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Comparison of R and GeoDa Software in Case of Stunting Using Spatial Error Model

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ABSTRACT

Gorontalo city is the capital of Gorontalo province which has a high incidence of stunting. This high incidence rate needs to get attention because stunting can further become one of the indicators of the low quality of human resources in Gorontalo. One method that can be used to analyze the factors that cause stunting is the spatial regression method, namely Spatial Error Model (SEM). SEM model can analyze used R and GeoDa software. The purpose of this study is to find out the factors that affect stunting in Gorontalo City and compare the results of the Spatial Error Model analysis based on the results of R and GeoDa software. The results showed that there are two variables that have a significant effect on stunting incidence, namely the variable number of Complete Basic Immunization (IDL) and the amount of proper sanitation. The R and GeoDa software comparison results showed there were several similar outputs i.e. LM test output, parameter estimation and R-square value, while the different outputs were Moran's I test output, Breusch-Pagan test, and AIC value. Although Moran's I test output and Breusch-Pagans test are different, but they produce the same conclusion. The AIC value produced by GeoDa is smaller than R software.

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A. INTRODUCTION

Stunting is a chronic nutritional problem in toddlers caused by children's nutritional intake is not met in long time (Akolo, 2022). Stunting characterized by a shorter child's height compared to their peers. The problem of chronic malnutrition is a problem that is increasingly being found in developing countries, including Indonesia (Permatasari et al., 2021). Stunting can be the main threat to human quality and competitiveness of the Indonesian nation. A stunting child is not only impaired by physical growth (short body or dwarf) only, but also has an impact on his brain development, thus affecting his abilities and achievements in school (Angelia and Nurhafnita, 2020). Gorontalo is one of the provinces that has a high incidence of stunting which is about 11.0% in 2020 (Kementerian Kesehatan RI, 2020). This incidence rate is quite high so it needs to get attention from the public, especially the government, because stunting not only has a bad impact on the personal but can further become one of the indicators of the low quality of human resources in Gorontalo Province. To be able to lower the incidence of stunting, it is necessary to conduct research on the factors that cause high incidence of stunting.

One method that can be used to analyze the factors that cause stunting is the regression method. Regression analysis is method used to examine the relationship between the dependent and independent variable (Ningsih and Dukalang, 2019). One of the regression methods is spatial regression. It is a method that can explain the relationship between the number of stunting in each region and the factors that affect it. Spatial regression consists of several models namely Spatial Autoregressive Model (SAR), Spatial Error

Model (SEM) and Spatial Autoregressive Moving Average (SARMA) (Pratiwi et al., 2020). The spatial model used in this study was the Spatial Error Model (SEM).

SEM is a spatial model that contains spatial errors (Samadi et al., 2017). There are several software that can be used to analyze SEM model, namely R software (Rahmawati et al., 2015) and GeoDa software (Afifah, 2017). Software R is a free software and fast analysis, has good graphics capabilities, excels in simulation and analysis (Sarvina et al., 2017), while GeoDa software is a software that specializes in analyzing spatial data, geovisualization, spatial autocorrelation and spatial modelling (Jaya, 2018).

In recent years, a lot of research on stunting using the spatial analysis and software R or GeoDa in data analysis. Khan and Mohanti (2018) research about spatial heterogeneity and correlates of child malnutrition in district of India using GeoDa software in analysis (Khan and Mohanty, 2018). (Akolo, 2022) research about the comparison of the spatial weighting matrix on the SAR and SEM models using the R software (Akolo, 2022). Djara, et.al (2022) conducts research about modelling the prevalence on stunting toddlers using SAR model and R software for data analysis (Djara et al., 2022). Based on previous research, it is known that there has been no research on the comparison of the results of the R and GeoDa software, especially the analysis of the SEM model in the case of stunting. With a variety of software that can be used to analyze the SEM model, different results will be obtained from one another due to the different approaches between the software, so it is necessary to test the accuracy of the software used. Thus, this study aims to compare the results of the SEM analysis based on the results of running programs with R and GeoDa software to determine the factors that influence stunting in the city of Gorontalo and compare the results of SEM analysis based on the results of running programs with R and GeoDa software.

B. LITERATURE REVIEW

1. Spatial Error Model (SEM)

SEM is a linear regression model that has spatial correlation to its errors (Balebu and Oktora, 2022). The common model for SEM is presented in the following equation.

$$y = X\beta + u \tag{1}$$

with

$$u = \lambda W u + \varepsilon \tag{2}$$

$$\varepsilon \sim N(0, \sigma^2 I) \tag{3}$$

λ is a coefficient of spatial error that indicates the degree of correlation of spatial error influence from one region to another region around it.

2. Spatial Dependency Test

The test to find out spatial dependencies in a model error using Moran's I statistics (Fitron and Zain, 2013). The hypotheses used are:

$H_0 : I_M = 0 (nointer-locationdependencies)$

$H_1 : I_M \neq 0$ (inter-location dependencies available)

Moran index calculations are presented in equations (4)

$$I_M = \frac{n \sum_{j \neq i}^{k} (y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n} \sum_{j \neq i}^{n} w_{ij} \sum_{i=1}^{n} (y_i - \bar{y})^2} \tag{4}$$

statistical tests presented on the equation (5):

$$Z = \frac{I_M - I_{M0}}{\sqrt{var(I_M)}} \tag{5}$$

criteria: reject H_0 if $|Z| > Z_{\alpha/2}$

3. R Software

Software "R" is an *Open Source System* used for data processing as well as statistical analysis based on programming. Software "R" was developed since 1995 by Robert Gentleman and Ross Ihaka of the Statistics Department of the University of

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Auckland, New Zealand and has been widely used by statisticians around the world (Sarvina et al., 2017). This software has many functions and several advantages, namely: it is free software and fast analysis, has good graphics capabilities, excels in simulation and analysis and statisticians can develop other methods into a package that is ready to use. According to McCreight (2012) in (Sarvina et al., 2017), this "R" software is very good because it is powerful, easy to learn syntax, has a diverse package that is accompanied by scientific publications, both in the form of books and journals so it is easy to use. The "R" software is also supported by the scientific community and has been widely used for various fields of science

4. GeoDa Software

According to Comar, et al (2003) GeoDa is a program used to perform spatial data analysis, geovisualization, spatial autocorrelation and spatial modeling in the form of free license so that it is free to use anyone at no charge (Afifah, 2017). GeoDa program can be used in several different operating systems namely Windows (XP, Vista, and 7), Mac OS, and Linux. GeoDa functions are classified into 6 categories, namely spatial analysis, data exploration, mapping, multivariate analysis, spatial autocorrelation, and spatial regression. In addition, GeoDa can also perform classic linear regression calculations. Spatial regression method contained in GeoDa is spatial autoregressive and spatial error method by using the maximum estimate of likelihood.

C. RESEARCH METHOD

The data used in this study is stunting incidence data and its factors in Gorontalo City 2018. The units analyzed in this study are all sub-districts in Gorontalo city, which consists of 9 sub-districts. Data obtained from the Health Office of Gorontalo city 2018. The dependent variables used in the research is stunting incidence, and independent variables used are Total Basic Immunization (IDL), Number of Proper Sanitation, and Amount of Exclusive Breastfeeding. The stages of this research:

1. Descriptive Data Analysis.
2. Determining spatial weighting matrix.
   The weighting matrix used in this study is the queen contiguity matrix.
3. Spatial dependency diagnosis.
   onducting spatial dependency tests using Moran's I and Lagrange Multiplier tests, as well as spatial heterogeneity tests using the Breusch-Pagan test. Each test is done with R and GeoDa software.
4. Estimate and testing the significance of SEM parameters. Estimating SEM parameters and the testing the significance of SEM parameters using R and Geoda Software.
5. Comparing the accuracy of SEM model output software R and GeoDa. At this stage, compare the SEM accuracy using R-Squared and AIC value. The best model is the model has the largest R-Squared and the smallest AIC value.
6. Conclusions

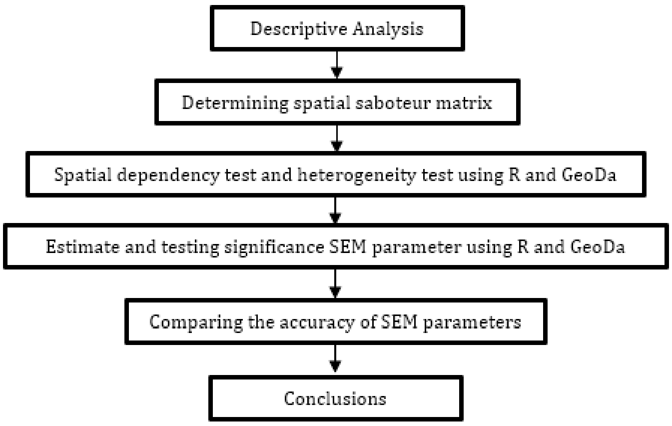

Figure 1. The stages of research

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D. RESULTS AND DISCUSSION

1. Research Data Sources and Variables

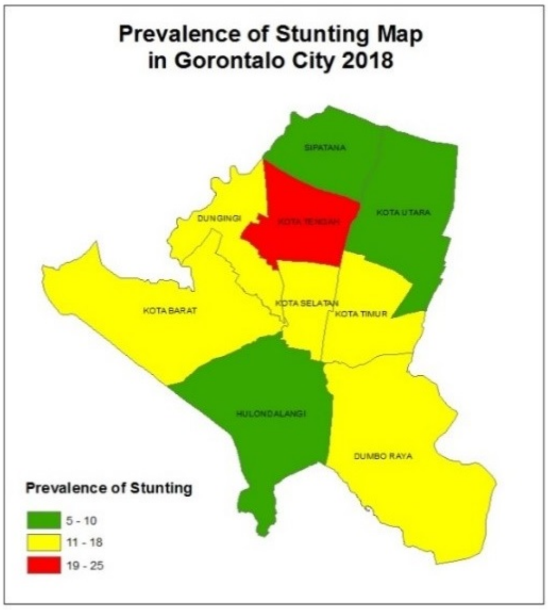
Descriptive analysis is an exploration of data that can provide an overview of the state of a research data. Descriptive data analysis for stunting incidence data and its factors is presented in Table 1.

Table 1. Descriptive Analysis

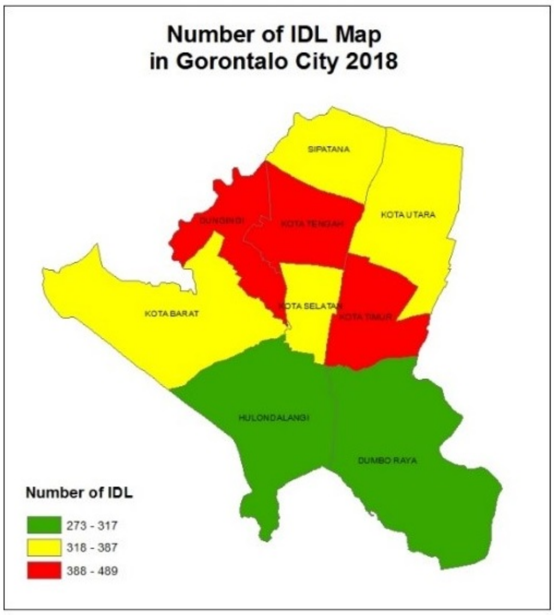
Variable	Mean	Min	Max	Standard Deviation
Stunting (Y)	13.56	5	25	5.90
Number of IDL (X1)	381.89	273	489	69.17
Number of Proper Sanitation (X2)	5082.44	3625	7219	1138.34
Exclusive Breast Milk Quantity (X3)	221.78	84	442	126.95

Based on Table 1 and Figures 2a and 2b, it is known that the average incidence of stunting in Gorontalo city in 2018 was 13.56 or about 13 cases with a standard deviation of 5.90. The lowest stunting cases of 5 cases occurred in Sipatana Subdistrict (green area in Figure 2) while the highest cases of 25 cases occurred in Kota Tengah Subdistrict (red area in Figure 2b). The average number of Complete Basic Immunizations (IDL) in Gorontalo in 2018 was 381.89 or about 382 toddlers, where the lowest number of IDL as many as 273 toddlers were in Hulonthalangi subdistrict (green area in Figure 2b), while the highest number of IDL was 489 in Kota Tengah subdistrict (red area in Figure 2b).

Based on Table 1 and Figure 2c and 2d, it is known that the average amount of proper sanitation in Gorontalo city in 2018 was 5082.44 or about 5082 units with a standard deviation of 1138.34. The lowest amount of proper sanitation as many as 3625 units was found in Hulonthalangi Subdistrict (green area in Figure 2) while the highest amount of proper sanitation as much as 7219 units was found in the East City District (red area in Figure 2c). The average number of exclusive breast milk in Gorontalo in 2018 was 221.78 or about 222 toddlers, where the lowest amount of Exclusive breast milk as many as 84 toddlers was in the South City subdistrict (green area in Figure 2d), while the highest number of exclusive breast milk as many as 442 toddlers were in the Central City subdistrict (red area in Figure 2d).



(a)



(b)

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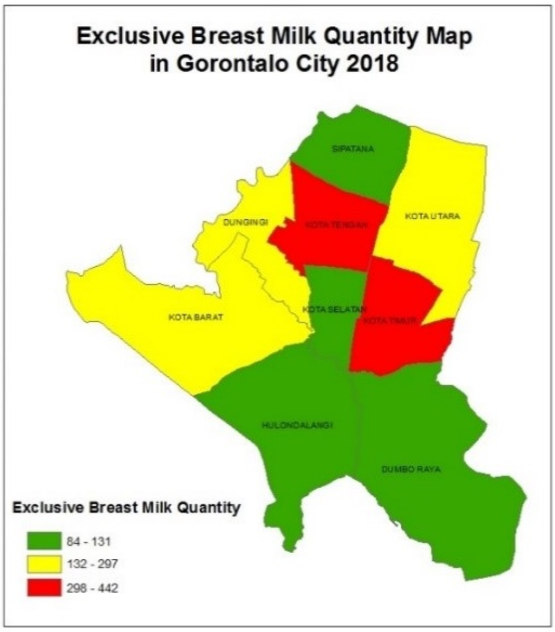
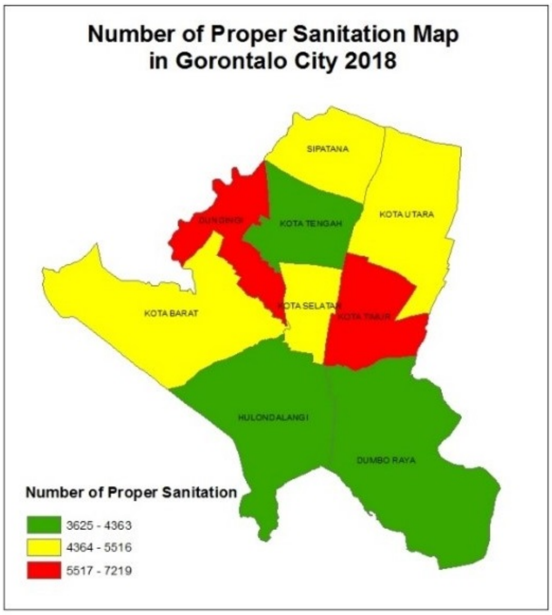


(c)



(d)

Figure 2. Map of (a) prevalence of stunting; (b) number of IDL; (c) exclusive breast milk quantity; (d) number of proper sanitation

2. Spatial Weighting Matrix

The initial stage in spatial regression model analysis is the determination of spatial weighting matrix. The spatial weighting matrix used in this study is a matrix with a Type Queen Contiguity, which is a matrix of weights that pays attention to the intersection of the corners on the map. For subdistricts that are close to each other (tangent side / angle) then is given a weight of 1, while for subdistricts that are not close (not tangent side / angle) is given a weight of 0 (Sarvina et al., 2017). Based on the concept, obtained spatial weighting matrix is as follows.

$$W_{unstandardized} = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix} \tag{6}$$

Equation (6) is not a standard weighting matrix. In this study, standardized weights were used because R and GeoDa software analysis usually uses those weights. Therefore, the weighting matrix in the equation (7) will be standardized by dividing each component of the matrix weight above by the sum of each row. When each row is summed, it returns the number 1. The standardized weighting matrix is presented in the following equation (2)

$$W_{unstandardized} = \begin{bmatrix} 0 & 0.33 & 0.33 & 0 & 0.33 & 0 & 0 & 0 & 0 \\ 0.33 & 0 & 0 & 0 & 0.33 & 0 & 0 & 1 & 0 \\ 0.20 & 0 & 0 & 0 & 0.20 & 0.20 & 0.20 & 0 & 0.20 \\ 0 & 0 & 0 & 0 & 0 & 0.33 & 0.33 & 0.33 & 0 \\ 0.20 & 0.20 & 0.20 & 0 & 0 & 0.20 & 0 & 0.20 & 0 \\ 0 & 0 & 0.20 & 0.20 & 0.20 & 0 & 0.20 & 1 & 0 \\ 0 & 0 & 0.25 & 0.25 & 0 & 0.25 & 0 & 0 & 0.25 \\ 0 & 0.25 & 0 & 0.25 & 0.25 & 0.25 & 0 & 0 & 0 \\ 0 & 0 & 10.500 & 0 & 0 & 0.50 & 0 & 0 & \end{bmatrix} \quad (7)$$

3. Spatial Effect Test

After determining the spatial weighting matrix, the next direction is to perform spatial effect testing. The spatial effects test was spatial dependency effects using Moran's I and Lagrange Multiplier tests, while the spatial heterogeneity effect used the Breusch-Pagan test.

a. **Morans I Test with R and Geoda Software**

The hypotheses for spatial dependency testing using the Likelihood Ratio Test are as follows (Angelia and Nurhafnita, 2020): H_0 : No spatial correlation H_1 : There is spatial correlation The test results using R and GeoDa software are shown in Table 2.

Table 2. Moran's I Testing

	Software R		Software GeoDa	
	LR Test Value	**p-value**	**LR Test Value**	**p-value**
Moran's I	0.2116	0.0764	0.2116	0.0726

Table 2 shows that the LR test value using both R and GeoDa software turns out to produce the same value of 0.2116, what distinguishes the two is p-value where the R software produces p-value of 0.0764 while GeoDa software produces p-value of 0.0726. Both p-values are more than $\alpha = 0.05$ so they fail to reject H_0. Thus it can be concluded that there is no spatial correlation between regions / sub-districts.

b. **Lagrange Multiplier Test with R and Geoda Software**

LM test is one of the spatial dependency tests other than Moran's I. To be more sure of the existence of dependency effect or not, the LM test is conducted. The LM test used 3 hypotheses: hypotheses for spatial lag dependencies (SAR models), for spatial error dependencies (SEM) and mixed dependencies of lag and spatial error (SARMA). The test hypothesis is used as follows.

1. Spatial lag dependencies (SAR)
   $H_0 : \rho = 0$ (no spatial lag dependencies)
   $H_1 : \rho \neq 0$ (there is a spatial lag dependency)
2. Spatial error dependencies (SEM)
   $H_0 : \lambda = 0$ (no spatial error dependencies)
   $H_1 : \lambda \neq 0$ (there is a spatial error dependency)
3. Mixed dependencies of lag and spatial error (SARMA)
   $H_0 : \rho, \lambda = 0$ (no spatial dependencies lag and error)
   $H_1 : \rho, \lambda \neq 0$ (there are spatial dependencies lag and error)

Table 3. Lagrange Multiplier Testing

	Software R		Software GeoDa	
	LR Test Value	**p-value**	**LR Test Value**	**p-value**
LM (lag)	0.1015	0.7501	0.1015	0.7501
LM (error)	0.7334	0.3918	0.7334	0.3918
Robust LM (lag)	4.0718	0.0436*	4.0718	0.0436*
Robust LM (error)	4.7038	0.0301*	4.7038	0.0301*
LM (SARMA)	4.8052	0.0905	4.8052	0.0905

Table 3 shows that R and GeoDa software produce the same LM test value and have the same p-value, where from Table 2 it is known that there are two significant tests namely Robust LM (lag) and Robust LM (error) tests. This is indicated by a p-value less than $\alpha = 0.05$. This means that spatial lag dependencies and error dependencies occur in stunting incidence data and its factors, so that this data can be modeled with SAR regression and SEM regression. However, since this study only discussed about SEM model, the modeling using SAR was not done.

c. **Spatial Heterogeneity Test with R and Geoda Software**

Table 4. Breusch-Pagan Testing

	Software R		Software GeoDa	
	LR Test Value	**p-value**	**LR Test Value**	**p-value**
Breusch-Pagan	3.2425	0.3557	1.7549	0.6248

Based on Table 4 it is known that the values of the Breusch-Pagan test for R and GeoDa software produce different outputs. However, both outputs produced the same conclusion that p-value is more than $\alpha = 0.05$, so it failed to reject H_0. Thus it is concluded that the variance in each location is the same (spatial homogeneity).

d. **SEM Models Using R Software**

Parameter estimation and parameter significance testing using R software are presented in Table 5.

Table 5. Parameter significance testing with R software

	Estimate	SE	Z	p-value
Intercept	-3.5058	7.7936	-0.4498	0.6528
Number of IDL	0.0654	0.0309	2.1170	0.0343*
Amount of Proper Sanitation	-0.0024	0.0010	-2.4132	0.0158*
Exclusive Breast Milk Quantity	0.0173	0.0125	1.3803	0.1675
Lambda	0.6990	0.2037	3.4317	0.0006*

Based on Table 5, Lambda parameter is significant because it has a p-value less than $\alpha = 0.05$. In addition, there are 2 other variables that are significant, namely the variable number of Complete Basic Immunizations (IDL) and the number of proper sanitation, where each of these variables has a p-value of less than $\alpha = 0.05$.

From the results of the estimated parameters in Table 5, the SEM model can be formed as follows.

$$Y_i = -3.5058 + 0.0654X_{1i} - 0.0024X_{2i} + 0.0173X_{3i} + \hat{u}_i \tag{8}$$

with

$$\hat{u}_i = 0.6990 \sum_{j=1,i\neq j}^{n} w_{ij}\hat{u}_j + \varepsilon_i, \quad where i = 1, 2, 3, \ldots, 9$$

Based on the SEM model in the equation (8) obtained the interpretation of the model as follows:

1. Coefficient λ means that there is a stunting incidence relationship between one sub-district and another adjacent sub-district. For example, South City District adjacent to the East City Subdistrict, it turns out that stunting incidents in the two sub-districts have almost the same value of 15 and 16 incidents, as well as for other sub-districts that are close to each other.

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2. The variable coefficient of IDL amount of 0.0654 indicates that every increase of one person who has IDL then stunting incidence will increase by 0.0654 units assuming other variables are considered constant.
3. The variable coefficient of the amount of proper sanitation of -0.0024 indicates that every increase of one unit of households that has proper sanitation then the incidence of stunting will decrease by 0.0024 units assuming other variables are considered constant.

e. **SEM Models Using GeoDa Software**

Parameter estimation and parameter significance testing using GeoDa software are presented in Table 6.

Table 6. Parameter significance testing with GeoDa software

	Estimate	SE	Z	p-value
Intercept	-3.5058	7.7936	-0.4498	0.6528
Number of IDL	0.0654	0.0309	2.1170	0.0343*
Amount of Proper Sanitation	-0.0024	0.0010	-2.4132	0.0158*
Exclusive Breast Milk Quantity	0.0173	0.0125	1.3803	0.1675
Lambda	0.6990	0.2037	3.4317	0.0006*

Table 6 shows the exact same output as Table 5. This means that testing the significance of SEM model parameters using both R software and GeoDa software turns out to produce the same output so that the conclusion is also the same. The model and interpretation are the same as those discussed earlier.

f. **Comparison of SEM Model Accuracy with R and GeoDa Software**

After testing the significance of the parameters, it was then compared to the accuracy value of SEM models processed with R and GeoDa software. Accuracy values are usually used to determine the best model. In this study, the accuracy used was R-Square and AIC. The results of the accuracy of both software are presented in Table 7.

Table 7. Comparison of accuracy of SEM models with R and GeoDa software

	Software R	Software GeoDa
R-Square	0.740	0.740
AIC	57.952	53.952

Based on Table 7, it is known that the R-Square value for both software is the same as 0.740. This suggests that the SEM model on stunting incidence modeling and its factors resulted in R-Square accuracy of 74%. In addition to the R-Square value, AIC can also determine the goodness of a model. From Table 6, it is known that the AIC value generated by GeoDa software is smaller than that of R software.

E. CONCLUSION AND SUGGESTION

Based on the results of the discussion, it can be concluded some results as follows. There are two variables that have a significant effect on stunting incidence, namely the variable number of Complete Basic Immunizations (IDL) and the amount of proper sanitation. This factor must be seriously considered by the government to reduce the incidence of stunting in Gorontalo city. The government must control the provision of complete immunization for every infant and toddler and ensure the availability of healthy sanitation in every sub-district in Gorontalo City.

Result of comparison of R and GeoDa software are several similar outputs i.e. LM test output, SEM model parameter estimation and R-square value 74%, while the different outputs were Moran's I test output, Breusch-Pagan test, and AIC value (AIC of R is 57,952 and AIC of GeoDa is 53,952). Although Moran's I test output and Breusch-Pagan test are different, but they produce the same conclusion, the AIC value produced by GeoDa software is smaller than R software. Based on these results, it can be seen that if analyze the SEM model, it is best to use GeoDa software to get a better level of accuracy.

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