

Simulation of the *Abbaji Ammotere* Case for *Silariang* Using Mathematical Modeling in Bugis Society

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Abstract. Silariang is a form of deviant behavior that is consciously carried out by men and women by taking shortcuts in marriage without getting the blessing of the family. The causes of silariang are not getting parental approval, cash problems, promiscuity, pregnancy out of wedlock. Abbaji ammotere is an alternative solution to improve relationships with family. This research aims to build a SEIR models. This model is divided into four classes, namely the class of people who have the potential to carry out silariang, the class of people who are affected by carrying out silariang, the people who carry out silariang, and the people who return to their parents (Ammotere Abbaji). The data used is primary data obtained by distributing questionnaires to 204 samples which were carried out offline for silariang perpetrators and online for vulnerable and affected communities. The real data results of the SEIR type model produce a basic reproduction number (R_0) of 0,20381767, which means that the range class will experience a significant increase in the sense that at any time they will be affected and practice silariang, while for classes that have practiced silariang this will decrease over a certain period of time.

1 Introduction

Mathematical modeling is a technique for presenting a complex system in a mathematical model. One technique used For describe something complex system to in mathematical models called modeling mathematics. Mathematical model covers variables, parameters and function states relation between variables and parameters. By general, mathematical model classified to in a number of category namely the phenomenon model (phenomenological model) and the mechanistic model [1]. The classic SEIR model has four elements, namely S (susceptible), E (exposed), I(infectious) and R (recovered). So, $N = S + E + I + R$ means the total number of people. The basic hypothesis of the SEIR model is that all individuals in the

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model will have four roles over time. The SEIR model has some limitations for real situations, but it provides a basic model for the study of various types of epidemics [2].

In the S E IR model, population man shared become three group, that is suspect with symbol S, infected with symbol I, *Exposed* is symbolized by E and healed or *recovery* with symbol R, each of which is given in s, i and r shapes. S or *susceptible* in S E IR modeling is individuals who do not infected but group This can infected disease. Therefore _ That group this also has possibility for become infected be I or *infected*. I or *infected* is individuals who can spread disease in susceptible individuals. The time required by the patient infection disease named period disease. After experience period disease Then individual This move and become recovered individuals or *recovered*. R or *recovered* is individuals who have healed or immune in her life [3]. Apart from use in the field health model S E IR can also used in the field social is one of them For saw an increase in *Silariang cases*.

Silariang is a form of deviant behavior carried out consciously by men and women by taking shortcuts in marriage to achieve a life together between men and women as husband and wife without get approval from party family. Reason happen marry run / *run around* No exists approval from parents, cash problems, promiscuity, pregnancy out of wedlock. *Abbaji ammunitio* is an alternative solution to improve relationships with family [4].

The impacts experienced after doing silariang are limitations in carrying out daily activities, dropping out of school, feeling isolated because they have to hide, feeling no longer considered, getting bad treatment such as being stoned by the family, and feeling demeaned by people because of the behavior carried out, as for the description The age of those who perform silariang is more than 15 years old with a silariang period of ± 2 years [5].

One solution from *silariang* is *Ammotere abbaji* which is interpreted as the return of the perpetrator of the elopement to the family to apologize and ask for blessing. After receiving blessing, the family held a peaceful event in the form of a reception. This reception was marked by the arrival of women who wore head coverings, because they felt ashamed of their actions. Meanwhile, the men prepare luggage in the form of money or other items called "*erang-erang*". After that, they asked for blessings from their parents by greeting the entire family who attended the *Abbaji reception* [6].

Several studies on social cases using mathematical models, research conducted by [7] about the SEIR mathematical model of online gaming addiction ; two points are obtained balance , that is point balance free addiction and period balance addiction ; stability point balance free addicted as well as number reproduction base $R_0 = 0.089$ which shows that No happen transmission addicted from One individual to individual other . Meanwhile, research conducted by [8]. regarding models of smoking behavior stated that the analysis stability state that point equilibrium free smoker will achieved when $\beta < 0.00031$ and point equilibrium endemic smoker will achieved when $\beta > 0.00031$. Built model is modification from the model, so that with do addition transmission by smokers weight and behavior healed from smoker more light _ relevant with actual situation, required _ longer time for going to point equilibrium. On the other hand, there has been no research on social cases, namely *Silariang* using mathematical models.

Based on explanation above, then writer interested For lift the title" **Simulation of the Ammotere Abbaji Case on Silariang using Mathematical Modeling in the Bugis Society**"as effort reinterpretation to marriage silariang, communication process is required For merges with his family like ready. marry silariang (marrying run) resulted in estrangement connection in family. Beside That limit interaction with environment social. should avoid action silariang, on the side That deed This leaving behind with legal religious perspective positive nor customs that apply to society

2 Literature Review

2.1 Differential Equations

Equality differential is containing equations derivative something function yet known, named $y(x)$ and who wants determined from equality the In life daily equality differential appears in the mathematical model engineering and applied [9].

Order of equations differential determined by the derivative highest in equality that. Following This is example equality differential;

$$1. x^2 \frac{d^2 y}{dx^2} - 6x \frac{dy}{dx} = 0 \quad \text{variable free} = x; \text{variables not free} = y$$

$$2. y' = e^x + \sin x \quad \text{variable XE "variable" is free} = x; \text{variable not free} = y$$

$$3. \frac{d^2 q}{dt^2} - 3 \frac{dq}{dt} + 10q = 4 \quad \text{variable free} = t; \text{variables not free} = q$$

$$4. \frac{d^2 v}{dx^2} + \frac{d^2 v}{dy^2} = 0 \quad \text{variable free} = x, y; \text{variable not free} = v$$

2.2 Differential Equation Solutions

Solution from something equality differential is equation that contains variables from equality differential and fulfilling equality given differential. If $f(x)$ is solution from equality differential, then $f(x)$ and its derivatives will fulfill equality differential that.

Given equality differential

$$\frac{dx}{dt} = f(t, x)$$

Where f is function in the two given variables. Anything function derived $x = \phi(t)$ which fulfills equality This For all t in an interval is called solution.

2.3 Systems of Differential Equations

System equality differential is something a system containing n pieces equality differential, with n pieces a function that does not is known, where n is number round positive more big The same with 2. Between Eq one differential with each other interconnectedness and consistency. Form general from something system of n equations order First have form as following :

$$\frac{dx_1}{dt} = g_1(t, x_1, x_2, \dots, x_n$$

$$\frac{dx_2}{dt} = g_2(t, x_1, x_2, \dots, x_n$$

$$\vdots$$

$$\frac{dx_n}{dt} = g_n(t, x_1, x_2, \dots, x_n$$

With $x_1, x_2, \dots, x_n$ is the independent variable and t is the dependent variable, $x_1 = x_1(t), x_2 = x_2(t), \dots, x_n = x_n(t)$ Where $\frac{dx_n}{dt}$ is the derivative of a function x_n with respect to t , g_i is functions that depend on variables $x_1, x_2, \dots, x_n$ and t [10].

2.3.1 System Equality Differential Normally linear

For example given system equality differential usually nonlinear following

$$\dot{x} = f(x), x \in R^n$$

$$\text{With } x(t) \in R^n$$

is a vector-valued function in t and $f: U \rightarrow R^n$ is a smooth function defined on a subset $U \subset R^n$. By using the Taylor expansion around a fixed point $\bar{x}$, the system of equations can be written as follows

$$\dot{x} = \dot{\eta} = J\eta + \varphi(\eta)$$

where J is the Jacobi matrix which is expressed as follows:

$$J = \frac{\partial f(\bar{x})}{\partial x} = \begin{bmatrix} \frac{\partial f_1}{\partial x_1} & \frac{\partial f_1}{\partial x_2} & \cdots & \frac{\partial f_1}{\partial x_n} \\ \frac{\partial f_2}{\partial x_1} & \frac{\partial f_2}{\partial x_2} & \cdots & \frac{\partial f_2}{\partial x_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial f_n}{\partial x_1} & \frac{\partial f_n}{\partial x_2} & \cdots & \frac{\partial f_n}{\partial x_n} \end{bmatrix}$$

2.3.2 Equilibrium Point

For example given system autonomous

$$\begin{aligned} \frac{dx}{dt} &= X(x, y, z) \\ \frac{dy}{dt} &= Y(x, y, z) \\ \frac{dz}{dt} &= Z(x, y, z) \end{aligned}$$

Point (x^*, y^*, z^*) with $X(x^*, y^*, z^*) = 0$, $Y(x^*, y^*, z^*) = 0$, $Z(x^*, y^*, z^*) = 0$ is called the critical point, this critical point $E = x_1^*, x_2^*, x_3^*$ is the solution to the equation above which has a constant value because $\frac{dx}{dt} = 0$, $\frac{dy}{dt} = 0$, $\frac{dz}{dt} = 0$ the condition that causes $\frac{dx}{dt} = 0$, $\frac{dy}{dt} = 0$, $\frac{dz}{dt} = 0$ it is called the equilibrium state and the point that meets it is called the equilibrium point [11].

2.3.3 Eigenvalues and Eigenvectors

For look for eigenvalues of matrix A of size $n \times n$, then equality $Ax = \lambda x$ can written down as following:

$$(\lambda I - A)x = 0$$

With I matrix identity. Equality it has solution not zero if and only if,

$$\det(\lambda I - A) = 0$$

Equality above mentioned equality characteristics [12].

2.3.4 Routh Hurwitz method

The eigenvalues of A are the roots of the characteristic polynomial $\det (\lambda I - A) = 0$. If the roots its characteristics difficult determined so For determine stability point equilibrium required other methods
Given equality characteristics with degree n as following:

$$\lambda^n + a_1\lambda^{n-1} + a_2\lambda^{n-2}+..+a_{n-1}\lambda + a_n = 0$$

With the coefficients a_i being real numbers and $i = 1,2,3,...,n$, a matrix can be formed from this equation H_j ,

$$H_j = \begin{bmatrix} a_1 & 1 & 0 \\ a_3 & a_2 & a_1 \\ a_5 & a_4 & a_3 \end{bmatrix}$$

Point equilibrium will stable If mark coefficients in Eq characteristics fulfil condition

3 Methods

The type of research used is applied research with a quantitative approach sourced from primary data, then secondary data, namely data directly collected by researchers as support from the first source. It can also be said that data is arranged in the form of documents such as books , journals and related theses with related research with *Ammotere Abbaji Case for Silariang Perpetrators*

The population in this study is the entire population of South Sulawesi province in 2023 aged 15-29 years, amounting to 1,576,920 people. The sampling technique in this study is *probability sampling* which is a type of sampling technique where sampling is done randomly. Slovin's formula is used to determine the sample size with a selectable level of significance:

$$n = \frac{N}{1 + Ne^2}$$

The population in South Suawesi in 2023 aged 15-29 years is as large as 1576920one person, so the sample size can be obtained, namely:

$$n = \frac{N}{1 + Ne^2}$$
$$n = \frac{1576920}{1 + (1576920)(0,07)^2} = 204$$

Researcher collects data use in research this is ie Questionnaire/Questionnaire, Documentation , Literature Study. The data obtained was then analyzed by data tabulation then analyzed by simulation using *Maple software* after that, the results were then analyzed interpreted in form a mathematical model the next simple one used For explain about traits *silariang case* from corner look mathematics.

4. Results And Discussion

4.1 SEIR Mathematical Model in the Silariang Case

In research This there is a number of assumptions used for modeling the *silariang* case, namely:

- a. Samples used are people in several districts, one of which is Gowa Regency
- b. It is assumed that people who have partners are the same as the number of people who do not/have not had partners
- c. Potential community to do *silariang* namely people who have a partner.
- d. People who are in the *silariang category* are people who do not receive blessings, panai money, are pregnant out of wedlock.
- e. People who are in the *recovered category* are people who have done *silariang* later return to parents/ *Ammotere Abbaji*.
- f. Population constant (closed), meaning

$$N = S(t) + E(t) + I(t) + R(t)$$

Based on assumption so obtained S E IR model for *silariang* case in form of transfer diagram that can be seen in Figure 1 below.

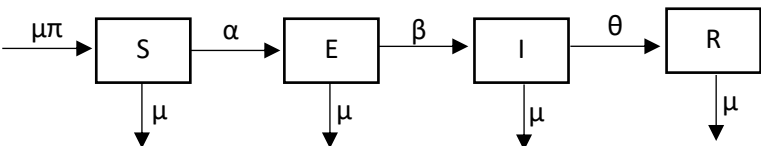


Fig. 1. SEIR model of the *Abbaji ammunition case* for *silariang* perpetrators
Variables and parameters used in the SEIR mathematical model for the *Silariang* case can seen on

Table 1. SEIR Model Variables and Parameters

Parameter	Information
S	Susceptible individuals practice <i>silariang</i>
E	Individuals who are influenced to do <i>Silariang</i>
I	Individuals who do <i>Silariang</i>
R	Individuals who perform <i>Ammotere Abbaji</i>
π	Rate of individuals aged 15-29 years who are aware of <i>silariang</i> cases
μ	Rate of individuals aged 15-19 years who do not have a partner
α	The rate at which individuals are affected to perform <i>silariang</i>
β	The rate of individuals doing <i>silariannng</i>
θ	Rate of Individuals doing <i>Ammotere Abbaji</i>

Based on assumptions and relationships between variables and parameters in Figure 1 can explained in Eq following:

$$\frac{dS}{dt} = \mu\pi - (\alpha i + \mu)S \tag{1}$$

$$\frac{dE}{dt} = \alpha iS - (\beta + \mu)E \tag{2}$$

$$\frac{dI}{dt} = \beta E - (\theta + \mu)I \tag{3}$$

$$\frac{dR}{dt} = \theta I - \mu R \tag{4}$$

In this system, scaling is carried out, namely forming the system in the form of a proportion between the number of individuals in one population and the total population. The system is simplified by using notation

$$s = \frac{S}{\pi}, e = \frac{E}{\pi}, i = \frac{I}{\pi}, r = \frac{R}{\pi}$$

The system can be simplified by deriving using the chain rule and equation substitution as follows:

$$\frac{dS}{dt} = \mu - (\alpha i + \mu)S \tag{5}$$

$$\frac{dE}{dt} = \alpha iS - (\beta + \mu)E \tag{6}$$

$$\frac{dI}{dt} = \beta E - (\theta + \mu)I \tag{7}$$

$$\frac{dR}{dt} = \theta I - \mu R \tag{8}$$

Analysis of the SEIR Mathematical Model in the *Ammotere Abbaji case for Silariang* Perpetrators is as follows:

Table 2. Initial Values

Parameter	Mark
S(0)	107
E(0)	14
I(0)	18
R(0)	65
N	204

Table 3. S EIR model parameters *Silariang* case

Parameter	Mark
N	204
π	0.24
α	0.19
β	0.07
μ	0.08
θ	0.36

4.2 Equilibrium Point

- a. Behavior-independent equilibrium point $E_0 = \{1,0,0,0\}$

b. Endemic behavioral equilibrium point
- $$E_1 = (s, e, i, r) = \left(\frac{\beta\mu + \beta\theta + \mu^2 + \mu\theta}{\alpha\beta}, \frac{\mu\alpha\beta - \beta\mu^2 - \beta\mu\theta - \mu^2 - \mu\theta}{\alpha\beta(\beta + \mu)}, \frac{\mu\alpha\beta - \beta\mu^2 - \beta\mu\theta - \mu^2 - \mu^2\theta}{\alpha(\beta\mu + \beta\theta + \mu^2 + \mu\theta)}, \frac{\theta(\alpha\beta - \beta\mu - \beta\theta - \mu^2 - \mu\theta)}{\alpha(\beta\mu + \beta\theta + \mu^2 + \mu\theta)} \right)$$

4.3 Stability Analysis Point Equilibrium

Matrix Jacobian from point equilibrium free behavior

$$\begin{bmatrix} -\mu & 0 & -\alpha & 0 \\ 0 & -(\beta + \mu) & \alpha & 0 \\ 0 & \beta & -(\theta + \mu) & 0 \\ 0 & 0 & \theta & -\mu \end{bmatrix} \tag{9}$$

For know stability E_0 So first look for the eigenvalues. If λi is eigenvalues of $J E_0$ then

$$\left| \lambda \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} -\mu & 0 & -\alpha & 0 \\ 0 & -(\beta + \mu) & \alpha & 0 \\ 0 & \beta & -(\theta + \mu) & 0 \\ 0 & 0 & \theta & -\mu \end{bmatrix} \right| = 0$$

$$\lambda + \mu \left| \begin{bmatrix} \lambda + (\beta + \mu) & -\alpha & 0 \\ -\beta & \lambda + (\theta + \mu) & 0 \\ 0 & -\theta & \lambda + \mu \end{bmatrix} \right| = 0$$

$$\lambda + \mu \begin{vmatrix} \lambda + x & -\alpha & 0 \\ -\beta & \lambda + y & 0 \\ 0 & -\theta & \lambda + \mu \end{vmatrix} = 0$$

$$(\lambda + \mu)((\lambda + x)(\lambda + y)(\lambda + \mu) - (\lambda + \mu)(-\beta)(-\alpha)) = 0$$

$$(\lambda + \mu)(\lambda + \mu)(\lambda^2 + a\lambda + b) = 0$$

Obtained $\lambda_1 = -\mu$, $\lambda_2 = -\mu$ and $\lambda^2 + a\lambda + b = 0$

For $\lambda^2 + a\lambda + b = 0$ using the Hurwitz criteria :

$$H_1 = |a| > 0$$

$$a = x + y = (\beta + \mu) + (\theta + \mu) > 0$$

$$H_2 = \begin{vmatrix} a & 1 \\ 0 & b \end{vmatrix} > 0$$

$$\text{If } R_0 < 1 \text{ then } H_2 > 0$$

According to Hurwitz root criterion equality the negative real number , with $H_1, H_2 > 0$. With stability theory, the $R_0 < 1$ equilibrium point is disease free (1,0,0,0) stable asymptotic local .

Matrix Jacobian from point equilibrium endemic behavior:

$$\begin{bmatrix} -(\alpha i^* + \mu) & 0 & -\alpha s^* & 0 \\ \alpha i^* & -(\beta + \mu) & \alpha s^* & 0 \\ 0 & \beta & -(\theta + \mu) & 0 \\ 0 & 0 & \theta & -\mu \end{bmatrix} \quad (10)$$

For know stability E_1 So first look for the eigenvalues. If λi is eigenvalues of $_J E_1$ then

$$\begin{vmatrix} \lambda & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{vmatrix} - \begin{bmatrix} -(\alpha i^* + \mu) & 0 & -\alpha s^* & 0 \\ \alpha i^* & -(\beta + \mu) & \alpha s^* & 0 \\ 0 & \beta & -(\theta + \mu) & 0 \\ 0 & 0 & \theta & -\mu \end{bmatrix} = 0$$

So that obtained $\lambda = -\mu$ and $\lambda^3 + a_1\lambda^2 + a_2\lambda + a_3 = 0$

$$H_1 = |a_1| = x + y + \alpha i^* + \mu > 0$$

$$H_2 = \begin{vmatrix} a_1 & 1 \\ a_3 & a_2 \end{vmatrix} = a_1 a_2 - a_3$$

$$a_1 a_2 - a_3 = xy\mu + (\alpha i^* + \mu)(x + y)(x + y + \alpha i^* + \mu) > 0$$

From the explanation above is known that $H_1 > 0, H_2 > 0, H_3 > 0$, with the Routh Hurwitz criterion the roots of the equation are negative real numbers. According to stability theory, the endemic equilibrium point E_1 will be locally asymptotically stable when $R_0 > 1$.

4.4 Reproduction Number

Mathematical model S E IR case silarianang value number reproduction basic (R_0) i.e.

$$R_0 = \frac{\alpha\beta}{(\beta + \mu)(\theta + \mu)} = 0,20381767 \quad (11)$$

which means perpetrator of *silariang* has no effect to other vulnerable individuals in sample. Number reproduction basis obtained not enough from One show that amount individuals who practice *silariang* will decrease in period time certain.

4.5 SEIR Model Simulation Using Maple :

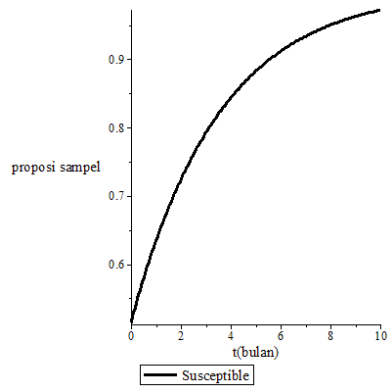


Fig. 2. Susceptible

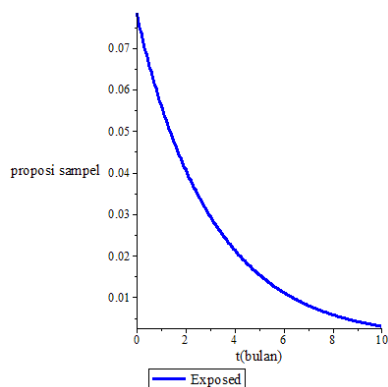


Fig. 3. Exposed

Figure (2) show simulation amount potential individuals to carry out detectable (susceptible) *silariang* for every month. Amount potential individuals to engage in *social behavior* reached 52 % of amount sample or The same with 107 individual who will prone to addicted from 204 samples. every month increases and stabilizes at a certain time.

Figure (3) show simulation amount individuals who are beginning to be affected to carry out *detected* behavior(exposed). for every month. Number of individuals affected experience decline every month and need it time a number of month For reach amount Lowest that is 6% of amount sample or The same with 14 individual who will affected from 204 these individuals and cases will stabilize over a certain time.

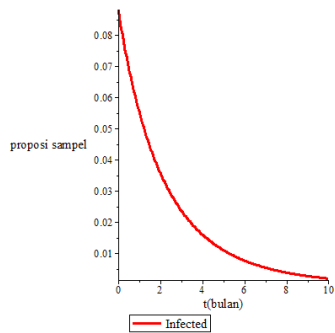


Fig. 4. Silariang

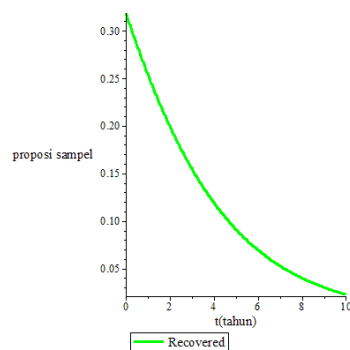


Fig. 5. Ammotere Abbaji

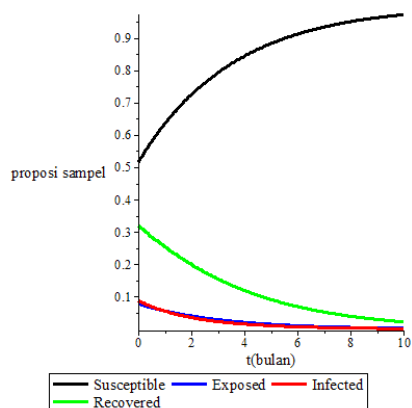


Fig. 6. SEIR Model Simulation

Figure (4) show simulation amount individuals who *are* infected (*infected*) are detected for every month. Amount infected individual experience decline at each month and need it time the next few months for reach amount Lowest that is 8 % of amount sample or the same with 18 individuals who practice *silariang* from 204 sample, and will stabilize/disappear within a certain time.

Figure (5) shows simulation amount Individuals who have done *silariang*, in other words, have returned to their parents to improve their relationship with their family, which is called *ammotere abbaji* (*recovered*) for every month. Amount individual who performs *ammotere abbaji* experience decline at each month and need it time the next few months for reach amount Lowest that is 31 % of amount sample or the same with 65 individuals who have done *silariang* from 204 sample, and will be stable over a certain time.

Figure (6) shows that amount sample in class Suspectable need time around 10 month for reach amount highest. For amount sample in class *exposed* experience decline for every month and will reach amount lowest in the month 10th. For amount sample in class *infected* experience decline for every month and will reach amount lowest in the month 10th. In the 10th month for all classes except the Suspectable class No experience increase or decline amount (constant).

5 Conclusion

From the results and discussions that have been carried out done can obtained conclusion as following. Formulation of the SEIR model for the *Abbaji ammotere* case for perpetrators of *Silariang* in the form of the following differential equation.

$$\begin{aligned}\frac{dS}{dt} &= \mu\pi - (\alpha i + \mu)S \\ \frac{dE}{dt} &= \alpha i S - (\beta + \mu)E \\ \frac{dI}{dt} &= \beta E - (\theta + \mu)I \\ \frac{dR}{dt} &= \theta I - \mu R\end{aligned}$$

Simulation results of the SEIR model of the *Abbaji ammunition* case for *silariang* perpetrators can concluded that Amount potential individuals to do *silariang* that is 107 individuals from 204 samples, Total individuals who are beginning to be affected to do

silariang, namely 14 individuals from 204 samples, Total individuals who carry out *silariang*, namely 18 individuals from 204 samples, Total individuals who return to parents to do *ammotere abbaji* viz 65 individuals from 204 samples, with

$$R_0 = 0,20381767$$

which means perpetrator of *silariang* has no effect to other vulnerable individuals in sample. Number reproduction basis obtained not enough from One show that amount individuals who practice *silariang* will decrease in period time certain.

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