite.* www.rabiesalliance.org/rabies/ diakses tanggal 16 Januari 2015.

[12] Putra.(AAG). 2012. *Telaah Singkat Kompleksitas Penanganan Rabies dan Analisis Perkembangan Pemberantasannya di Provinsi Bali: Suatu Pendekatan Ecohealth*. Artikel Ilmiah. Buletin Veteriner, BBVet Denpasar, Vol. XXIV, No. 80, Juni 2012. ISSN: 0854-901X