GIS For Dengue Surveillance: A Systematic Review

By SULISTYAWATI

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Sulistyawati Sulistyawati, Fajar Fatmawati

Abstract: The global incidence of dengue increased in recent decades in more than 100 countries. The use of Geographical Information Systems (GIS) to produce a map of the disease incidence is essential to improve the preparedness of the disease outbreak. Dengue surveillance consists of some activities; one of them is identifying the number and distribution of cases. The purpose of this study was to review the role of GIS in dengue surveillance system based on previous studies. Methods: Thirty-three articles met the inclusion criteria for this study based on Prisma Guideline. Result: Some studies reported using GIS to generate dengue modelling and dengue risk map from the case reported. Some of them presented a dengue case based on frequency distribution: age group, population, gender, demographics, climate, and environment. Conclusions: The use of GIS in dengue surveillance is essential to know incidence distribution and to advocate the decision-maker accordingly.

Index Terms: GIS, Surveillance, dengue.

1. INTRODUCTION

The global incidence of dengue increased in recent decades. Recognised more than 100 countries are dengue fever endemic with an estimated 3.9 billion people at risk of dengue virus infection. The number of cases reported in 2010 amounted to 2.2 million, then increased in 2016 indicated by the large dengue outbreaks worldwide with an increase of more than 3.34 million. Region of the Americas, Southeast Asia and the Western Pacific are most severely affected. The decline in cases of dengue fever occurred in 2017-2018 with 53% of reduction. However, since then a significant increase happened in 2019 in the Western Pacific such as Australia, Cambodia, China, Laos, Malaysia, Philippines, Singapore, Vietnam and Africa region such as the Congo, Ivory Coast, Tanzania [1] Disease surveillance is critical to identify the case distribution and to see the disease severity in the population. Geographical Information Systems (GIS) performs to investigate the distribution patterns and areas of potential transmission of dengue with spatial analysis. Geographic Information Systems (GIS) is a visual tool to generate map purposed to be used on a decision support system such as for supporting disease prevention. This tool is widely used in some fields; however, in public health, the usage still limited due to its complexity and the high requirements on the data input process [2]. Even though, through GIS, health officials can predict, identify and target high-risk areas with appropriate measures. This study is part of a more significant project aimed at In recent years, the using of GIS on public health already widespread, including on the dengue disease. However, an update about the rule of GIS on dengue surveillance is needed. This study aimed to review the role of GIS in a dengue surveillance system in some previous studies.

2 METHODS

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2.1 Search Strategy

This review consisted of an online literature search published in English using Google Scholar and PubMed. A searchable database with combinations of key terms "Geographic Information System", "GIS", "spatial", "surveillance", "dengue haemorrhagic fever", "dengue fever" is contained in the title and abstract. Journal article chosen is publications during 2015-2019. Articles journal filtering is done by looking at the title, keywords, and abstract as appropriate, next is the full text of which met the inclusion criteria included in the analysis.

2.2 inclusion Criteria

The criteria include the following:

1. The article should explain the use of GIS in dengue surveillance
2. Articles should use epidemiological study designs such as spatial, temporal and descriptive studies.
3. Research taken only research published during the years 2015-2019 around the world.

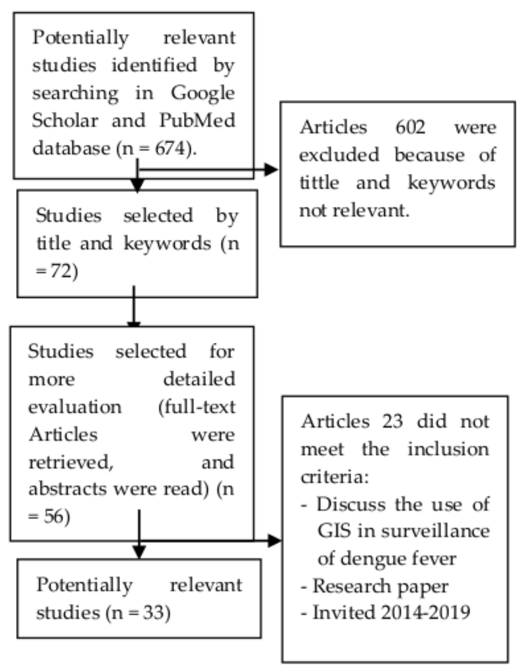

Figure 1. *Review flow charts*

3 RESULTS AND DISCUSSION

3.1 Literature search

This review consisted of an online literature search published in English. Articles were taken using Google Scholar and PubMed. All articles selected were published in the last five years (2015-2019). The initial search of Google Scholar and PubMed resulted in 674 articles. Review titles and keywords that do not include 602 articles, leaving 72 articles. Then identified based on full text produced in 56 articles. Of these, 33 articles met the inclusion criteria based on relevant abstracts. The methodology and the main findings of the 33 articles are summarized in table 1.

3.2 About study design used

Almost all of the studies using retrospective analytic study, but there was one study using a prospective cohort study [3]. Most studies using secondary data of dengue cases with periods ranging from 5 months to 16 years. There are ten sets of data of dengue cases used more than five years and the remaining 23 studies using the data set is less than five years. Analysis of Geographic Information System (GIS) used in the review of this research among which the Point Density method, Empirical Bayesian Kriging method, Moran's I, Kulldorff's, Average Nearest Neighbor (ANN), Spatiotemporal cluster analysis, Ecological niche models, LISA brittle-Ord, Predictive models (MAXENT), and hot spots. The modelling and the risk map of dengue were representing the dengue fever cases in addition to the frequency distribution is also seen by age group, population, gender, demographics, climate, and environment.

3.3 Population data and demographic

Most studies use population distribution, density and the environment to illustrate the risk of dengue fever. Secondary data were taken primarily from government health agencies such as health departments and community health centres. Demographic data, especially apparent age and sex, are used in the two studies. According to Jim, children younger than 14 years and women at higher risk of dengue infection [4], This research was also supported by research Ahmad, that the populations most affected are women is 47% compared with 21% of men[5], Several studies indicated that socio-demographic factors, such as population growth, level of education, demographic structure and urbanization, affect the dengue spreading [6]. High population growth creates densely populated areas so that the potential transmission of dengue virus will be very high [7],[8],[9],[10],[11]. This makes Aedes aegypti mosquitoes do not need to fly so that the dengue epidemic spreading quickly [12]. Besides, according to Respati's study, who said the use of land for housing development purposes without a development plan would increase the transmission of dengue disease [13]. It is also supported research by Arifin who stated that the dengue distribution influenced by unplanned settlements such as the number of buildings, population density, land-use patterns of settlement and population mobility which are difficult to predict [12].

3.4 Climate and Environment

Almost all of the studies linking the spread of dengue fever with climate conditions. As research by Edirisinghe, in the Matara District, Sri Lanka mentioned that the high dengue vector distribution within three years occurred primarily during the rainy season [14]. In Delhi, India, relative humidity and average temperatures have relationships in transmission and distribution pattern of dengue cases [15]. In East Timor, dengue cases also positively associated with temperature and rainfall [4]. However, not for the area in Samut Songkhram, climatic factors studied are not associated with dengue because this area has a proper drainage system [8]. Good drainage pattern, a clean environment, an area with high wind speeds, and the low-temperature region makes the area is not prone to the incidence of dengue [16].

Table 1. *Characteristic of studies on GIS for dengue surveillance*

Author (s)	Study area	Models used	Findings
Edirisinghe [14]	Matara District, Sri Lanka	GIS analysis	• The presence of high dengue vector distribution within three years, especially during the rainy season • Based on GIS analysis, Hittatiya City West, Fort, Isadeen and Kotuwegoda as dengue hotspot
Jat [15]	Delhi, India	- Point Density method - Empirical Bayesian Kriging method)	• A high density of dengue infection occurs in the year 2011 - 2012 • The maximum predicted value higher in the area of Maulana Azad Medical College Campus, Bhalswa, KhabasPura, Village Karawal and Palam Village • Relative humidity and an average temperature associated dengue cases in Delhi
Pakhare et al. [17]	Bhopal, India	GIS analysis	• The pattern of the spread of epidemics and identify hot spots are located in the south and cold spots in the northern city of Bhopal
Hashim et al. [7]	Seksyen 7, Shah Alam, Malaysia	- ANN analysis - Kernel density estimation analysis	• Of dengue cases was very crowded at an average distance of 219.2 meters • The residential area is identified as a dengue hot spot
Chaiphongpachara et al. [8]	Samut Songkhram, Thailand	GIS analysis	• Muang Samut Songkham, the only region with a very high risk, include 79,78km2 • The residential area is a location that has a high risk of dengue fever • Meteorological factors not related to the incidence of dengue in the region Samut Songkhram
Sulistyawatiet	Yogyakarta, Indonesia	Spatial scan statistics	• Mergangsan sub-district is an area with a significant level of high

al. [18]		(SaTScan)	Dengue cases in Yogyakarta
Rivyantanti et al. [19]	Parks District, Madiun, Indonesia	GIS analysis	• Spatial analysis showed that the risk ABJ & HI and PSN bad practices affecting the increase in the incidence of dengue
Sulistyawatiet al. [9]	Sleman District, Yogyakarta, Indonesia	GIS analysis	• DHF cases higher in urban areas than rural areas or rural-urban transition
Hazrin et al. [10]	Putrajaya, Malaysia	- Moran's I - ANN - kernel Density	• Of dengue cases was very crowded at an average distance of 264.91 meters • The residential area is identified as a dengue hot spot
Sudsom et al. [20]	Songkhla, Thailand	Spatial and statistical Analyst Tools	• Spatial distribution patterns found any significant results in the group of households located near the border area of space spraying after spraying
Anno et al. [21]	Sri Lanka	Space-time analysis	• Transmission of dengue fever in Sri Lanka occurs spatially heterogeneous
Dom et al. [22]	Subang Jaya, Malaysia	GIS analysis	• The population density as a risk factor for the incidence of dengue
Respati et al. [13]	Bandung, Indonesia	GIS analysis	• The spread of dengue fever cases has a wide impact in the area of East Bandung • The use of land to be used as housing be factors increasing disease transmission
Fareed et al. [16]	Rawalpindi-Islamabad and Swat district, Pakistan	Spatial-temporal analysis	• Dengue disease annually spatially shifted to neighbouring towns and suburbs
Huang et al. [23]	Tainan, Kaohsiung, and Pingtung, Taiwan	Spatial autocorrelation analysis	• High dengue cases were in southern Taiwan • The area that became the main hotspot is a metropolitan area
Ganguly et al. [24]	Kolkata, Bengal	-Spatial autocorrelation analysis - Moran's I	• Moran's I indicate that dengue cases occurred in areas of investigation in groups • Reduction in the density of breeding sites in each year
Espinosa et al. [25]	Tartagal, Argentina	- Spatial analysis -Predictive models (MAXENT)	• Breeding sites are the highest in the eastern and south-eastern city of Tartagal, and the lowest is in the downtown area
Vincenti-Gonzalez et al.[26]	Maracay, Venezuela	Hot Spot Analysis	• DHF cases highly clustered in and around the house at an average distance of 20-110 meters
Straddle et al. [27]	Guangzhou, China	Spatial-temporal analysis	• Baiyun district was the region with the highest spread of dengue cases
Ratanawong et al.[28]	Thailand	Mapping and clustering analysis	• Dengue infection is clustered between the school, and school classrooms due studied contain many other kinds of mosquito breeding developments
Falco'n-Lezama et al. [3]	Morelos State, Mexico	spatial Analysis	• Mobility of the population living in small urban areas exceeds the limit of the local health authority
Akter et.al [29]	Queensland, Australia	Spatial and temporal analysis Space-time cluster analysis	• The most severe outbreaks occurred during 2013 and 2014 in the north tropical Queensland • The highest number of dengue cases in Cairns • The maximum impact of dengue cases occurred at weeks 22 and 27 of a total of 37 weeks
Ahmad et al. [5]	Punjab, Pakistan	GIS analysis (hotspot)	• The population most affected are women 30 years and consist of 47% compared with 21% of men
Acharya et al. [30]	Nepal	Spatiotemporal cluster analysis	• Distribution of dengue cases was very crowded around the area Chitwan and Jhapa • Children (≤14 years) and a high risk women
Wangdi et al. [4]	Timor Leste	Moran's I LISA The brittle-Ord	• Climatic factors are predictors of dengue cases • High incidence of dengue in January • Positively associated with factors of temperature, precipitation and demographic
Ong et al. [31]	Singapore	spatial analysis	• Improved breeding Aedes percentages (BP) as risk factors for dengue transmission spatial
Sanna et al. [32]	Guangdong, China	Richards models Spatiotemporal cluster analysis	• Model richards show hotspot areas such as Yuexiu, Baiyun, Liwan, Tianhe, Haizhu, Zengcheng, Dongguan city • Yuexiu Guangzhou area is the starting point of an outbreak that spread to neighbouring regions and other cities
Arifin et al. [12]	Tanjungpinang City	Spatial-temporal	• The population density is correlated with the number of dengue cases • In the area of land use such as housing, transmitted dengue cases normatively
Liu et al. [6]	China	Spatiotemporal cluster analysis Ecological niche models	• Guangdong Province and Yunnan is an area with a high risk of dengue cases
Majid et al. [11]	Seremban, Negeri Sembilan, Malaysia	spatial analysis ANN analysis	• Of dengue cases in 2008 and 2009 clustered west Seremban • Regions with high hotspot occur in Seremban, which is a residential area
Pangilinan et al. [33]	Philippines	Moran's I and Kulldorff's	• High DHF cases occurred in the northern cities such as Malabon, Navota, Caloocan and Valenzuela as vulnerable to flooding will be a breeding place of mosquitoes
Hamer et al.	Suriname	Moran's I	• High DBD case in Suriname, namely in 2009, 2007 and 2012

[34]	• The area that became a hotspot is Blauwgrond and Rainville

3.4 The benefit of GIS on disease prevention

Generally, GIS usage in disease prevention has a broad implementation. Not only in dengue disease but also in other public health problem, such as Malaria, measles and leptospirosis that were using many aspects of analysis [35]–[40]. Those mentioned study proved that GIS is a powerful tool for supporting disease surveillance as part or disease prevention.

4 CONCLUSION

The use of GIS in dengue surveillance is needed to generate a map of the area with the data to detect the incidence of dengue disease accurately. This method also can see the distance between each area, identify areas of high risk, and the nearest health services to improve the accessibility of health service in various areas. Thus, the incidence and spread of dengue disease can be expected to do the decision-making process by all sectors of health for preventive action through an effective resource.

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