Dengue Virus Transmission during Outbreak within Endemic Area in Indonesia : A Spatial and Temporal Analysis

By SULISTYAWATI

Dengue Virus Transmission during Outbreak within Endemic Area in Indonesia : A Spatial and Temporal Analysis

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ABSTRACT

Continous surveillance of DENV tranmission pattern is undoubtedly important to provide a proper input to the dengue prevention and control programme. However, the DENV transmission pattern in outbreak event is still under research. This study interested to analyse the spatio temporal distribution of dengue cases in the area of study, particularly during outbreak event. Coordinate of 404 cases from 2016 outbreak in Banyumas Regency, Indonesia were collected by GPS 78 S with Viewranger/Maverick application. Two clusters area were identified during outbreak, and the initial place of outbreak is surprisingly occured in the border area, assuming that human movement and imported cases may play role in outbreak event. The distribution pattern of outbreak is clustered, as consequence of limited flight range of *Aedes sp* mosquito, high density population and rainfall. Information from our study highlighted where and when public health resources should be concentrated.

Key words: dengue, virus, transmission ,spatial, temporary, analysis

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INTRODUCTION

Dengue disease is still become a major public health problem, particularly in tropical regions due to the abudance of its vector, *Aedes aegypti* and *Aedes albopictus*[1,2].It is caused by Dengue Virus (DENV), genus Flavivirus (family Flaviviridae), which consisted of 5 serotypes (DENV-1, 2, 3, 4 and 5)[3]. DENV infection mostly asymptomatic, however several cases could lead to severe disease such as Dengue Haemmorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS) [4,5]. The spread of DENV infection drives by its transmission vector, mosquito *Aedes aegypti* as main vector and *Aedes albopictus* as secondary vector [2]. There is a current need to provide effective preventive for DENV infection since this virus expands not only in tropical countries but also currently in non tropical countries due the spread of A*e.albopictus*[6].Dengue is highly endemic in Indonesia and still become one of the main health problems in this country since it was detected in the cities of Jakarta and Surabaya in 1968 [7]. Although the case fatality rate (CFR) of DENV infection is declining but reports illustrated that among countries in Southeast Asia, Indonesia has the highest economic burden of dengue [8,9]. Spatial distribution of DENV infection could be influenced by several factors such as uncontrolled urbanization, human mobility, climatic changes, and socioeconomy factors [10-12]. In Indonesia, prevention and control efforts currently focus on reducing the number of mosquito populations by several approaches ranging from larvacides until genetic mosquito modifications[13]. However, despite local authorities spend around 6.75 million US$to control vector populations, Indonesia have seen a drastic increase in the number of cases since 2011 [14], therefore calling for novel strategies to control the transmission of dengue in the country. The epidemiology of dengue disease change overtime, following the change in its vector bionomic, enviromental changes, land use and other demographical tranformation [15]. Those facts causes the change DENV transmission pattern in several areas[16-18].Continous surveillance about the DENV tranmission pattern is indeed important to provide a proper input to the dengue prevention and control programme. However, the DENV transmission in dengue outbreak event is still under research. This information is crucial for dengue outbreak preparedness, particularly in dengue endemic area. In recent years, the utilisation of geographical information system (GIS), a computerized system that combines spatial and descriptive data for mapping and analysis is being increasingly used to collate and map available epidemiological information [19]. This advanced analytical tool has been widely used in disease surveillance and monitoring, identification of high-risk diseases affected areas, prioritize areas for mitigation and surveillance plan, programming and monitoring the incidence record, providing an effective tool for visualization and spatial analysis of epidemiology data and environmental exposure [20,21]. It is indeed interesting to analyse the spread of dengue cases in the event of dengue outbreak using GIS. In 2016, in Banyumas Regency, Central Java Indonesia had a devastating outbreak from 14 February to 30 March 2016, with 536 of dengue cases with 11 people died. This study interested to analyse the spatio temporal distribution of dengue cases in the area of study, particularly during outbreak event. This information will provide valuable input to the health authorization to prevent dengue outbreak in endemic area.

SUBJECT AND METHODS

Ethical statement

This study was carried out with ethical approval from Ministry of National Education, Faculty of Medicine University of Jenderal Soedirman REF 145/KEPK.VII/2016

Study area

The study area in this study is surrounding of capital town of Purwokerto in Banyumas Regency. This regency located in the southwest of Central Java Province, Indonesia. Coordinates for this location are as follows: 108" 39` 17`` - 109" 27` 15`` East longitude, and 7" 15` 05``- 7" 37` 10`` South latitude. This area of study showedhigh risk of dengue infection reported during the period 2000 to 2013, around ⅓ of the total number of cases(1250/3810) recorded in this regency. Purwokerto, capital town of Banyumas regency showed high proportion of high socio-economic with 4 hospitals.

Data Collection and Analysis

Patient data was collected from Banyumas Regency Office. The official number of dengue cases during outbreak were 536, however only 464 patient were included in this study due to the complete information. GPS coordinates points were collected from all 464 patients in the regency using GPS 78 S with Viewranger/Maverick application. Validity and reliability of GPS testwas conducted by calibration technique. Data was analysis using overlay technique spatial analysis, consist of analysis of point pattern method that is elementary analysis of disease, Nearest Neighbour Index (NNI), Convex hulls and Cluster Analysis of illness date with SatScan softwere.

RESULTS

The study area, Banyumas Regency, experienced a regular dengue cases every year, with several outbreak happened in 2008, 2010, 2013 and 2016. In 2016, this area undergo the most devastating outbreak with 990 cases during a year. The detail of dengue cases fluctuation from 2002 to 2016 can be seen in Figure 1.

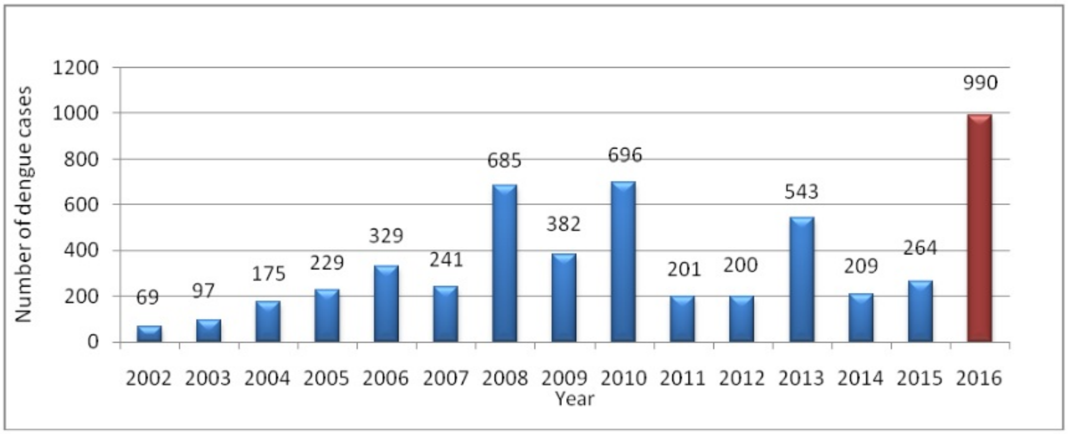

Figure 1. Fluctuation of dengue cases in Banyumas Regency from 2002-2016.

The dengue outbreak period was happened from 14 February to 30 March 2016 with 536 dengue cases with 11 died. The spread of disease can be seen in Figure 2.

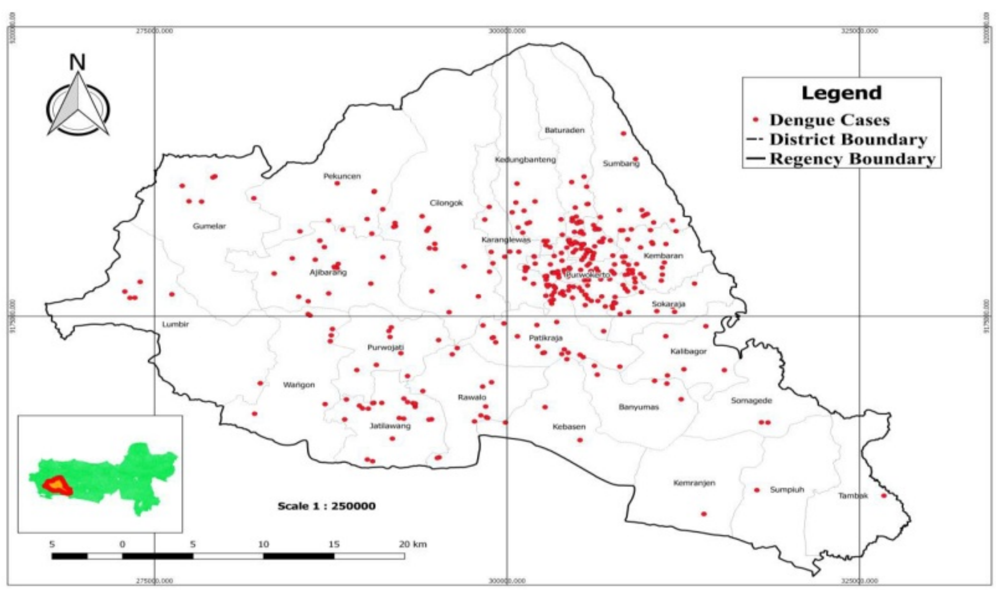

Figure 2. The spread of dengue cases during outbreak in Banyumas Regency 2016

Distribution pattern of DHF outbreaks was analysed by calculating the nearest neighboring distance index or Nearest Neighbour Index (NNI) obtained through Quantum GIS software .

Table 1. Distribution pattern of dengue outbreak in Banyumas Regency 2016

Parameter	Year
	2016
Area (m^2)	1.134.154,210
Number of cases	436
Cases	404.00
NNI	0.54052409
Distribution pattern	*Clustered*

The spread of DHF cases extends to almost all sub districts in Banyumas District, with details as illustrated in the map in Figure 3.

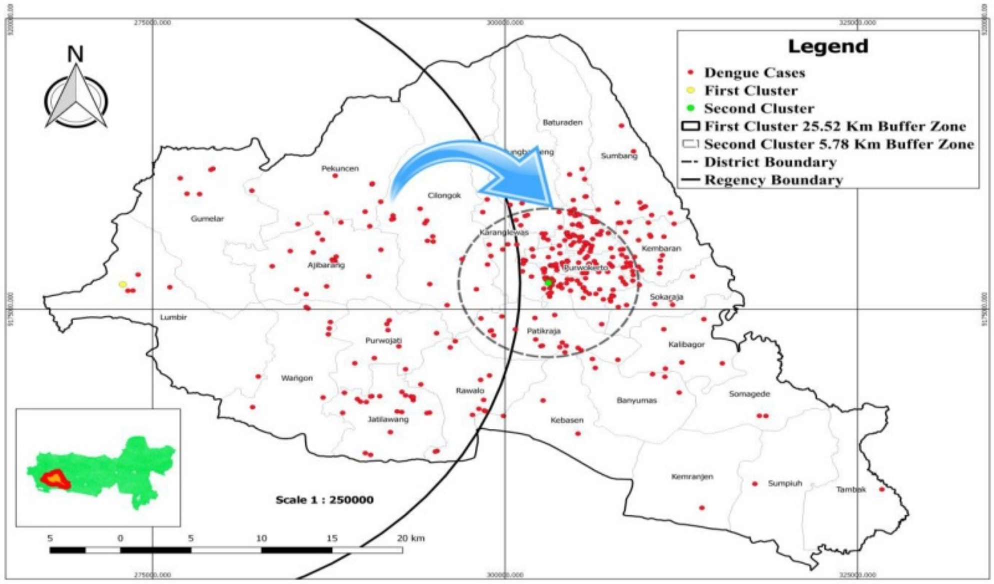

Figure 3. Movement from first cluster and second cluster during dengue outbreak 2016.

Based on Figure 3, the wide spread of dengue outbreak in Banyumas Regency in 2016 was 1,134,154,210 m2.Based on the results of the analysis analysis using space time permutation on the software SatScan showed the existence of 2 clusters cases of dengue outbreaks. The first cluster in Lumbir, Ajibarang, Wangon and surrounding areas with 99 cases occurring during 1-29 February 2016 with a radius of 25.52 km (p-value = 0.000) and the second cluster in Purwokerto City, Karanglewas and surrounding areas with the number of cases 190 that occurred on the period of 1-31 March 2016 with a radius of 5.78 km (p-value = 0.000).

Table 2. Spatial clustering of dengue outbreak based on the date of illness

No	Area	Radius (Km)	Beginning	End	*Observed*	*Expected*	*p-value*
1	Sub district Lumbir, Gumelar, Ajibarang, Wangon, Jatilawang, Pekuncen, Cilongok	25,52	1-2-2016	29-2-2016	3,62	27,36	0.000
2	Purwokerto, Karanglewas, Patikraja, Kedungbanteng	5,78	1-3-2016	31-3-2016	1,38	137,50	0.000

DISCUSSION

Dengue outbreak in Banyumas Regency affected to almost all areas within the district, spread over 1.134.154. 210 m of area in Banyumas regency, and caused 536 of dengue cases with 11 people died. Based on space time permutation analysis, there are two clusters during outbreak 2016 which interesting to be observed. The first cluster located in west part of Banyumas regency (Lumbir, Ajibarang, Wangon) which occured during 1-29 February 2016 within a radius of 25.52 km. The second cluster was happened in the capital of regency (Purwokerto) and its surrounding areas on the period of 1-31 March 2016 within a radius of 5.78 km. Surprisingly, the outbreak initially emerged in the east area of Regency, and then moved spread to Purwokerto, capital city of regency. Since 2000, a high number of dengue cases was clustered in Purwokerto as the most endemic area of dengue in the regency[10,22]. It is interesting that in outbreak event, other areas of the regency turn out as the initial place of outbreak. The first cluster located in border area of regency, near Cilacap regency which known as industrial area. And then, the movements into high-risk areas (capital of regency) lead to individual infection, and local transmissionestablished when infected individuals return to their homes where aedes vectors abundant. The human mobility betwen people in the border area could be an explanation behind the initial event of oubreak. Several studies believes that human mobility as an important driver of DENV tranmission [12,23]. Dynamic human travel had stronger affects to the spread of DENV infection than the mobility of *Aedes sp*[24]. This is possibly a consequence of a short distance of the flight range of primary vector of dengue, *Aedes aegypti*[25-27].The limited flight range of *Aedes sp* also could explain the clustered pattern of DENV transmission both space and time [28,29]. As we found in this study based on NNI, the distribution pattern of DENV transmission in the area of study during outbreak is clustered. This results is also observed in the several studies of dengue transmission [21,29]. A complex immune interactions among the circulating serotypes in certain area, could cause temporal and spatial patterns of infection[30,31]. Unfortunately, there is no information about serotypes of dengue virus during outbreak.

Between two clusters of epidemic in the area of study, the second cluster (Purwokerto) had more devastating effect (190 cases) than the first cluster (99 cases). This is suggested that at the second location it is more favorable for the spread of dengue cases, because it causes more cases, with a closer radius between cases. The case radius is also closer to the first cluster (5.78 km) compared to the second cluster (25.52 km). This might be explained by the demographical condition of second cluster (Purwokerto) which is urban, high population density and rainfall (Supplementary1). The risk of dengue was higher in urban area largerly explained by high population density, households with water storage container as mosquito breeding sites, and high rainfall[32,33]. Several previous studies believes that there is relationship between rainfall and dengue outbreaks[34-36]. High rainfall combined with high temperatures resulted high humidity which associated with higher feeding activity, development and survival of *A. aegypti*[37,38].

The initial event of outbreak which happened in outside of "hotspot" area of dengue is a crucial information for the dengue prevention and control program. The risk of human mobility in border area or imported cases should be addressed. The possibility of imported cases also should be considered. In several cases of dengue outbreak, the early date of the first imported and locally transmitted case was mostly responsible for the outbreak [39,40]. By identifying spatial cluster of dengue cases in endemic area is essential for planning and preparedness of dengue control. Two cluster area were identified in this study will help local health instutions to plan suitable interventions for dengue disease. Information from our study highlighted where and when public health resources should be concentrated. In addition, our study suggested that besides the "hotspot" area we need to aware other areas with high risk of imported cases such as border area.

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