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Refining The Dengue Vulnerability Assessment Based on Dengue Vulnerability Framework Malaysia (DVFM): Descriptive and Panel Data Analysis

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Abstract

This study refining the dengue vulnerability assessment using the Dengue Vulnerability Framework Malaysia (DVFM) to describes the vulnerability of dengue in Malaysia during the period of 15 years to identify high-low risk areas among sample of studies (except Wilayah Persekutuan Putrajaya). The dengue reported cases in Malaysia were analyzed using the data provided by the Disease Control Division Vector, Ministry of Health Malaysia (MOH) from 2003-2017. As per literature, factors influencing the vulnerability to infectious disease outbreak were identified as population density, urbanization, medical care workforce, medical care infrastructure, public health delivery, safe water and sanitation as well as economic strength. This framework was tested using empirical cases of dengue outbreak in Malaysia. The dataset used was obtained from widely available data (from the Department of Statistics Malaysia (DOSM) and Health Indicator Report by MOH). From 2003-2017, 829, 299 cases have been reported in Malaysia. The highest number was recorded in 2015 (63198, Selangor). The key findings from this assessment included the states with their vulnerability and actual dengue reported cases. The results also concluded that the framework prediction did not match the actual outbreak reported. Recently in Malaysia, the reported cases have increased steadily in most areas. The surveillance and control strategies should be strengthened especially for areas with the most vulnerable to dengue outbreak without deprioritizing the least vulnerable state. Further research should be conducted to explore other drivers that may reflect the vulnerability of dengue outbreak.

Keywords: *Dengue Outbreak, Vulnerability Assessment, State-Rank, WADI, IDV*

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INTRODUCTION

This study regards vulnerability assessment as the way to conceptualize the interaction between the chosen vulnerability variables (population density, urbanization, medical care workforce, medical care infrastructure, public health delivery, safe water and sanitation as well as economic strength) to the empirical cases of dengue in Malaysia. Dengue is part of infectious diseases and since its first case reported in 1902, dengue had been ranked first among the top killing infectious diseases in Malaysia (Fong & Ahmad, 2019). The Crisis Preparedness and Response Centre (CPRC), Ministry of Health Malaysia reported that only within the year 2020 (January to May), accumulative total reported dengue cases in Malaysia were 41,234 cases (CPRC, 2020). The government has spent for dengue treatment and awareness campaign from the past few years. Shaari et al. (2015) reported under National Strategic Plan on Dengue Prevention and Control, RM50 million (approximately USD12 million) in 2009. Dengue Task Force Committee was formed to monitor the plan in 2013 and Communication and for Behavior Impact (COMBI) had been set up in 2016 in as a continuous effort in eradicating dengue outbreak Ironically, there is yet no specific treatment and vaccine against dengue and it is hard to predict its outbreak pattern.

To date, it can almost say that the government policies can do some improvement. Based on the dengue evaluation plans for the year 2008 to 2020, the number of reported dengue cases and death in year 2008 is increasing more than half of the reported cases in occur are in Klang Valley and obviously more than 80% reported cases are in urban area. The evaluation reveals that about 80 per cent staffs abide to dengue guidelines and rules to update the vekpro system. This led the ministry to change the updating style starting year 2014. Regardless years changes, there are not much improvement being made as per fogging, vector control, entomological surveillance, and dengue programs. Not even half of the target is achieved indicating serious action need to be taken by the government to ensure their goal in preventing dengue is achieved.

In the past ten years, the “dengue vulnerability assessment” has become predominantly important to assess the country’s ability to prevent or contain a dengue outbreak in conjunction with the increasing number of dengue reported cases worldwide. Other than Malaysia, lots of empirical studies had been conducted in various region. Arunachalam et al. (2010) studies the eco-bio-social determinants for dengue vector breeding involving six Asean cities (India, Indonesia, Myanmmar, Philippines, Sri Lanka, and Thailand). The prediction for dengue outbreak based on disease surveillance, meteorological and socio-economic data also had been conducted in Thailand (Jain et al., 2019). In Indonesia, Wanti et al. (2019) using survey to find relation between Dengue Hemorrhagic Fever and the house conditions.

There is a need to define target areas as a control measure when the transmission of dengue outbreak becomes serious. However, this is a challenge in areas without adequate data and technical resources to develop predictive models and early warning systems including low-income regions and newly endemic areas that were left unidentified (Eisen & Eisen, 2011). Additionally, vulnerabilities level should be clear on where are the most vulnerable areas and what contributes to their vulnerabilities. Hence, recent studies welcomed the development of the rigorous and quantitative-based tools to assess the vulnerability and resilience of countries to infectious diseases (Moore et al., 2016).

There is a substantial body of research concerning vulnerability frameworks in dengue that can guide the instructional design such as the Water-Associated Disease Index (WADI) and the Infectious Disease Vulnerability Index (IDVI). The WADI provides the best framework to illustrate dengue vulnerability assessment, whereas the IDVI provides the recent infectious disease vulnerability assessment. However, the result from this vulnerability assessment might be sometimes associated negatively with the number of dengue reported cases, hence requiring more empirical research. Therefore, this study intends to fulfil the gaps of knowledge for methodological.

To date, not much studies have been done by matching the framework. The present study adds to the limited body of knowledge by integrating WADI and IDVI elements on vulnerability assessment involving the dengue outbreak. Besides, the vulnerability assessment variables such as demographics, healthcare, public health and economics have widely been discussed by previous studies, but rarely focused on regional scope creating the new methodological gap. Most studies rather highlighting international cases (Moore et al., 2016; Gelfeld, 2015; Fullerton et al., 2014) and countries cases (Dickin et al., 2013); Dickin & Schuster-Wallace, 2014). More importantly, there are limited number of studies that used time series or panel data in conducting vulnerability assessment compared to 15 years of duration as done in this study. In other perspective, it is impossible to simply summarize the discussions on dengue vulnerability assessment without conducting the ranking analysis.

Hence, the aim of the present study is to indicate the level of state vulnerability to dengue outbreak based on case of dengue in Malaysia from the year 2003 to 2017.

METHODS

The data is being collected in Microsoft Excel before being analyzed using Stata Version 16. First, the information on the number of dengue reported (dependent variables) and the variables assesses are collected as per Table 1. Based on sources in Table 1, it can be seen that the data is gather from various sources such as the Department of Statistics Malaysia (DOSM), Health Indicators by Ministry of Health Malaysia (yearly publication) and Dengue Control Division Ministry of Health Malaysia (refer the resource person, Dr. Norhayati). Second, the information is being transform as per natural log logarithm to create data standardization. Third, the command "revrs" being use in to obtain the flipped value. Other variables (except population density and urbanization) needed be interpret as high number indicate good/low vulnerability to a dengue outbreak, vice versa. The missing value was compensated through interpolation method.

The descriptive analysis compares the state vulnerability to a Dengue outbreak based on their percentage and ranking score. For panel data regression analysis, Poolability, Breusch-Pagan Lagrange Multiplier (BPLM) and Hausman test are being conducted to help selecting the best model (either Fixed effects models (FEM), Pooled OLS (Ordinary Least Square), or Random Effect Model (REM). Robust estimates are also conducted to increase accuracy of the data.

Table 1. Data Measure and Sources

Variables	Measure	Indicator	Hypotheses	Sources
Population Density	Persons per square km	High=bad	High number of people per square (km) indicate high population density that increases the vulnerability to dengue outbreak due to overcrowding	DOSM
Urbanization	Percentage of persons living in urban areas	High=bad	High percentage of persons living in urban area indicate bad situation as it increases the vulnerability to dengue outbreak due to high contact with numerous persons in urban area	Health Indicators (MOH)
Medical Care Workforce	Numbers of doctors under MOH	High=good	High numbers of doctors indicate good situation as having stronger workforce availability to decreases the vulnerability to dengue outbreak.	Health Indicators (MOH)
Medical Care Infrastructure	Numbers of hospital bed under MOH	High=good	High number of hospital bed is good condition as it shows high preparation of medical care infrastructure that able to decreases the vulnerability to dengue outbreak.	Health Indicators (MOH)
Public Health Delivery	Percentage coverage with third dose of Diphtheria, Tetanus and Pertussis (DTP) vaccine	High=good	High number of percentage coverage in DTP indicate good health service delivery which able to decreases the vulnerability to dengue outbreak.	Health Indicators (MOH)
Safe Water and Sanitation	Houses Covered with Safe Water Supply in Rural Area	High=good	High number of houses covered with safe water supply in rural area indicate good condition as availability of potable water, sanitary conditions, and proper hygiene is better protected against dengue outbreak	Health Indicators (MOH)
Economic Strength	GDP per capita	High=good	High GDP per capita indicate better economic strength that is good condition as it can decreases the vulnerability to dengue outbreak due to state financial capability	DOSM
Dengue Reported Cases	Numbers of dengue reported cases	High=bad	High number of dengue reported cases indicate the bad situation of dengue outbreak in a state	Dengue Control Division, MOH

Results

Figure 1. Total Dengue Reported Cases in Malaysia, 1999 to 2019

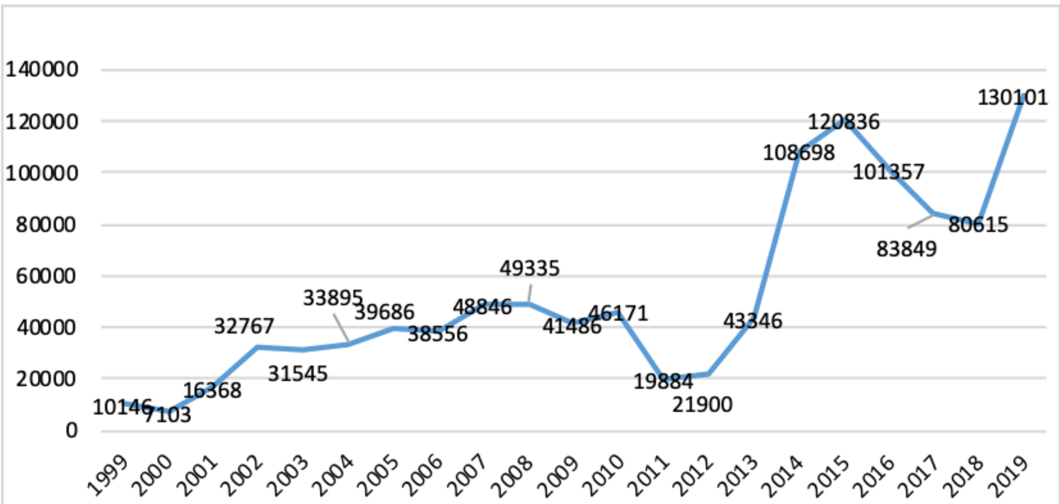

Table 2. Ranking for Dengue Reported Cases Based on State in Malaysia, 2003-2017

State	Ranking for Dengue Reported Cases	Total Number of Cases	Percentage (%)
Johor	3	74,910	9.03
Kedah	11	19,165	2.31
Kelantan	5	47,625	5.74
Melaka	12	18,497	2.23
Negeri Sembilan	8	26,090	3.14
Pahang	9	25,015	3.01
Perak	4	56,570	6.82
Perlis	14	3,405	0.41
Pulau Pinang	6	36,052	4.34
Sabah	10	23,179	2.79
Sarawak	7	28,752	3.46
Selangor	1	368,276	44.40
Terengganu	13	16,297	1.96
WP Kuala Lumpur	2	85,189	10.27
WP Labuan	15	368	0.04
Total		**829,390**	**99.95**

Table 3. Percentage of Total Dengue Reported Cases out of Total Number of Discharges in MOH Hospitals

Year	Total Number of Discharges in MOH Hospitals	Total Number of Dengue Reported Cases	Percentage (%)	Source
2003	1715,152	31,545	1.84	HI 2006
2004	1807,429	33,895	1.88	HI 2006
2005	1855,020	39,686	2.14	HI 2006
2006	1905,819	38,556	2.02	HI 2006
2007	1970,958	48,846	2.48	HI 2012
2008	2072,449	49,335	2.38	HI 2012
2009	2139,768	41,486	1.94	HI 2012
2010	2100,375	46,171	2.20	HI 2012
2011	2151,829	19,884	0.92	HI 2012
2012	1836,304	21,900	1.19	HI 2012
2013	1769,777	43,346	2.45	HI 2017
2014	2251,704	108,698	4.83	HI 2017
2015	2350,675	120,836	5.14	HI 2017
2016	2352,815	101,357	4.31	HI 2017
2017	2148,830	83,849	3.90	HI 2017

*Data for Total Number of Discharges in MOH Hospitals is taken from HI or Health Indicator from stipulated year and Total Number of Dengue Reported cases is taken from Norhayati (2020)

Figure 1 displays the dengue reported cases in Malaysia from the year 1999 to 2019 accounting to two decades of dengue trend recorded. From the figure, the trend was fluctuated but then obviously increased with only 31545 cases in 2003 and 83849 in 2017. The reported cases were also dramatically high from the year 2014 to 2019 with peak indication in year 2015 by 120836 cases. From the analysis, it was found that the pattern of reducing trend was unable to sustain for period more than one year regardless various dengue preventive programs and strategies set up by the government.

Table 2 illustrates the total number of dengue outbreak from the year 2003-2017, indicating the areas of concern. The total number of dengue reported cases was 829390 with an average of 55292 cases per year. By far, the highest count was in Selangor with by 368276 cases representing approximately 44% out of total percentage of dengue outbreak. The dengue outbreak in WP Kuala Lumpur (10%) and Johor (9%) have also displayed some of the largest outbreaks but four times lower than that in Selangor. In contrast, states with the lowest reported cases were Perlis (1%) and WP Labuan (0%).

Meanwhile in Table 3 above shows the percentage of total dengue reported cases out of total number of discharges in MOH hospitals. From this analysis, it can be concluded that the highest percentage was only 5% out of total discharge cases reported. On average, dengue represented only 2.64% out of total number of discharges in MOH hospital.

State Vulnerability Ranking

To what extent this vulnerability assessment can predict and rank the state vulnerability to the dengue outbreak correctly? In order to interpret this result, this study was concluded by ranking method using 1-15, 1-5 (most vulnerable), 6-10 (medium vulnerable) and 11-15 (least vulnerable). This ranking score for each category and each state is established by based on their ranking obtained from early hypothesis developed in Table 1. As the data is collected in ratio numbers, high or low value number is rank as according to the hypothesis for each variable assess. For instance, for Population Density, high number indicate bad situation as overcrowding may lead to high vulnerability to a dengue outbreak and may lead to high number of dengue reported cases. Hence, the state that obtain lowest score ranking (WP Kuala Lumpur) is considered as the most vulnerable state as per assessment under population density alone. Similar assessment is given for the rest of the assess variables and the result is based on Table 4 below.

Most Vulnerable State in Malaysia

Based on Table 4, the state is considered as the most vulnerable state to the dengue outbreak if it obtains the lowest score (1-5) and *vice versa*. This score is inter- related with the hypotheses mentioned in Table 1 above. When the state obtains bad indicator score, their ranking score is low, and this led to their total vulnerability score is also low able to lead the state to become the most vulnerable to a dengue outbreak. Examining the three most vulnerable states, Table 4 reveals few surprises with the ranking of Perlis (1), Kelantan (2) and Terengganu (3). Several notable trends emerged from this result; among these three states, Terengganu and Kelantan (except Perlis) both were considered under the least vulnerable based on population density, while Kelantan and Perlis (except Terengganu) both were considered as the least vulnerable. By considering these two variables (population density and urbanization), these three states should not be ranked as the most vulnerable state.

However, despite good indicator for previous variables, these three states have the most vulnerable aspect in other variables such as medical care workforce, medical care infrastructure, public health delivery, water and sanitation and even economic strength. Overall, based on the mentioned variables, all states were ranked as most vulnerable except Kelantan in medical care infrastructure (rank medium vulnerable), Terengganu in public health delivery and economic strength (rank medium vulnerable) and Perlis in safe water and sanitation (rank medium vulnerable).

This finding shows that the rank is contradicting the real scenario of dengue reported case, which revealed the highest ranking for dengue reported case by Selangor (1), followed by Wilayah Persekutuan Kuala Lumpur (2) and Johor (3).

Least Vulnerable State in Malaysia

The three least vulnerable states were Sarawak (15), Johor (14) and Selangor (13). This was because the score in most variables assessed (especially medical care workforce and medical care infrastructure) indicated that these states were among the least vulnerable with rank range of 11-15. In the aspect of population density, Sarawak was most less densely populated. With its size and population, Sarawak was overall least vulnerable. Johor was moderately vulnerable (8) and Selangor has most vulnerable (4) ranking in the aspect of population density. Likewise, in the aspects of safe water and sanitation as well as economic strength, Johor and Selangor can be considered as the least vulnerable. However, Sarawak was seen struggling in terms of safe water and sanitation, making it to be listed among the top three most vulnerable states. There are still many places in Sarawak, together with Kelantan and Sabah that are not fully accessible with safe water and sanitation. Besides, in the aspect of economic, Johor (7), Selangor (11) and Sarawak (13) indicated that only Johor was moderately vulnerable, while Selangor and Sarawak were least vulnerable. Overall, considering all aspects, the ranking for the least vulnerable states was Sarawak, Johor and Selangor.

Again, this rank is contradicting the real scenario for dengue reported cases. The ranking for least vulnerable state for dengue should be WP Labuan (15), Perlis (14) and Terengganu (13). Rather than listed as states with lowest reported dengue incidence, Perlis and Terengganu were claimed to be the states that are most vulnerable to dengue outbreak.

Dengue Outbreak as Empirical Examples

From the table, analysis shows that each state has its own strengths and weaknesses as per estimated variables. This result also summarizes that the prediction (ranking vulnerability score) did not accurately occur as per real case (number of dengue reported cases) if the count combines vulnerability component. This can be referred to Selangor as it recorded the highest number of dengue reported cases as supposedly and should be listed as the most vulnerable state for dengue outbreak. However, in the present prediction (ranking vulnerability score), the result was contradicting as Selangor was ranked number 13 (implies as among the most least vulnerable state after Johor and Sarawak).

Overall, it was concluded that the framework was almost devastating in predicting dengue outbreak. However, this insignificant result does not mean this study should be eliminated. In every research, no social sciences theories and researchers can guarantee that 100% of their result will follow their hypothesis and prediction. Moreover, this study is experimental. Experimental study has lots of hypotheses that need to be tested and if the result is insignificant, it requires justification and maybe able to show that there are possibilities for further discovery in other aspects of future studies.

It is undeniable that even the state regarded as the safest with lowest incidence rate based on number of dengue reported cases (such as Terengganu and Perlis) can be listed as the most vulnerable state if considering and combining the vulnerability assessment. This result indicates that the prediction can go far from the actual cases if only the statistical elements are being testified.

Table 4. State Vulnerability Ranking from Most Vulnerable to Least Vulnerable

State	Population Density	Urbaniza-tion	Medical Care Workfor ce	Medical Care Infrastruc -ture	Public Health Delivery	Safe Water and Sanitation	Economic Strength	Ranking Vulnera-bility Score	Ranking for Dengue Reported Cases
Johor	8	6	13	13	12	11	7	14	3
Kedah	7	11	8	10	4	5	2	4	11
Kelantan	11	15	5	6	2	1	1	2	5
Melaka	5	5	3	3	10	13	10	5	12
Negeri Sembilan	9	8	6	5	11	10	9	9	8
Pahang	14	13	7	7	8	7	8	11	9
Perak	10	7	12	15	5	6	5	10	4
Perlis	6	14	2	2	3	8	4	1	14
Pulau Pinang	2	3	9	8	13	9	12	8	6
Sabah	13	10	10	12	14	2	3	12	10
Sarawak	15	12	11	11	7	3	13	15	7
Selangor	4	2	15	14	9	12	11	13	1
Terengganu	12	9	4	4	6	4	6	3	13
WP Kuala Lumpur	1	1	14	9	1	14	15	7	2
WP Labuan	3	4	1	1	15	15	14	6	15

Table 5. Determinants of DVFM using the panel estimation

VARIABLES	(1) POLS	(2) FEM	(3) REM	(4) POLS ROBUST	(5) FEM ROBUST	(6) REM ROBUST
revlpd	-0.3541***	-4.5053**	-0.3529***	-0.3541***	-4.5053***	-0.3529***
	(0.0566)	(1.7495)	(0.1025)	(0.0491)	(1.5117)	(0.0927)
revlur	0.7443**	0.8485**	0.9784**	0.7443**	0.8485*	0.9784**
	(0.3680)	(0.4014)	(0.3882)	(0.3698)	(0.4478)	(0.4687)
lmcw	0.3607***	-0.3708*	0.1356	0.3607***	-0.3708**	0.1356
	(0.1002)	(0.1958)	(0.1269)	(0.0931)	(0.1388)	(0.1093)
lmci	1.1954***	0.3783	1.3639***	1.1954***	0.3783	1.3639***
	(0.1256)	(0.3900)	(0.1823)	(0.1067)	(0.2966)	(0.2210)
lphd	-0.2654	-0.4956	-0.2875	-0.2654	-0.4956**	-0.2875*
	(0.3191)	(0.3055)	(0.3008)	(0.2061)	(0.1721)	(0.1729)
lsws	-1.6694	0.1602	-1.1575	-1.6694	0.1602	-1.1575
	(1.5554)	(2.0926)	(1.8986)	(1.3659)	(1.5647)	(1.2765)
les	0.0376	0.3692	0.2826	0.0376	0.3692	0.2826
	(0.1691)	(0.3799)	(0.2437)	(0.1653)	(0.3211)	(0.1897)
Constant	4.8749	23.7186	0.0703	4.8749	23.7186**	0.0703
	(7.2390)	(15.4673)	(9.2345)	(6.2978)	(10.1660)	(5.8912)
Observations	225	225	225	225	225	225
R-squared	0.7964	0.1239		0.7964	0.1239	
Number of codes		15	15		15	15

POLS, FEM and REM is the panel model. POLS is Pooled OLS, FEM is Fixed Effect Model and REM is Random Effect Model. Initial panel estimates (such POLS, FEM and REM) may suffer from standard error problem due to differences in individual units in the panel structure units over time. Thus, the standard error must be corrected using robust estimates.

Revlpd is the logarithm of population density, revlur is the logarithm of urbanization, lmcw is the logarithm of medical care workforce, lmci is the logarithm of medical care infrastructure, lphd is the logarithm of public health delivery, lsws is the logarithm of safe water and sanitation, and les is the logarithm of the economic strength.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Result from Poolability, Breusch-Pagan Lagrange Multiplier (BPLM) and Hausman obtained the p-value less than 0.05. This shows that the Fixed Effect Model is being chosen as the best fit model. As per Table 5 above, it shown that 3 independent variables are significantly influenced the vulnerability of dengue reported cases (population density, urbanization and medical care workforce). There is 4 independent variable that is not significantly influence the vulnerability of dengue reported cases (medical care infrastructure, public health delivery, safe water and sanitation and economic strength). Despite 3 independent variables is significant, this study only accepts two hypotheses (urbanization and medical care workforce) as both variables are significant and align with the initial hypothesis.

DISCUSSION

This section urges better justification for result obtained in Table 5 above. Various reasons are compiled based on the previous studies. Population density (PD) has a negative impact on the correlation of dengue reported case, DEN. This result rejects the first hypothesis whereby, there is a positive association between these two variables is expected. This result indicates significant relationship between the population density and dengue reported cases with the p-value of <0.05. Based on this result, it shows that the hypothesis is rejected, in a way the result implies that higher population density rate led to lower vulnerability to dengue reported cases. This result is supported by most studies that find the positive association between the population density and vulnerability to dengue reported cases (Aruchanalam et al., 2010), however, this result is align with the condition mentioned by Jain et al. (2019) and Chiung et al. (2018). Jain argues that despite high density may lead to increasing number of dengue outbreak, in order to highly put the responsibility, it depends on other variables that may appear such as the number of neglected garbage. Similarly, Chiung et al. (2018) found that this relationship is weak. In application to this study, for the state that is listed under highly populated such as WP Kuala Lumpur (1), Pulau Pinang (2) and WP Labuan (3), their number of dengue reported case did explain the logic, by result of WP Kuala Lumpur (2),Pulau Pinang (6) and WP Labuan (15) . Look the case in Labuan, even it is 3rd highest densely populated density, the number of dengue reported cases is the lowest.

As for urbanization, UR, the estimated result demonstrates a positive correlation influence on dengue reported cases. This result is aligning with the second hypothesis that expects their association between these variables are positive. Higher urbanization rates lead to higher vulnerability to dengue reported cases. Based on this result, it shows that the hypothesis is accepted, in a way the result implies that higher urbanization rate led to higher vulnerability dengue reported cases. This result also indicates that there is a significant relationship between the urbanization and the vulnerability to dengue reported cases. This result is align with the study conducted by Azami et al. (2020), Packierisamy et al. (2015) and by Vythilingam and Wan Yusoff (2017). These scholars had commented that urbanization and dengue is like complementing each other.

Same as urbanization, the result indicates that there is significant relationship between the medical care workforce, MCW, to vulnerability of dengue reported case. This result accepts the initial hypothesis indicating there are negative relationship between these two variables with dengue reported case. Initial hypothesis indicate that higher medical care workforce will lead to lower the vulnerability to dengue reported cases based on their coefficient relationship is negative. This result lead us to also accept the third hypothesis. This study interpreted this result by the study that prove the statement by the Minister of Health, Dr Adham Baba that claim Malaysia's doctor to population ratio is 1:454 across the public and private sectors better than WHO target 1: 255 goal. Despite they are research and argument that still did not agree on the adequacy of the number of doctors in Malaysia, this study is in line with this result by agree that the number of doctors is adequate for the case of dengue. It should also be highlighting that dengue only cover dengue is only 2.64% out of total number of discharges in MOH hospital (Table 3)

For medical care infrastructure, MCI, this study found that this relationship is not significant. However, the negative correlation between these variables is aligning the initial hypothesis that predict the same. Despite that, the hypothesis needs to be rejected as it is insignificant despite the correct negatively association between the medical care infrastructure and the vulnerability to dengue reported cases. This result implies that higher the medical care infrastructure will lead to lower vulnerability to dengue reported cases. This result is not the same as per study suggested by Abdulrazec et al. (2016) that claim the significant problem of shortage in hospital bed when their average bed population ratio of 6.8/10,000 in India. In Malaysia, Dengue only cover 2.64% out of total number of discharges in MOH hospital (Table 3), this small number may lead to the result unable to represent the same result obtain from the study by Abdulrazec.

So far, this study finds public health service delivery, PHD, demonstrate a negative influence on the vulnerability to dengue outbreak. This result is aligning with the fifth hypothesis that predict the negative correlation between public health service delivery and the vulnerability to dengue outbreak. Initial hypothesis predict that the high level of public health service delivery decreases the vulnerability to dengue outbreak. However, when being apply to this study, the result indicate that public health service delivery did not have significant relationship to vulnerability to dengue reported cases. The insignificant result may due to the nature of public health service delivery in Malaysia itself. This variable assess the measure of health service delivery by assessing the percentage coverage with third dose of Diphtheria, Tetanus and Pertussis (DTP) vaccine or measles vaccine due to unavailability of the data assessing the percentage coverage for dengue vaccine (until now dengue vaccine is unavailable in Malaysia). Despite the scholars (Moore et al., 2016; Gelfield et al., 2015); indicate that high percentage is good as the country is assumed to have better able to deliver health basic primary care services is better able to respond to the disease outbreak, this study proves that this variable is not suitable for infectious disease of concern, Dengue. The nature of the DTP3 vaccination rate require up until 3rd dose to be completed (this study refer the 3rd dose), and overall, all the states in Malaysia reach 90% and above except for 2 states, Kelantan and Wilayah Persekutuan Kuala Lumpur. For Kelantan, the DTP assessing covering is decreasing every year starting year 2009 (82.3%) to 2017 (74.9%). For Kuala Lumpur the DTP3 vaccination rate is not reaching 90% at the earlier year, 2003 (59.9%) to 2010 (80.88%) but for the rest of the year, the rate is reach 90% and above. The result from these 2 states may create outlier in data due to as the data is far differ from the rest 13 other states. This outlier creates abnormality in data, and this explain why the result is not significant.

Other than population density and medical care infrastructure, the Safe water and Sanitation, SWS, is another variable that able to prove the initial hypothesis is rejected based on its coefficient relationship. The result indicate that the safe water and sanitation have the positive impact on the correlation of vulnerability to dengue reported cases and this result is contradict with the expected negative association between these two variables. According to Moore et al. (2016), high safe water and sanitation may decrease the vulnerability to infectious disease, however, based on positive coefficient, the result turn that higher the safe water and sanitation, higher the vulnerability to dengue outbreak. The justification behind this is that reject the conditions occurs in Indonesia (Wanti et al., 2019) and India (Malholtra et al., 2014). This study claims that there are majority of the community still using water container due to the shortage of water. However, in the case of Malaysia, majority of the location did not have the issue of shortage in water. Supporting by the by Chandren et al. (2015), even Orang Asli community in Malaysia have access to safe water but their problem is they did not know that Dengue can even breed in clean water. So, this lead to the increasing number of dengue outbreak despite the safe water and sanitation had been provided by the government in Malaysia.

Lastly for economic strength. ES, the result indicates that there is no significant relationship between the economic strength and the vulnerability to dengue reported cases. Not only insignificant, but this study is also rejected this variable due to reverse relationship to the initial hypothesis. Initial hypothesis predicted that there is negative relationship between the economic strength to the vulnerability to dengue reported cases by higher economic strength decrease the vulnerability to dengue outbreak (that is positive influence in the context of this study). Previous study by Packierisamy et al. (2015) and Shepard et al. (2013) contradict the finding in this study. However, Moore et al. (2016) had proven that in the case of applying IDVI to countries vulnerability, even the state might outperform their economic indicator-their overall normed vulnerability score was better (higher value) than their normed economic score alone. This study presumes the reason related to this study is due to the sample Previous studies consist purely international level or countries. As this study is conducted using the 15th Malaysian state sample, the result can be different, considering the 15th Malaysia state is mostly consisting of the state or regional level.

Apart from that, there must be a possible reason behind the contradicting result from the real scenario. One is related with the variables chosen. The measure chosen in this study was basically different from the practice or the literature to fit the purpose of Malaysia context. For instance, variable medical care workforce was measured by the numbers of doctor under MOH despite the literature using the measurement of number of doctors per population. Likewise, in terms of medical care infrastructure, this study measured the number of hospital bed under the MOH, while the literature measured the number of hospital bed per population. The justification to apply number of doctors rather than number of doctors per population was due the assessment on the government context (only focus on MOH that is not private).

It was argued that the number of doctors will be bigger if this study included the numbers from the private sectors and non KKM, yet, that number would still unable to reflect the objective in this study. This study wants to focus on doctors in the public sectors as it is easier to relate with the government policy and budget that are mostly related to their MOH staff. More importantly, their numbers would still be the biggest in service compared to the private sectors. This study was also aware that the number of doctors as per population ratio might be more reflective to show the availability of health professionals to entertain the dengue outbreak; however, the calculation for doctor per population will combine the number of doctors in public and private sector.

Thus, it is better to focus on the data related with government (only KKM or MOH) to ensure that this study can relate the government policy and initiatives to curb dengue as per the implementor from government servants. Similarly, to the above scenario, the threshold for medical care infrastructure was in number and high number indicates a low vulnerability to dengue outbreak.

Besides, to justify on why "number of hospital beds under MOH is higher than that per 1000 population" is to explain the distribution of facilities based on government budget. It should be aware that even dengue is part of highly reported infectious diseases in Malaysia, the distribution of hospital beds does not rely on dengue cases.

Limitation and implication of the study

This study acknowledges several limitations and provides some suggestions and improvements for future studies.

1) Data

This was deemed as the most challenging aspect in this study, which is common in studies that use secondary data. This implies that there is a need to improve the usability of open and public data. Firstly, in the aspect of accessibility. Even most data are widely open to access, most dengue-related work in Malaysia requires collaboration from the owner of the data (especially the Ministry of Health Malaysia) to share the data. However, the slow process in ethical application and guidelines may have affected health data availability.

Second, the timeliness of the data provided by the Ministry of Health Malaysia. While demographic data (population density and urbanization) are promptly released yearly and periodically on the DOSM website, other data especially relating to Health Indicators are delayed when they are supposed to be promptly published online. For instance, the publication of data on Health Indicators for the year 2018 is only being available almost at end of the year 2019. This issue restricted the researcher to use the period 2003 to 2017. More challenging, the dengue data requires a significant turn- around time before it is provided on demand. To ethically permit the use of data from the Ministry of Health, the researcher is required to undergo an ethical process under the National Medical Research Register (NMRR) to ensure there is no violation of information that has occurred. This is a significant challenge to any research or effort to conduct near-real-time monitoring of dengue that becomes the main focus of the present study. Third limitation about the uniformity of the data format and sources. From experience, the data obtained from public data may be shared via various formats either excel spreadsheet, graphic file, or document format. To ensure this data reached the requirement needed, the use of standard data operation should be adopted.

2) Replicability

Replicability is one of the main components needed in research to bring newness to the field of study. The results in this thesis provide a robust and comprehensive framework to assess and predict dengue vulnerability. Based on the results, the predictive model does not fully explain the variations in the occurrence of dengue cases due to the influence of other factors. This study investigates the facts and "plausible causes" behind it and accepts this is the uniqueness of this thesis. Different factors including the population, the setting, measurement (original or adapt or adopt), operational definition, analysis techniques, or the theory led to the results and were responsibly justified.

To increase replication, future research should employ more observations or a larger period of study that could provide a better estimation of the DVFM model. Future studies can use quarterly data and extend the period of study. Apart from that, future studies should benefit from the usage of panel data. Panel data contain information on both intertemporal dynamics and the individuality of the entities that may allow one to control the effects of missing or unobserved variables. The outcome would be useful as references for other newer members of ASEAN countries such as Brunei, Vietnam, Cambodia, Myanmar, and Laos.

CONCLUSION

In conjunction with the increasing risk to Malaysia posed by Dengue outbreak, it is essential to have a clear understanding on the current vulnerabilities across the state-*where* is the most vulnerable state and *what* contributes the most to their vulnerabilities. This study has developed dengue vulnerability assessment tool for Malaysia landscape as a tool to help identifying states that are potentially most vulnerable to dengue outbreak due to a confluence factors such as population density, urbanization, medical care workforce, medical care infrastructure, public health delivery, safe water and sanitation as well as the economic strength. This information can help the government and the relevant state actors to allocate and prioritize their programs for their area of weaknesses proactively to decrease the number of dengue outbreak. Although this tool is almost reliable in indicating the dengue outbreak scenario in Malaysia, it is undeniable that it is an interactive tool. The end users may change the variables or measures to reflect their beliefs or changing realities on the ground. This tool was intended to identify high-low risk areas among study samples, showing a result that was almost devastating to reflect dengue outbreak. Other researchers would do better in taking more extensive measures to address the vulnerability to dengue outbreak at state level in Malaysia in advance of future case. This approach seeks to visualize a good concept or method that has the potential to measure dengue susceptibility, but its effectiveness is yet to be improved.

DECLARATION OF COMPETING INTEREST

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare absence of conflicting interests with the funders.

DECLARATIONS

Ethics approval from Medical Research and Ethics Committee (NMRR) was obtained under NMRR-20-454-53850 (IIR).

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