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Cluster Analysis Of Chikungunya In Bandung City, Indonesia

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Abstract

Chikungunya disease is a kind of a mosquito-borne viral disease that causes fever and severe joint pain. Identifying high-risk cluster of Chikungunya is important for effective control and treatment. Here we propose spatiotemporal cluster analysis based on a simple approach, inverse distance weighting (IDW) with contour lines plot. We apply our method to identify high-risk clusters of Chikungunya in Bandung city, Indonesia. We use the data from 2012-2014. We found the high-risk clusters were concentrated in the northern regions of Bandung.

Keywords: cluster, chikungunya, IDW, spatiotemporal

Introduction

Chikungunya first occurred in 1952 during an outbreak in southern Tanzania [1]. This disease is kind of a mosquito-borne viral disease that causes fever and severe joint pain. Chikungunya is transmitted to humans by the bites of infected female Aedes aegypti and Aedes albopictus mosquitoes. The mosquitoes feed throughout daylight hours and the peaks in the early morning and late afternoon. WHO recorded more than 40 countries ware infected including Indonesia and was first recognized in 1982 in East Sumatera. It has been transmitted to other islands including Java, Kalimantan, Bali, Flores, and Sulawesi [2]. Bandung is one of the city in West Java, Indonesia which reported has high incidence of Chikungunya. In period 2012-2014 were found 894 cases ([3] [4] [5]). Controlling Chikungunya transmission is needed to reduce the number of incidences.

Disease mapping method is widely used to identify the high-risk in order to develop a etiological hypothesis to find the risk factors that may have significant effects on disease transmission [6]. Standardized incidence ratio (SIR) was used often. However, it is difficult to find the appropriate interval in order to identify spatial clusters [6]. Here we propose to use inverse distance weighted and surface contour method to create a spatial cluster based on SIR [7].

Material and Method

Material

Chikungunya and population data in period 2012 – 2014 were obtained from Bandung city health profile (2013-2015). The Bandung map was extracted from google map using Raster package in R. The data are presented in Table 1.

Table 1. Number of cases, Expected Risk and SIR

District	Number of Cases			Expected Risk			SIR		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
Andir	16	0	9	7.46	18.09	9.65	2.14	0.00	0.93
Antapani	6	0	6	5.70	13.80	7.36	1.05	0.00	0.82
Arcamanik	0	11	55	5.30	12.57	6.74	0.00	0.88	8.16
Astanaanyar	0	0	0	5.26	12.78	6.81	0.00	0.00	0.00
Babakan ciparay	0	55	0	11.25	27.45	14.61	0.00	2.00	0.00
Bandung kulon	0	0	0	4.51	11.00	5.86	0.00	0.00	0.00
Bandung wetan	0	0	0	10.89	26.57	14.15	0.00	0.00	0.00
Bandungkidul	0	13	20	2.38	5.71	3.05	0.00	2.28	6.56
Batununggal	0	0	0	9.25	22.41	11.95	0.00	0.00	0.00
Bojongloa kaler	0	0	0	9.21	22.47	11.96	0.00	0.00	0.00
Bojongloa kidul	8	8	0	6.55	16.02	8.53	1.22	0.50	0.00
Buahbatu	0	45	11	7.27	17.66	9.41	0.00	2.55	1.17
Cibeunying kaler	0	5	10	5.42	13.19	7.03	0.00	0.38	1.42
Cibeunying kidul	0	20	0	8.25	20.04	10.68	0.00	1.00	0.00
Cibiru	0	59	12	5.51	12.92	6.95	0.00	4.57	1.73
Cicendo	12	93	0	7.63	18.49	9.86	1.57	5.03	0.00
Cidadap	0	33	50	4.49	10.80	5.77	0.00	3.06	8.67
Cinambo	0	0	0	1.93	4.55	2.45	0.00	0.00	0.00
Coblong	138	55	23	10.06	24.45	13.03	13.72	2.25	1.77
Gedebage	0	0	0	2.84	6.57	3.55	0.00	0.00	0.00
Kiaracondong	0	0	5	10.09	24.46	13.05	0.00	0.00	0.38

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District	Number of Cases			Expected Risk			SIR		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
Lengkong	0	0	0	5.45	13.28	7.07	0.00	0.00	0.00
Mandalajati	0	15	10	4.86	11.66	6.23	0.00	1.29	1.61
Panyileukan	10	8	13	3.08	7.22	3.88	3.25	1.11	3.35
Rancasari	0	7	0	5.88	13.88	7.45	0.00	0.50	0.00
Regol	0	8	17	6.23	15.20	8.09	0.00	0.53	2.10
Sukajadi	0	13	0	8.29	20.09	10.71	0.00	0.65	0.00
Sukasari	0	0	4	6.27	15.18	8.10	0.00	0.00	0.49
Sumur Bandung	0	0	0	2.80	6.60	3.54	0.00	0.00	0.00
Ujung berung	0	11	0	5.88	13.88	7.45	0.00	0.79	0.00

Method

Moran's I

In spatial data analysis, there are two important issue. The first is spatial dependency and second, spatial heterogeneity [8]. Moran's I is widely used to evaluate the first issue and heteroscedasticity and non-stability checking used to deal with the second issue. Here we deal with the first issue. Define r_i denotes the standardized incidence ratio (SIR). SIR is defined by [9]:

$$r_i = \frac{y_i}{E_i}, i = 1, \dots, n \quad (1)$$

where n is number of areas, y_i denotes the number of cases and E_i is the expected rate. The expected rate is defined as [10]:

$$E_i = N_i \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} N_i} \quad (2)$$

where N_i is the population at risk at *i-th* area. Moran's I statistic measures the spatial autocorrelation and is calculated as follows [6]:

$$I = \frac{1}{s_r^2} \frac{\sum_{i=1}^{n} \sum_{\{j:i\neq j\}} w_{ij} (r_i - \bar{r})(r_j - \bar{r})}{\sum_{i=1}^{n} \sum_{\{j:i\neq j\}} w_{ij}} \quad (3)$$

where $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$, $s_y^2 = \frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2$, i and j were the region indexes and w_{ij} indicated the adjacency between district i and district j.

$$w_{ij} = \begin{cases} 1 & \text{if } i, j \text{ are adjacent neighbors} \\ 0 & \text{otherwise} \end{cases}$$

We assume the spatial dependency are constructed by queen adjacency spatial weight matrix. The value of Moran's I from -1 to 1. A positive 1, indicates strong positive spatial dependency and for value 0 indicates there is no spatial dependency.

Inverse Distance Weighted

The Inverse Distance Weighted (IDW) method is widely recognised as the basic method in interpolation [8]. The main idea of this method is that all the points on the earth's surface are considered to be interdependent, on the basis of distance. It can be formulated as:

$$\hat{r}_p = \frac{\sum_{j=1}^{m} r_j / d_j^2}{\sum_{j=1}^{m}\left(1/d_i^2\right)} \quad (4)$$

where $\hat{r}_p$ is the predicted of the relative risk (SIR) of point p where the interpolation is affected with r_j denotes observed relative risk at point j; d_j is the Euclidean distance from point j to p with m is number of point that were connected to point p. To identify the cluster we drawing contour lines. It can be drawn by rules (i) only connected point of equal values, (ii) lines can never touch or cross, (iii) lines must extend to the edge of the map

Result and Discussion

The Chikungunya disease was found at 20% districts from 30 districts in Bandung in 2012. The number of districts was infected increased significantly in 2013. We observed there were 57% of districts were infected. The percentage was slightly decreasing in 2014 becomes 47%. The statistics of number of cases and standardized incidence ratio (SIR) show in Table 2.

Table 2. Statistics of number of cases and SIR

Statistics	Year	Mean	Minimum	Maximum	Standard Deviation
Cases	2012	6.333	0	138.000	25.217
	2013	15.300	0	93.000	23.299
	2014	8.167	0	55.000	13.814
SIR	2012	0.765	0	13.718	2.565
	2013	0.978	0	5.030	1.366
	2014	1.305	0	8.666	2.372

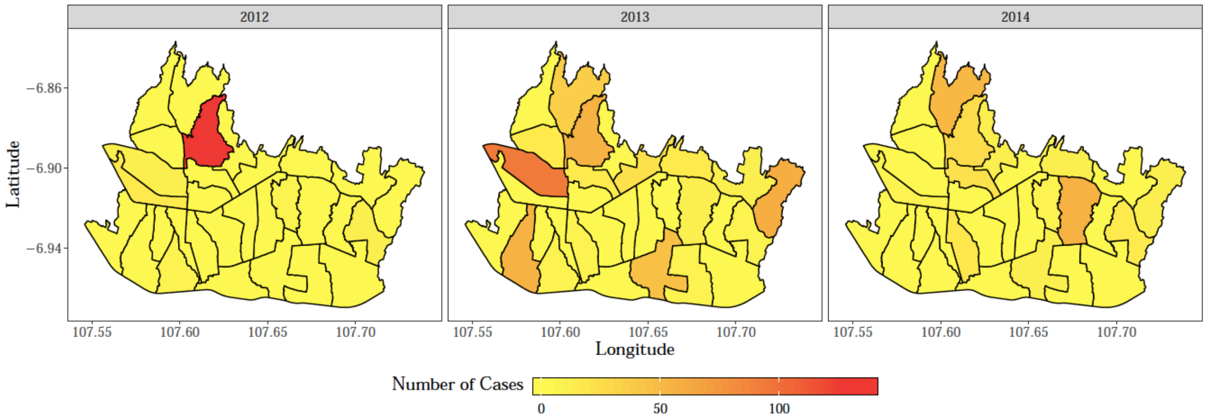

Figure 1. Spatiotemporal number of Chikungunya cases

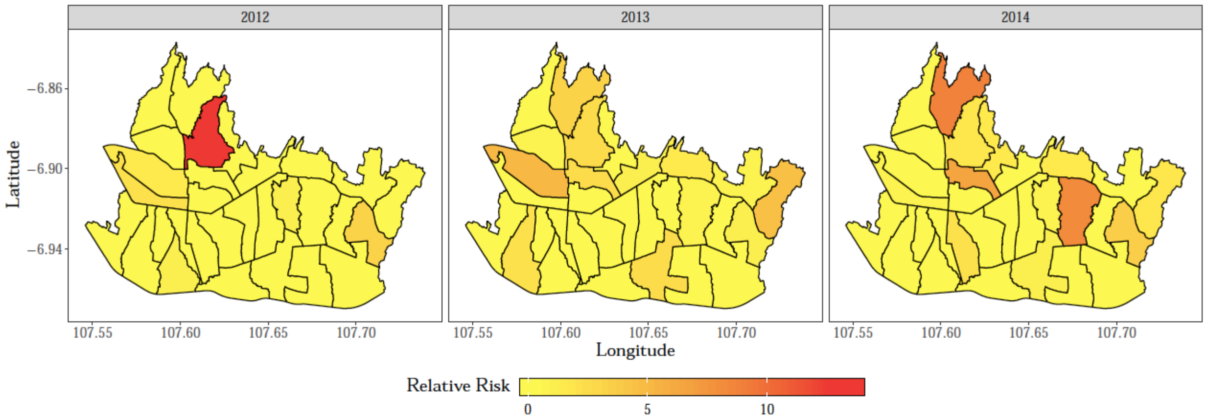

Figure 2. Spatiotemporal distribution of standardized (SIR)

Figure 1 and 2 show the number of cases and SIR area distributed randomly. It can be also evaluated using Moran's Index in Figure 3.

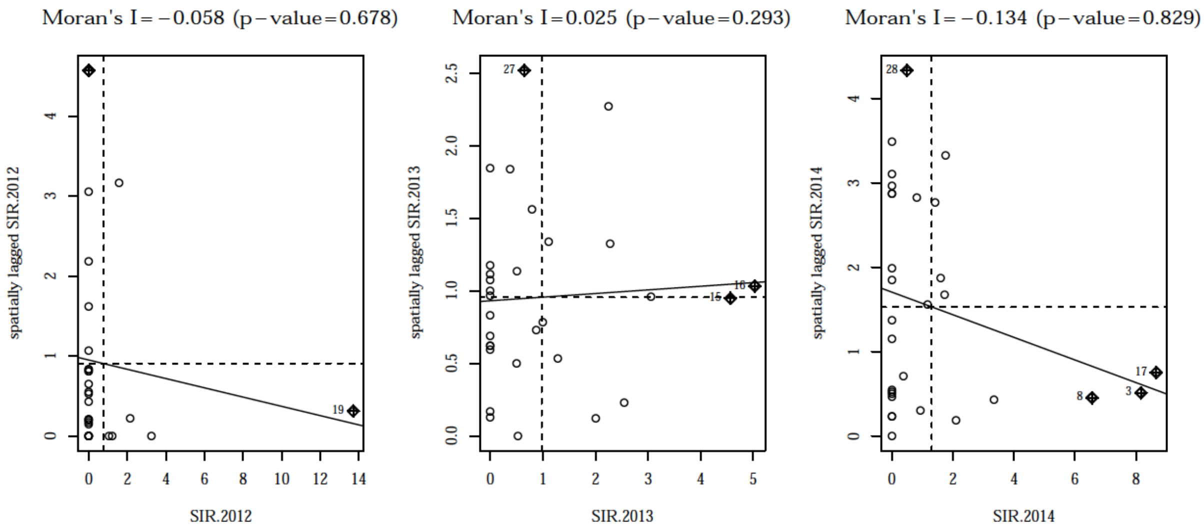

Figure 3. Moran’s Index (2012-2014)

Although Moran's Index is not different from zero, it seems that chikungunya is always found in the northern part of Bandung every year. We proposed to use inverse distance weighed approach to construct spatiotemporal cluster of Chikungunya disease in Bandung, Indonesia based on standardized incidence ratio (SIR) variable in periods 2012-2014. To identify the clusters, we use contour method.

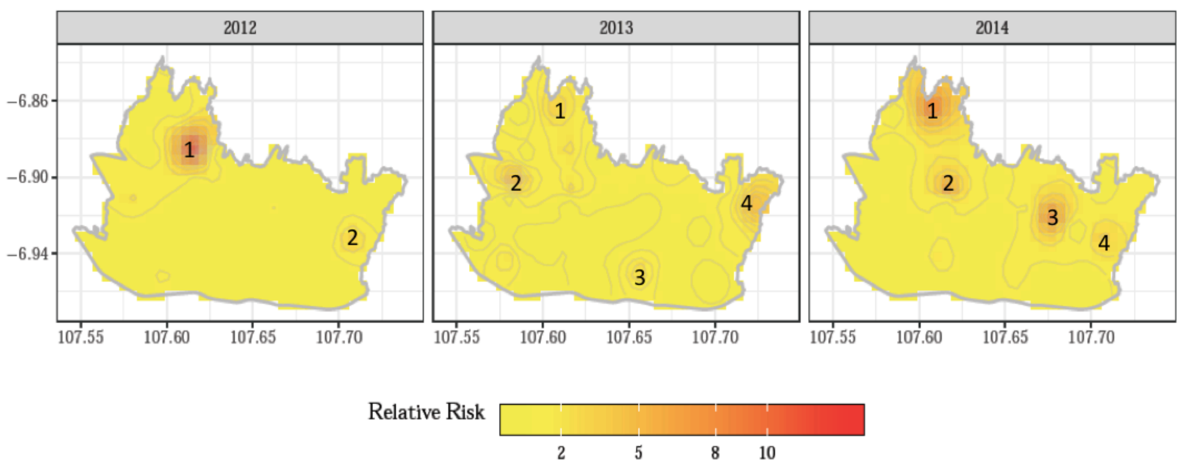

Figure 4. Spatiotemporal clusters based in IDW and contour analysis

Figure 4 shows the spatiotemporal cluster of Chikungunya. Here we found 2 high-risk clusters in 2012, it increased significantly become 4 high-risk clusters in 2013 and 2014.

Conclusion

Chikungunya has a similar vector with dengue disease. The vector is Aedes Aegypti mosquito. The transmission of Chikungunya is easier because people travel everywhere and every day. They can bring the virus to new areas in Bandung. Chikungunya has affected 894 peoples in Bandung in the period 2012-2014. The early detection of chikungunya spread is important to control and prevention of the outbreak. We have developed a method to identify the high-risk clusters of Chikungunya by space and time based on IDW and contour methods. From IDW and contour methods we can identify the high-risk cluster. In 2014, the high-risk clusters were found concentratedly in the northern and eastern of Bandung regions.

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