

# Leroux Spatial Model for Mapping the Relative Risk of Dengue Fever in Makassar

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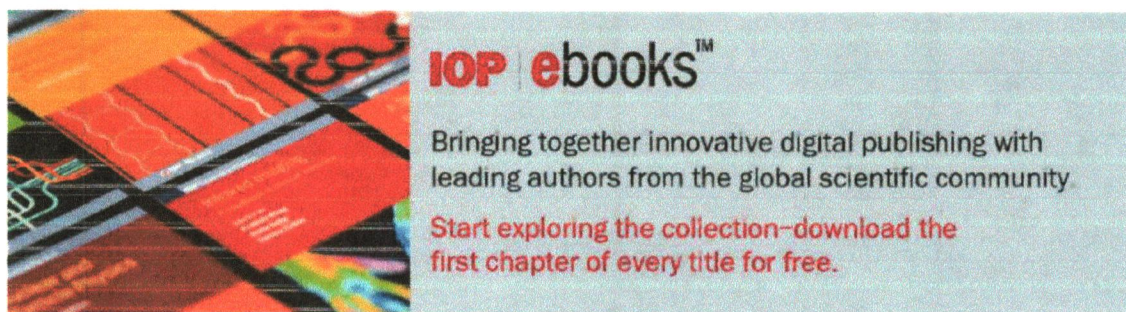
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## Leroux Spatial Model for Mapping the Relative Risk of Dengue Fever in Makassar

S A Thamrin<sup>1\*</sup>, Rosdiana<sup>1</sup>, A K Jaya<sup>1</sup> and Ansariadi<sup>2</sup>

<sup>1</sup>Department of Statistics, Hasanuddin University, Makassar, Indonesia

<sup>2</sup>Department of Epidemiology, Hasanuddin University, Makassar, Indonesia

\*e-mail: tuti@unhas.ac.id

**Abstract.** One of the health problems in Makassar city is dengue fever (DF) disease. To find out areas in Makassar that are at high risk of spreading DF, a relative risk analysis can be done. Bayesian Conditional Autoregressive (CAR) is a model used in disease mapping by taking into account the smoothing of the estimated relative risk and using spatial information to obtain a better estimate of relative risk. The Leroux model is a prior used in the CAR model for estimating the relative risk of DF in Makassar city. The relative risk estimation is used for geographic mapping of DF. In this model random and spatial variables are used. The results of this study indicate that DF medium relative risk occurred in some sub-districts of Makassar city. It indicates that the population in these areas susceptible and more likely to be infected with DF disease. This gives a clue so the Health Department of Makassar city can provide more intensive treatment to medium relative risk sub-districts so that the spread of DF disease in Makassar can be overcome.

**Key words:** Bayesian Autoregressive Conditional, Dengue fever, Leroux, Mapping, relative risk

### 1. Introduction 2

Dengue fever (DF) is one of the major public health problems in Indonesia [1]. The number of people and vast distribution area is increasing along with the increasing mobility and population density. The spread of DF varies from state to state and the risk of spreading were different. Therefore, the relative risk analysis is needed to see any location that has a high risk of developing DF. The difference in the location also allows the spread of DF difference. Therefore, the need to include the spatial dependence information to analyze the relative risk of DF.

One of methods for mapping disease with attention to the smoothing of the estimated value of the relative risk and use spatial information to obtain a relative risk estimation which is relatively better is a Bayesian conditional autoregressive (CAR) model Leroux. Model Leroux is an alternative model to the data of the area that was introduced by Leroux et al [2]. This model has only one component of the random effects that model the relative risk.

Bivand, et al [3] perform spatial data analysis using R Integrated Nested Laplace Approximation (R-INLA). This paper will provide a new paradigm for the model that fits in Bayesian analysis. Estimation of the relative risk using a Bayesian CAR has also been done by Sunengsih [4] who compared three models in the estimation of relative risks. Additionally, Thamrin and Alimun [5] used a Besag-York-Mollie (BYM) model with a Bayesian approach to estimate the relative risk of DF in Makassar. In this



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paper, the estimated of relative risk of DF for each sub-district in Makassar will be analyzed using a Leroux model with Integrated Nested Laplace Approximation (INLA).

**2. Materials and Methods**

**2.1 Data source**

The data used in this paper are the data of DF patients in Makassar city, Indonesia in the year 2011-2016, involving 14 sub-districts represented by neighborhood between the sub-district and the other sub-districts. This data was obtained from the Health Department of Makassar. The highest number of cases occurred in 2013 with a total of 265 cases whereas the lowest cases in 2015 with a total of 131 cases.

**2.1.1 Leroux Spatial Model**

In estimation theory, there are two approaches, namely the classical statistical approach and a Bayesian statistical approach. Classical statistical inference process fully rely on the data samples taken from the population. Then, Bayesian statistics, in addition to utilize the sample data obtained from population also takes into account an initial distribution of the so-called prior [5].

Prior distribution is the initial distribution that must be known to determine the posterior distribution of the data. If in determining the prior distribution is not appropriate, then the posterior distribution also would not be appropriate. Therefore, the Bayesian method workflow is necessary to determine the appropriate prior distribution. The main problem in the Bayesian method is how to choose a prior distribution to indicate uncertainty about the unknown parameters.

Bayesian CAR is a disease mapping technique that model the relative risk with regard smoothing the estimated value of the relative risks. It also incorporates the spatial information to reduce the error of the estimated relative risk parameters in order to obtain a more reliable estimation value [3, 4].

Suppose the random variable  $y = \{y_1, y_2, y_3, \dots, y_n\}$  is a univariate vector which expresses the number of cases in  $i^{th}$  location for  $i = 1, 2, \dots, n$ . The response variable  $y_i$  is assumed to follow the Poisson distribution that can be written as follows:

$$y_i \sim \text{Poisson}(e_i \theta_i)$$

with  $e_i \theta_i$  is the mean of a Poisson distribution [5].

To obtain the relative risk model of hierarchical Bayes approach was used to estimate the model parameters using INLA approach. The model will be used in this paper is the structure of prior with the Leroux model. This model has only one component of a random effect without including the intercept or additional covariates. This random effect is only model the relative risk [7]. This model was introduced by Leroux with the prior models [8] as follows:

$$\begin{aligned} \phi_i | \phi_{-i} &\sim N \left( \frac{\rho \sum_{j=1}^n w_{ij} \phi_j}{\rho \sum_{j=1}^n w_{ij} + \rho}, \frac{\tau^2}{\rho \sum_{j=1}^n w_{ij} + 1 - \rho} \right) \\ \tau^2 &\sim \text{Inverse-Gamma}(a, b) \\ \rho &\sim \text{Uniform}(0, 1) \end{aligned} \tag{1}$$

Here  $\rho$  is the spatial dependency parameter that takes values in the unit interval.

**3. Results**

In this study, the number of DF cases was observed in 14 sub-districts in Makassar city, the location of each sub-district is given in Figure 1. The number of dengue cases for each sub-district is given in the Figure 2. From Figure 2, sub-district of Rappocini has the highest number of DF cases in 2011 to 2018 (208 cases). Different when viewed from each year. In 2013 the number of DF cases in the sub-district of Mangala is higher compared with the sub-district Rappocini.

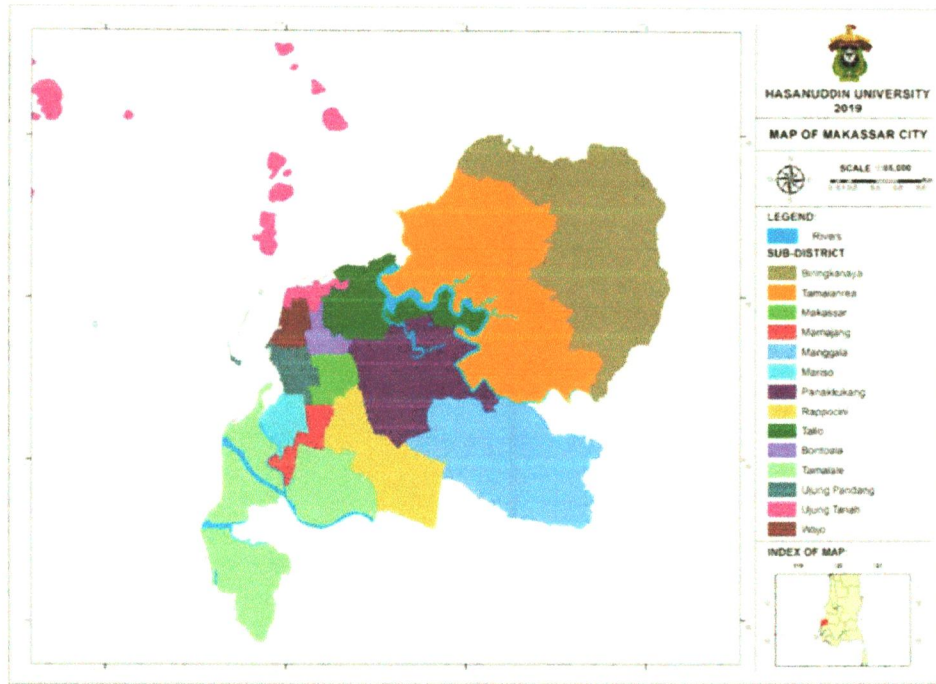


Figure 1. Map of Makassar city, South Sulawesi, Indonesia

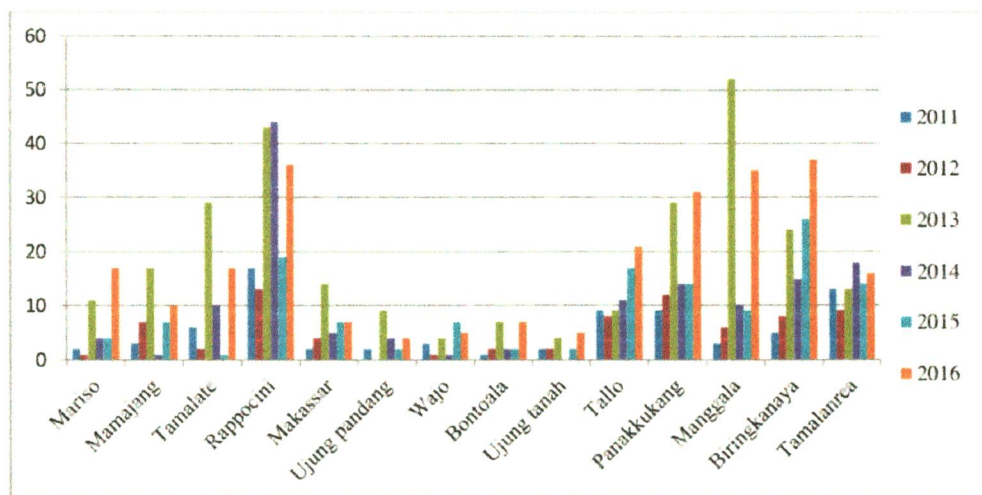


Figure 2 The number of dengue cases in the city of Makassar based sub-district in 2011-2016

The estimation of the relative risk of DF in Makassar city was obtained based on the model Leroux in equation [1]. Table 1 presents the relative risk of DF for each sub-district in Makassar city from 2011 to 2016. The relative risk was highest in Rappocini sub-district in 2014, while the lowest relative risk

occurred in 2012 in the sub-district of Makassar. For each year high-risk sub-districts affected by DF, namely Tamalanrea sub-district in 2011. Then Panakkukang sub-district reached a relative risk value of 1.0464 in 2012. Manggala sub-district reached a relative risk value of 1.9521 and 1.1732 in 2013 and 2016, respectively. The relative risk of spreading DF in Rappocini sub-district reached 2.5539 in 2014. Wajo sub-district with a relative risk reached 1.3714 in 2015. After obtaining the relative risk value for each sub-district location, then these values are mapped. This map will classify each location sub-districts into relative risk levels.

**Table 1.** The relative risk of each sub-district in Makassar city, Indonesia in 2011-2016

| Sub-district  | Relative risk |        |        |        |        |        |
|---------------|---------------|--------|--------|--------|--------|--------|
|               | 2011          | 2012   | 2013   | 2014   | 2015   | 2016   |
| Wajo          | 1.0054        | 0.9949 | 0.7939 | 0.6700 | 1.3714 | 0.9733 |
| Ujung Pandang | 0.9904        | 0.9841 | 1.2229 | 1.1535 | 0.9470 | 0.9691 |
| Ujung Tanah   | 0.9784        | 0.9999 | 0.5956 | 0.4714 | 0.8878 | 0.9200 |
| Tamalate      | 0.9586        | 0.9367 | 0.9187 | 0.6256 | 0.5410 | 0.8358 |
| Tamalanrea    | 1.1359        | 1.0443 | 0.7557 | 1.5090 | 1.2116 | 0.9740 |
| Tallo         | 1.0173        | 1.0177 | 0.5188 | 0.8388 | 1.1767 | 0.9630 |
| Rappocini     | 1.1168        | 1.0426 | 1.3811 | 2.5539 | 1.0946 | 1.0909 |
| Panakkukang   | 1.0098        | 1.0464 | 1.0319 | 0.9675 | 1.0322 | 1.0722 |
| Mariso        | 0.9639        | 0.9698 | 1.0714 | 0.7882 | 0.8508 | 1.1218 |
| Manggala      | 0.9757        | 1.0108 | 1.9521 | 0.8160 | 0.9033 | 1.1732 |
| Mamajang      | 0.9771        | 1.0340 | 1.3176 | 0.5121 | 1.0114 | 0.9832 |
| Makassar      | 0.9458        | 0.0041 | 0.9895 | 0.7160 | 0.9623 | 0.8927 |
| Bontoala      | 0.9499        | 0.9968 | 0.7672 | 0.6143 | 0.8648 | 0.9424 |
| Biringkanaya  | 0.9871        | 0.9952 | 0.7093 | 0.8284 | 1.3343 | 1.0429 |

From Figure 3 it can be identified that the relative risk of DF cases is very low in 2012 in Makassar sub-districts and in Ujung Tanah sub-district in 2014. For the low to moderate category of relative risk from 2011-2016 occurred in the sub-districts of Wajo, Ujung Pandang, Tamalate, Tamalanrea, Tallo, Panakkukang, Mariso, Mamajang, Bontoala and Biringkanaya. Furthermore, Rappocini sub-district is in the medium category. However, it increased dramatically in 2014 which resulted in the Rappocini sub-district having a very high risk of spreading DB. In 2013, Manggala sub-district was at a high risk of contracting DB disease in Makassar city.

#### 4. Conclusion

To estimate the relative risk values were better, in this paper the Leroux CAR model was used. From this model, the value of the relative risk of each sub-district involving spatial effects are presented in a geographical map. Relative risk map is useful to identify the vulnerable areas affected by DF. Medium risk sub-districts namely Manggala and Rappocini in 2013 and 2014, respectively, which indicates that the population in the area susceptible and more likely to be infected with DF disease. This gives a clue so the Health Department of Makassar city can provide more intensive treatment to medium risk sub-districts so that the spread of DF disease in Makassar can be overcome.

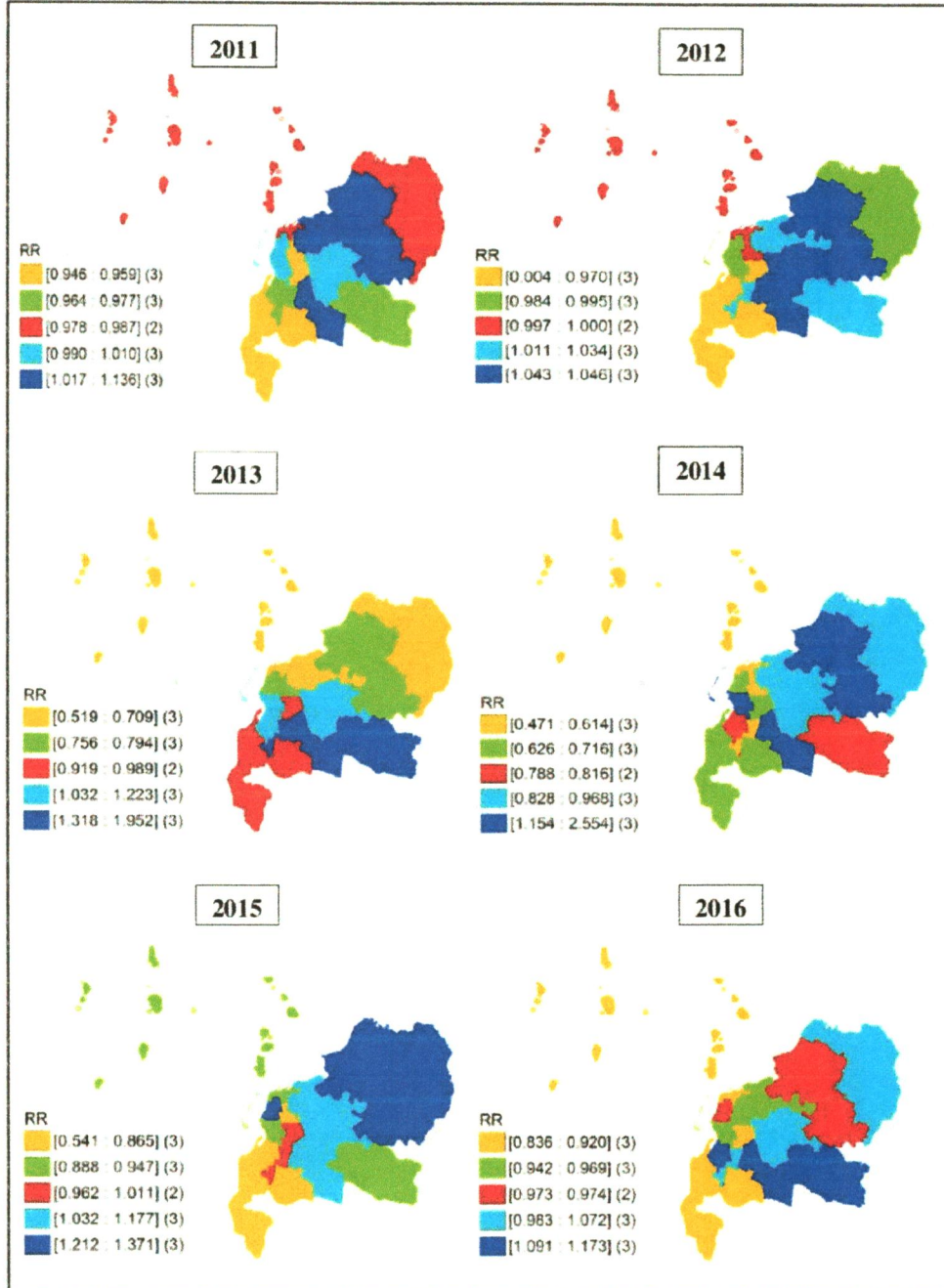


Figure 3. Relative risk (RR) map for DF based on Leroux model in 2011-2016 in Makassar city, Indonesia.

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