

## Predicting the misconception of dengue disease based on the awareness survey

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### ABSTRACT

Mosquito-borne disease such as dengue fever is a pervasive public health problem around the world and further investigation is needed to rectify the misunderstanding of the disease among communities. This requires a personalized information delivery, which will effectively fix the problem. The process of personalizing information requires several major steps: (i) determine the attributes which will be used to interpret a person, (ii) selects an algorithm which will accurately and efficiently classify the person according to the retrieved background information, and (iii) recommends the correct information to rectify the particular misunderstanding. This research paper considers the first two steps. First, data regarding the knowledge, attitudes and prevention practices are determined from the established literature where some variables give a significant impact on the predictive model. In the second step, five performed machine learning algorithms were tested for the classification task. The result indicates that the use of support vector machine and decision tree algorithms provide the best performance in classifying the person's understanding regarding the dengue fever.

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## 1. INTRODUCTION

The rate of mosquito-borne diseases (MBDs) outbreak is always increased every time the seasons change due to various factors such as socioeconomic and environmental changes, socio-geographical, imported cases and human movement patterns [1, 2]. All of the elements can continue the mosquito propagation and increase the difficulties of controlling the MBDs as predicting the future consequences in a changing environment demands a greater understanding of the array of biological and environmental features [3]. Current MBDs outbreak prediction systems were developed based on environmental factors such as flood, types of building, daily mean temperature, daily rainfall and vegetation index [4-7]. House Index and Breteau Index features were also often included in the predictive model to denote the risk areas [8]. Most studies have proven that climate change gives a significant impact on the increasing risk of dengue cases by using a data mining classification algorithm [9, 10]. Obtaining such data requires constant observation around the hotspot area, but, the environmental monitoring system alone still cannot decrease the infection of dengue virus [1].

To improve the prediction framework, the morbidity rate forecasting works better when the vectors like *Aedes aegypti* and *Aedes albopictus* female mosquitoes and larvae index were selected as parameters as

reported in [11]. Thus, this generates an idea to include the attributes based on the human behaviors regarding the MBDs as in [12-18] and put it into the predictive model to classify one's misconception in a personalized e-learning system. This research proposes the human knowledge, attitudes and preventive practices to be included in the machine learning approach in order to identify and provide a simple MBDs awareness program in a personalized e-learning environment. The proposed predictive framework for the personalized e-learning environment is illustrated in Figure 1.

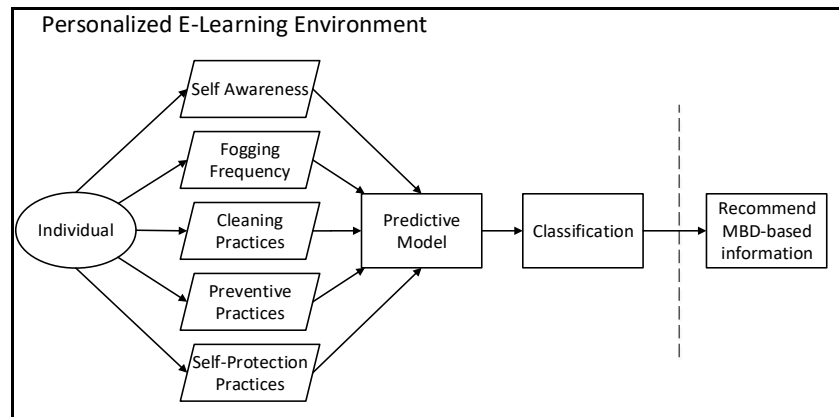


Figure 1. A predictive system to classify the user's misconception of MBDs in a personalized e-learning environment

To curb the MBDs particularly in hotspot areas, it is important to ensure that members of the public have adequate awareness through effective educational intervention. Social media usage such as Facebook and Twitter were the preferred source of dengue information among the public [19]. Health stakeholders of many countries often tweet and create a special posting to announce the epidemic outbreak of dengue in certain areas. This includes how to control the endemic and to provide early information about disease detection to the public. However, accessing such information might be hard for the people who lived in the rural and remote areas. Relevant MBDs-based information can be recommended to mold positive attitudes and educate the best preventive practices among the children. For instance, personal attributes and environmental factors such as region, specific location features and climate contexts were used in [20] to predict the human's risk of contracting infectious diseases. While in [21], an application is also made for the user to submit the information related to mosquito prevalence (e.g. felt, seen, bitten, heard mosquitoes). The public also can report the presence of *Aedes* that is a vector mosquito at the current location immediately and report dengue cases in the household or surrounding communities. This open application requires active citizen engagement and combined with other data, such as ovitrap egg counts and micro-climate data to propose the stakeholders proactively in disease prevention, control and education. However, the application might faces underreport when there is no participation from the people at certain places.

## 2. RESEARCH METHOD

Dengue knowledge, attitudes, and practices surveys have been conducted frequently to describe the communities' prevention towards the disease. It is expected that the knowledge of dengue and *Aedes* is high among the public due to the good risk practices for dengue and good risk perception that have been promoted through mainstream media and in education. An online community-based survey was carried out on the 1st September 2018 until 10th December 2018 with 640 respondents of the Malaysian public aged 7 years old and above. The questionnaire is posted and shared in a few Malaysian Facebook science-based pages and other groups.

The self-administered structured questionnaire covered all aspects of demographic profiles include gender, age, marital status, education level, and housing type. Concerning the awareness of the dengue issue, the participants need to answer general knowledge of mosquitoes such as the mosquito's breeding sites, mosquito's prevention method and mosquito's active biting time. Concerning to the awareness of dengue presence and prevention practices, the participants were asked to provide information regarding the fogging frequency in their living area. The fogging activity, in this context, was interpreted as their location might be a hotspot area or not. This follows a section on thirteen questions in the True/False setup relevant to cleanliness, trash management, water reservoir management and mosquito repellent usage. The logical flow

of the questionnaire culminated as a part of the action by the study participants associated with the general knowledge of mosquito behavior.

The online survey is the fastest way to collect data as respondents' backgrounds are varied while keeping their anonymity. The items on the questionnaire were adapted from previously validated instruments with some modifications to meet the research objective. Close-ended questions are used to enhance the simplicity and easiness of analysis. Respondents just need to choose the best answer according to their existing knowledge.

Both descriptive analysis and machine learning were used in the experiment. Descriptive analysis was utilized to summarize the socio-demographic such as age, gender, marital status, ethnicity, highest education and type of residence. The machine learning algorithms were tested on 18 attributes of individual knowledge, attitudes and practices such as cleanliness; waste management; clogged drains and stagnant water handling; aerosol spray or mosquito repellent usage; cloth types and color usage, and the misconception of mosquito's breeding site, mosquito's active bite time and dengue disease transmission. Table 1 described the selected features that are found relevant to the proposed framework.

Table 1. Selected features mapping to the personalized e-learning environment

No.	Features	Importance
1.	Aware of the <i>Aedes</i> mosquitoes presence within the living area	To promote mosquito control practices through educational programs where strategies related to environmental management can be developed for mosquito control when there is an appearance of it.
2.	Fogging in housing area frequency	To identify the availability of stagnant water that are not disposed of properly or taken care of by the communities as a potential breeding site.
3.	Cleaning the area around the house	To identify the practices of cleaning where everyone lived in a different area and they might have a different set of attitudes and practices of the cleaning habit.
4.	Dumping trash in the right place	
5.	Dumping trash that can hold water in the right place	
6.	Cleaning the drains or clogged waterways frequency	
7.	Closed or discarded water reservoir before a long vacation	To identify the level of preventive practices where different demographics might have a different type of water management in their living space.
8.	Checking larvae at the water reservoir	
9.	Putting Abate/chemicals in water reservoirs to avoid larvae	To identify the level of self-protection practices as the smallest effort that can be done to avoid mosquito's bite.
10.	Wearing long-sleeved shirts and long pants to prevent mosquito bites	
11.	Using mosquito repellents such as liquids, coils, or trap in the living area	
12.	Using an aerosol spray to disperse mosquitoes in the dark area	
13.	Wearing bright colored clothes to avoid mosquito bites	
14.	Sleeping in the mosquito net	
15.	Applying mosquito repellent cream on the body	

The machine learning algorithms training and testing were performed by using WEKA application, a data mining application developed at the University of Waikato in New Zealand. Different kinds of predictive models were built and the forecasting performances of those models were evaluated. The algorithms used in the model building are support vector machine (SVM), decision tree (DT), Logistic regression (LR), naïve bayes (NB) algorithm and artificial neural network (ANN). Tenfold cross-validation technique was utilized to obtain the accuracy of each algorithm in classification. Such classification algorithms comparison had been done to predict the chronic kidney disease (CKD) where naïve bayes performs the highest accuracy [22].

### 3. RESULTS AND DISCUSSION

There are 640 respondents who administered the online survey. When the gender ratio is concerned, the relative proportion of females respondents was higher (80%) when compared with male participants Table 2. 76.4% of the respondents are aged 18 to 40 years old, 12.5% aged 7 to 17 years old and 11.1% aged more than 40 years old where more than 60% of them are married. The largest number of the respondents is coming from the Malay ethnic group (93.1%) followed by others (Chinese, Indian, Dusun, Kadazan, Melanau, Bidayuh, Brunei, and Iban). Most of the respondents have attained tertiary education (73.5%) followed by secondary school (26%) and primary school (0.5%). This illustrates that most respondents are well educated and should have minimal knowledge of MBDs especially dengue fever. It is also found that most of the respondents lived in a terrace or a twin house (43.7%).

Amongst the survey participants, 91.9% of respondents declare that they are aware of the presence of *Aedes* mosquitoes in their area shown in Table 2. When asked about the frequency of fogging in their residential area, more than 10% of respondents reported that it always happens in their place. Over 50% of respondents described that their house has medium to many plants, and near 70% of them are living out of the urban area.

Table 2. Demographic information about participants surveyed

Characteristics	N	%
Sex		
Female	512	80
Male	128	20
Age (range)		
7-17	80	12.5
18-40	489	76.4
41+	71	11.1
Marital Status		
Married	409	63.9
Single	231	36.1
Ethnicity		
Malay	591	93.1
Others	49	6.9
Highest education		
Primary school	3	0.5
Secondary school	166	26
Tertiary education	470	73.5
Types of residence		
Flat/Apartment/Condo	168	26.3
Terrace/Twin House	280	43.7
Bungalow/Village house	192	30

The majorities of people surveyed have never experienced dengue fever; however, near 20% of them have gone through it before. It is found that 18% of respondents did not clean the area around their house and there might be a correlation to the rise of the dengue fever. Furthermore, it is also reported that the prevention practices among the respondents were very high, where 98.9% of them throw the trash in the right place.

It is found that more than 80% of respondents were disposing of the rubbish that can hold water in the right place; ensure the water reservoir is closed or discarded before a long vacation, and; always check the water reservoir to avoid larvae. Additionally, the number of other characteristics has varied where near 30% respondents have never cleaned the drains or clogged waterways; 28% of them did not use an aerosol spray to disperse mosquitoes at dark area; near 40% respondents did not use mosquito repellent such as liquids, coils, or trap in their living area; and only 25% respondents put abate or chemicals in water reservoirs to avoid mosquito larvae. Furthermore, near half of respondents wear long-sleeved shirts and long pants to prevent mosquito bites and wear bright-colored clothing to prevent mosquito bites. Only 3.9% of respondents used a mosquito net for sleeping and 11.4% apply the mosquito repellent cream to their body.

Although 91.1% of respondents declared that they were aware of the *Aedes* mosquito's appearance, there were 67% of respondents who cannot answer the three questions correctly as illustrated in Table 3. Thus, they are classified as having a misconception of the MBDs issue. The previous study shows the majority of respondents just finished secondary school and only 54.6% of them have a high level of knowledge regarding the dengue infections [15]. This result indicates that the current number of misconceptions is very high among the public although they are highly educated. Respondents might think they have sufficient knowledge regarding the dengue through the information they obtained from the television, newspaper, radio, social media, and awareness campaign, but that might not comprehend or half delivered where more than half of them are found unable to answer the questions correctly. Therefore, it is very important for the education stakeholders to include the prediction system into their e-learning system to identify the target users and increase their MBDs awareness in a personalized manner.

In order to correctly identify a person's understanding regarding the MBDs issue, the performance of selected machine learning algorithms was evaluated. The selected algorithms will be used for training and testing to classify the person whether they need further intervention based on the 18 features as listed in Tables 3 and 4. The true-positive (TP) rate, false-positive (FP) rate, precision, recall, F-measure, and time took to build the classifier are presented in Table 5 for each algorithm. It is found that the SVM and DT are the most precise algorithms to classify the person's misunderstanding with the precision of 0.994 and 0.008 false-positive rate. However, DT took lesser time than SVM to classify due to the input type was categorical and not continuous. Surprisingly, ANN performs inferior to the logistic regression model as the model-building process is less complicated for logistic regression, and may be considered not worthy of the artificial neural networks. In fact, the ANN model can be seen as nonlinear generalizations of logistic regression, and thus at least as powerful as that model which in this case, it was not significantly better to use neural networks.

Based on the result, the DT algorithm is found suitable to be used in the predictive model to support the objective of the research. Traditional dengue fever classification by using Naïve Bayes algorithm has

been conducted in [23] to identify positive or negative results, based on several attributes such as fever, bleeding, flu, myalgia, and other symptoms with the precision of 0.92. As in [24], the DT algorithm has been used to predict patients with severe dengue that may warrant admission based on several variables (e.g. vomiting, pleural effusion, and systolic blood pressure) which return precision rate up to 0.81. It is also has been used in [25] to propose a patient-monitoring plan and outpatient management of fever in resource-poor settings by using the clinical features and laboratory indicators to identify the severity of the dengue cases.

A study suggests the increase of knowledge through social media can influence the positive attitude and practices of dengue prevention measures [26]. However, social media alone cannot be personalized to fulfill the criteria as human attitude regarding the MBDs was not taken into consideration. This study is proposing the misconception of the disease can be identified among the public in the form of a quiz upon using the e-learning system. Once the system obtained enough information regarding the user's awareness background, it will analyze and personalized the relevant information regarding the MBDs between the learning sessions. The information is also can be fed directly to the target user, such as the children. His can be done based on a few rules where the children might be at a very young age of using the Internet or the children who lived in rural areas. Otherwise, feeding such information to a non-target user will be wasting the resources. Further investigation is needed to identify the differences of culture, socioeconomic background, and location which may also contribute to the preventive practices among the children. Thus, this paper highlights the big opportunity for the health authorities and education stakeholders to promote such campaigns through e-learning systems or any available open learning platform.

Table 3. Awareness of dengue presence and prevention practices

No.	Features	N	%
	I am aware of the presence of <i>Aedes</i> mosquitoes in my area		
1.	Yes	588	91.9
	No	52	8.1
	What is the frequency of fogging in your housing area?		
	Always	65	10.2
2.	Sometimes	173	27
	Seldom	280	43.8
	None	122	19.1
	I often clean the area around the house		
3.	Yes	525	82
	No	115	18
	I dump trash in the right place		
4.	Yes	633	98.9
	No	7	1.1
	I dump trash that can hold water in the right place		
5.	Yes	559	87.3
	No	81	12.7
	I often clean the drains or clogged waterways		
6.	Yes	460	71.9
	No	180	28.1
	I make sure the water reservoir is closed or discarded before a long vacation		
7.	Yes	552	86.3
	No	88	13.7
	I always use an aerosol spray to disperse mosquitoes in the dark area		
8.	Yes	461	72
	No	179	28
	I always check the water reservoir so there are no larvae		
9.	Yes	547	85.5
	No	93	14.5
	I use mosquito repellents such as liquids, coils, or trap in my living area		
10.	Yes	395	61.7
	No	245	38.3
	I put Abate/chemicals in water reservoirs to avoid larvae		
11.	Yes	161	74.8
	No	479	25.2
	I wear long-sleeved shirts and long pants to prevent mosquito bites		
12.	Yes	324	50.6
	No	316	49.4
	I wear bright colored clothes to avoid mosquito bites		
13.	Yes	310	48.4
	No	330	51.6
	I sleep in the mosquito net		
14.	Yes	25	3.9
	No	615	96.1
	I always apply mosquito repellent cream on my body		
15.	Yes	73	11.4
	No	567	88.6

Table 4. Knowledge of *Aedes* characteristics

No.	Questions	N	%
	I know <i>Aedes</i> mosquito breeding in the following areas:		
	Stagnant water		
1.	Septic tank		
	Drain with waste		
	Container with clear water		
	I know <i>Aedes</i> mosquitoes actively bites at the following times:		
	Dawn		
2.	Afternoon		
	Evening		
	Night		
	How is dengue transmitted?		
	Mosquito bites		
3.	Contaminated and exposed foods		
	Don't know		
	Correctly answer all questions	211	33
	Incorrectly answer some/all questions	429	67

Table 5. Performance comparison of the classification algorithms

Algorithms	TP rate	FP rate	Precision	Recall	F-measure	Time taken (second)
NB	0.991	0.009	0.991	0.991	0.991	0.01
LR	0.991	0.012	0.991	0.991	0.991	0.24
ANN	0.986	0.012	0.986	0.986	0.986	6.32
SVM	0.994	0.008	0.994	0.994	0.994	0.16
DT	0.994	0.008	0.994	0.994	0.994	0.05

#### 4. CONCLUSION

Based on the awareness survey, the majority of respondents applied good practices in dengue preventive measures. An effective prediction model to detect the MBDs misconception is still needed to identify the communities' awareness and enhance their knowledge by recommending information about dengue prevention and early symptom recognition. A predictive system should be embedded to analyze the user's behavior and provide personalized information. Several features that have been selected for the study are found relevant for the proposed framework. This research proposes the Decision Tree algorithm in the predictive model construction of the online dengue awareness program by taking into account the human behavior and their current knowledge regarding the MBDs. The research focuses on *Aedes* and dengue transmission due to the high number of dengue fever and dengue hemorrhagic fever cases in Malaysia compared to other MBDs. Considerably more work is needed to identify features and causes of other MBDs such as Malaria, Zika, and Chikungunya including geospatial analysis and environmental factors.

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