APPLYING RATIONAL MODEL APPROACH IN DECISION MAKING FOR PREVENTIVE MEASURES OF ZIKA OUTBREAK

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ABSTRACT

Background: In November 2016, the WHO has declared Zika virus (ZIKV) infection as a public health emergency of international concern. Affected countries have to decide on the suitable control measures of ZIKV outbreak. This article aims to apply the Rational Model in the decision-making of ZIKV outbreak control measures.

Materials and Methods: Adopting a scoping review method, articles were identified using three databases through the keywords “decision making theories” or “problem solving” and “public health” or “community health”. Only articles written and published in English within the last 15 years were included. After filtering, 10 articles were reviewed.

Result: The Rational decision-making model is positioned as the most promising, effective, and functional decision-making approach for ZIKV outbreak as it reduces chances of error and optimize resources. There are five domains of control measures in ZIKV outbreak which are decision support tools; technology development; surveillance and monitoring; infrastructural development and behavioural. In Malaysia, integrated vector management, entomological and disease surveillance, enhance infrastructural development and behavioural were practiced in control measures of ZIKV outbreak.

Conclusion: The most common models used in decision making is the Rational Model and the Contingency Model. The basic concepts of Rational Model in decision-making for preventative measure of ZIKV outbreak were discussed in this article.

Keywords: decision making, rational model, Zika virus outbreak
1.0 Introduction

Decision-making is a fundamental process. It plays an important part of managing an outbreak. Fallon (2012) described decision making as a pillar of an effective outbreak management. It is also being exemplified as a thought process of choosing the right choice from all of the possible options available (Mhenareswari, 2014). Making the right choice is desirable by every organization to maximize the benefit and gain desirable outcome. However, to accurately decide is a challenging process. Decision-making requires in-depth understanding of the situation in which the decision is to be made. All possible options are generally being looked through to weigh the possible advantages and disadvantages before considering the ultimate solution. There are a lot of literatures proposing different mechanisms of decision making such as Heracleous (1994) and Russo & Schoemaker (2002).

One of the mechanisms is as a seven-step process of decision-making as shown in Figure 1:

![Figure 1: Seven step in decision making (Mhenareswari, 2014).](image-url)

In this first step, the desired goal is often set up to visualise the end result that the organization is trying to accomplish. Next, all information pertaining to the decision to be made is collected in order to come up with a possible solution. Then, all the possible options are outlined or brainstormed. Subsequently, the advantages and disadvantages of each alternative are identified. Making the right choice may be based on the highest pros or the most significance choice or even the most favourable choice. After making the final decision, often the option is translated into action. The last step is re-evaluating the solution that has been carried out (Mhenareswari, 2014). These seven-steps can be used as a framework by any
decision makers to recommend the best solution for any organization at many different levels of decision-making.

There are several models available to assist the process of decision-making. One of the most frequently applied models in decision-making is the rational model which is a method of systematically selecting a solution from possible options based on logic and facts (Uzonwanne, 2017). In a public health organization, managing an outbreak often requires higher level decision-making of more intense or serious in nature such as in the event of a Zika virus (ZIKV) outbreak.

2.0 Zika Virus Outbreak

The ZIKV is an arthropod-borne virus from the Flaviviridae family, which includes other well known viruses such as dengue, Japanese encephalitis and yellow fever viruses (Sam, Chan, Vythilingam, & Sulaiman, 2016). The virus was first isolated from a monkey in Uganda and the first human case reported was in 1952 when it infected a 10 year old female from Nigeria (Lim, Lim, & Yoon, 2017). Since then, there were only scattered cases reported until 2007 when an outbreak occurred on Yap Island, Federated States of Micronesia (Lim et al., 2017). It was during that outbreak, approximately 5,000 Yap’s residents aged more than 3 years old were infected with ZIKV (Song, Yun, Woolley, & Lee, 2017). Since 2010, sporadic cases of ZIKV infection have been reported in several South East Asian countries such as Thailand, Cambodia, Malaysia, Indonesia and Philippines (Song et al., 2017).

In Malaysia, ZIKV was first isolated from Aedes Aegypti mosquito in 1966, though several serological studies suggested that it existed earlier than that (Lim et al., 2017). In September 2014, a traveller from German was tested positive for ZIKV in Malaysia, followed by an indigenous case of a 67 year old man from Petaling Jaya, Selangor who was tested positive for ZIKV infection in September 2016 (Lim et al., 2017).

ZIKV mode of transmission is primarily through a mosquito bite though it can be also transmitted through sexual contact, vertical transmission, during breastfeeding and unscreened blood transfusion (Song et al., 2017). As it is transmitted to human through Aedes mosquito, Malaysia being a home for Aedes Aegypti, is at risk to similar outbreak. Besides, multiple modes of ZIKV transmission make it even more difficult to develop control strategies against the pathogen.

ZIKV infection, often asymptomatic, it can also present with viral infection-like symptoms such as, fever, myalgia, arthralgia, headache and conjunctivitis (Sam et al., 2016). These vague symptoms and signs often lead to misdiagnosis or late recognition of ZIKV infection. However, studies have demonstrated a potential link between ZIKV outbreak and some devastating neurological complications such as microcephaly and Gullien Barre Syndrome (GBS) (Rabaan, Bazzi, Al-Ahmed, Al-Ghaith, & Al-Tawfiq, 2017). Microcephaly is a neurological condition by which a foetus brain does not develop accordingly, resulting in a smaller size head which may be caused by toxins or infection (Song et al., 2017). Whereas GBS is an acute neural illness that manifests as lower, bilateral and symmetrical deficit in sensorimotor development (Rabaan et al., 2017).
ZIKV is considered a risk to a country like Malaysia as it can cause disastrous complications and has many local vectors. Therefore, this article aims to explore the application of most commonly used decision-making model for planning of ZIKV outbreak prevention in Malaysia. This includes strategies that have been developed for ZIKV prevention and controls measures in Malaysia since the recent outbreak in Malaysia in 2014. The decision-making model used in this article is based on the steps explained in the next section.

3.0 Materials and Method

There are few models in decision-making in Public Health such as the Rational Model, the Contingency Model and the Garbage Can Model. A literature review was done to search for articles and identify commonly used models for decision applied in decision-making during an outbreak?$. Relevant studies were identified using literature searching based on the formulated research question from the electronic databases, PubMed, ScienceDirect and Google Scholar. The phrases used for this literature search were, ‘decision making theories’ or ‘problem solving’ and ‘public health’ or ‘community health’. A total of fourteen articles, reports and theses were identified, selected and analysed. Ten of the articles are using Rational Model while four of them are using Contingency Model.

4.0 Results and Discussion

Following our analysis and literature review, the two most common models used in decision-making is the Rational Model and the Contingency Model. The basic concept of Rational Model will be discussed in this article.

4.1 Rational Model

Rational decision-making is a more advanced type of decision-making model, laying emphasis on the characteristics of thorough research and logical evaluation, selecting among possible choices based on reason and facts (Uzonwanne, 2016). Rational decision-making model is therefore were used in higher level of decision-making on a more serious nature. These are the sort of decisions that managers and higher-level leaders are faced with in their leadership roles (Uzonwanne, 2016).

In rational decision-making models, decision makers evaluate a number of possible substitutions from different possible situations before selecting a choice (Oliveira, 2007). These possible situations or scenarios are weighed by probabilities, and decision makers can determine the expected end result for each choice (Oliveira, 2007). The final choice that the decision maker chooses would be the one offering the best-predictable consequence and with the highest prospects of consequence (Oliveira, 2007).
Rational decision-making may involve several different processes. Regardless of the various steps in each process, rational decision processes have similarities that mostly result in effective solutions. A model of rational decision making is presented in Figure 2:

**Figure 2: Rational Model in Decision Making**

Rational Model gives more advantages such as it will be on scientifically obtained data that will reduce the chances of errors, more consistent and will consider all aspects of the problem with all possible solutions before making a final decision. Rational decision-making is positioned as the most promising, effective, and functional decision-making process for leaders, managers, and individuals, especially when stakeholders, investments, and high stakes are involved. The Rational model of decision-making is also considered as a more advanced type of decision-making model. Therefore, in this article, we are going to explore and apply Rational Model in the decision-making for preventative measure of ZIKV outbreak.

### 5.0 Applying Rational Model Approach in Decision Making for Preventive Measures of ZIKV Outbreak

The application of the “Rational model” on preventive measures of ZIKV outbreak is discussed in the following sections.

#### 5.1 Identifying the Problem that Requires a Solution

On the 1st of February 2016, WHO declared ZIKV infection as a Public Health Emergency of International Concern (PHEIC)(WHO statement, 2016b). This declaration was made following escalating cases of Microcephaly and Guillain-Barré Syndrome (GBS) that have been temporally associated with Zika virus transmission in some areas. Cases of microcephaly and other neurological disorders were profoundly seen in countries that were having endemic ZIKV infections: Brazil, France, United States of America, and El Salvador.

In Malaysia, the first ZIKV case was reported on the 31st of August 2016. The patient was a fifty eight year-old lady residing in Bandar Botanic, Klang (Ministry of Health, 2016). The lady is a mother to a daughter who was working in Singapore and had a confirmed ZIKV
infection. The patient and her husband went to visit their daughter and the travelling period was from the 19th of August 2016 until the 21st of August 2016. She noticed a rash on the 28th of August 2016 and sought for medical treatment on the 30th of August 2016 at a general practitioner (GP). She was diagnosed with suspected ZIKV infection by the GP and referred to Hospital Sungai Buloh. At Hospital Sungai Buloh the result of her urine PCR (Polymerase Chain Reaction) test on the 31st of August 2016 was found positive for ZIKV. Her husband did not show any symptoms of ZIKV infection. From the investigation, the source of infection was likely from Singapore as her daughter was having similar symptoms on the same day as the patient.

The first autochthonous ZIKV infection was reported on the 2nd of September 2016 in Sabah (Ministry of Health Malaysia, 2016). The patient was a 61-year-old male of Dusun descent living in Likas, Sabah. He developed a fever on the 27th of August 2016 and sought treatment at Luyang Health clinic. As his condition worsened, he went to Queen Elizabeth Hospital 2 on the 31st of August 2016. He was also suffering from other comorbidities which were hypertension, coronary heart disease, chronic kidney disease, kidney stones and gout which made his condition worsened. Both his blood and urine tests were tested positive for ZIKV. Further investigations concluded that this was a local transmission since the patient did not travel to places with endemic of ZIKV infection.

Until the 30th of September 2016, there were a total of 7 cases of ZIKV infection reported in Malaysia (Ministry of Health Malaysia, 2016). During the 5th meeting of WHO emergency committee dated on 18 November 2016, the Director General lifted the PHEIC on zika virus infection (WHO statement, 2016a). However, long term plans and mechanisms were devised for this issue.

5.2 Identifying the Solution Scenario

Due to the rapid emergence of ZIKV infection and its complications, the disease is now becoming a concern all over the world including Malaysia. Unfortunately, little is known about the full progression of the disease including pathogenesis, transmission, complications, and treatment of ZIKV.

Since the 1st February of 2016 when PHEIC was announced, WHO has categorized Malaysia in the second group which is: “area either with evidence of virus circulation before 2015 or area with ongoing transmission that is no longer in the new or reintroduction phase, but where there is no evidence of interruption”.

(WHO, 2017)

To identify the solution scenario for ZIKV infection, the main strategies outlined by CDC for control measures of ZIKV infection can be used which are:

1. Preventing Mosquito Transmission
2. Preventing Sexual Transmission
3. Preventing Zika Infection During Pregnancy
4. Blood Donation Screening

(CDC, 2017a)

These strategies can be used in controlling and preventing ZIKV in Malaysia.
5.3 Carrying Out a Gap Analysis

ZIKV has the potential to rapidly amplify and is easily transmitted particularly in countries that have vectors like Malaysia. As the disease is not confined to one geographical area, it is paramount to control the transmission of the disease particularly at international travel gates. Besides that, climate change and global warming can result in rapid transmission of the disease. High temperature and humidity increases the chance of the mosquitoes to find new breeding sites. This results in more active breeding activities which increase the number of mosquitoes. In addition, globalisation and decay in public health infrastructure has also contributed to the increased number of mosquitoes. Improper drainage of stagnant water and the dumping of garbage can provide potential breeding sites for mosquitoes. Another concern on ZIKV infection is both the natural history and the progression of the disease are not fully understood. Currently in the diagnostic test for ZIKV infection, we are using MAC ELISA and viremia. However, the sensitivity and specificity of the tests are still unknown.

The incubation period of ZIKV is also still unknown but is expected to be similar to other flavivivirus infections which is less than 1 week (Petersen, Jamieson, Powers, & Honein, 2016). Another unknown detail of ZIKV infection is the neurological implications. Up until now, both geographical and temporal association between Guillain–Barré syndrome and Zika virus outbreaks have been observed in the affected countries (Petersen et al., 2016). Other neurological complications such as meningoencephalitis and acute myelitis have also been observed with ZIKV infections.

Furthermore, the full spectrum on complications caused by ZIKV is yet to be determined. Currently, clinical findings concluded that microcephaly causing congenital malformation can be passed during periconceptional or interauterine or perinatal transmission (Petersen et al., 2016). Another route of transmission is by having sex with an infected partner. Besides that, ZIKV infection may also transmit through blood transmission. For now, the route of transmission of ZIKV infection is still not yet confirmed. However, carers or family members should be informed that blood or body fluids from a person who is severely ill due to ZIKV infection might be infectious. There is currently no evidence of transmission through breastfeeding or spreading through direct contact or coughing (Petersen et al., 2016).

5.4 Gathering Facts, Options, and Alternatives

The development of effective control measures of ZIKV outbreak can be drawn from models and strategies used in the management of Dengue and Chikungunya virus (Tami, Grillet, & Grobusch, 2016). However, one should not be limited to Dengue and Chikungunya Virus management but should also refer to other intervention of diseases that might be useful if they share same characteristics as ZIKV infection. Below are alternatives of control measures of ZIKV outbreak as depicted in figure 3 that was construct from combination of Malaria control measures by WHO (Mendis, 2008) and vector borne control measures (Rather, Kumar, Bajpai, Lim, & Park, 2017; Tami et al., 2016; WHO, 2006; Sharma & Lal, 2017).
5.5 Analyzing Option Outcomes

CDC has outlined the possible solution scenarios to directly curb ZIKV infection. Therefore, we can integrate both approaches from CDC and vector borne control measures suggested previously to produce effective control measures of ZIKV infection. The option strategies that can be used to control ZIKV infection in Malaysia are discussed in the following subsections.

5.5.1 Decision Support Tools

One of the options of ZIKV outbreak control measures is Geography Information System (GIS). GIS is developed by using a well-documented entomological surveillance that merged with the information of disease surveillance to estimate potential outbreak zones in order to prioritize mosquito control during 2016 outbreaks. This strategy was used as an early warning system to target prevention and control actions in arboviruses (Tami et al., 2016). The swift spreading of ZIKV and the potential large scale infection of the disease in *Aedes* infested areas make it important to develop an early warning system such as GIS to predict areas prone to ZIKV amplification and therefore prevent an outbreak (Tami et al., 2016).

Shared information on the first occurrence of the disease with affected local and international counterparts will help to maximize public awareness, encouraging changes in individual behaviour and community participation, in order to control the vector and its breeding sites. An effective communication strategies will enable people to take the best informed decisions about protecting themselves, their families and communities (WHO, 2016). The objective is to prioritise the most vulnerable public population in order to emphasize the risks of ZIKV infection. In this case women of childbearing age and pregnant women are considered to be the most at risk in public.

5.5.2 Technology Development

Currently, there is no vaccine available for the preventive treatment of ZIKV (Rather et al., 2017). However, ongoing research is being done by scientists to develop ZIKV vaccine.
Recently USA and India company are developing ZIKV vaccines and awaiting clinical and pre-clinical trials end of this year (Sharma & Lal, 2017). As ZIKV vaccine is yet to develop, more strategies have put into anti-viral treatments. However, up to date there is no anti-viral treatment available. Since there is similarity between DENV and ZIKV, knowledge from DENV was used in the development of anti-ZIKV therapeutics. However, most challenging part is to develop an anti-ZIKV therapeutic drug for pregnant women (Sharma & Lal, 2017).

5.5.3 Surveillance and Monitoring

Besides that, surveillance of ZIKV infection helps policy makers and authorities in decision making which is also another main strategy used in countries with endemic dengue virus. The combination of entomological surveillance and disease surveillance enables implementation of appropriate ZIKV control measures. Entomological surveillance is used to determine changes in geographical distribution and density of vector and obtain relative measurement of vectors population over time. It should be carried out in the dry and wet seasons alike, and should encompass both the early and adult stages of the mosquito. Singapore for example, in addition to larvae surveys, the population trends of A aegypti and A albopictus have been monitored via gravitrap-based sentinel surveillance, involving 34 sites and 4,300 gravitraps since august 2013. The data are used to monitor the Aedes population dynamics (Jie et al., 2017).

The unexpected potential link between ZIKV outbreak and some devastating neurological complications such as microcephaly and Gullien Barre Syndrome (GBS) have led countries with endemic ZIKV infection to do disease surveillance on these two outcomes as well besides than ZIKV infection. Currently, countries with endemic ZIKV infection is recommended to provide contraceptive services, vigilance antenatal care and safe abortion services (Sharma & Lal, 2017).

On top of that, vector control is another approach of controlling ZIKV infection. It is best to consider integrated vector management (IVM) when applying vector control of ZIKV. IVM is well suited approaches because some vectors are responsible for multiple diseases, and some interventions are effective against several vectors. As ZIKV is transmitted by the same vector as Dengue fever and Chikugunya, the method of containing arbovirus is practically the same. IVM encourages effective coordination of the control activities among all sectors that have an impact on vector-borne diseases, including health, water, solid waste and sewage disposal, housing and agriculture. Commensurate benefits for non-health-sector partners make it more likely that IVM approaches will be effective. For example, alternate wet/dry (intermittent) irrigation, combined with other vector control methods, has been effective in controlling the vectors of malaria and Japanese Encephalitis in China, India, Indonesia and Sri Lanka. It also allows a more economic usage of irrigation water, thereby reducing farmers’ costs. Part of IVM efforts should focused on the reduction of mosquito breeding sites through removal of habitats and the use of the larvicides such as Bacillus thuringiensis israelensis (Bti) and temephos. In areas with ZIKV infection transmission, adulticiding should be done via space spraying. Outdoor thermal fogging can be done with primiphos-methyl whilst indoor misting can be done with primiphos-methyl or synthetic pyrethroid-based aerosol sprays with residual spraying used as complementary measures.

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5.5.4 **Infrastructure Development**

The fourth strategy is infrastructure development which includes proper drainage of stagnant water as well as proper reservoir and proper garbage management to hamper vector proliferation (Rather et al., 2017). This allows prevention of mosquitoes’ breeding reservoir and reduction of mosquito’s ability to transmit virus. Besides that, development programmes, including irrigated agriculture, hydroelectric dam construction, road building, forest clearance, housing development and industrial expansion, all influence vector-borne diseases. Opportunities for proper planning within and between sectors should be integrated in strategies for ZIKV control measures.

5.5.5 **Behavioural**

One of the main strategies is by protecting humans from mosquito bites through various measures. This can reduce human contacts from mosquitoes’ bite which includes protection from vector contact and by making a mosquito-proof home (CDC, 2017b). This can be done by wearing long sleeved shirts and pants, stay in places with air conditioning and window and door screens to keep mosquito outside. For exposed skin, usage of environmental protection agent EPA-registered insect repellent is recommended. Any items that hold water like tire, buckets, flowerpot saucer or thrash container must be eliminated. Storage containers also have to be tightly covered. For large containers of water that will not be used for drinking proposes that cannot be covered or dumped out, usage of larvicides to kill mosquito larvae is recommended. Mosquitos rest in dark and humid areas. Hence, use an outdoor insect spray to kill mosquitos in areas where they rest (CDC, 2016).

The next step is by limiting the vector or source from potentially causing urban transmission. This could be done through limiting human travelling to infected areas and restrain especially to the most vulnerable group which is pregnant women. People who contracted this illness or returning from an area with risk of ZIKV infection should help to prevent others from getting sick, by preventing mosquito bites during the first weeks of illness and have protected sex (CDC, 2016).

5.6 **Selecting Best Possible Options**

In this step selecting the best possible option has to derive from a comprehensive analysis of option outcomes which will produce the desirable result. A Public health decision makers has to take into account all current issues, situation and goals. The primary cause of the re-emergence of ZIKV is ultimately came from human behaviour causing the amplification of hosts and vectors (Rather et al., 2017). Mitigation initiatives should be strengthened and focused on primary prevention of ZIKV which is vector control, enhanced surveillance, community mobilization and enforcement.

Thus, incorporating integrated vector management is rational in view of its efficiency and cost effectiveness in situations where resources are limited. Innovative methods are needed for the surveillance and control measures of ZIKV infection. The swift spreading of this [arbovirus](http://www.cdc.gov/) and the potential large scale infection of the disease in Aedes infested areas make it important to develop an early warning system such as Geography Information System (GIS) to predict areas prone to ZIKV amplification and therefore prevent an outbreak (Tami et al., 2016).
Apart from that, community engagement activities should be initiated to educate the public on awareness (i.e. prevention of mosquito bites), encourage source reduction (i.e. destruction of mosquito breeding sites) by mobilizing and empowering the community.

5.7 Implementing Decision for Solution and Evaluating Final Outcome

In most countries endemic for vector-borne diseases including Malaysia, health reforms have resulted in decentralization of decision-making and resource allocation. In decentralization, decision making is brought to the most appropriate lower level of administration, transferring the responsibility of planning, budgeting and implementing certain functions from the central government to district or local units. Hence, public health services are transferred from central ministries to districts, and the role of the ministries is limited to policy, guidance and technical support. This is to ensure implementation of control programs are flexible and tailored according to local suitability. A prerequisite for decentralization is that the skills and capacity for analysis and decision-making must be firmly established at district level. Capacity for vector control at district level often requires further strengthening for the implementation of logistically complex programmes in prevention of arbovirus outbreak.

6.0 Conclusion and Recommendations

Public health specialist make decision every day and the health of the population depend on it. In situation where decision makers have to judge between known and unknown facts about a problem, implementing the rational model approach in decision making enable appropriate, efficient and effective resolution in yielding the best possible outcome. Decision making on public health differs from one problems to another and even from time to time depending on the current health situation. Thus, decision making approach can be based on any theory that cognate with desirable goals.

Declaration

Authors declare that this manuscript has never been published in any other journal and it was written as a part of assignment in the Health Service Management course (Master of Public Health), Department of Community Health, Universiti Putra Malaysia, under the title decision-making theory.
Authors contribution

Author 1: information gathering, preparation and editing of manuscript
Author 2: information gathering, preparation and editing of manuscript
Author 3: information gathering, preparation and editing of manuscript
Author 4: information gathering, preparation and editing of manuscript
Author 5: final review of manuscript and final editing

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