



***BAYESIAN NETWORK OF INFLUENCE OF SOCIODEMOGRAPHIC
VARIABLES ON DENGUE RELATED KNOWLEDGE, ATTITUDE, AND
PRACTICES IN SELECTED AREAS IN SELANGOR, MALAYSIA***

LAMIDI-SARUMOH ALABA AJIBOLA

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By

LAMIDI-SARUMOH ALABA AJIBOLA

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Philosophy**

August 2019

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DEDICATION

To my mother (Mrs. Risikat Amope Lamidi) who never stop trying to learn till her last breath. May Allah (swt) grant her Al-Jannah Firdaus (Ameen).

To my father (Mr. Fatai Ajani Lamidi) who is too selfless to think about himself other than his children.

To my husband (Mr. Maruf Abidoye Sarumoh) for his humility and financial support.

To my beloved son (Master Abdulmalik Sarumoh Adesope) for sacrificing mother's love unknowingly at a tender age for this dream to come true.

Finally, to those who dare to take the right actions in spite of uncertainty and fear.

“No one is alone, we are all nodes in a network”

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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Dengue viral infection is a global health problem that has spread exponentially across the tropical and sub-tropical regions of the world. Malaysia is one of the affected tropical regions that has experienced a significant rate of morbidity and mortality in the last few years. There was an increase of 63.9% morbidity rate and 71.4% mortality rate of dengue incidence in Malaysia between 2013 and 2015 and more than half of these incidences occurred in the state of Selangor. There are many complex factors that contribute to the incidence of dengue, for example, climatic condition, environmental factors, socioeconomic status, socio-demographic variables, human behaviour, and health belief pattern among others. Among the various factors aforementioned, human behaviour tends to contribute immensely to the incidence of dengue because the vectors spreading dengue virus depends on the human environment and human behaviour for their survival and sustenance. Therefore, quantifying the awareness about the dengue vectors, dengue infection and preventive practices can be used to curtail the spread of the infection and reduce the vectors. The main objective of this research is the novel application of Partial least square path analysis (PLS-PA) to explore the latent sub-constructs of knowledge, attitude, and practices (KAP) on dengue via R programming language. Also, the application of Bayesian network (BN) to assess the influence of socio-demographic variables on dengue KAP in some selected areas of Selangor, Malaysia. Data of socio-demographic variables, medical history about dengue, knowledge about dengue fever and its vectors, attitude towards dengue incidence, elimination of dengue vectors and practices to eradicate the dengue infection and vectors was collected using a structured validated bilingual questionnaire. The data collected was used to learn the

structure of BN via some known algorithms using R programming language. Based on related literature on KAP regarding dengue studies done in Malaysia from 1986 to 2017, a framework of handcraft BN was also formulated with dengue KAP expert opinion. The actual KAP on dengue that was inadequate among the respondents were verified and revealed with PLS-PA. The knowledge that was inadequate among the respondents were knowledge on primary and secondary transmission of dengue fever, knowledge on possible breeding sites of dengue vectors and knowledge on the severity of dengue fever and vectors. The attitude that was deficient among the respondents were the attitude towards the elimination of dengue vectors and the attitude towards severity and prevention of dengue fever. The preventive practice that was inadequate among the respondents was the elimination of adult mosquitoes. Knowledge, attitude and practice Bayesian network model (KAPBNM) was used to visualize and quantify the pattern of KAP on dengue infection and vectors given the socio-demographic variables of the respondents. Quantifying the KAP dengue based socio-demographic variables from KAPBNM, individuals with primary school education training had low knowledge on dengue. The Chinese and Indians working in the private sector had poor attitude and individuals living in flats and apartment buildings had poor preventive practices. Using a BN to model dengue KAP provides the best effective approach for approximate reasoning and classification because of its capability to encode dependencies among socio-demographic variables and the latent construct of dengue KAP. It also narrows down the search for individuals who need to improve the KAP regarding dengue. There was a clear confirmation that the novel application of the PLS-PA and BN to KAP on dengue study has shown improved results and reduces vagueness of intensifying KAP regarding dengue programs in some selected areas in Selangor, Malaysia. In conclusion, the PLS-PA presented the exact dengue KAP that is insufficient among the respondents and the approximate reasoning with BN showed highest probability of individuals who has low KAP on dengue based on socio-demographic variables attributed each latent constructs of dengue KAP concurrently.

Keywords: Dengue; Knowledge; Attitude; Practices; Selangor; Partial least square path analysis, Bayesian network

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**RANGKAIAN BAYESIAN BAGI PENGARUH PEMBOLEHUBAH
SOCIO-DEMOGRAFI DENGAN PENGETAHUAN, SIKAP DAN
AMALAN BERKAITAN DENGAN DENGGI DI SELANGOR, MALAYSIA**

Oleh

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Jangkitan virus denggi adalah masalah kesihatan global yang telah merebak secara meluas di kawasan tropika dan sub-tropika. Malaysia adalah salah satu kawasan tropika yang terjejas yang telah mengalami kadar morbiditi dan mortaliti yang signifikan dalam beberapa tahun kebelakangan ini. Terdapat peningkatan morbiditi sebanyak 63.9% dan 71.4% peningkatan kadar kematian akibat denggi di Malaysia antara 2013 dan 2015 dan lebih separuh daripada kejadian ini berlaku di negeri Selangor. Terdapat banyak faktor kompleks yang menyumbang kepada berlakunya denggi, contohnya keadaan iklim, faktor persekitaran, status sosioekonomi, pembolehubah sosio-demografi, tingkah laku manusia, corak kepercayaan kesihatan antara lain. Antara pelbagai faktor yang dinyatakan, perilaku manusia cenderung menyumbang kepada kejadian denggi kerana vektor yang menyebarkan virus denggi bergantung kepada persekitaran manusia dan tingkah laku manusia untuk kelangsungan hidup. Oleh itu, mengukur kesedaran mengenai vektor denggi, jangkitan denggi dan amalan pencegahan boleh digunakan untuk mengurangkan penyebaran jangkitan dan mengurangkan vektor. Objektif utama penyelidikan ini adalah penggunaan *Partial least square path analysis* (PLS-PA) untuk meneroka sub-konstruk laten pengetahuan, sikap dan amalan (KAP) terhadap denggi melalui bahasa pengaturcaraan R. Selain itu, rangkaian Bayesian (BN) digunakan untuk menilai pengaruh pembolehubah sosio-demografi terhadap KAP di beberapa daerah terpilih di Selangor, Malaysia. Data pembolehubah sosio-demografi, sejarah perubatan tentang denggi, pengetahuan tentang demam denggi dan vektornya, sikap terhadap kejadian denggi, penghapusan vektor dan amalan berkaitan denggi untuk membasmi jangkitan denggi dan vektor telah dikumpulkan melalui soal selidik dwibahasa berstruktur. Data yang dikumpul digunakan untuk mempelajari struktur BN melalui beberapa algoritma yang diketahui menggunakan bahasa

pengaturcaraan R. Berdasarkan kajian lepas berkaitan KAP berhubung kajian denggi yang dilakukan di Malaysia dari tahun 1986 hingga 2017, rangka kerja BN juga dirumuskan berdasarkan pendapat pakar KAP denggi. KAP sebenar mengenai denggi yang tidak mencukupi di kalangan responden telah disahkan dan didedahkan dengan PLS-PA. Pengetahuan yang tidak mencukupi di kalangan responden adalah pengetahuan mengenai transmisi demam denggi di peringkat primer dan sekunder, pengetahuan tentang tempat pembiakan yang mungkin berlaku di dalam vektor denggi dan pengetahuan tentang keparahan demam denggi dan vektor. Sikap yang kekurangan pula adalah sikap terhadap penghapusan vektor denggi dan sikap terhadap keparahan dan pencegahan demam denggi. Amalan pencegahan yang tidak mencukupi di kalangan responden adalah penghapusan nyamuk dewasa. Pengetahuan, sikap dan amalan model rangkaian Bayesian (KAPBNM) digunakan untuk memvisualisasi dan mengkuantifikasikan corak KAP terhadap jangkitan denggi dan vektor yang berdasarkan pembolehubah sosio-demografi responden. Kuantifikasi pembolehubah sosio-demografi berdasarkan demam denggi KAP dari KAPBNM mengenalpasti bahawa individu yang mempunyai latihan pendidikan sekolah rendah mempunyai pengetahuan yang kurang tentang denggi. Orang Cina dan India yang bekerja di sektor swasta mempunyai sikap yang kurang baik dan individu yang tinggal di flat dan bangunan apartmen mempunyai amalan pencegahan yang buruk. Menggunakan BN untuk model dengue KAP menyediakan pendekatan yang berkesan untuk mengenalpasti sebab dan klasifikasi yang hampir sama dengan keupayaan untuk mengkodkan kebergantungan di kalangan pembolehubah sosio-demografi dan pembinaan laten denggi KAP. Ia juga memudahkan pencarian individu yang perlu memperbaiki KAP berhubung denggi. Terdapat pengesahan yang jelas bahawa aplikasi baru PLS-PA dan BN kepada KAP mengenai kajian denggi telah menunjukkan hasil yang lebih baik dan mengurangkan kekaburan untuk mengukuhkan KAP mengenai program denggi di beberapa kawasan terpilih di Selangor, Malaysia. Kesimpulannya, PLS-PA mengenalpasti KAP denggi yang tidak mencukupi di kalangan responden dengan tepat dan sebab dengan BN menunjukkan kebarangkalian tertinggi individu yang mempunyai KAP rendah terhadap demam denggi berdasarkan pembolehubah sosio-demografi yang mengaitkan setiap pembinaan laten denggi KAP serentak.

Kata kunci: Denggi; Pengetahuan; Sikap; Amalan; Selangor; Partial least square path analysis, rangkaian Bayesian

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"Always remember that you are a node in a network, your actions and inactions affect other nodes positively or negatively"

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

BN	Bayesian Network
BIC	Bayesian Information Criterion
BDe	Bayesian Dirichlet equivalence
BDeu	Bayesian Dirichlet equivalent uniform
CIT	Conditional Independent Test
CPT	Conditional Probability table
DAG	Directed Acyclic Graph
DF	Dengue Fever
DHF	Dengue Hemorrhagic Fever
DSS	Dengue Shock Syndrome
DV	Dengue Virus
DVI	Dengue Virus Infection
EFA	Exploratory Factor Analysis
JPD	Joint Probability Distribution
KAP	Knowledge, Attitude, and Practices
KAPBNM	Knowledge, Attitude, and Practices Bayesian Network Model
KMO	Kaiser-Meyer-Olkin
PCA	Principal Component Analysis
PLS-PA	Partial Least square path Analysis
SES	Socioeconomic Status

CHAPTER 1

INTRODUCTION

1.1 Overview

Dengue fever (DF)/Dengue virus infection (DVI) is an arbovirus tropical infectious disease which can be transmitted from human to mosquito and mosquito to human through the bite of infected female *Aedes spp.* namely *Aedes aegypti* and *Aedes albopictus* (Lambrechts, Scott, & Gubler, 2010).

The dengue virus (DV) that causes dengue fever is a single positive-stranded ribonucleic acid (RNA) virus which belongs to family Flaviviridae, genus Flavivirus (Smit, Moesker, Rodenhuis-zybert, & Wilschut, 2011; Guzmán & Kourí, 2002). DVI may be symptomatic, asymptomatic and can sometimes lead to life-threatening conditions such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) (Guzmán & Kourí, 2002). From 2008 till recent, DVI has remained a serious global health threat (World Health Organization, 2012) because of its rapid growth and continuous increase in morbidity and mortality rate across the globe. The spread of DF requires immediate interventions by health sectors, policymakers on the health and most importantly the involvement of individuals living in endemic areas (WHO, 2013; WHO, Environmental management, 2017).

1.1.1 Importance of the study

The likelihood of not contracting DF in an environment with the potentiality of the abundance of dengue vectors depends on the right knowledge, appropriate attitude, and good preventive practices. Yboa and Labrague (2013) emphasized that the main factor preventing the elimination of dengue fever and vectors is inadequate knowledge.

In Malaysia, some studies had shown that inadequate knowledge about signs and symptoms, inadequate knowledge on primary and secondary transmission of dengue and poor preventive practices could increase the spread of dengue vectors (Al-Adhroey, Nor, Al-Mekhlafi, & Mahmud, 2010; Wong, Abubakar, & Chinna, 2014). Despite the fact that some factors affecting DF and its vectors are controllable, DF still poses an overwhelming economic and diseases burden on the endemic countries. Constant fogging of hotspots areas which are mostly used to control the adult vectors has some health implication for asthmatic patients and other related diseases. All chemical control of dengue vectors has an adverse effect on human health (Sarwar, 2015). KAP regarding DF and vectors seems to be the most healthy and safest way of curtailing the spread of the DVI and reduction of the vectors. During the

1950s and 1960s in the Americas (Schliessmann, 1967), dengue was effectively eliminated through an eradication program named “eradication of open source breeding site”. There was a setback in the 1970s due to rapid urbanization and abrupt slowdown of the eradication program. In an epidemiological survey, success was recorded in northern Thailand where eliminating mosquitoes possible breeding sites has reduced the number of dengue cases in a region (Benthem et al., 2002). Community health education has also been proven to be an effective way to reduce dengue vector and their breeding sites in Mexico (Espinoza-Gómez, Moises Hernández-Suárez, & Coll-Cárdenas, 2002). One of the effective methods of controlling and preventing DF is vector control which depends immensely on human behaviour (Dieng et al., 2010). These above-mentioned studies had affirmed the importance of KAP regarding dengue incidence as an essential way of reducing the spread of the DVI and vectors to the nearest minimum.

1.1.2 Rationale of the study

Considering all the factors that affect the incidence of dengue; climate change, weather, environmental factors, socioeconomic status (SES), health belief pattern, lack of awareness contribute vastly to the incidence of DF in Malaysia than all other factors. Al-Zurfi et al., (2015) highlighted the need to increase awareness through mass media and campaigns in order to change people’s attitude and preventive practices concerning the incidence of DVI in an interventional study conducted in Cheras, Malaysia.

The awareness of dengue vectors and DVI is also the cheapest way to control the menace of dengue compared to the diseases risk and economic burden after the incidence of dengue had already occurred. Ng et al., (2015) stated that Malaysia spent 0.03% of the country’s gross domestic product (GDP) on its National Dengue control program which is equivalent to US\$73.5 million in 2010 rather than minimum capital spent on awareness of dengue vector and its infection.

The SES of individual living in a country and human capital has a direct effect on Gross Domestic Product (GDP) per person of the economy (Ali, Egbetokun, & Memon, 2018). Every citizen of a country has SES attributed to them which consequently influences the KAP regarding dengue vectors and its infection. Socio-demographic factors encapsulate the SES which was evaluated and quantified in this research as an underlying factor affecting KAP regarding dengue. The significance of the research is that it will reveal the extent to which socio-demographic factors affect the knowledge of dengue vectors and infection, attitude towards dengue incidence and prevalence and the usual practices to prevent it.

1.2 Problem statement

Many perceived the notion of prediction as an estimation of fixed values rather than a prediction of actual changes that can be expected. In actual sense, real-world situation and population do not conform to fixed points because some uncontrollable factors are caused by constant changes. The population change due to birthrate, death rate, emigration and immigration, industrialization, urbanization as time passes by. The climatic conditions and environmental factors from time to time produce changes either in the level of the variables or the parameters. Thus, because of these inevitable changes, it is necessary to introduce greater realism and methodology into an underlying model to make it possible to link theoretical interpretations more systematically with newly collected data either secondary or primary.

Many KAP studies regarding dengue in Malaysia left many questions unanswered, some of the results were consistent but it does not reflect all the underlying factors which are supposed to be considered simultaneously and the changes that may occur after the data has been analyzed. BN provides means of incorporating newly collected data (likelihood) into a model (prior) to get better prediction (posterior) for the future. Previous researches on KAP regarding dengue studies had pinpointed the fact that socio-demographic factors significantly affect KAP on dengue incidence in many parts of the affected regions in the world (Naing et al., 2011; Al-Dubai, Ganasegeran, Alwan, Alshagga, & Saif-Ali, 2013; Leong, 2014; Syed et al., 2010). Many of researches came up with statistical results based on descriptive analysis, bivariate analysis and multivariate analysis, simply comparing two or more factors with each other while the underlying important factors were silenced in the process. This research acknowledges the existence of inevitable changes that may occur after data collection which had been ignored in many studies. Additionally, formulation of a model which can be used to make approximate inference and prediction of consequences through 'what-if-analysis'.

1.3 Justification of the study site

Selangor is one of the most populous and developing states in West Malaysia with 9 districts. Based on 2017 estimated population, Selangor has a population of 6.39 million which makes up to 20.49% of the Malaysian population (Chief Statistician Malaysia, 2017). Despite the decreasing reported cases of dengue in Malaysia from 2015 to 2017 as shown in Figure 1.1 (120,836 reported cases was reduced to 83,848 reported cases), the state of Selangor continue to account for more than 50% of dengue reported cases (Ministry of Health, Malaysia, 2018).

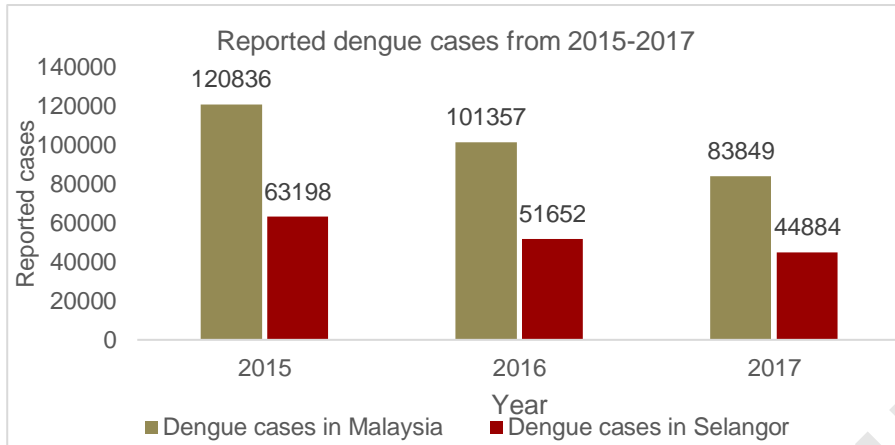


Figure 1.1 : Reported dengue cases from 2015 – 2017

In 2015, the state of Selangor accounted for 52.3% of the overall dengue reported cases in the country. In the following year, the morbidity rate was 51.0% and in 2017, 53.5% of dengue cases were also reported (Figure 1.1). From 1st January 2018 to 1st September 2018, Malaysia recorded the dengue morbidity rate of 51,307 cases with a total of 29 deaths, the dengue cases in Selangor was 29,205 cases which were 56.9% of the overall dengue cases in Malaysia (“Dengue : Selangor tops the list | New Straits Times,” 2019). The morbidity rate of dengue in Selangor could be attributed to industrialization, urbanization, immigration from rural to urban areas, trades and travel. Nevertheless, it can be specifically pinpointed that Selangor is densely populated and densely populated area is a risk factor for the possible spread of DVI (Pongsumpun et al., 2008). Figure 1.2 shows the location of Selangor on the map of Malaysia.



Figure 1.2 : The map of Malaysia
(Source: Volina, Image ID: 1607161)

1.4 Research questions

This research extends the application of the Partial least square path analysis and Bayesian network in the behavioural domain towards dengue fever and its vectors.

1. Are the latent constructs of KAP regarding dengue unidimensional?
2. How can the actual KAP regarding dengue that is inadequate among the respondents be evaluated?
3. How can a BN be constructed for the influence of socio-demographic variables on KAP regarding dengue?
4. Is a BN efficient for studying the influence of socio-demographic variables on KAP regarding dengue?

1.5 Research objectives

The research questions above can be untangled into these research objectives.

1. To validate a KAP questionnaire that is applicable to Malaysian populace through the harmonization of instruments used in past studies (RQ 1).
2. To evaluate of the latent constructs of the KAP regarding dengue with PLS-PA (RQ2).
3. To construct a structure of novel KAP BN that synthesizes information from the data collected (RQ 3).
4. To parametrize the novel BN such that it can be used for approximate reasoning of how socio-demographic factors influence KAP regarding dengue (RQ3).
5. To quantify KAP regarding dengue based on different level of socio-demographic factors (RQ 3).
6. To verify and validate the novel BN with regards to KAP on dengue (RQ 4)

1.6 Significance and originality of the study

This research establishes the practical application of structure learning and parameter learning of the influence of socio-demographic variables on dengue KAP dengue. Development of a model that integrates different advance statistical methods and quantify socio-demographic factors influencing KAP regarding dengue through probabilistic reasoning. To date, there is no BN model that combines health history on dengue, socio-demographic factors and type of residence as factors affecting KAP in Malaysia (Chapter 2, Table 2.4). To the best of our knowledge, this study is first to design a BN and path analysis for a KAP regarding dengue study.

The second significance of this study is the visualization of the model resulting from the Bayesian network which narrows down the search for information. It magnifies the detection of patterns, facilitates inference of results and encodes information in a tractable way. Visualization capacitates the end-user of the model to comprehend result at a glance and 'what-if analysis' can be carried out without necessarily understanding the details of the BN modeling framework.

1.7 Thesis overview

From Chapter 2 to Chapter 8 of this thesis is structured as follows: Chapter 2 describes the methodological approach of the related literatures to the study. Chapter 3 presents the research materials and methodology, results from the pilot study and exploration of the latent constructs of KAP regarding dengue. Chapter 4 presents the descriptive analysis of the research data, categorization of the target variables and correlation analysis. Chapter 5 evaluates the latent constructs of the target variables with PLS-PA. Chapter 6 introduces the Bayes theorem and application, structure learning of the BN via some known algorithms and supervised learning, parameter learning, estimation and validation. Chapter 7 presents the discussion of the results, strengths and limitations of the study and finally, Chapter 8 presents conclusions and recommendations.

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