Impact of weather on dengue disease

Dengue is the most tropical infectious disease that is transmitted by the Aedes aegypti mosquito. The dengue disease incidence rises as a serious public health problem with 2. 1 billion people at risk. In Malaysia, the dengue disease over the last 40 years has become worst epidemic in the country's history. This study aimed to analyses relationship between weather parameters and increase of dengue incidence among university Putra Malaysia students, to identify the direct or indirect effect of weather on dengue incidence and to determine the relationship of dengue disease located in UPM (SERDANG). The objective of this study was to assess the effect of meteorological parameters variation on the dengue virus transmission between UPM students. We obtained data on monthly weather parameters including relative humidity and median mean temperature and rainfall amount and monthly dengue cases. Analysis was conducting by employing correlation and regression, plotting. A total of 7 years of dengue occurrences since 2005 to 2011 were plotted, 2005 and 2010 were the highest years with dengue cases rates while, 2006 and 2007 were the lowest dengue incident rates. Analysis of monthly mean temperature data for UPM indicated that the months which having very warm days has higher dengue rates while, the precipitation months has more direct effect on these rates. On the other hand, humidity is the most factors have highest impact on dengue incidence between UPM students.

Keywords: Weather impact, dengue incidence, UPM students.

INTRODUCTION

Dengue fever (DF) and Dengue hemorrhagic fever (DHF) possess recurred as 1980s and rapidly come to be a main epidemiological menace worldwide;

especially in South East Asia and Western Pacific Region. Dengue fever is rampant in more than 120 countries alongside approximated 2. 4 billion populations at the chance and annual dengue infection of 52 million cases according to World Health Organization, (WHO, 2005). Of this, Asia Pacific Area shares the biggest burden of dengue alongside approximated above 75% of the 2. 5 billion populaces at chance living in the region. As yet, the particular causes for the re-emergence of dengue are not completely comprehended. Though, the U. S. centers for Disease Control and Prevention has recognized factors such as weather factors and accelerated urbanization, poor areas, increased global excursion, and lack of competent vector manipulation arrangement as a few of the main determinants that possess gave globe rise of DE/DHF as a main area condition burden (U. S. C. D. C. P, 2007).

In Malaysia Dengue considered as endemic disease with four serotypes of dengue viruses. Dengue is the most threaten disease to public health in Malaysia. Around the world 50 million cases are reported each year about the dengue disease infection (WHO, 1999). Dengue is endemic in Malaysia the first case was recognized in Penang 1902, while the first dengue hemorrhagic fever outbreak was reported in 1962, likewise in Penang (Ska, 2006). . In the year 2005 MALAYSIA experienced the worst past outbreak of dengue incidence alongside 326. 5 cases each 100, 000 populations. The overall dengue cases in Malaysia augmented from (39, 597 person) and (84 person deaths) in 2009 to (45, 037 person) and (133 person deaths) in 2010 (HM, 2010). It is notifiable that Selangor state has the highest (dengue cases) followed by (Johor and Sarawak) for 2010 (MOH, 2010).

The urban and also rural areas of Malaysia are the greatest predominant habitations for the spread of the (yellow fever mosquito) species which is Aedes aegypti (Mohd et al., 2006). The mosquitoes of yellow fever can be found in the area of stagnant water and also in severe drainage (Mohd et al., 2006). The patients of dengue will suffer symptoms include vomiting, rashes on the skin, headache, nausea and muscle pain (NCID, 2005).

Recent Studies have shown that temperature could have an impact on feeding characteristics, population size, maturation period and survival rate of Aedes mosquitoes and pupae, and larvae mature female mosquitoes mortality rate as a function of temperature Between 11 °C and 42°C. (Hii, Y et al . 2009).

Many Studies shown that the high temperature have an impact on the population magnitude and maturation period, the survival rate of Aedes mosquitoes and the Feed characteristics.

Aedes mosquitoes on temperature which ranging from 16°C to 31°C, experience lower mortality rates , a study in French Guiana illustrated that at favourable environment condition Aedes mosquitoes capable to live 76 days .

On the other hand, heavy rain decrease survival rate of female mosquitoes and destroys larvae in short time but in long term, it creates plentiful breeding resources. Simultaneously, Aedes mosquitoes at a higher temperature 32°C rises feeding frequency more than twofold compared to the temperature at 24°C.

Extremely Low rainfall rates will increase surroundings temperature, usage of water storage and water and air-coolers may serve as breeding habitats.

Finding the relationship between weather factors mainly (temperature, rainfall, humidity) It can be useful for prioritizing prevention in public health sector decision making.. A threat prediction of dengue outbreak can be produced so local health officials can expect the number of cases and make proper strategy to control it.

Example

The dengue disease epidemic has become more serious problem in serdang with increasing about 14 percents for 2011 (Mstar, 2011). Selangor state recorded highest cases of dengue incidence compared to other states (MOH, 2010). For Seri Kembangan area, the dengue disease epidemic noted the 75 cases on 2009 while for year 2010, a total of 158 cases were reported (Mstar, 2011). The major source of Aedes mosquito breeding is in factories, abandoned housing projects, from the construction sites and vacant plots land (Thammapalo et al., 2001). The aim of this study an association amid dengue incidence and mean temperature, humidity and rain also more discuss how meteorological conditions impact on the rise of dengue in Universiti Putra Malaysia across the period 2005-2011 and to identify the most high risk years with dengue incidence.

The result of this study will be highlighting the connection between dengue cases and weather parameters within Seri kambangan 2005 – 2011. Health sector planners and policy maker’s benefit from this kind of studies as it generates useful information which further can be used for the creation of schematic approaches for disease prevention, interceptive studies and control programmes. This study is important as it can help in delaying or reducing the incidence of disease and its related socioeconomic implications at the individual and the community level as a whole.

Results achieved were used to recognize the patterns of dengue cases and the degree of dependence of dengue incidences on the weather parameters. In this study, we tried to provide additional details on relationship between dengue rates with weather parameters. Attention was focused on four years with lowest dengue incidence (2006 and 2007) also the highest two years with dengue cases (2005 and 2010) were inspected, and statistical analysis has been done to find evidence on the degree of correlation between the dengue and climate factors (precipitation, relative humidity , temperature).

METHODOLOGY

2. 1 Study area

Universiti Putra Malaysia is a public school which is approximately 22 km south of capital city Kuala Lumpur by road which located at latitude of 2°59 ´57Ë N and longitude of 101°42´28Ë E. The main campus of UPM is located at Serdang, Selangor state which cover an area of 1, 200 hectares of spectacular natural landscape and the topography is between 49m to 52m above sea level (figure 1). Universiti Putra Malaysia has a population of 29, 724 in first semester of 2011/ 2012 session. The staff population is 6, 100 that include academic, non-academic and sporting staff while that of student is 23, 624 which include post graduate and undergraduate students. Out of the total population of students, only 14, 108 are residing on campus while others stay off campus.

The Malaysian peninsula has a typical equatorial climate characterized by constantly high annual temperature and heavy rainfall. Temperature range is practically the same all over Malaysian peninsula throughout the year and is only governed by the height of the land above sea level; there are important differences in the amount and seasonal distribution of the rainfall in different part of the country. An average mean rainfall is about 2489mm which distributed throughout the year, with the bulk of the rain concentrated in the month of October and November, and its rains comparatively less in May to September (dry season) than October to April (wet season). Monthly average temperature are high on the month of April and May while December and January are the months with the low average temperature. Mean daily dry season (May to August) temperature range from 31°C to 34°C and the mean daily wet season (November to February) temperature range from 29°C to 32°C.

2. 2 Data Source

The Weather parameters data of UPM (2005- 2011) was obtained from Malaysian meteorological department (MMD). Temperature had estimated

This data was distributed into monthly data per year. This parameters which include (rainfall, humidity, mean maximum temperature) has been used to understand degree of dengue fever dependence on weather parameters (Morrison et al., 1998).

Dengue epidemiological data monthly basis and annually was obtained from UPM PUSAT KESIHATAN from (2005 to 2011). dengue haemorrhagic fever (DHF) or dengue fever (DF) were recognized as clinical dengue cases with confirmed laboratory blood tests of dengue viral infection of any serotypes Under the Infectious Diseases Act in Malaysia, it is needed for all medical practitioner must inform all confirmed or recognized dengue cases within 24 hours to the Ministry of health. (Infectious Disease Prevention and Control Act 1988).

The only data which obtained from UPM PUSAT KESIHATAN were number of monthly and annual cases.

2. 3 statistical analyses

All the dengue cases were plotted in the graph by using Minitab 16 version. Calculating and investigating the variability of rainfall, humidity and temperature indices, creating scatter plots and charts of Dengue fever cases against meteorological conditions variables, correlation analysis.(Amarakoon et al., 2004).

Here we analysed the association of rainfall and temperature, Humidity alongside dengue transmission in every single year in University Putra Malaysia. We only exclude 3 years owing to the very small dengue cases.

The cases of dengue disease were examined includes geographic distribution and spatial gender distribution (Srivastava et al., 2009). The purpose of geographic distribution is to determine the distribution of dengue cases among Kuantan district. Apart from that, the gender distribution was categorized into two groups which were male and female. The statistical significant between both gender were analyzed by using t-test.

2. 3. 1 Spatial distribution

The spatial distribution of dengue incidence within concession of Kuantan was observed. The spatial autocorrelation method measures the relationship among values of variable according to the spatial arrangement of the values (Chang, 2010). The Moran's I method was selected to test whether the dengue cases within Kuantan district is spatially correlated or not (Er et al., 2010). The area units where numerical ratio or interval data were available were the area where the Moran's I normally applied (Nakhapakorn & Jirakajohnkool, 2006). It considers both point locations and variation of an attribute at the location and finally it can evaluate whether the pattern of dengue cases within Kuantan district were clustered, dispersed or random. The Moran's I measure can be compute by (Er et al., 2010):

Where N is the number of cases, is the mean variables, is the variable value at particular location I, Xj is the variable value at another location j, and Wij is a weight indexing location of I relative to j. in Moran's I range, a strong negative spatial autocorrelation is in the range of -1 and a strong positive autocorrelation is in the range +1. The value 0 means it is spatially random pattern.

2. 3. 2 Distance Analysis

The Average Nearest Neighbour (ANN) is one of the techniques for point distance analysis. It was used to analyzed the distance between each point, to determine whether the point pattern is clustered, random or regular (Clark & Evans, 1994). In this study, the ANN was tested to predict whether the dengue incidence is cluster or not. The ANN analysis predicts the distance between each feature centroid and its nearest neighbour centroid. If the average distance is less than 1, the point pattern was considered clustered whereas if the average distance is greater than 1, the point was considered dispersed. The average nearest method is computed by:

(1)

Where is the observed average distance between each feature and their nearest neighbour. is the expected average distance for features given a random pattern. The average neighbour analysis also can produce the ZANN score, which indicates the likehood that the pattern could be a result of random chance. The ZANN score is computed by:

(2)

Where:

(3)

2. 3. 3 Buffer analysis

Buffering is a system operation that generates zones that consist of area within the specific distance with selected features (Chang, 2010). In this study, buffering was conducted to determine the extended neighbouring buffering method is used. The 500 meter radius of buffer were carried out from the dengue disease cases point as the mosquitoes flies at the maximum distance of 600 meter from the breeding site (Madanayake et al., 2010). A study conducted by de Freitas and de Olivera (2009) found that 50%-90% of female A. Aegypti flew up to 350 meter and 500. 2 meter and their maximum displacement was 690 meter.

2. 3. 4 Hot Spot Prediction

The Kernel density estimation interpolation was used to predict the hot spot locality (Jeefoo et al., 2011). Kernel density estimation is one of the method that applied to identify high risk areas within point patterns of disease incidence and also can defines the level of the high risk of that area (Bithell, 1990). Kernel density estimation is an interpolation that compatible for single point locality. The Kernel density estimation is the better hot spot identifier than cluster analysis. It can measures the density of point feature in each of the output raster cell . This method has been applied in previous study on spatial mapping on dengue disease to locate " hot spot" for dengue cases in the district of Hulu Langat (Er et al., 2010). Jeefoo et al, (2011) has used the kernel density to locate the spatio-temporal diffusion of dengue pattern and prove that the hot spot area have an influence on the spread of an infectious disease.

RESULTS AND DISCUSSION

3. 1. annual Dengue incidence years (2005-2011).

During the study time, dengue cases (Fig. 1) increased from 37 cases were reported in year 2006 to 75 cases reported in 2009, after which, annual reported dengue cases have amplified alongside greater temperature and humidity alongside record of 52 cases in year 2008 and peaked in year 2005 alongside 159 cases. The incidence next cut to 40 cases in 2007 and resurged in 2011 alongside 48 cases. In the study period the highest dengue cases were described in August of year 2010 with 44 cases. The extremely months with high dengue occurrence were between July – December.

Results obtained in this discover are given in tables 1 to 4, and figures 1 to 12. Tables contain results for correlation of dengue occurrences alongside meteorological conditions parameters. While, figures show relationship between weather factors and dengue cases.

reveals period sequence of weekly meteorological conditions predictors and dengue cases. Singapore experienced the highest weekly mean temperature of 30. 48C in year 2005 followed by 30. 38C in year 2002. The highest weekly mean

temperature in the discover era was recorded in week 17 of year 2005 alongside zero weekly cumulative precipitation. As the most extended dry spell of 40 dates transpired in the early two months of 2005, highest weekly cumulative precipitation was recorded as 388 mm in week 51 of year 2006. Overall, weekly mean temperature for year 2000-2003 fluctuated from 25. 7 to 30. 38C; as the scope was 25. 530. 48C for 20042007. Concurrently, weekly cumulative rain in years 20002003 fluctuated from 0 to 260 mm alongside average 42 mm and the scope was 0388 mm alongside average 44. 5 mm for years 20042007.

Our results of this study indicates that precipitation and temperature were positively associated with monthly dengue cases informed in University Putra Malaysia (Table 1) which mean they seems to have played an important role in increase of dengue cases . Although, humidity hazy days and foggy days were have suspicious association with dengue cases occurrence but still not powerful as other parameters.

3. 2 Correlation and Regression coefficients.

Both Humidity and Temperature display positive role in cases number and the humidity shows suspicious response with high significant effect (P-value < 0. 001). The rainfall did also exhibit that significant effect shown in humidity and temperature (P-value = 0. 972). The highest humidity at 76. 3, 75. 7 induced 7, 6 dengue cases, respectively. Moreover, most dengue cases noted with highest temperature and high amount of rainfall.

Correlation results are very significant in relation to mean maximum temperature (P-value = 0. 860) and dengue occurrences. It is clear that rainfall associated with dengue cases (R^2 = 85. 5) which mean 85. 5 % rainfall associate with dengue cases. In particular mean median humidity seems to have moderate positive role in dengue transmission compared to the other variables with (P-value = 0. 779) and (R^2 = 60. 7)

Figure 1, simplify rainfall amount for year 2006, shows that the precipitation playing very strong contributor factor for increase and decrease of dengue cases, while box plot confirms table 1 results (p-value) which is represents the percentage of total rainfall vs. dengue occurrence. Even though rainfall scale has increased over the last seven decades precipitation does show statistically significant (r square = 92. 0 and p- value = 0. 970).

As shown in Fig. 2, dengue rate has increased linearly with monthly mean temperature at January and December with 7 and 6 cases as temperature increasing; plot confirms that temperature is participating factor of transmission of dengue virus owing to the positive relationship between temperature and dengue cases .

Simplify relationship between humidity and dengue cases. As Fig3 illustrated humidity play doubtful contributor of increasing dengue diseases occurrence. From 70. 1 % to 71. 1% only one case has been recorded, while percentage of fogy months increased cases of dengue rises instantly. At 74. 1 per cent 4 cases were informed and 7 dengue cases when humidity reached 76. 3%.

CONCLUSION

The weather factors that affected the rising of dengue disease incidence have been identified, which were the temperature and humidity and rainfall. The study showed that the most weather conditions factors which contributed to the high incidence of dengue cases within UNIVERSITI PUTRA MALAYSIA area among seven years 2005-2011 were rainfall and temperature which were have very strong correlation with dengue cases. The result of the graphs plot shows that the three studied weather elements where positively associated with increase of dengue cases among students of UNIVERSITI PUTRA MALAYSIA area and

The data presented in this study are important because it give baseline information on the main factors contributed of transmitting dengue virus for a particular zone. It is recommended that collecting forecasting data for the three specific factors to predict potential future cases to make efficient plan to control dengue transmission in case of epidemic and expect the number of dengue occurrence.

When these strategies are implemented, the diverse costs associated with dengue cases will decrease.

All of these results should be considered in the future patterns prediction of dengue transmission. Early warnings of dengue epidemics based on climate information are effectively communicated to public health decision makers and Climate accounts for some variation in dengue risk, Important to account for confounding factors. For future work incorporate better understanding of disease transmission process.

The lack of information about specific factors which playing main role of high dengue disease incidence will lead to improper Vector surveillance and control management in case of dengue outbreak in specific zone and may loss many of lives. Understand connection between weather and dengue transmission will develop capability of national dengue management and diagnostic and impacts assessment of dengue mosquito vectors.

The spatial distribution of dengue incidence within Kuantan district for 2011 has been mapped included geographic distribution and gender distribution. The geographic distribution has shown the highest distribution of dengue cases in Kuantan. The gender distribution has revealed that male population has the higher incidence of dengue cases.

The buffer analysis was conducted to see the most high risk area for dengue fever incidence. It was identified that the high risk area were 500 meter radius from the dengue cases incidence. By using the statistical analysis, the pattern of spatial distribution of dengue incidence can be determined by spatial autocorrelation and was supported by distance analysis. The hot spot locations for dengue incidence were located by using kernel density estimation.

As a conclusion, the Geographic Information System (GIS) provided a very useful tool in the health mapping. Furthermore, the GIS has played an important tool for effective surveillance and prediction of the dengue outbreak in order to reduce the number of dengue cases.

Acknowledgement

The author thanks to University Putra Malaysia (UPM), Kuantan District Health Office Pahang, Department of Town and Country Planning , Kuantan who provided the data and advices.

Anker, M. & Arima, Y. 2011. Male-female differences in the number of reported incident dengue fever cases in six Asian countries. Western Pacific Surveillance and Response Journal. 2: 2. doi: 10. 5365/wpsar. 2011. 2. 1. 002.

Barrera, R., Delgado, N. Rogi, M. G., (2000). Stratification of a city with hyperendemic dengue hemmorrhagic fever. Retrieved on 6th November, 2010 from http://www. popline. org/docs/1354/153852. html

Bithell, J. K. 1990. An Application of density estimation to geographical epidemiology. Statistics in Medicine., 9, 691-701

Chang, K. T. 2010. Introduction of Geographical Information System. New York: McGraw Hill.

Clark, P. J., Evans, F. C. 1994. Distance to nearest neighbour as a measure of spatial relationships in populations. Ecology. 35: 445-453

Curriero, F. C., Patz, J. A., Rose, J. B & Subhash, L. 2001. The association between extreme precipitation and waterborne disease outbreaks in United States. American Journal of Public Health. 91(8): 1194-9

Eong, O. E. 2001. Changing pattern of dengue transmission in Singapore. Dengue Bulletin, 2001, 25: 40-44

Er, A. C., Rosli, M. H., Asmahani, A., Mohamad Naim, M. R. & Harsuzilawati, M. 2010. Spatial mapping of dengue incidence: a case study in Hulu Langat District, Selangor. International Journal of Human and Social Sciences. 5(6): 410-414

Halstead, S. B. 1995. Dengue in the health transition. The Kaohsiung Journal of Medical Science. 10: 2-14

Harian Metro, 2010. Kes Denggi meningkat, 133 kematian tahun ini.

http://www. harian-metro-online. com./kes-denggi-terus-meningkat-tahun-ini (retrieved on 23 October 2011)

Jeefoo, P., Tripathi, N. K., Souris, M. 2011. Spatio-Temporal Diffusion Pattern and Hotspot Detection of Dengue in Chachoengsao Province, Thailand. Int. J. Environ. Res. Public Health 8: 51-74; doi: 10. 3390/ijerph8010051

Madanayake, M. P, Gunatilake, J., Haji, A., Iqbal, M. C. M. 2010. A GIS approach to generatea dengue risk map. Msc. Thesis. University of Peradeniya, SriLanka.

Martinez, R. 2006. Geographic information system for dengue prevention and control. Working paper for the Scientific Working Group on Dengue

Research, convened by the Special Programme for Research and Training in Tropical Diseases, Geneva, 1-5 October 2006

Mohd, D. M. A., Shaaban, M. G., Taib, N. & Leman, N. 2006. The study of dengue disease by GIS software in urban area of Petaling Jaya Selatan. International Conference in GIS and public Health. Hong Kong, June 27-29. Pp16.

Morrison, A. C., Getis, A., Santiago, M., Rigau-Perez, J. G. & Reiter, P. 1998. Exploratory space-time analysis of reported dengue cases during an outbreak in florida, puerto rico, 1991-1992. Am. J. Trop. Med. Hyg., 58(3): 287-298.

Mstar, 2012 More dengue campaigns in schools and residential areas , SERI KEMBANGAN

http://thestar. com. my/news/story. asp? file=/2012/3/5/nation/10854555&sec= nation (retrieved on 5 March 2012)

Nakhapakorn, K., Jirakajohnkool, S. (2006). Temporal and spatial autocorrelation statistics of dengue fever. Dengue Bull 30: 177-183.

Nakhapakorn, K. & Tripathi, N. K. 2005. Using GIS technology to identify risk area of dengue fever (DF) and dengue haemorrhagic fever (DHF). 8th Annual International Conferences, Indonesia, August 22-26

National Centre for Infectious Diseases, 2000. Travellers Health. Virginia.

Otero, M., Solari, H. G. & Schweigmann, N. 2005. A stochastic population dynamics model for Aedes aegypti: formulation and application to a city with temperate climate. Bulletin of Mathematics Biology.

Pejabat Tanah Jajahan Kuantan, 2011. http://ptjk. pahang. gov. my/keluasan. php (accessed 18th March 2012)

Skae, F. M 1992. Dengue fever in Penang. British Medical Journal. 2: 1581-1582.

Shekhar, KC. & Huat, O. L. 1993. Epidemiology of dengue/dengue hamorrhagic fever in Malaysia-A retrospective epidemiology study 1973-1987. Part I: Dengue hemorrhagic fever (DHF). Asia-pasific Journal of Public Health, 6: 15-25

Srivastava, A., Nagpal, B. N., Joshi, P. L., Paliwal, J. C., Dash, A. P. 2009. Identification of malaria hot spots for focused intervention in tribal state of India: a GIS based approach. International Journal of Health Geographics, 8: 30 doi: 10. 1186/1476-072X-8-30

Thammapalo, S., Chongsuwiwatwong, V., McNeil, D. & Grater, A. 2005. The climate factors influencing the occurrence of dengue haemarrhagic fever in Thailand, Southeast Asia. Journal of Tropical Medicine and Public Health. 36 (1): 191-7

Tran, A. Deparis, X. et al., 2004. Dengue spatial and temporal patterns, French Guiana, 2001. Available from: http://www. cdc. gov/ncidod/EID/vol10no4/03-0186. htm retrieved 6th November, 2010.

Wagatsuma Y., Ali, M., Emch, M. & Breiman, R. F. 2003. Use of a geographic information system for defining spatial risk for dengue transmission in bangladesh: role for aedes albopictus in an urban outbreak. Am. J. Trop. Med. Hyg., 69(6): 634-640.

World Health Organization, WHO 1997. Dengue haemorrhagic fever: Diagnosis, treatment, prevention and control, 2nd Edition. Geneva

World Health Organization, WHO 1999. Strengthening implementation of the global strategy for dengue fever and dengue haemorrhagic fever, prevention and control. Report of the Informal Consultation. Geneva, October 18-20

Yew, Y. W. 2009. Seroepidemiology of dengue virus infection among adults in Singapore. Annals of the Academy of Medicine. 38: 667-275

Hii, Y., Rocklöv, J., Ng, N., Tang, C., Pang, F., & Sauerborn, R. (2009). Climate variability and increase in incidence and magnitude of dengue incidence in Singapore. Global Health Action, 2. doi: 10. 3402/gha. v2i0. 2036

Notification requirement under section 10(2) Infectious Disease Prevention and Control Act 1988.