

Determination of Stunting Risk Factors Using Spatial Interpolation Geographically Weighted Regression Kriging in Malang

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Abstract: Stunting is a condition of toddlers who have less height than their age. The high percentage of stunting is influenced by several factors, namely access to healthy latrines, quality of drinking water, clean living habits, access to health services and exclusive breastfeeding. There is an indication that an area is reported as having high percentage of stunting, then the nearest area has the same condition. This study uses Geographically Weighted Regression Kriging spatial interpolation to predict risk factors for stunting by considering the proximity of the region. The data was secondary data obtained from each Puskesmas in Malang Regency, 2019. The observation unit is 24 sub-districts in Malang Regency. Based on the R2 value of the GWR model with a Fixed Gaussian Kernel weight, it is better to use than the weighted GWR Rook Contiguity model. It is known that in general the factors that influence stunting are Access to Posyandu, exclusive breastfeeding 1-6 Months, quality drinking water and Handwashing Behavior with soap. Prediction of Stunting Prevalence in Map Form Based on GWR Kriging Interpolation shows that stunting is high in several districts, namely Gedangan, Ampel Gading, Sumbermanjing Wetan, and Poncokusumo Districts

Keywords: stunting risk factor, GWR, Kriging

Abstrak: Stunting merupakan kondisi balita yang memiliki tinggi badan kurang dari usianya. Tingginya persentase stunting dipengaruhi oleh beberapa faktor yaitu akses jamban sehat, kualitas air minum, kebiasaan hidup bersih, akses pelayanan kesehatan dan pemberian ASI eksklusif. Ada indikasi bahwa jika suatu daerah mempunyai persentase stunting yang tinggi, maka daerah terdekatnya cenderung mempunyai kondisi yang sama. Penelitian ini menggunakan interpolasi spasial *Geographically Weighted Regression Kriging* untuk memprediksi faktor risiko stunting dengan mempertimbangkan kedekatan wilayah. Data penelitian merupakan data sekunder yang diperoleh dari masing-masing Puskesmas di Kabupaten Malang Tahun 2019. Unit observasi adalah 24 kecamatan di Kabupaten Malang. Berdasarkan nilai R2 model GWR dengan bobot Fixed Gaussian Kernel lebih baik digunakan daripada model Rook Contiguity dengan bobot GWR. Diketahui bahwa secara umum faktor yang mempengaruhi stunting adalah Akses ke Posyandu, Pemberian ASI Eksklusif 1-6 Bulan, Kualitas Air Minum dan Perilaku Cuci Tangan Pakai Sabun. Prediksi Prevalensi Stunting Dalam Bentuk Peta Berdasarkan GWR Kriging Interpolasi menunjukkan tingginya stunting di beberapa kabupaten, yaitu Kecamatan Gedangan, Ampel Gading, Sumbermanjing Wetan, dan Poncokusumo.

Kata Kunci: faktor risiko stunting, GWR, Kriging

INTRODUCTION

Stunting is a condition where toddlers have less length or height if compared to age.¹ A toddler stunting including chronic nutritional problems caused by various factors such as social-economy condition, maternal nutrition during pregnancy, pain in infants, and lack of nutrition in infants.² The implication is that children who are stunted, sufferers of stunting can experience decreased neurodevelopmental and cognitive function and increase the risk of developing chronic disease.³

The stunting problem is a major nutritional problem faced by Indonesia. Based on Riskesdas data, stunting rates in Indonesia is 27,67% in 2019. Distribusi geografis prevalensi stunting di Indonesia menunjukkan bahwa belum ada wilayah di Indonesia yang terbebas dari stunting. Prevalensi tertinggi di beberapa wilayah di NNT dan Sulawesi tengah dan terkecil (< 20%) di DKI Jakarta.²

There is an assumption that if an area has a high stunting percentage, then the nearest area will experience the same condition. Thus, there should be statistical modelling method that involve information location in this research.

Spatial data is defined as data measurement which contain information location. Basic assessment of Spatial data is the law as stated by Tobler "Everything is related to everything else, but near things are more related than distant things".^{4,5} *Geographically Weighted Regression (GWR)* is a point approach technique linear regression model that will be the model weighted regression. Weight used in the GWR model can illustrate closeness of relations between regions. Accuracy weighting is needed because of weighting value represent the location of the data.⁶ Weights are grouped into two namely *distance* and *area (contiguity)*.⁷

Model GWR is used to predict the observed value at each observation location, but observations outside the sample cannot be predicted by GWR Model.⁸ To overcomes these problems method Kriging can be used. Kriging is a technique geostatistics to predict and interpolating data at locations that not sampeled.⁹

Ordinary Kriging is used to estimate the value of observation on a specific location by observing the same data same in other location. Interpolation of ordinary kriging uses semivariogram,¹⁰ semivariogram divided by 2 namely experimental semivariogram and theoretical semivariogram. However, based on the model there are three types namely *spherical*, *exponential* dan *gaussian*.¹¹ That method often used in several studies including research about stunting.

Based on both theory and research, the author interested in researching stunting cases in Malang Regency by using the spatial interpolation GWR Kriging with a weighting matrix distance and area. The research variables are percentage of stunting, healthy latrines access, quality of drinking water, the habit of using soap hands, *posyandu* access coverage and exclusive breastfeeding 1-6 months. The result provides information about factors causes stunting and distribution maps of stunting in Malang Regency so that there should be a suitable policy from policy makers adjusted to each location.

The purpose of this research is to find out the factors causes stunting in 24 Districts of Malang Regency with the GWR method and create a prediction map of stunting distribution using kriging method with a distance and areas weighting matrix that can be used as a basis for policy regional determination stunting based on weighting of the analysis.

MATERIALS AND METHOD

Secondary data about stunting and risk factors was obtained from each Puskesmas in Malang Regency year 2019. The observation unit was 24 sub-districts in Malang Regency. From the multiple linear regression analysis R^2 value was 0.22, it has a small value. Geographically Weighted Resression method was used because there was heterogeneity in the data.

Spatial interpolation GWR kriging using a matrix weighting distance and area stages explained as follows:

1. Doing GWR analysis, including
 - a. Test spatial assumption namely heterogeneity spasial using *Breusch Pagan* statistics test.
 - b. Determine the weighting distance,
 - i. Calculate euclide distance.
 - ii. Determine optimum bandwidth.
 - iii. Determine the weighting matrix *Fixed Gaussian Kernel*.
 - c. Determine the weighting area (*Rook Contiguity*).
 - d. Estimates parameter GWR models.
 - e. Testing the parameters of GWR models.
 - f. Determine of GWR Model with the best weighting.
2. Doing Kriging Analysis, including
 - a. Prepare a spatial data location map which is a map of the results of digitization contains data attribute information spatial

- b. To form the models of experiment and theoretical semivariogram
- c. To form the best semivariogram that is exponential model for interpolation stunting with the GWR models.
- d. Make interpolation of contour maps stunting.

RESULT

The results of the GWR analysis on stunting data and several risk factors are presented sequentially according to the analysis process.

Modelling GWR with Fixed Gaussian Kernel weighting

Table 1 shows the value of optimum bandwidth with weighting *Fixed Gaussian* is 67905.23. It means that the point inside radius 67905.23 considered influential optimal in forming parameters model. Other informations obtained is coefficients determination (R^2) value in GWR model is 0.2650504.

Table 1. Summary of Estimator Result GWR Model.

Bandwidth	67905.23
R^2	0.2650504
SSE	740.2695

Table 2. Subdistrict Grouping

Group	Subdistrict	Significant Variables
1	Sumbermanjing Wetan, Tirtoyudo, Ampelgading, Poncokusumo	Access coverage of <i>Posyandu</i>
2	Donomulyo, Kalipare, Pagak, Bantur, Gedangan, Dampit, Wajak, Turen, Bululawang, Gondanglegi, Pagelaran, Kepanjen, Sumber Pucung, Kromengan, Ngajum, Wonosari, Wagir, Pakisaji, Tajinan, Tumpang	Access coverage of <i>Posyandu</i> and exclusive breastfeeding 1-6 months.

Modelling GWR with weighting Rook Contiguity

Table 3 shows the result of GWR analysis with weighting *Rook Contiguity*. There are 9 groups which is shown in Table 3.

Table 3. Subdistrict Grouping

Group	Subdistrict	Significant Variables
1	Kalipare, Pagak, Bantul, Gedangan, Sumbermanjing Wetan, Tirtoyudo, Wajak, Pagelaran, Kromengan, Wonosari, Wagir, Tajinan, dan Tumpang.	-
2	Dampit, Poncokusumo, Pakisaji	The access for drinking water quality
3	Donomulyo	Habit of using soap hands
4	Gondanglegi, Ngajum	Exclusive breastfeeding 1-6 months
5	Sumberpucung	The access of drinking water quality and exclusive breastfeeding 1-6 months
6	Kepanjen	Habit of using soap hands and Access coverage of <i>Posyandu</i> .
7	Turen	The access of drinking water quality and exclusive breastfeeding 1-6 months and Access coverage of <i>Posyandu</i> .
8	Bululawang	The access of drinking water quality and exclusive breastfeeding 1-6 months, Access coverage of <i>Posyandu</i> , and habit of using soap hands
9	Ampelgading	Access coverage of <i>Posyandu</i> and exclusive breastfeeding 1-6 months

Table 2 shows two significant difference of variables which influence stunting. Access coverage of *posyandu* mostly causes stunting for Group 1. Different from group 1, not only access coverage of *posyandu* which causes stunting but also exclusive breastfeeding 1-6 months.

Group 1 in Table 3 shows absence variables that have a significant influence on stunting prevalence. In group 2 only variable access of drinking water quality that influence stunting prevalence. It was found in Dampit Poncokusumo and Pakisaji. Group 3 shows habit of using hand soap that influence stunting prevalence in Donomulyo. Group 4 shows that exclusive breastfeeding 1-6 months has a significant influence on stunting prevalence in the Gondanglegi and Ngajum. Seen in group 5 that the access of drinking water quality and exclusive breastfeeding 1-6 months give significant influence on stunting prevalence in Sumberpucung. Group 6 shows habit in using hand soaps, and coverage access of *Posyandu* has a significant influence on stunting prevalence in Kepanjen. In group 7 it is known that access of drinking water quality, coverage access of *posyandu*, and exclusive breastfeeding 1-6 Months has significant influence on stunting prevalence in Turen. Group 8 shows access of drinking water quality, habit in using hand soaps, coverage access of *posyandu*, exclusive breastfeeding 1-6 Months gives significant influence on stunting prevalence in Bululawang. Meanwhile, group 9 shows that coverage access of *posyandu* and exclusive breastfeeding 1-6 Months has an significant influence to the stunting prevalence in Ampelgading.

Comparison GWR Method with weighting Fixed Gaussian Kernel and Rook Contiguity

The comparison of GWR with the weighted method of *Fixed Gaussian Kernel* and *Rook Contiguity* is presented in Table 4. Based on Table 4, the R^2 values on GWR model with weighting *Fixed Gaussian Kernel* bigger compared to weighting *Rook Contiguity*. GWR model with weighting *Fixed Gaussian Kernel* is better to modelling stunting prevalence in Malang Regency and the interpolation GWR Kriging was carried out.

Table 4. Comparison R^2 values on GWR Model

Weighting	R^2
Fixed Gaussian Kernel	0.26
Rook Contiguity	0.000064

Interpolation GWR Kriging

The results of GWR kriging interpolation using exponential semivariogram are presented in the form of a prediction map to make it more informative and useful. Based on the prediction map in Figure 1, it is estimated that in 2019 the percentage of stunting is high in several areas in Malang Regency. In Figure 1, the high percentage of stunting is indicated by the red areas, namely Gedangan, Ampel Gading, Sumbermanjing Wetan, and Poncokusumo Subdistricts.

On the contrary, in the regional section the middle namely Gondanglegi Subdistrict has low percentage of stunting that marked on the map in dark green. The predicted value of stunting prevalence in this place by using Kriging GWR interpolation ranging from 14.7% to 16.9%.

DISCUSSION

By using the weighting function Fixed Gaussian Kernel, CV Fixed Gaussian Kernel, CV minimum of 1834.053 and bandwidth minimum of 1834.053 and bandwidth amounted to 67905.23. GWR modeling is done by inserting a weighting with method weighted least square. Spatial weighting matrix for each location was used to form GWR model, so that each district has different models.

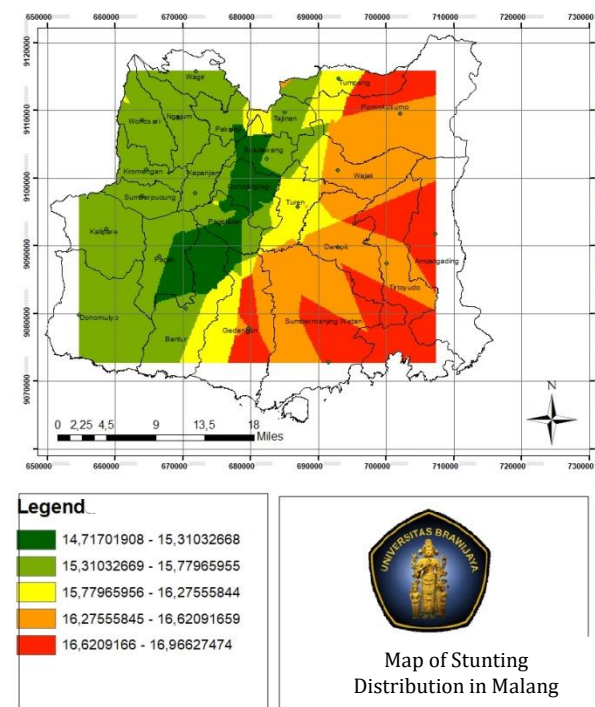


Figure 1 Prediction Map of Distribution Stunting di Malang Regency in 2019

In the GWR model, there is significance testing parameter partially conducted to determine the parameters which has a significant effect with the following hypothesis:¹²

$$H_0: \beta_k = 0$$

$$H_1: \beta_k \neq 0; k = 1,2,3$$

Based on parameter significance testing in GWR model, it can be seen that significant variables are grouped in Table 2. In spatial data modeling using the area approach, one of them in this study was used *Rook Contiguity*,¹³ approach sides and angles, for GWR modelling. This weighting is used to determine GWR model parameters on each observation location.

After the parameters obtained at each subsequent observation location, then it used significance testing parameters partially to find out the parameter which has a significant influence to stunting prevalence, use weighting *Rook Contiguity* with hypothesis as follows.¹²

$$H_0: \beta_k = 0$$

$$H_1: \beta_k \neq 0; k = 1,2,3$$

Based on significance testing, there were grouping of significance variables in Table 3. Table 3 shows that several factors that influence stunting in several areas in Malang Regency include exclusive breastfeeding 1 - 6 months, access to drinking water quality, coverage of posyandu and habit in using hand soap.

Stunting is a growth disorder of children who experience malnutrition, recurrent infections,¹⁴ inadequate psychosocial stimulation,¹⁵ and genetics.¹⁴ Undernutrition in children can result from uncovered exclusive breastfeeding for 1-6 months. Breast milk is the perfect food for babies, especially those aged 0-6 months because it contains nutrients needed for optimal baby's growth.^{16,17}

Ease of access to drinking water is related to the availability of clean water facilities and infrastructure. According to Rohman and Syahrul (2017),¹⁸ the unavailability of clean water facilities and infrastructure will cause infectious diseases, especially infections of the digestive tract because they are related to the provision of healthy and clean food and drinks. In addition, the behavior of washing hands using soap is a part of a clean lifestyle that can prevent the entry of infectious agents, especially gastrointestinal infections. The availability of clean water facilities and infrastructure and the behavior of washing hands using soap are important in preventing the incidence of gastrointestinal infections. Digestive tract infections due to viruses, bacteria or parasites will reduce the body's ability to

absorb nutrients from food intake so that the body will experience nutritional deficiencies. If this happens to children, it will hinder growth and development. In addition, digestive infections will also reduce appetite, cause vomiting and diarrhea in sufferers so that it will affect metabolism in the body which in turn will result in stunting in children.¹⁹

Comparison of analysis results based on weighting distance and area is done for find out the best weighting use R^2 value that presented on Table 4. Table 4 showed that GWR model with weighting *Fixed Gaussian Kernel* better to modelling prevalence stunting di Malang Regency. Geographically Weighted Regression Kriging interpolation using the exponential semivariogram method produces a prediction map (Figure 1). The forecast map in Figure 1 shows that in 2019 the estimated percentage of stunting is high in several districts, namely Gedangan, Ampel Gading, Sumbermanjing Wetan, and Poncokusumo Districts. In the middle section of the region, Gondanglegi District, the percentage of stunting is quite low. This informed the Malang Regency government to pay more attention to these districts regarding the prevention of stunting in children.

CONCLUSION

Variable which has a significant influence to the stunting prevalence on the GWR model is Coverage Access to Posyandu, exclusive breastfeeding 1-6 Months, quality of drinking water and habit in using hand soaps.

GWR model with distance weighting *Fixed Gaussian Kernel* better to use for modelling stunting data 2019 in Malang Regency. The predicted results of interpolation GWR Kriging with exponential semivariogram show that stunting is high in several districts, namely Gedangan, Ampel Gading, Sumbermanjing Wetan, and Poncokusumo Districts.

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