SPATIAL DISTRIBUTION OF DENGUE FEVER AND ITS ASSOCIATION WITH ENTOMOLOGICAL INDEX IN KOTA BHARU FOR YEARS 2014 – 2016

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By

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LIST OF SYMBOLS AND ABREVIATION

AI	Aedes Index
BI	Breteau Index
CI	Container Index
GIS	Geographical Information System
MOH	Ministry Of Health
MREC	Medical Research Ethics Committee
SPPS	Statistical Package for the Social Science
USM	Universiti Sains Malaysia
<	Less than
>	More than
%	Percentage

ABSTRAK

ANALISIS TABURAN RERUANG DEMAM DENGGI DAN PERKAITAN DENGAN INDEKS ENTOMOLOGI DI KOTA BHARU ANTARA TAHUN 2014 - 2016

Latar Belakang: Demam denggi tersebar di semua kawasan tropika dan endemik di hampir 100 buah negara di seluruh dunia. Di Malaysia, terdapat beberapa negeri yang merupakan kawasan endemik untuk denggi, termasuklah Negeri Kelantan. Pada tahun 2014 Kelantan telah mencatatkan bilangan wabak demam denggi terbesar sepanjang tempoh 15 tahun pemantauan demam denggi dijalankan.

Objektif: Tujuan kajian ini adalah untuk menganalisa taburan reruang demam denggi dan untuk menentukan perkaitan demam denggi dengan indeks entomologi di Kota Bharu antara tahun 2014 – 2016.

Metodologi: Analisa ini menggunakan kaedah kajian ekologi yang dijalankan pada January 2017 menggunakan data sekunder dari sistem survelan E-dengue. Data yang diperolehi merupakan data sekunder dari pelbagai format termasuk ms excel dan shapefile yang disokong oleh poligon ESRI. Di dalam analisa ini ujian regresi linear berganda digunakan dalam analisis perkaitan antara demam denggi dan indek entomologi iaitu indeks Aedes, indeks Breateau dan indeks Bekas.

Keputusan: Terdapat 16513 kes demam denggi yang telah dinotifikasi ke dalam system survelan E-dengue sepanjang tempoh tiga tahun iaitu 2014 – 2016 bagi daerah Kota Bharu. Hasilnya terdapat 4 mukim yang menjadi fokus penyebaran kejadian demam denggi. Mukim itu adalah mukim Kota Bharu, Kota, Panji dan Kubang Kerian. Setiap suku ketiga setiap tahun juga menunjukkan berlakunya peningkatan kes demam denggi yang ketara. Di dalam analisa ini ujian regresi linear berganda digunakan dalam analisis perkaitan antara demam denggi dan indek entomologi. Hasilnya pada tahun 2014, hanya indeks bekas sahaja yang signifikan dengan regresi koefisien 0.13 (95% CI 0.10, 0.15), P = 0.001, manakala bagi tahun 2015 dan 2016, hanya indeks Aedes sahaja yang ketara dengan regresi koefisien 32.37 (95% CI 24.43, 40.30), P = 0.001 dan 54.90 (95% CI 48.29, 61.52), P = 0.001.

Penutup: Dengan menggunakan analisa taburan reruang, demam denggi di Kota Bharu tertumpu di empat mukim utama, iaitu mukim Kota Bharu, Kota, Panji dan Kubang Kerian. Keutamaan dari segi kawalan dan pencegahan yang maksima haruslah ditumpukan di empat mukim berkenaan bagi memutuskan rangkaian jangkitan demam denggi di daerah Kota Bharu ini. Terdapat hubungkait yang sangat signifikan di antara demam denggi dan indeks entomologi khususnya untuk indeks Aedes dan indeks bekas.

KATA KUNCI: demam denggi, indeks entomologi, analisa reruang,

ABSTRACT

SPATIAL DISTRIBUTION OF DENGUE FEVER AND ITS ASSOCIATION WITH ENTOMOLOGICAL INDEX IN KOTA BHARU 2014 - 2016

Background: Dengue fever is endemic in nearly 100 countries around the world. In Malaysia, there are some states that are endemic for dengue, including Kelantan. In 2014, Kelantan had the highest number of dengue fever cases during the last 15 years based on surveillance for dengue fever.

Objective: The aim of this study was to describe the spatial temporal distribution of dengue fever cases in Kota Bharu and to determine the association between dengue fever cases and entomological index in Kota Bharu between 2014 -2016.

Methodology: This analysis used the method of ecological studies conducted in January 2017 using secondary data from E-dengue surveillance system. The data obtained were secondary data from various formats including MS Excel and supported by a polygon shapefile ESRI. Multiple linear regression, according to years was used to assess the association between number of cases and the various entomological indices (Aedes index, Breateau index and Container index)

Result: There were 16513 dengue cases have been notified to the E-dengue Surveillance system over a period of three years from 2014 to 2016 for the Kota Bharu district. Total case distribution showed four sub-districts, namely Kota Bharu, Kota, Panji and Kubang

Kerian were endemic of dengue. In the multiple linear regression for year 2014, only the container index was significant, while for 2015 and 2016, only Aedes index was significant with regression coefficient 0.13 (95% CI 0.10 to 0.15), P = 0.001. While for 2015 and 2016, only Aedes index was significant with regression coefficient 32.37 (95% CI 24.43, 40.30), P = 0.001 and 54.90 (95% CI 48.29, 61.52), P = 0.001 respectively.

Conclusion: Four main sub districts, namely sub district Kota Bharu, Kota, Panji and Kubang Kerian were endemic for Dengue Fever. Control and prevention should be intensified in this four endemic areas. Although the entomological indices were associated with the cases, its pathway would need further investigation.

KEY WORDS: dengue fever, spatial distribution, entomological index,

Chapter 1

INTRODUCTION

1.1 Introduction

Dengue fever is a mosquito-borne viral disease that has expeditiously spread all around the world in recent years. Dengue virus is transmitted by a female mosquitoes mainly from species of *Aedes aegypti* and *Aedes albopictus*. Generally, there are four main serotypes of the virus that cause dengue which is DEN-1, DEN-2, DEN-3 and DEN-4. Dengue fever is outspread throughout the tropics, with local divergence which might be influenced by climate, rainfall, temperature and poorly planned urbanization.

1.2 Epidemiology of dengue

Dengue is now endemic in more than 100 countries. It has been estimated that there are approximately 390 million dengue infections per year based on global estimate (Bhatt *et al.*, 2013).

In Malaysia, dengue is principally an urban disease. There are six state which continously reported the highest cases. There are Selangor, Wilayah Persekutuan Kuala Lumpur, Johor, Pulau Pinang and Kelantan. The observed outbreak seems to show a trend whereby the occurance is every 5 to 8 years, there were years 1974, 1982, 1987, 1991 and 1998. Since 2001, the trend has slightly changed with the highest number of dengue cases was reported in 2008, with total of 49335 cases. Another sharp increase in the number occurred in 2013 with a total of 43346 dengue fever cases registered. Selangor had the highest number of cases reported in 2014, followed by Kelantan, Wilayah Persekutuan Kuala Lumpur & Putrajaya cases and Johor (Mohd-Zaki *et al.*, 2014).

Kelantan is located at east coast region of Peninsular Malaysia. There are 10 districts in Kelantan and Kota Bharu is its capital city. Between years 2000 to 2015, dengue epidemics trend in Kelantan have been observed to occur every 3 to 4 years. These were in years 2003, 2007, 2010 and reached highest number of dengue cases in 2014. In 2014, Kelantan saw the largest dengue outbreak in its history. Although dengue was not declared as an emergency, it was handled as an emergency with the activation of the National Security Council at the Kelantan state level. An extra budget was given by the Ministry of Health to the Kelantan State Health Department for intensified control and preventive purposes. Despite these efforts, Kota Bharu remains the main district of Kelantan with the highest number of Dengue cases.

1.3 Geograhic Information System (GIS)

A geographic information system (GIS) is a technology that can be used for scientific investigations, resource management and development planning. It is a systematic directory that is capable of capturing, storing, analyzing and displaying geographical referenced data. GIS may allows planners to easily calculate emergency response times in the event of a natural disaster (Calistri *et al.*, 2007).

The application of GIS may aid the investigation into characteristic of the diseases as related to the space aspects which give rise to the development of spatial epidemiology. In Malaysia and specifically in Kelantan, study regarding spatial epidemiology still underutilized due to limited number of expertise in this field.

In Kota Bharu, there are 15 sub-districts. By using GIS applications, all the cases of dengue fever in Kota Bharu between 2014 – 2016 can be plotted and analyzed the distribution of the case more thoroughly in all 15 sub-districts concerned. The name and distributions of the sub-districts of Kota Bharu are shown in Figure 1.2.

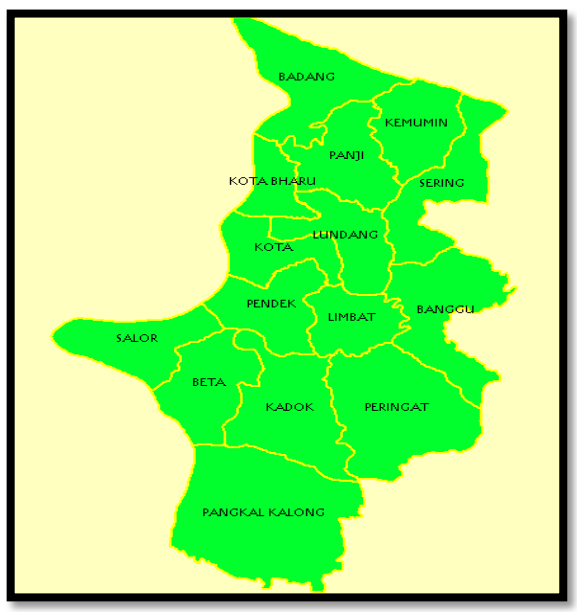

Figure 1.2: Sub-districts in Kota Bharu and its distribution

1.4 Dengue surveillance

There are three main components of a dengue surveillance. These are disease surveillance, vector surveillance, monitoring of environmental and social risks. For vector surveillance, the entomological surveillance is used to determine changes in the geographical distribution and density of the vector (Beatty *et al.*, 2010). Other extra information that can be gained from this surveillance are assessment of the control programs, obtain relative measurements of the vector population in the area, and facilitate appropriate decisions regarding interventions (Gubler, 1987).

Generally, there are number of methods available for monitoring immature and adult populations. The main objectives of *Aedes* mosquito surveillance methods are baseline infestation survey, monitoring infestation levels Aedes index (AI), control program monitoring, surveillance against reinfestation, and evaluation of control methods. All of this objectives can be accomplished with larval survey, collecting data on mosquito landing on humans or biting them, collection of resting mosquitoes and using ovitrap (Dickin *et al.*, 2014).

In Kelantan, since 2014, data related to entomology indices was actively collected for dengue control programme. This data was stored in the E-dengue surveilance system. In general, there are three main indices will be collected periodically, namely Aedes index (AI), Breteau index (BI) and Container index (CI). This data will be analyze periodically by entomologist, and the result will be disseminated to control and prevention team.

1.5 Rationale of the study

Dengue fever is endemic disease in Kota Bharu. There has been rapid urbanization in Kota Bharu leading to urban sprawling to its surrounding areas. There is very little study, that shows the spread of dengue fever across this newly urbanized area. Meanwhile the factors responsible for the occurrence of dengue in a locality can be multidimensional. Sociodemographic, environmental factors and practice regarding dengue prevention among local communities all are the important determinants.

There is also no proper study to show the vector distribution which can be measure using entomological index and dengue cases in Kota Bharu, Kelantan.

By knowing the correlation, will allow better targeted planning and intervention strategy. Through this analysis, the results can be used by the policy makers for further interventions to improve and strengthen current dengue preventive and control programe.

1.6 Research questions

i. What is the geographical distribution of dengue fever cases in Kota Bharu district for years 2014 - 2016?

ii. Is there any monthly pattern or trend in dengue cases in Kota Bharu distrist between 2014-2016?

iii. Is there an association between dengue cases and the entomological index in Kota Bharu district between 2014- 2016?

1.7 Objective

1.7.1 General objective:

To determine the spatial temporal distribution of dengue fever cases and its association with entomological index in Kota Bharu for years 2014 - 2016.

1.7.2. Specific objectives:

i. To describe the spatial temporal distribution of dengue fever cases in Kota Bharu for years 2014 - 2016.

ii. To determine the association between dengue fever cases and entomological index in Kota Bharu between 2014 -2016.

1.8 Hypothesis

H_1 There are significant associations between number of dengue cases and entomological index in Kota Bharu for years 2014 - 2016.

H_0 There is no significant association between number of dengue cases and

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter will present the literature review of this study. Section 2.2 will present the socio-demographic about dengue fever, section 2.3 regarding the environmental factors, section 2.4 regarding the vector with a focus on entomology index, section 2.5 regarding the virus of dengue fever and lastly section 2.6 using geographic information system (GIS) in spatial distribution of dengue fever.

2.2 Socio-demographic factor of dengue fever

Human element is an important factor as human is the host for the transmission of dengue virus. Under the human element, sociodemographic background of the populations in that particular locality plays an important role for the occurrence of dengue outbreak (Sessions *et al.*, 2009).

A study conducted at a province in Thailand which involved 1200 participants from urban and semi-urban areas found that increasing age was associated with higher risk of dengue fever. The sociological analysis model also revealed plausible significant determinants of older age have higher risk for infection and they also can contribute more in community effort in environmental management by clean-up campaign (Surachart *et al.*, 2012).

Dengue infections affected all age groups and gender. A study in Negeri Sembilan in 2010, involving 1466 cases of dengue infection showed more males were affected than females with the ratio 1.4 : 1.0. The pattern of male predominance was observed consistently over several years across six culturally and economically diverse countries in Asia. In 2006, about 80% of reported dengue cases in Malaysia were in the more than 15 years age group (Cheah WK, 2014).

A study that was conducted in state of Selangor, Malaysia, with a total of 5200 confirmed dengue cases that had legible and existing address reported in Subang Jaya Health Office from 2006-2010 found mostly the population infected with dengue fever were employed with the percentage of 52.2% (Dom *et al.*, 2013).

Meanwhile in Singapore, predominance of dengue cases also in adults compare to children. These age-dependent differences in the outcome of dengue infection may be due to differences in vascular permeability which children have a greater propensity for vascular leakage, under normal physiologic conditions compare to adults (Ooi *et al.*, 2006)

2.3 Environmental factors

Environmental factors undoubtedly play an important role in the occurrence of dengue infection in a locality. Dengue viruses and the mosquitoes as the vector are sensitive to the environment. Temperature, rainfall, humidity, housing pattern, urbanization, poor garbage disposal and type of water supply are have well-defined roles in the transmission cycle. Therefore a small change in these conditions may contribute to increase incidence of dengue fever cases.

Dengue fever incidence per block, has positive correlation with its premises which are shop-houses, empty houses, brick-made houses and houses with poor garbage disposal (Thammapalo *et al.*, 2008). This was because the distance that an aedes mosquito could fly ranged from a few metres to around 200 metres. Nowadays, there are also quite a number of houses that were built with gutters without knowing that the presence of gutters is actually one of the risk factors associated with dengue infection.

Household surroundings such as having gardening area is also a risk factor for dengue infection in a locality. The garden may harbor containers that hold water, breeding ground for mosquito larvae (Phuong *et al.*, 2008).

Meanwhile another study was conducted in Vietnam showed that areas with a high population density or adequate water supply did not experience large dengue cases. The risk of dengue was higher in rural than in urban areas, largely explained by lack of piped water supply, and when human population densities falling within the critical range (Schmidt *et al.*, 2011). With inadequate water supply, residents would tend to use water container for storage. The use of water containers meant that there were more potential sites for dengue to breed.

For the temperature factor, its known to play a role in adult vector survival, viral replication, and infective periods. Increase in temperature may result in increased survival and migration of vectors. Interm of global warming, this may create climatic and environmental conditions conducive to the proliferation of *Aedes* species globally (Murray *et al.*, 2013).

Lastly, with regard to climate and rainfalls, a study conducted from Cambodia found that these factors were significantly associated with dengue fever incidence in some regions of Cambodia, with the time lags of up to three months. It also reveal the association between dengue fever incidence and climate also apparently varies according to locality. The authors suggested that a prospective dengue early warning system would likely be best implemented at a local or regional scale, rather than nation-wide (Choi *et al.*, 2016).

2.4 The vector

Aedes aegypti and *Aedes albopictus*, the main vector of dengue viruses is an insect closely associated with human being and their dwellings. Human being not only provide the mosquitoes with blood as its meal but also water-holding containers which can be found in and around the premis needed to complete their development. The mosquito lays its eggs on the sides of containers with water and eggs hatch into larvae after a rain or flooding. Then the larvae changes into a pupa in about a week and into a mosquito in two days. Common bitting time for this mosquito is early morning and dawn. This mosquito flying distance is around 200 meter radius and capable of flying nonstop through the journey (Higa, 2011).

From an entomological viewpoint, the lack of appropriate understanding and knowledge regarding the difference in vector mosquitoes, *Ae. aegypti* and *Ae. albopictus*, is one of the major reasons for the current difficulty in disease control. One of the way to gain more insight regarding the vector is through doing entomological surveillance (Gopaul, 1995). Entomological surveillance is used to determine changes in the geographical distribution and density of the vector, evaluate control programs, obtain relative measurements of the vector population over time, and facilitate appropriate and timely decisions regarding interventions. Around the world, three main indexes which is Aedes index, Breteau index and Container index are used as indicator of disease burden. This index refer to immature population of the mosquito.

The Aedes index refer to the percentage of the premis or houses infested with larvae or pupae. Based on a study done, the Aedes index was consistently low in most cities which had a proper solid waste management and routine chemical control around the premis (Codeço *et al.*, 2015).

For the Breteau index, it refer to the number of positive containers over 100 houses inspected. Wijayanti *et al.* (2016) attempted to use Breteau index to predict dengue outbreak and identify places with high risk of dengue transmission in the area. It was demonstrated that in the endemic areas, mosquitoes tend to have a more conducive environment to survive from eggs to become pupae, and environments with greater survival of mosquitoes to the pupal stage correlated to a higher number of reported dengue cases in endemic areas.

Lastly, Container index can be define as the percentage of water-holding containers infested with larvae. Based on one study, by doing larvaciding work that involved door-to-door search for immature stages of *Aedes* spp. mosquitoes, the percentage of container index can be reduced significantly (Basker *et al.*, 2013). The treatment cycle of larvicide depends on the species of mosquito, seasonality of transmission, patterns of rainfall, duration of efficacy of the larvicide and types of larval habitat (Shah, 2011).

2.5 Dengue virus

Dengue fever is caused by Dengue virus, which is a single stranded RNA positive-strand virus of the family Flaviviridae, genus Flavivirus. There are four antigenically different serotypes of the virus, consist of Den 1, Den 2, Den 3 and Den 4 (Bäck and Lundkvist, 2013) . The first infection may cause minor symptoms, but secondary exposure can cause severe diseases. Within the four serotypes, Den 2 has been claimed to be the most dangerous strain with its capability for transovarial transmission. Transovarial transmission may provide a mechanism that allows the virus to survive during dry or cold seasons. A study was conducted to examine the persistency of transovarial dengue virus DEN-2 in a Selangor strain of *Aedes aegypti* mosquitoes.

The female mosquitoes were fed with blood containing dengue virus. The infected mosquitoes were able to transmit dengue virus for five generations (Rohani *et al.*, 2008).

2.6 Geographic Information System (GIS) in spatial distribution of dengue fever

GIS are databases that can capture, store, analyze, and display data that are linked by a common spatial coordinate system (Tang and Tsoi, 2007). GIS allows further investigation of surveillance data through spatial statistical analyses and visualization of patterns and relationships between disease and the environment. GIS are most commonly used for data visualization in dengue surveillance, allowing identification of the distribution of disease and changes over time and identification of spatial relationships with risk factors for disease.

GIS can be employed for tracking the spatial pattern of dengue fever distribution. It not only provides the maps and plots of the cases but also gives the spatial combination of various data including the distribution of disease, geographical data such as the landscape, rivers and weathers. Studies using the GIS have shown the disease interaction with the environment and provided a new approach to prevent them (Tang and Tsoi, 2007).

Maps for visualization of dengue surveillance data are particularly useful for public health professionals advocating for increased resources, such as vector control or laboratory facilities for serological confirmation of disease, because policy makers respond more positively to maps rather than raw numbers or graphs (Hsu *et al.*, 2012).

Mapping the distribution of dengue in a geographic area allows instant visual identification of areas at risk and enables faster mobilization of resources. GIS can enhance dengue surveillance, and it describes recent technological advances for improved targeting of prevention and control programs (Sarfraz *et al.*, 2012).

2.7 Conceptual framework

The factors that are associated with dengue fever transmission can be broadly classified into four main categories which are socio demographic factor, environmental factor, entomological index, and other factor which include climate, virus serotype and geographical setting.

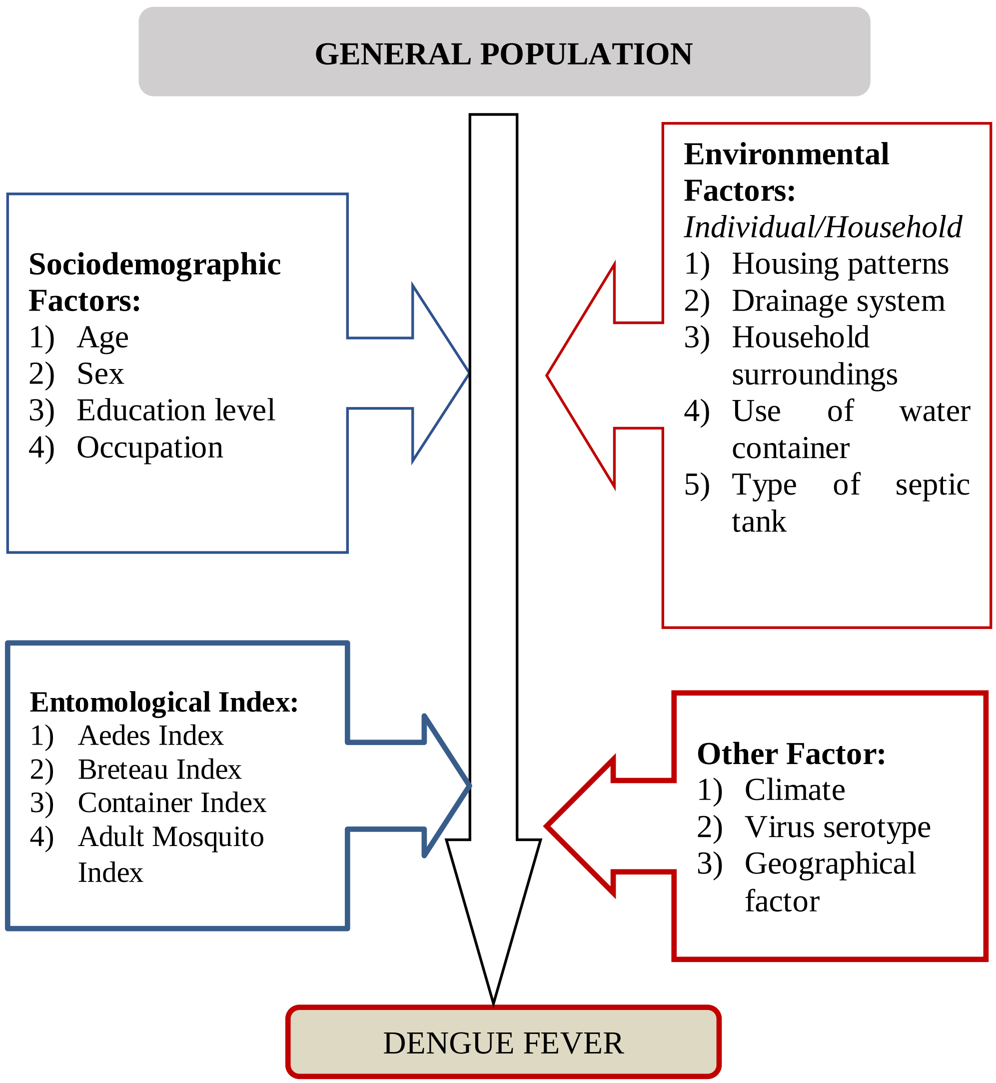

Figure 2.1: Conceptual framework of this study

Chapter 3

METHODOLOGY

3.1. Study design

This study applied an ecological study design. An ecological studies examine group level determinants when studying a disease because not all disease determinants can be conceptualized as in individual level attribute. Hence the need to consider feature of the groups to which individual belongs to (Diez Roux, 2001).

3.2. Study period

This study was conducted between December 2016 and April 2017.

3.3. Study location

This study were carried out at 15 sub districts in Kota Bharu district.

3.4. Study population

3.4.1. Reference population – All reported dengue fever cases in Kota Bharu, Kelantan.

3.4.2. Source population – All reported dengue fever cases from E-dengue Surveillance Kelantan Database in Kota Bharu.

3.4.3. Sampling frame – All Reported dengue fever cases based on E-dengue Surveillance Kelantan Database 2014- 2016 for Kota Bharu.

3.5. Subject criteria

3.5.1. Inclusion Criteria - Reported dengue fever cases based on E-dengue Surveillance Kelantan Database 2014-2016.

3.5.2. Exclusion Criteria - Incomplete data : > than 20% of variables

3.6 Sample size estimation

The sample size calculation was done according to the objectives of the study.

3.6.1 Sample size calculation for Objective 1:

There is no specific calculation which all reported dengue cases in Kelantan database from 2014-2016 were taken.

3.6.2. Sample size calculation for Objective 2:

To determine the association between dengue fever cases and entomological index in Kota Bharu between 2014 -2016.

Sample size calculation by using 2 proportion formula:

$$n = \frac{Po(1 - Po) + P1(1 - P1)}{(P1 - Po)2} . (Z\alpha + Z\beta)2$$

Where,

- $Z\alpha$=1.96 and $Z\beta$=0.84
- P1 = estimated proportion of vector density in expose group
- Po = proportion of vector density in non expose group
- m = P1:Po=1
- α = 0.05

Power = 80%

Table 3.1**:** Summary of sample size calculation for associated factor between dengue fever cases and entomological index

Variables	**α**	**Power**	**m**	**P0**	**P1**	**n**	**n x 2**
Adult Mosquito Index	0.05	0.8	1	0.04 (Marco neira et al, 2014)	0.5	13	26
Aedes index	0.05	0.8	1	0.05 (Parasuraman et al, 2013)	0.6	14	28

The largest estimated sample size (n) calculated is from Objective 2 based on the study done by *Parasuraman et al*. (2013) on the Aedes index which is 28. For this study, only 15 sub districts were used.

3.7. Research tools

3.7.1 Proforma

Patient's proforma sheet consisting of socio demographic data and coordinate for each of the dengue cases (appendix A).

3.7.2 E-dengue Surveillance Kelantan Database

The E-dengue Surveillance Kelantan Database is an online system, where all positive dengue fever cases that fulfill the case definition are reported. The reporting is compulsory and needs to be done within 24 hours by a health personel. Meanwhile entomological data were taken by the entomology unit in Kelantan Health State Department following reported dengue cases in the community.

3.8 Data collection

This study involved secondary data collection which was extracted from E-dengue surveillance Kelantan Database in excel format. All the information which consist of socio-demographic characteristics and coordinate of the dengue fever cases were transferred into the study proforma. All data were reviewed and the required information was recorded in data collection form.

3.9 Definition of operational terms

3.9.1 Dengue fever

Clinical symptoms may include a fever and two of the following criteria, vomiting, nausea, aches and pains, rash, leucopenia, and tourniquet test positive. All of the cases must have laboratory confirmation (MOH, 2015).

3.9.2 Aedes Index (AI)

The percentage of premises positive for aedes larvae. The formula for AI is as below:

$$\frac{\text{Number of premis +ve Aedes larvae}}{\text{Number of premis inspected}} \times 100$$

3.9.3 Breteau Index (BI)

The number of positive containers per 100 houses in a specific location. The formula is as below:

$$\frac{\text{Number of positive containers}}{\text{Number of houses inspected}} \times 100$$

3.9.4 Container Index (CI)

The percentage of waterholding containers positive for aedes larvae. The formula is as below:

$$\frac{\text{Number of positive containers}}{\text{Number of containers inspected}} \times 100$$

3.10 Statistical analysis

Data was entered and analysed using IBM SPSS version *22*. After the completion of data entry, the data was checked, explored and cleaned. Preliminary data screening was performed to check any missing data. The data set was checked for any errors and any numerical variables were also checked for the normality of the data.

For objectives 1, socio demographic characteristics (age, sex, race, religion, occupation status) were tabulated for descriptive statistics and the data was presented in frequency (n) and percentage (%).

Spatial temporal distribution of dengue fever cases in Kota Bharu between 2014 - 2016, the geocoding and mapping was done by QGIS 2.16.3. (Quantum GIS Development Team 2016). The dengue fever cases data in MS Excel were converted to the ESRI-compatible shapefile using QGIS. The shapefile was in the projected RSO for Malaya in metres. The point pattern analysis was applied in order to determine the spatial distribution of dengue fever cases in Kota Bharu for years 2014 – 2016. Data were extracted from E-dengue surveillance system. In this study, all the dengue fever cases was plotted according to years and by three monthly progression. For the output, each year will show the dengue fever cases plotted in the map in a series of map.

For objective 2, multiple linear regressions were used to analyse the association between dengue fever cases and the entomological index which is Aedes index (AI), Breteau index (BI) and Container index (CI), according to years from 2014 – 2016.

Firstly for 2014, due to the non-normal distribution of dengue fever cases, the variable was transformed using Log(denguefevercases2014) to achieve a normal distribution. Using correlation, all the three variable (AI, BI, CI) were tested and the significant variable was included into the multiple linear regression. For 2014, the AI, BI and CI were significant and next in multiple linear regression all the variable were tested using stepwise method, forward method and backward method. Here the best model was backward method gave the best model fit.

For the second and third model (year 2015 and 2016), the dengue cases data were normally distributed. The step in model 2014 are repeated. In multiple linear regression, all the variable were tested using stepwise method, forward method and backward method. For 2015, the best model was using backward method while for 2016, the best model was stepwise method.

3.11 Ethical issues

This study used a secondary data collection, the main concern here was the confidentiality of the data. Only after approval by Human Research Ethical Committee (HREC) of USM the study was started. Letter of approval by HREC JePeM Code: USM/JEPeM/17010028 is attached in Appendix B. Letter of approval from National Medical Research Register (NMRR) with reference no: NMRR-16-2483-33665 is attached in Appendix C. The confidentiality of the data was strictly maintained. Only the author and supervisors had access to the data. There is no conflict of interest in this study.

3.12 Flowchart of the study

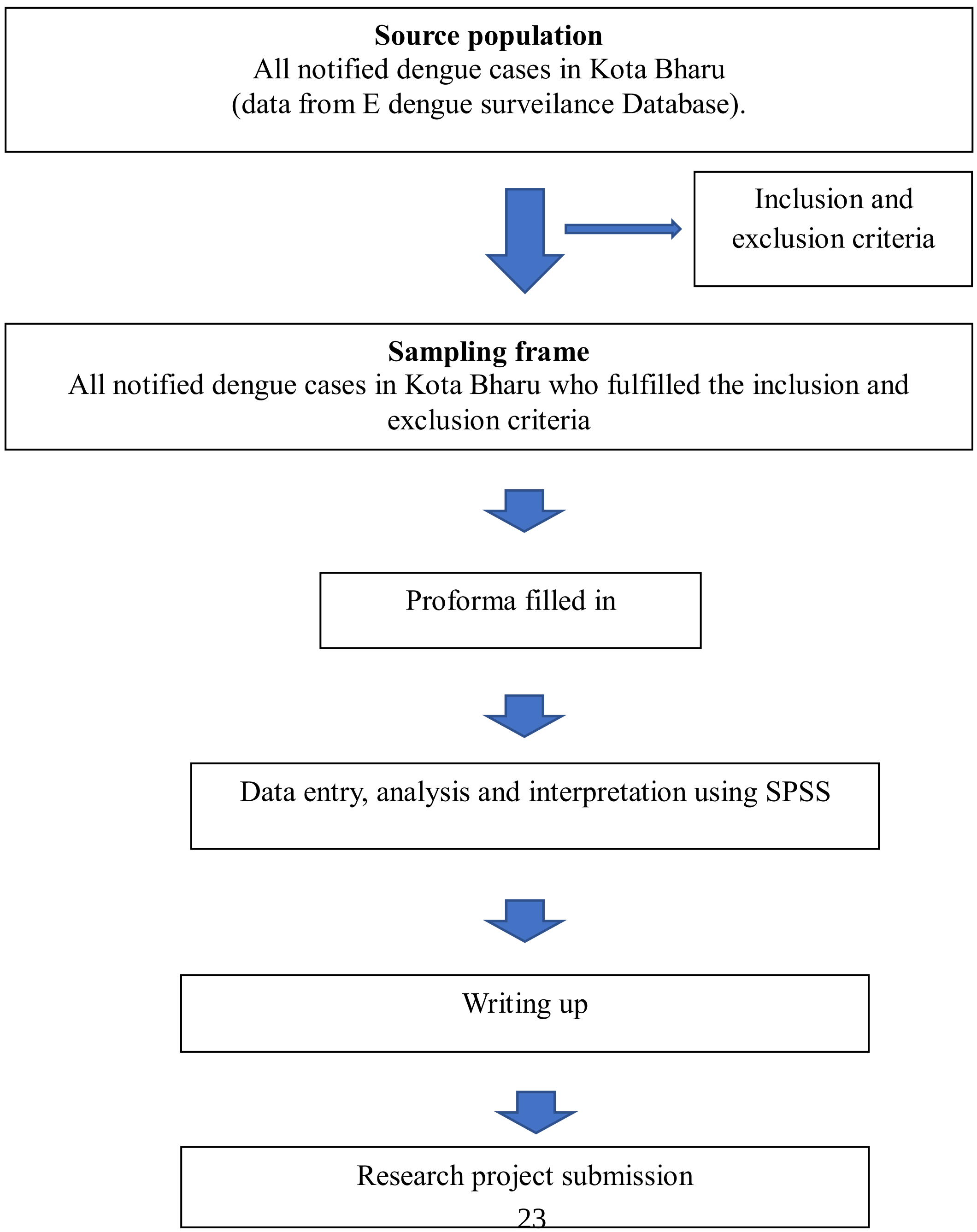

Figure 3.1 : Flow chart of the current study