# Space-Time Analysis for Dengue Surveillance: A Case Study in Sleman, Yogyakarta, Indonesia

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# Space-Time Analysis for Dengue Surveillance: A Case Study in Sleman, Yogyakarta, Indonesia

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## Abstract

**Introduction:** Surveillance is a dynamic activity that needs a continuous update to perform their function such as monitoring, evaluating, identifying high risk and supporting disease policy making. Geographic Information System (GIS) is a system for capture, store, analysis and visualise a phenomenon related to the geographical position including related particular disease. This tool is claimed powerful to support disease surveillance.

**Objective:** This study aims to apply retrospective space-time analysis using GIS on dengue cases to identify the clustering that may occur during the data period for supporting dengue surveillance.

**Method:** This research was a descriptive study by employed GIS technique-Satscan retrospective space-time permutation model. 159 confirmed dengue case sourced from Sleman District Health Office (Sleman DHO) between January 2017 to September 2018 was used as an input data. Geographical Positioning System (GPS) was employed to collect the coordinate location of the cases. The map was generated using Arc GIS.

**Results**: A most likely cluster and eight secondary clusters were detected in this study. The most likely cluster was found in Depok subdistrict during the middle of March to the middle of April 2018.

**Conclusions:** GIS shown as a powerful tool for dengue surveillance. Identification of space and time related to dengue is an alarm for related stakeholder on dengue prevention to prepare and prevent outbreak occurrence.

***Keywords:*** *Dengue, Scan statistic, Space-Time cluster detection, GIS, Sleman, Indonesia.*

## Introduction

Dengue is caused by DEN virus that transmitted by female Aedesaegypti that it is estimated responsible to 390 million infections each year[1]. Dengue is an infectious disease that closely associated with environmental condition and time pattern. In Sleman dengue-related to environmental aspects such as land cover, humidity and rainfall[2].Understanding the space and time pattern is essential for surveillance action on monitoring and preventing the dengue transmission.

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Geographical Information System (GIS) is an instrument for capture, store, analysis and visualise a phenomenon related to the geographical position of particular object[3,4]. GIS is a powerful tool on surveillance activity, as stated by some researches before. John Snow introduced this tool in 1854. On that time, he used GIS to study cholera outbreak in London[5]. Since then, GIS is widely used in public health study in many diseases' cases. A review from Jennifer et al. discussed the role of GIS for surveillance purpose[6], for example, recognising the triggers of dengue by assessing the correlation among the variable visually and geographical phenomenon. The important of GIS also said by another review that GIS could support dengue control program, such as by generating the vulnerable risk map[4].

According to Sleman government information, Sleman is divided into seventeen subdistricts that located in the north of Yogyakarta province, Indonesia. This district spreads over 574.82 $Km^2$, with more than 800.000 resident living over there[7]. Dengue in this district has been receiving attention from the local authority. The case number fluctuated throughout the year from 2013 to the middle of 2018 (Figure 1). Dengue case information in Sleman is captured through Integrated Disease Surveillance System or called as Surveilans Terpadu Penyakit (STP) and Hospital Information system or called as (SIRS). All of which are based on the patient visit in the hospital, primary health centre and other health facilities. A monthly report was generated from this activity to calculate the top 10 disease status[8].

Space-time permutation statistic is an algorithm which required case date of illness and coordinate position. This formula is a promising tool for early detection of particular disease outbreak[9]. Currently, information about the place and time of the disease occurrence is pivotal for preparing the disease prevention program by the stakeholder involved. There is growing evidence the usage of GIS method in disease-related environmental. However, information regarding space and time simultaneously is lacking, particularly in dengue. This research aims to apply retrospective space-time analysis using GIS on dengue cases to identify dengue cluster that may occur during the data period for supporting dengue surveillance.

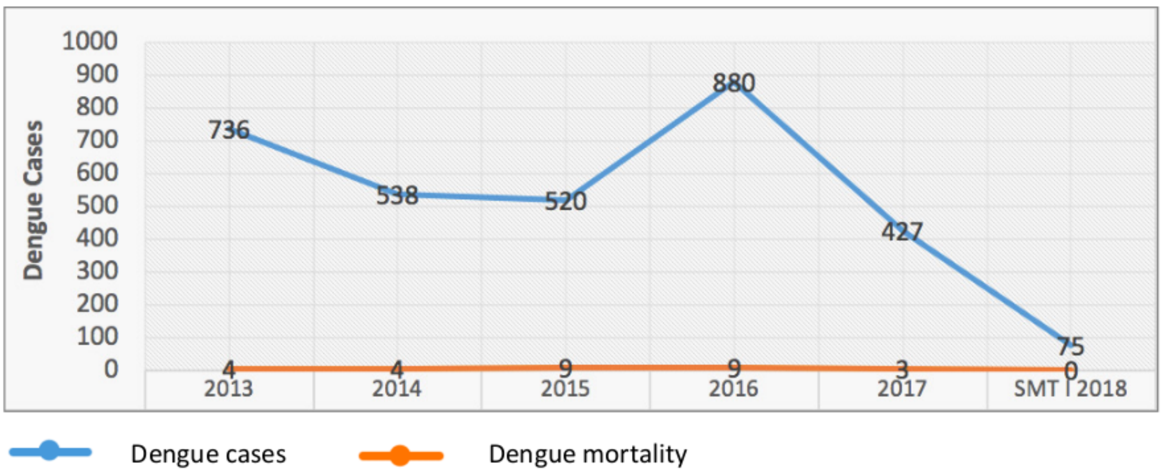


**Figure 1: Dengue case and mortality in Sleman district from 2013 to the middle of 2018**

## Material and Method

This research is a descriptive study to detect space and time cluster of dengue cases in Sleman, Yogyakarta (January 2017 to November 2018). Data collection and analysis was done in the end of 2018. Secondary data from Sleman District Health Office (Sleman DHO) was collected as input data of the study. Of 159 confirmed dengue cases who had a complete home address and date of illness was included. Geographical Positioning System (GPS) was employed to collect the coordinate location of the cases. For analysis purposes, we used the Retrospective Spatial Scan Statistic (Satscan) software. The Kulldorf space-time permutation model was used to discover the dengue cluster by using five days of Time Aggregation Length. The map was generated using Arc GIS.

## Results

According to our research, space-time analysis can be used on dengue surveillance study to inform where and when the dengue transmission potentially occurred. This information is essential to influence dengue program stakeholder to determine appropriate prevention of dengue outbreak.

During the data period - from January 2017 to November 2018, Satscan statistics detected nine clusters of dengue cases in Sleman, Yogyakarta. Among which, one cluster was significant (p-value $\leq 0.05$). This cluster centred at Depok subdistrict, in adjacent with the city of Yogyakarta and some other district in Central Java Province. The other eight clusters are spread over the Sleman, and they were not significantly space time associated. Complete information is summarised in Table 1 and Figure 2.

**Table 1. Cluster detection according to retrospective space time permutation model**

| Cluster ID | Data range | Cluster locations | Cluster radius (km) | Actual cases | Expected cases | P-value |
|---|---|---|---|---|---|---|
| 1 | 3/12/18-4/15/18 | -7.78311, 110.3928 | 2.34 | 8 | 1.19 | 0.022* |
| 2 | 7/5/17- 9/2/17 | -7.80071, 110.2959 | 2.78 | 13 | 3.65 | 0.176 |
| 3 | 7/30/17-8/18/17 | -7.69815, 110.4208 | 1.57 | 3 | 0.11 | 0.337 |
| 4 | 1/1/18- 1/10/18 | -7.66529, 110.3271 | 7.95 | 6 | 0.82 | 0.36 |
| 5 | 6/5/18- 6/19/18 | -7.81873, 110.4561 | 1.80 | 2 | 0.03 | 0.471 |
| 6 | 1/31/18- 2/19/18 | -7.74006, 110.3479 | 0.31 | 4 | 0.35 | 0.783 |
| 7 | 3/2/18- 3/6/18 | -7.74064, 110.3123 | 0.01 | 2 | 0.05 | 0.991 |
| 8 | 9/8/17- 10/2/17 | -7.72644, 110.4851 | 6.73 | 5 | 0.75 | 0.996 |
| 9 | 4/21/18- 5/5/18 | -7.76558, 110.3429 | 2.01 | 3 | 0.22 | 0.999 |

*significant cluster

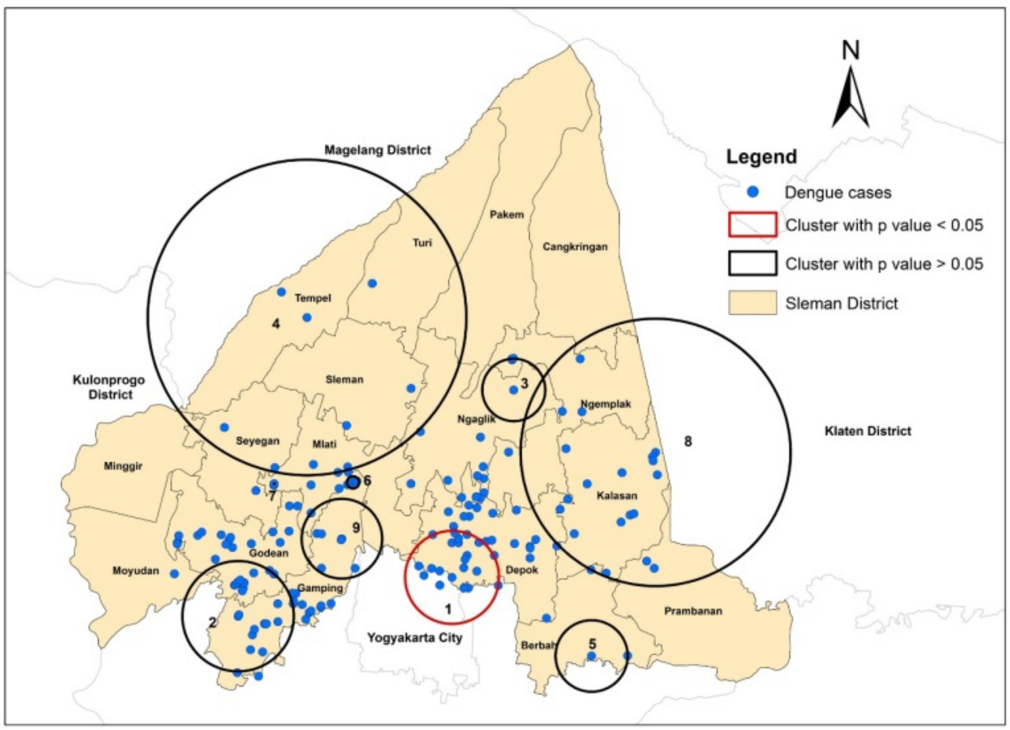


**Figure 2: Cluster map of dengue cases in Sleman, Yogyakarta, during 2017-2018.**

## Discussion

Geographic Information System (GIS) is a highly recommended tool on disease surveillance to monitor, control and prevention. Currently, many researchers use this method to study disease pattern to support the decision maker for taking the policy. However, dynamic and continuous analysis is needed to update the disease situation because of Dengue as one of environmental disease that changes over time. Identification following space and time will facilitate the development of dengue monitoring and may improve the response to the dengue outbreak.

In this study, we measured the using of space-time GIS analysis to identify dengue cluster that may occur during the data period. Through Satscan, we found 9 clusters; one of them significantly associated with space and time. Our study in Yogyakarta city also found a similar result, that dengue case was corresponding to space and time[10]. In Sleman during 2017-2018, a significant dengue cluster is detected centred in Depok sub-district from March 12 to April 15 of 2018. Since several years, Depok has received attention about dengue transmission in this area. According to Sleman DHO information, this area has been predicted as a vulnerable subdistrict in 2019 due to the high population density[11,12]. The previous study proved about the correlation between dengue incidence and population density, one of which in Sri-Lanka[13]. While in São Paulo-Brazil, dengue incidence clustered in an area that has a high population density because it increases the possibility of contact between infected mosquito and human[14].

The most likely cluster in Depok was at March 12 to April 15 of 2018. This occurrence is guessed coincided with the rainfall intensity in this location. According to the Meteorology Climatology and Geophysics Council, on March 2018. Depok subdistrict had high-intensity rainfall (301-400 mm)[1] while in April 2018 had medium rain between 150-200 mm[1]. A combination of high-intensity precipitation and proper temperature highly contributed to increasing dengue risk[17]. Rainfall is an essential aspect of Aedes development as they need stagnant water for breeding[18], rain builds breeding sites for larvae develop before it grows to adult mosquitos[19]. From this information shows when high-intensity rainfall occurred, it could potentially increase of dengue incidence if the prevention system is not ready.

Three clusters were detected in Gamping sub-district, while Mlati, Tempel, Ngaglik, Berbah and Kalasan subdistrict, on each of them was found one secondary cluster. Even though it was not significant, this result needs to pay attention for the stakeholder involved as part of dengue prevention. In our observation, there was also unique spot that we found dengue cases in high altitude that is> 500–999 m above sea level 2, namely in Tempel and Turi subdistrict. This information needs to be considered as part of climate change phenomenon that potential to extent the vulnerable area for Aedes development due to temperature increases[21], including in high altitude which is in a normal situation having a lower temperature. When the temperature is rising, it has implication to mosquito growth rate, reduces the interval on blood feeds, shortens the incubation period and contributed to virus evolution rate[22,23]. Accordingly, this information also provides an early warning on dengue transmission in the future.

## Conclusion

From this paper, we can see the power of GIS through space-time permutation analysis on surveillance activity. Cluster detection can help on dengue surveillance to providing early detection of dengue outbreak by knowing the association both space and time. This identification can lead to seeking the possible aspect that in uences the incidence. Future study is proposed to conduct a research related to the dynamic of rainfall and the association with dengue incidence. Secondly, to do research related to the changing of temperature and vector longevity in the research area.

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**Ethical Clearance:** This research was approved by the advisory board of Public Health Faculty, Universitas Ahmad Dahlan, Indonesia. Anonymity and confidentiality of participants were managed.

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