DengAway

A self-screening application for prevention and early detection of Dengue

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Abstract. Since user-centered information about dengue is limitedly available to the local public and even more limited in the Malaysian language, a need for centralized easy-understanding information in the Malaysian languages (i.e. English and Malay) has evolved. On top of that, insufficient communication may cause the lack of awareness within the Malaysian areas. A lot of people don't take precautions against mosquitoes and people living in risk areas often don't know how to do this. In addition, once people might suspect dengue, they hardly visit a doctor, which may cause risks and dangerous situations that could have been prevented. On top of that, having dengue without knowing or realising the risks may lead to an even faster spread of the virus. A centralized, easy-understanding information system with a self-screening tool may increase awareness. The aim of the current report is to describe an application to improve healthcare around dengue by early detection, increasing knowledge and raising awareness. The application includes both a self-screening tool as well as information on the virus, mosquitoes and protection. This will stimulate proper treatment of dengue and will raise awareness to eventually prevent the virus spread.

Keywords. Dengue, fever, Malaysia, self-screening, awareness

Contents

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1. Introduction

Dengue is an increasingly large problem in the Western Pacific Region and South-East Asia. Between 2001 and 2008, Cambodia, Malaysia, the Philippines and Vietnam had 1.020.333 reported cases between the four of them. From all of these reported cases, 4798 were fatal (WHO, 2019). However, over the years, the knowledge of the disease and management of dengue has improved. The oldest reports of dengue in Malaysia data back to 1902 (Kumarasamy, 2006). Unfortunately the amount of infections has increased vastly ever since. Malaysia is one of many countries in South-East Asia that are dealing with the issues of control and prevention of dengue. One way to improve this is by raising awareness for the disease and how you can prevent it. A second one is by early detection and treatment of infected individuals. Luckily, the healthcare system in Malaysia provides cheap healthcare since it is mostly funded by the government. There are many government clinics spread across the country to ensure proper care for its inhabitants. Unfortunately, the lack of knowledge causes a delay in help-seeking by the local communities, and some do not reach out for medical care at all.

This report describes the use case of early diagnosis and increased awareness of dengue. Using an ICT application, we aim to enable people to screen themselves for the disease and to provide them with advice accordingly. Additionally, the application will have an information page to provide the user with information about the disease and how to prevent infection. Some relevant literature will be discussed and afterwards we will look into the use case in depth in order to determine what kind of application we will build. This will then be used to develop a suitable solution, which shall be tested by the local community. Their feedback will in turn provide us with valuable information on the application and its contents. A value evaluation will be used to evaluate the sustainability of the model itself and the application. To conclude the report, suggestions for future works will be given and discussed thoroughly.

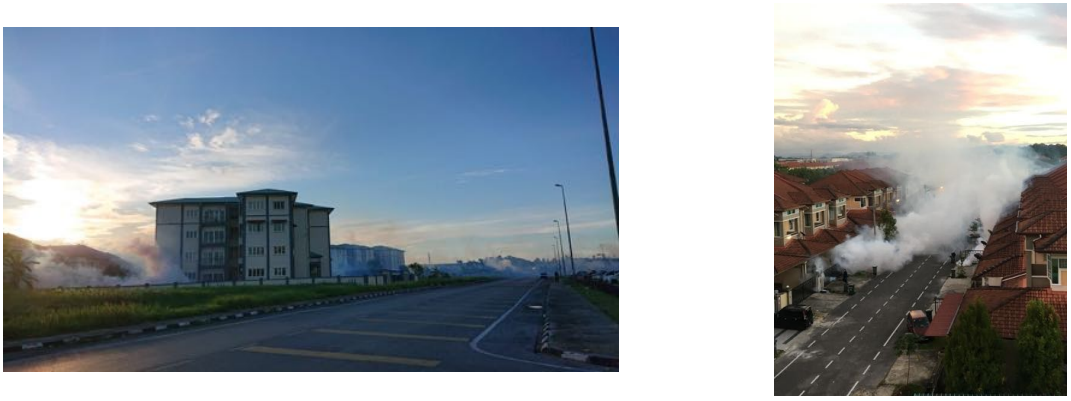
2. Relevant literature

Dengue is a disease that can be found in tropical and sub-tropical climates and is most prevalent in urban and semi-urban areas (WHO, 2019). The first case of dengue fever in Malaysia was reported back in 1902 and the first case of Hemorrhagic Dengue Fever in 1962 (Kumarasamy, 2006). Since these first cases, incidence has increased quickly, accompanied by an increase in mortality. For example, in 2013 there were 43,436 confirmed cases of dengue in Malaysia. However, in 2015 this had increased to 120,836 (Ghani et al., 2019). In Malaysia, something is considered an outbreak if there are more than 4 cases.

Dengue is widely known as inherently difficult to diagnose. Poor public knowledge about dengue symptoms also resulted in delays in medical help-seeking (Wharton-Smith et al, 2011). Dengue education should be done more frequently for people with a lower educational background and low income households (Ghani et al., 2018). Zaki et al. (2019) found out that more education and information on the influence of climate on dengue cases is required to increase public perception and response towards a dengue early warning system. Surprisingly however, people in hotspot areas are equally well informed as people in non-hotspot areas (Ghani et al., 2019). The majority of people in non-hotspot areas believe that they play a role in the prevention and control of outbreaks, whereas a lot of people in hotspot areas do not think that they can help prevent outbreaks.

One of the reasons that dengue awareness and prevention is important, is because of its serotypes. Dengue has four serotypes and infection with one will make you resistant for that particular type. However, its antibodies will respond more aggressively to infection with another serotype, making

that second infection a lot more dangerous to the host. The various serotypes are transmitted by mosquitoes of the *Aedes* family, but mainly by the *Aedes Aegypti*. This mosquito can be recognised by the white markings on its legs, and is most prevalent in tropical and subtropical areas between the latitudes of 35 °N and 35 °S. These areas are consistent with minimum winter temperatures of 10 °C. The *Aedes* mosquito cannot survive lower temperatures, which also implies that the mosquito is quite uncommon in areas higher than 1000 metres. The virus can only be transmitted by female mosquitoes, who prefer to spend their lives around the places where they matured. These often consist of standing water habitats, such as ponds and artificial containers (WHO, 2019). One of the methods used by the Malaysian government to target *Aedes* mosquitoes is 'fogging'. Fogging is a method in which insecticides are blasted through a machine together with water. This causes very small water droplets containing the insecticides to be spread across an area in order to exterminate adult *Aedes* mosquitoes (Oki et al., 2011). Even though the effectiveness of fogging is under heavy discussion, it is the preferred method for vector control whenever an outbreak area is identified.



(A) *(B)*

Figure 1. Fogging in the area of UNIMAS.

After infection, an incubation period of 4 to 10 days starts. Most infections are asymptomatic or subclinical (Halstead, 1974). For those who do show symptoms, multiple risk factors influence the severity of the disease and its symptoms, for example age ethnicity and any chronic diseases the patient might be suffering from. Mahmood et al. (2013) found that people suffering from bronchial asthma and pulmonary tuberculosis have a bigger chance of developing Dengue Hemorrhagic Fever and Dengue Shock Syndrome. It has been shown that having two or more comorbidities significantly increases the risk of organ involvement in people suffering from dengue (Pang et al., 2017). Not only serious chronic illnesses such as cardiac disorders, diabetes and bronchial asthma increases the chances of DHM and DSS, but also more common conditions such as obesity and allergies might play a role in this (Figueiredo et al., 2010). Most severe dengue cases originate from secondary infection and may lead to hemorrhage and shock. Especially young children are at risk and have a higher chance of Dengue Shock Syndrome (DSS) at primary infection (Sangkawibha, 1984). The classification of the types of dengue has become increasingly difficult to maintain over the past years. There are three categories, undifferentiated fever, dengue fever, and dengue hemorrhagic fever. The latter is in turn divided in four grades. Grade three and four are then defined as dengue shock syndrome (WHO, 1997).

In addition to the multiple categories of the disease, dengue has many possible manifestations. In figure 2, the difference between warning signs, criteria for probable dengue and criteria for severe dengue can be found. As can be seen, probable dengue has symptoms that are consistent with multiple diseases. This is one of the reasons that dengue is often hard to diagnose and even misdiagnosed (Kumarasamy, 2006).

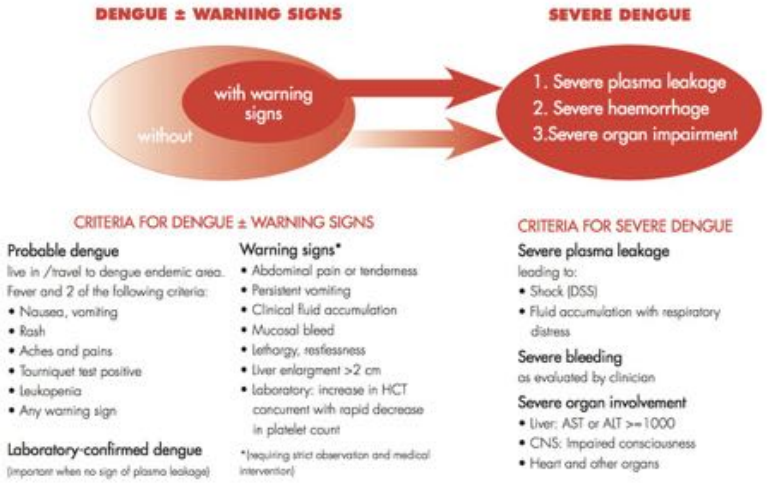


Figure 2. Warning signs and symptoms of (severe) Dengue.

3. Use case description

3.1 Interviews

All transcripts can be found in appendix 1.

3.1.1 Interview with Dr. Jane

During our interview with dr. Jane, we pitched our two ideas to her. We wanted to either make a hotspot mapping application, which would send alerts when you are in or enter a hotspot area, or a self-diagnosis tool which allows users to evaluate their symptoms and get advice on how to proceed. She indicated that both ideas are very interesting and could help the local community. However, she admitted that it is difficult to retrieve data about dengue from for example the government. She is currently working on mapping hotspot areas, but unfortunately we cannot use the same data due to privacy regulations. She told us that, considering the short period of time available for this project, the self-diagnosis might be the best option since that is very valuable for the locals, but also more realistic within four weeks.

3.1.2 Interview with Dr. Razitasham

Dr. Razitasham from the department of public health at the medical faculty of UNIMAS was also prepared to listen to our pitches about the two ideas. She as well was mostly enthusiastic about the self-diagnosis tool since it could be valuable for the community. Additionally, she has already helped us with brainstorming about possible questions for the application. As far as the hotspot mapping concerns, she indicated that it has been attempted before, but that it is very hard to get an accurate representation of the current situation due to data sharing restrictions. She told us that it might be interesting to look into expanding the application to multiple mosquito-borne diseases.

3.1.3 Interview with a patient

We interviewed a patient, which was one of our fellow students. Unfortunately, he was diagnosed with dengue in the second week we spent in Malaysia. Due to this diagnosis, he could not finish the course. We interviewed him in order to get an idea of how it must feel to have dengue. Additionally, we used his answers to check if our questions for the self-diagnosis application were accurate.

3.1.4 Second interview with Dr. Razitasham

After some idea development, we returned to Dr. Razitasham to evaluate the questions we are going to ask in the self-diagnosis application. She gave us advice on the layers that we use and the terminology of the questions and advice. After this meeting we decided to name our application a self-screening tool, since we only give advice and do not diagnose anyone with anything. The doctor also gave us advice on how to inform people and what kind of advice they should receive in each situation. Additionally, she told us a bit more about the healthcare system in Malaysia and the government clinics that are spread across the country.

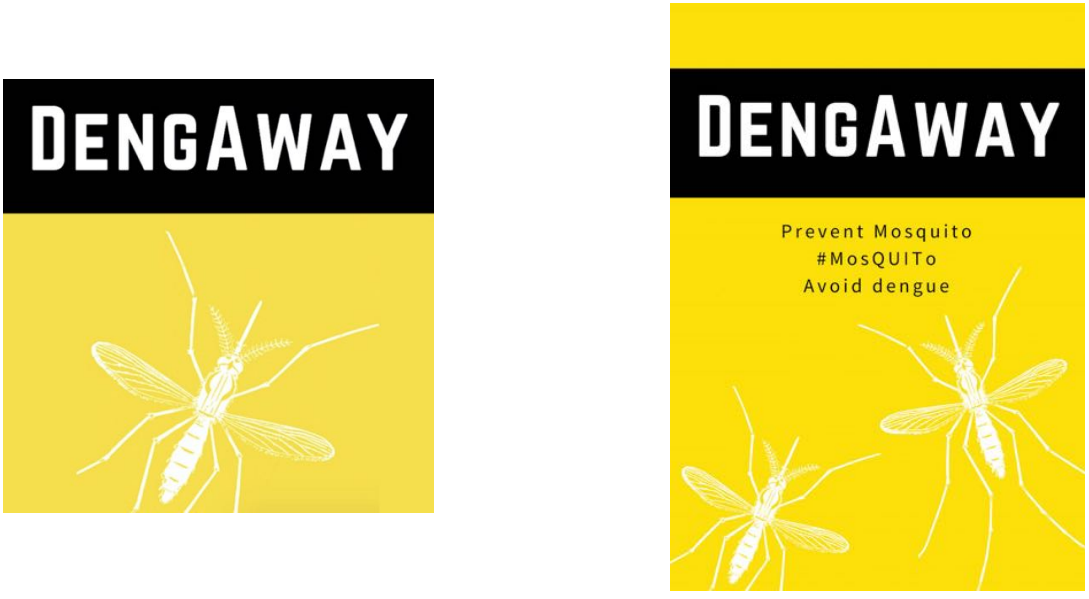
3.2 Name and Logo

3.2.1 Name

The name of our application is DengAway. This is an aggregation of dengue and away. DengAway has been chosen for the application since the aim is to aid the prevention and eradication of dengue in Malaysia. We have considered multiple names and after some brainstorming we decided that this name would be most suitable for the application. However, if the application would be expanded with more mosquito-borne diseases the name would have to be revised.

3.2.2 Logo

The logo has been designed to be simple, yet striking. In figure 3A, the design for the application itself can be found. Figure 3B shows the design that could be used as a folder or poster to raise awareness and make the application known by the general public.



(A) *(B)*

Figure 3. DengAway logo and design.

3.3 Summary of key idea

Mosquito-borne diseases causes millions of deaths among humans every year. One of these is dengue, which incidence has increased 30-fold over the past 30 years (WHO, 2019). Dengue is a flu-like disease which is transmitted by Aedes Aegypti and Aedes Albopictus mosquitoes. After the mosquito bites someone with dengue, it becomes infected and will spread the virus to all his

subsequent 'victims'. Since user-centered information about dengue is limitedly available to the local public and even more limited availability in the Malaysian language, a need for centralized, easy-understandable information in the Malaysian language has evolved. On top of that, a lack of communication may limit awareness within the Malaysian areas. A lot of people don't take precautions against mosquitoes and people living in risk areas often don't know how to do this. In addition, once people might suspect dengue, they hardly ever visit a doctor, which may cause risks and dangerous situations that could have been prevented by treating the disease and its symptoms. On top of that, having dengue without knowing or realising the risks may lead to an even faster spread of the virus. The aim of the DengAway application is to improve healthcare concerning dengue by early detection, increasing knowledge and raising awareness. Both a self-screening tool as well as information about the virus, mosquitoes and protection are embedded in the application which will stimulate prevention of the dengue virus.

3.4 Actors and goals

Table 1. A table with all stakeholders and their concerns.

Stakeholders	**Concern 1**	**Concern 2**
Government/ Health organisation	Lower number of dengue cases (and lower nr. of dengue deaths) for keeping country attractive.	Lower health costs and improving healthcare.
Travelers/ Citizens	Prevent dengue cases by having information about 'dangerous' hours, areas, prevention, and protection.	Know what to do when having or suspecting dengue. Advice based on symptoms.
Bolesian	Want information (in the form of a database) about detecting dengue and corresponding symptoms/areas/etc. to create an app for their customers.	When information is labeled, this can be used to create AI systems to make alert apps a.o. This can be used by european organisations to inform / alert travelers.

3.5 Context and scope

Our application is made for any non-medical expert around the Sarawak region, no matter what income or background. The app is specifically useful for those within the outbreak areas. Insufficient communication may cause the lack of awareness within Malaysia. A lot of people don't take precautions against mosquitoes and people living in risk areas often don't know how to do this. In addition, once people might suspect dengue, they hardly ever visit a doctor, which may cause risks and dangerous situations that could have been prevented. A centralized, easy-understanding information system with a self-screening tool may increase awareness and aid early detection.

The aim of the application is to improve healthcare concerning dengue by early detection, increasing knowledge and raising awareness. Both the self-diagnosis as well as the information about the virus, mosquitoes, and protection will stimulate prevention of the dengue virus. Since the application will advise people to go to the doctor when the probability of having dengue is above a certain threshold, proper cure can be given early in the course of the disease and more knowledge about the spread and development of the virus can be obtained. On top of that, vulnerable groups could be identified and properly cured to prevent progression to severe dengue (dengue hemorrhagic fever).

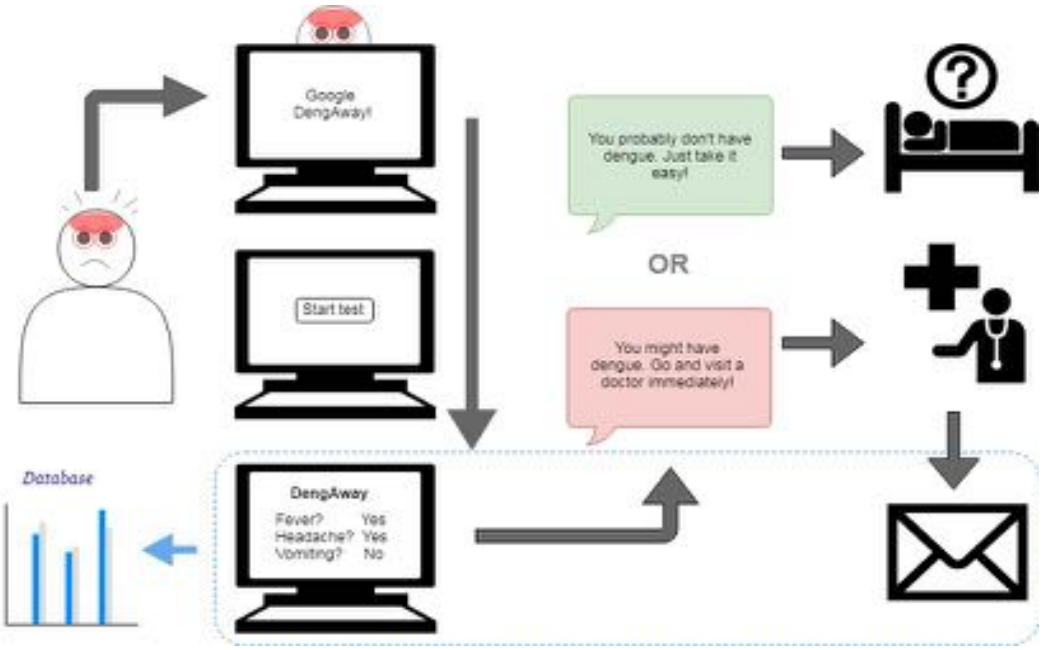


Figure 4. Visual representation of the scenario and the roles of the parties involved.

When a person, traveling to or living in Sarawak, doesn't feel well, or suspects dengue, he/she can find our application via google, relatives or medicals. After some information about the test, the test will start after pushing the start button. Based on the answers to several questions an advice is generated. Subsequently, the user gets asked to enter his/her email address, which can then be used to verify if this was a dengue case or not (i.e. the label). Both the label and the answers on the different questions within the self-diagnosis will enter the database. The database can be made available for both government/health organisations as well as Bolesian. A visual representation of this process can be found above in figure 4.

The scope of our application will span from the moment a user opens the DengAway webpage, until the advice is generated based on the self-screening. The behaviour of the user after receiving advice is not directly included in the scope (whether he/she actually goes to the doctor or keeps rest), but will be asked afterwards via email. Since the user has entered his/her email address, an email will be generated to verify diagnosis by a doctor and to verify what the user has done with the information. This data will, together with the data from the self-diagnosis, enter the database which is the last step of DengAway's scope.

The pilot demonstration should be able to show a webpage which can be visited by any user and via any device. Via this page the user should be able to go to the self-screening app and answer the questions. Depending on the answers, advice will be generated with regard to the likelihood of having dengue and the necessity of going to a doctor. This advice should be negative (you probably don't have dengue) if the person is healthy, and positive (you may have dengue) if the person has an increased risk of being infected with dengue. Following this, the user can enter his/her email address in order to receive a follow up email. In this email, the user will be asked whether he/she followed up the advice given by the application and if they were diagnosed with dengue or not. By entering his/her email address, the user automatically gives consent to the application to anonymously store the data. This data can then later on be used to finetune the self-screening tool and the advice given in the application. Additionally, it could be sold to third parties in order to create more applications with information about dengue or to monitor the cases in a country.

Since DengAway is a web-page, having a sufficient internet connection is required. On top of that, the application is in two languages; English and Malay, so sufficient mastering of one of these languages is required. On top of that, basic knowledge about health is required (i.e. know when fever occurs, know when one has a headache or skin rash). For children or people who lack sufficient communication skills in these languages, a relative may be able to answer the questions for them.

3.6 Needs assessment

At the start of the course ICT4D in the field, we received a document from the lecturers with an email from Bolesian. This email contained input for a Dengue, Zika, and Chikungunya case, which has the aim of providing near real time insight in the viruses causing these diseases. The aim of the case is to give insight into infections and risk regions. This will in turn raise awareness about the diseases, their risks, and the precautions that could be taken. After reading about this case, we started brainstorming about possible solutions. Two ideas were brought up, one mapping hotspot areas, and one providing a self-diagnosis tool.

On June 14th, we pitched these two ideas to Dr. Jane and Dr. Razitasham, both from UNIMAS. Their feedback led to the conclusion that a self-diagnosis application would be most valuable to the general public in the area of Sarawak and would also be the most feasible. One of the conclusions that was also drawn from these interviews was that it is very difficult to get data about these diseases for analyses. This is why it was considered more useful to collect our own data on symptoms.

Then, on June 17th, we interviewed a patient who was diagnosed with dengue. He confirmed that there is not a lot of data available on dengue, and that even doctors find it hard to recognize the symptoms of dengue. Even though he knew something was wrong, the doctors only diagnosed him later on with dengue fever. From this interview we concluded that there should be more information on the disease and its symptoms, as well as on prevention of dengue in order to ensure sufficient information and early diagnosis.

Figure 5. The group members with Dr. Razitasham.

From a second interview with Dr. Razitasham, we concluded that it is necessary to also include nearby clinics. Additionally, the application should include some information on the nearest clinics and when you can go to specific centers. During this interview we also decided on the term 'self-screening' rather than 'self-diagnosis', since we are not medical experts and thus cannot officially diagnose a person.

Conclusively, From these interviews we concluded that there is a need for an application that informs and warns the local population. The awareness of dengue should be improved since the disease is a big issue in Malaysia. To lower healthcare costs and mortality rates, early diagnosis is key. This is where our application also steps in. A self-screening tool would allow for easier decision making whether someone should seek medical help or not. This in turn could possibly increase early detection of the disease, which could also result in better control and combat of the disease.

3.7 Use case description

Due to the lack of knowledge about dengue and its symptoms, many people do not visit a doctor in time, or sometimes not at all. This increases the healthcare costs and causes a higher morbidity and mortality. When a person does not feel well, he or she can go online and visit the DengAway website. Here, a self-screening tool can be found. First, the person will have to answer some basic questions about his/her symptoms and environmental risk factors. In case the person is not entirely sure about a question, there will be a button to click on for more information, for example how to know if he/she has a fever. If there is no chance for the person to be infected with dengue, he/she will get advice to rest and drink a lot of water. When there is a reason for concern, the person will have to answer some more questions. In case it is not sure if it is dengue, the person is asked to answer the questions again the next day. When the tool suspects dengue, the person proceeds to the last questions that evaluate whether it is a care of severe dengue or not. Based on the outcome, the person is advised to either go to a doctor within the next hour, or to visit a doctor as soon as possible. The web application also contains information on the disease itself, so that the person can inform him/herself when advised to wait for a bit longer. Additionally, hotspot areas can be found such that the user can determine whether he/she lives in a hotspot area. Furthermore, information on prevention can be found in the application. Here, it is described what the person can do to protect his/her house and him/herself from the Aedes Aegypti mosquito and dengue.

3.8 Interaction and communication

Figure 6 illustrates the stakeholders and their roles in this particular use case. As can be seen, multiple stakeholders have the same interests. Figure 7 in turn shows which interactions take place between these stakeholders in order to achieve the goals that are shown in the use case diagram. As can be seen, most interactions are between the general public, the self-screening tool and the information page. The general public is crucial here since they have to provide information on their symptoms and give consent for sharing this data with third parties such as the government or companies such as bolesian.

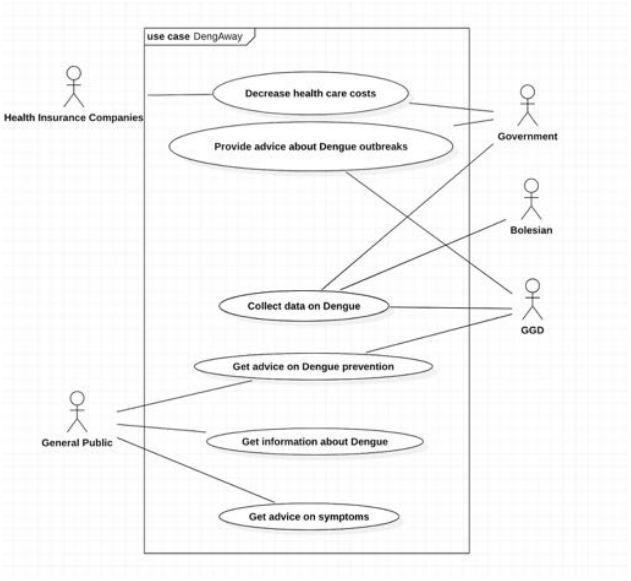


Figure 6. A use case diagram showing the stakeholders and their interests.

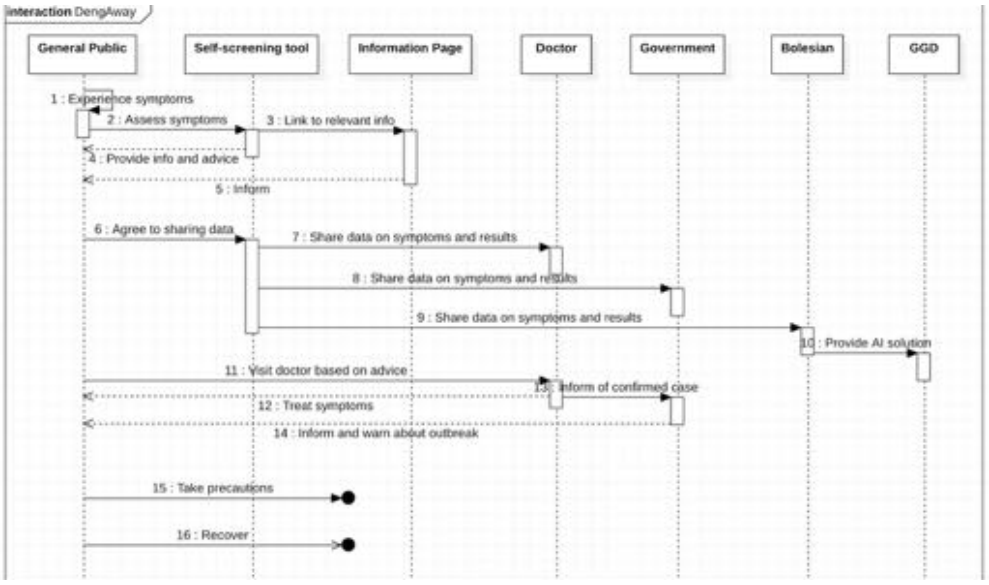


Figure 7. An interaction diagram showing the interactions between the stakeholders.

3.9 Information concepts

The class diagram in figure 8 shows the data model of the DengAway application. The general public has to have symptoms in order to make use of the self-screening tool, and an email address to receive a follow-up email on. They make use of the web application, which has information on dengue itself and information on prevention measures to increase knowledge on the virus. Additionally, the application needs a web address and a domain to be able to reach it since it is web based. This web application contains the self-screening tool. This tool contains questions to assess the symptoms. Based on the risk assessment, it uses an assessment formula to calculate the risk of being infected with dengue and generates advice on how to proceed and what measures should be taken.

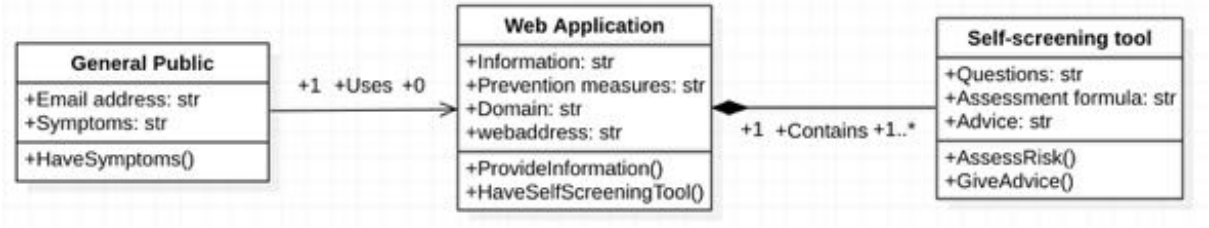


Figure 8. A class diagram of the application.

Figure 9 shows an UML activity diagram with all the actors that are involved in the process of and around the application. To start the process, a user needs to experience some symptoms. They can then access the application and open the self-screening tool. This will provide them with a result and advice based on this result. Some additional information can be given with the advice, but the user can also be redirected to different sections of the application containing more elaborate information on both the disease and how to prevent it. The user can then enter their email address in order to agree to data sharing. This data can then be shared with the government, which can in turn use this data for monitoring outbreaks and taking precautions such as fogging a specific area. The data can also be sold to companies such as Bolesian, which can use it to create products for their clients. The

user can, based on the advice provided by the self-screening tool, decide to take precautions to prevent getting infected with dengue, or go see a doctor in case there is a realistic chance they have already been infected.

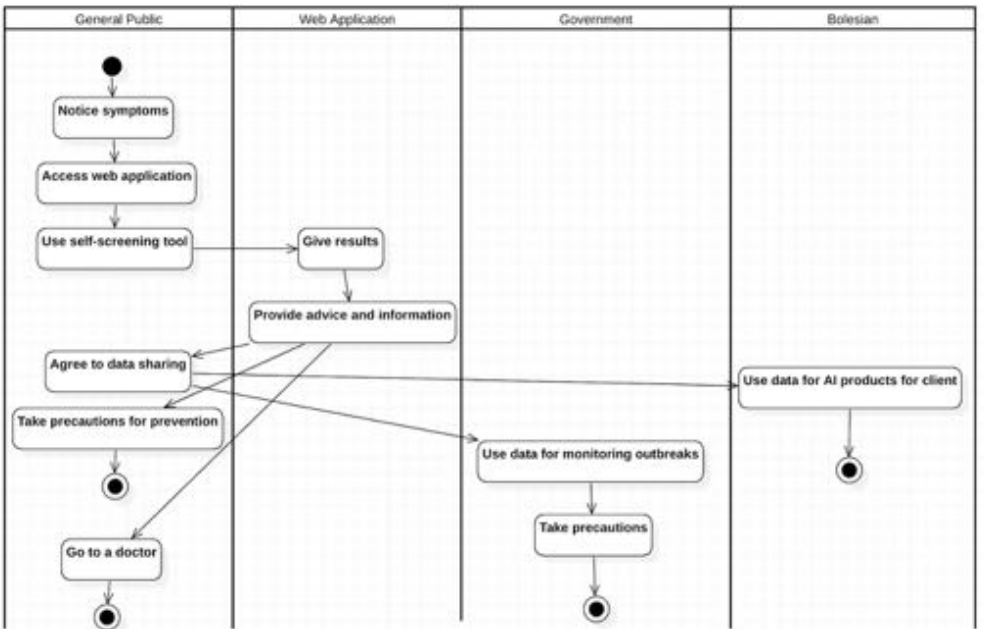


Figure 9. Activity diagram with all stakeholders of the application.

3.10 Technology infrastructure

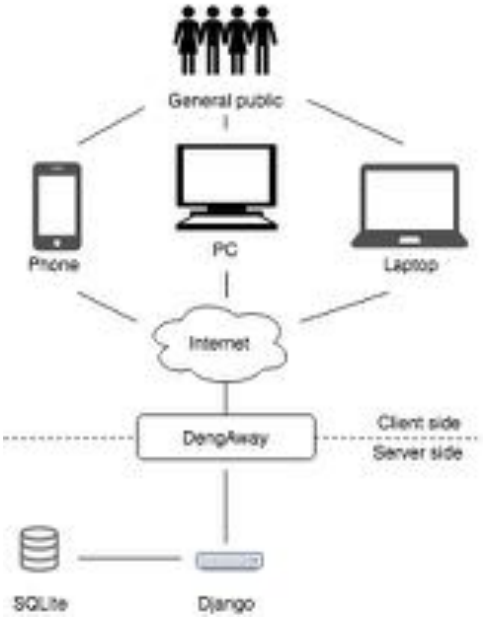


Figure 10. A visual representation of the technology infrastructure of the application.

Figure 10 illustrates the technology that is required for the application. The user will need a laptop, PC or a smartphone that can access the internet. This can be via WiFi or via 4G connection. Then,

they can easily access our DengAway application via their internet browser. On the server side, Django is used to create webpages and a SQLite database is used to store the data.

3.11 Cost considerations

Table 2. A table containing all expenses to be made to create the application and sustain it.

Type	*Costs*	*Paid by*
Web hosting	14.99 MYR/month	DengAway B.V.
Domain name	120 MYR/year	DengAway B.V.
Maintenance		DengAway B.V.
Marketing (i.e. Google adwords)	~4 MYR per click (depending on keyword)	Health care organisation
Internet connection on smartphone (local)	>35 MYR/month	User
Internet connection in home (local)	>89 MYR/month	User

3.12 Feasibility

The technical feasibility of the application is rather high. By combining the knowledge of all team members, it should be doable to implement the self-screening tool. It should also be feasible to connect this to a database and create a web application that contains the self-screening tool. Additionally, it is very doable to create a homepage and some information pages. However, there are some issues that may arise while implementing the application. One of them is the implementation of multiple languages. Malaysia has a wide variety of ethnicities, all with their own languages. Unfortunately, only a fraction of them speak English. This is why we would have to implement the Malay language as well, which could still be quite a challenge. Furthermore, the application should be understandable for everyone. Using the perfect terminology for both the questions of the self-screening tool and the information pages is crucial, yet very difficult since the educational level varies a lot within the local community. Looking at the cost considerations (table 2), it can be seen that most costs will be for the company hosting the application, which is DengAway B.V. for now. The only costs there would be for the users are the internet costs for both smartphone and/or at home. However, most people already have these internet connections and thus this should not be a very big issue concerning the use of our application.

Additionally, our application will be web-based. This implies that a steady internet connection is needed for the application to work. Unfortunately, a lot of rural areas in Malaysia, and more specifically Sarawak, do not have a reliable internet connection. It will also be difficult to actually publish the application, since the government will need to give permission for that. Also, privacy is a major issue for the application since we need to comply to both the Dutch and Malay law considering the use of personal data and anonymization. Illiteracy could also be an issue. To tackle this, it could be useful to implement spoken fragments in the future so that illiterate and blind people can also use the application.

3.13 Key requirements

The MoSCoW table below shows the key requirements of the system.

Table 3. Table describing MoSCoW elements of the application.

Must have	*Should have*	*Could have*	*Won't have*
- Application that enables you to answer questions and gives you an advice based on this. - Application available in both Malaysian and English. - Available via internet. - Easy to understand, anyone should be able to use it. - Information on prevention and general information. - Extra information available with questions.	- Available for phones, tablets and laptops. - Risk Areas in the neighbourhood. - Tested and evaluated by potential users during iterations. - User friendly interface to change the content to other languages/symptoms including a manual. - Option to enter email address for follow-up email. - Collecting information about 'action of user' after advice and dengue diagnosis via email afterwards.	- Learning algorithms to predict the next outbreak. - Hotspot areas notification. - Collecting information of application input/usage. - Offline availability, for example in the local network of Kampungs - Extension to other diseases. - Link with iDengue. - Crawled information from other platforms. - Extension for medical specialists. -Indication of the nearest medical clinic.	- An overflow of amount of questions. - Medical approved official prognosis, it's just a risk analysis/advise. - Too elaborate information.

As can be seen from table 3, our application will need questions in both English and Malay language and give advice based on the answers that the user gives. It should be available via the internet and be easy to understand. It has to not only provide extra information with the questions, but also general information and information on prevention. These are the minimum requirements for the application to be useful and valuable. To expand the application, we could make the application suitable for not only computers, but also laptops, phones and tablets. It should be evaluated by users to check if the interface is user friendly and the content is accurate. In order to collect information about the users, their symptoms, and the application itself, we could implement an option for the user to enter an email address to both give consent for storing the data and sending a follow-up email to ask what actions the user took and if they were diagnosed with dengue or not. Possible extensions for in a later stage would be implementing hotspot areas and alerts in the application. This way, users can receive an alert when they are in or are entering a hotspot or high risk area. Additionally, we could then also indicate the nearest medical clinic in case they need to visit a doctor. We could also add extensions for other diseases, such as malaria, zika, and chikungunya. It might also be useful to create an interface for medical experts or the government to monitor the disease in the area. Offline availability would also be good, since many kampungs have bad internet connectivity. This application will not have medically approved diagnosis, hence the change from self-diagnosis to self-screening. It will also not have too many questions or too elaborate information on the different subjects.

4. Final system design decisions

The background of the application is based on the logo that was discussed earlier. By analysing the color of this background, a suitable color was chosen for indicating the current page. We decided on

green, which also matches the progress bar of the self-screening tool. The background for the language selection and homepage has been darkened a bit to allow for a calmer opening of the application.

4.1 Homepage

Before the user gets to view the homepage of the application, he/she is presented with a language selection screen as shown in figure 11. To facilitate the selection, the flags of Malaysia and the United Kingdom have been used. When a user hovers over the flag, the languages are displayed in written text as well to ensure understanding of the flags.

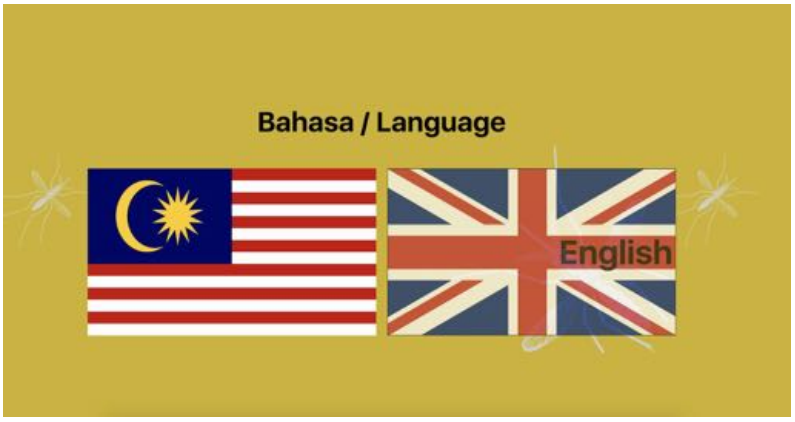


Figure 11. Language selection screen

After selecting the language, the user proceeds to the actual homepage that is shown in figure 12. Since the design is the same for both languages, only the english version of the designs will be shown from now on. We have chosen to make the self-screening the center of attention. All other sections of the application can be found in the buttons below the main text of the page to ensure that they can be easily accessed without drawing the attention away from the self-screening tool. A slight effect has been added to the homepage to make it less static.

Figure 12. Homepage screen

4.2 Information page

The information page contains only the most basic information on dengue. The goal of this page is to inform people about the disease without providing them with an information overload. To make sure people will actually read the entire page, the information has been kept brief. Some information about the disease in general, the Aedes mosquito, the different serotypes, and what you can do if you

suspect dengue is given. Additionally, the page contains links to more elaborate information on different websites.

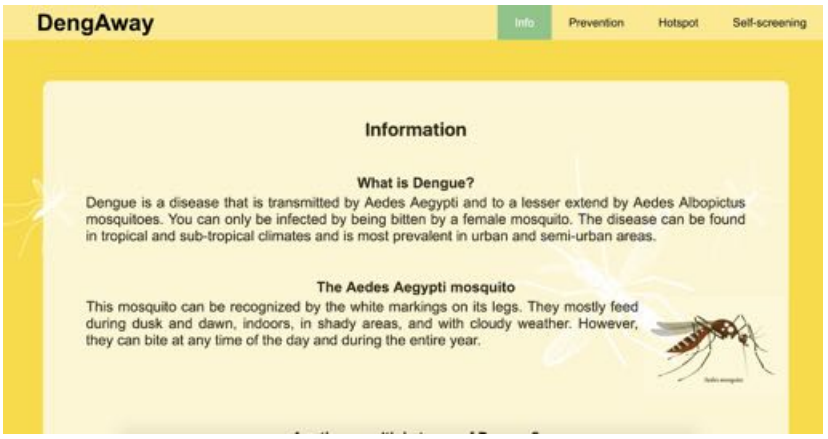


Figure 13. Part of the information page

4.3 Prevention page

The prevention page gives advice on how to prevent mosquitoes in and around the house and mosquito bites. The information here is short as well to ensure that people will not be overflowed with excessive information.

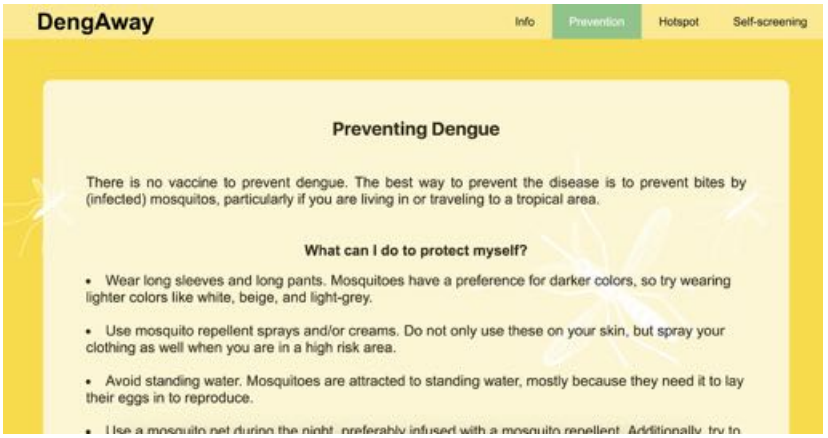


Figure 14. Part of the prevention page

4.4 Self-screening tool

The self-screening tool has the same bright yellow background. At first, users reach a startpage, followed by a privacy statement (figure 15A and 15B). While answering the questions, a green progress bar can be observed at the top of the textbox. This has been implemented in order for the user to know how many questions still remain unanswered. All questions have three possible answers, 'yes', 'no', and 'don't know'. We have decided on the 'don't know' button because people should still be able to use the application even though they might not understand how to verify all symptoms. After completing a sequence of questions, the user receives advice. This is either an end-advice, or a suggestion that the user should answer some extra questions in order to verify the symptoms. Figure 17 shows an example of an advice page.

(A) (B)

Figure 15. Startpage and privacy statement

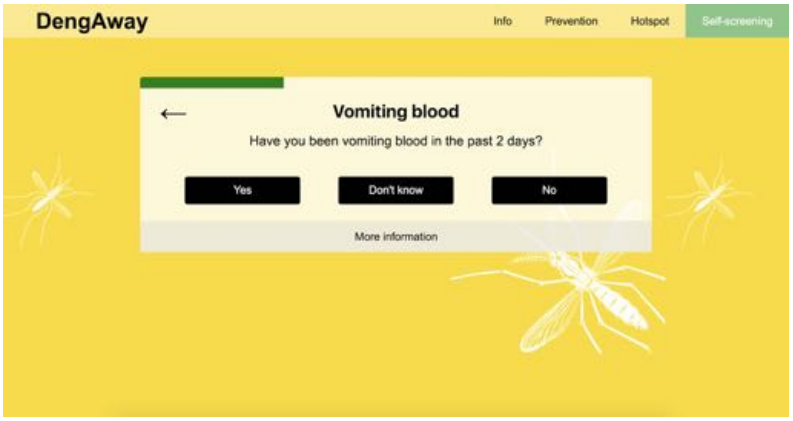


Figure 16. Example of a question page

Figure 17. Example of an advice page

4.5 Hotspot page

The application already contains a page where a hotspot tool could be added. This hotspot tool would complete the application since it would then also actually show risk areas instead of just talking about them. For now, this page contains a link to the iDengue website, which contains information on the current situation concerning dengue in Malaysia.

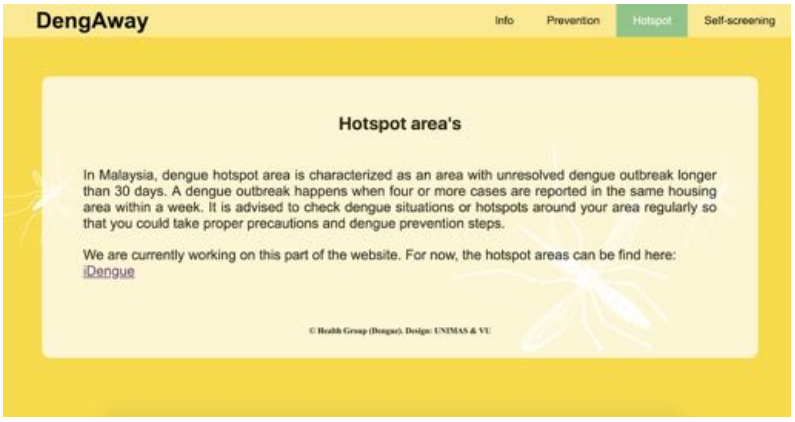


Figure 18. Hotspot page

5. Prototype description

5.1 How to access

Access the application via https://dengaway.w4ra.org/ or download it from the Google Playstore.

5.2 Data model

Figure 19 shows the structure of our database and its attributes. The questions will all have the title and the question itself. Additionally, they will be linked to the next question of that layer. The answers will consist of yes, no, and don't know. Combining these will generate a row that contains both the question and the answer given by the user. The data that will be stored from the user will consist of their email address. the eventual diagnosis, age, location, if the user completed the self-screening, on what date, if the follow-up email has been sent, and if they were eventually diagnosed with dengue. All questions, more information, and answers will have an attribute '_my', that will contain the Malay version of the text. All questions with corresponding answers belong to a layer. The layer combined with the score from the questions has multiple outcomes. It can be no (you don't have dengue), which redirects you to a corresponding advice page. It can also be maybe or yes, which will also redirect you to a corresponding advice page. This applies to all three layers.

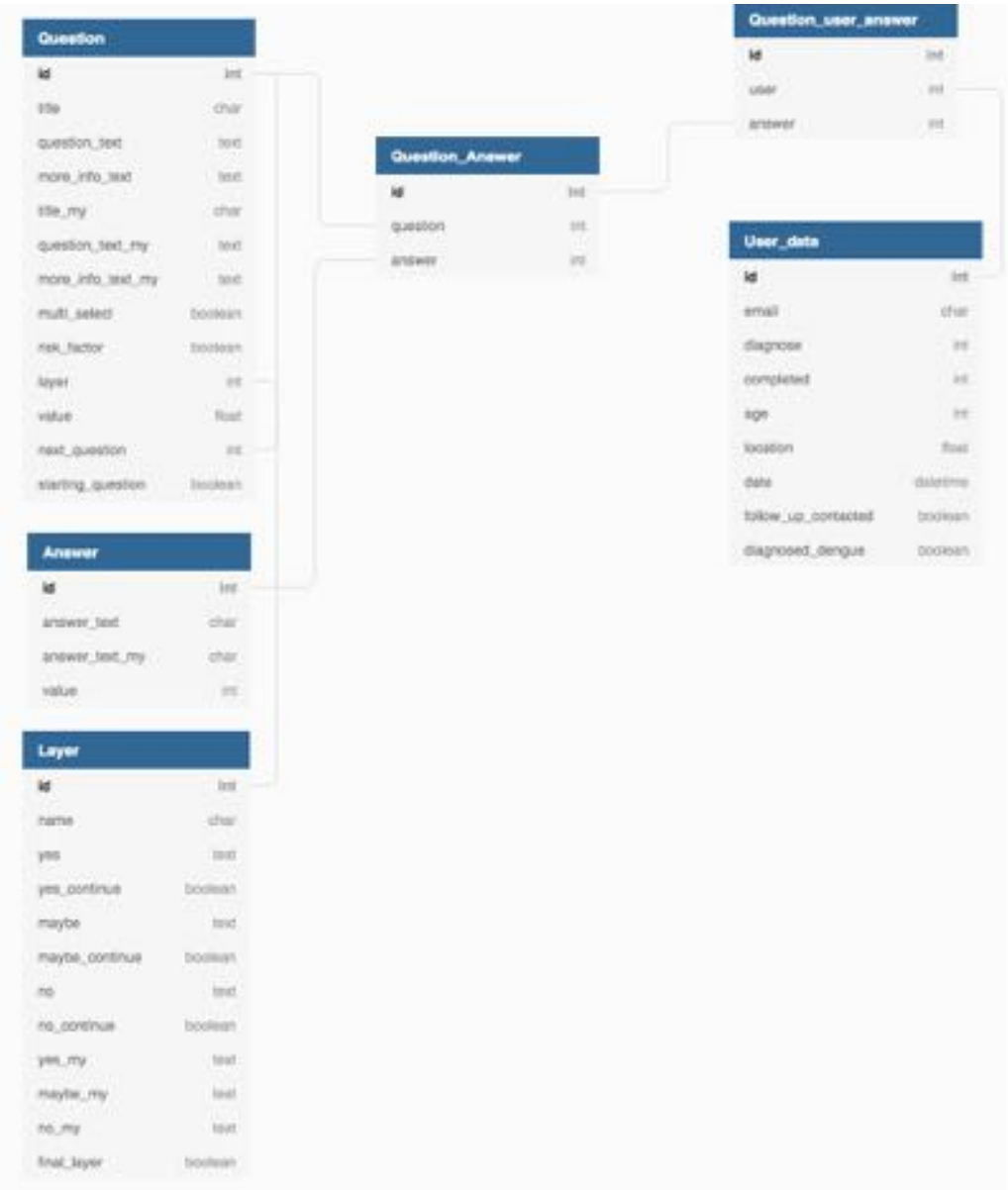


Figure 19. A schematic representation of the database structure.

5.3 Knowledge model

The DengAway system consists of two parts. First, the system has the function to provide general information to the user. The user can obtain information about the dengue virus and how this spreads among the environment as well as information about hotspot or outbreak areas and preventing mosquitoes. Second, the system provides a screening tool which tries to determine if a person may have dengue or even severe dengue. Based on this, the system gives an advice to the user whether or not go to see a doctor (or even to go see a doctor immediately). Since providing general information is not a task, but just a representation of available information, this report focuses on the screening, or diagnosing, tool.

5.3.1. Task knowledge

The main task of our system is to decide whether the user should be advised to (1) take it easy, (2) do the test again tomorrow, (3) go to the doctor or (4) go to the doctor immediately. Although the

system does not actually diagnose if someone has dengue or not, it does estimates the chance and acts upon that. In general, the system has a goal, an input and an output:

Goal – Give advice about what the user should do.
Input – Dengue symptoms and dengue risks of the user
Output – Decision of the system whether to advice 1, 2, 3 or 4 of the previous paragraphs.

5.3.2. Task decomposition diagrams

Layer level

The task decomposition diagram of the decision which advice should be given to the user can be found in figure 20. It was decided to perform the decision making process in three different layers to prevent 'healthy'-screened people from filling in unnecessarily many questions.
As people start the screening tool, they will start in layer 1. Layer 1 consists of only 7 questions that identify some risk factors of the environment and the presence of some general dengue symptoms. Based on this, the system quantifies the chance of having dengue and, therefore, the need to answer more questions (layer 2). Quantification is done based on a pre-set threshold. When the quantification of 'chance for dengue' exceeds this threshold, users will be directed towards layer 2. If not, they will be directed to the advice decision process.
Within layer 2 and 3, this process will be repeated. However, the thresholds differ between layers. All paths of the system will eventually result in an advice. The decision of which advice to report is made, again, based on the quantification and threshold of the last visited layer.

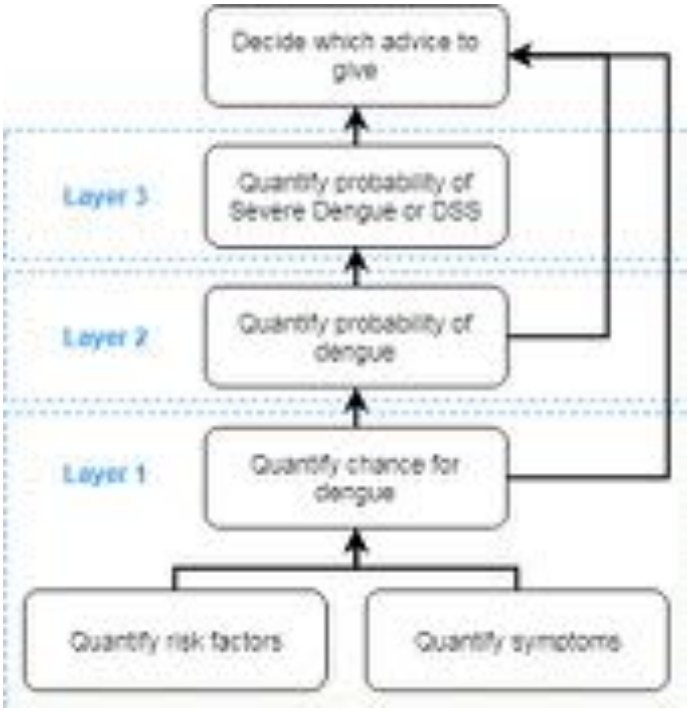


Figure 20. Task decomposition diagram at layer level

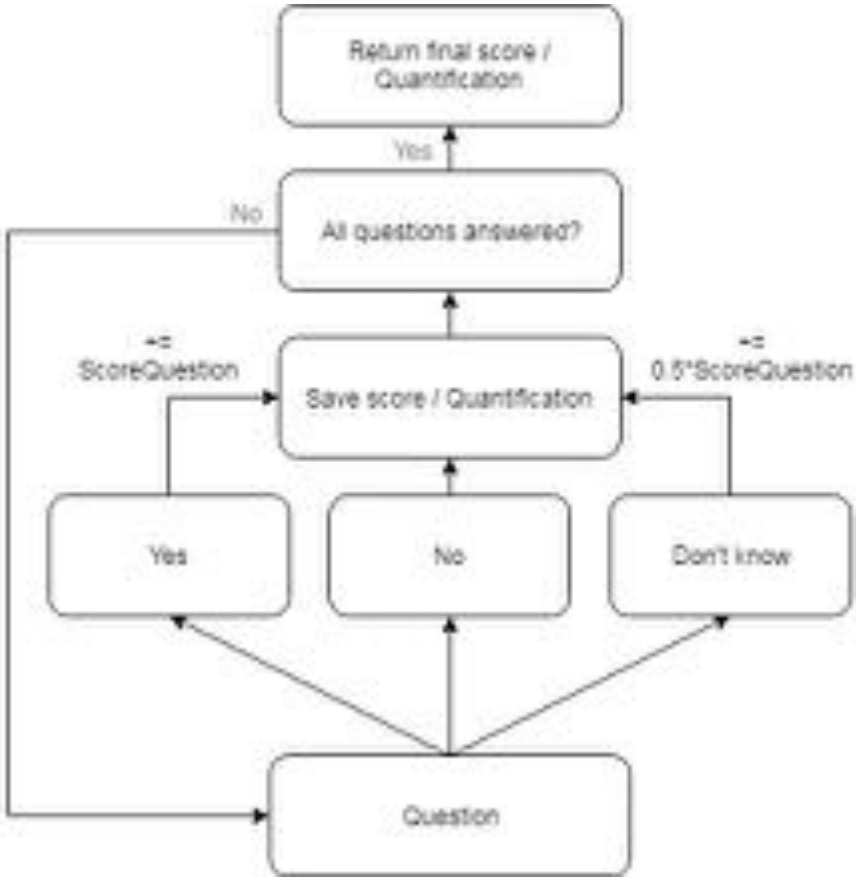


Figure 21. Task decomposition diagram at question level.

Question level
In order to calculate the quantification, or final score, a score is assigned to each question the user answers in each layer. Per layer, the score of each question is summed up and will be returned after the last question of that specific layer is answered (see figure 21). Accordingly, this 'final score' per layer is used at the layer level to decide what to do.
The score for each question depends on the answers given such that 'No' results in a score of 0, 'Yes' results in the maximal score, and 'Don't know' results in 0.5 times the score for 'Yes'. The maximal score depends on the question and is represented in Table 20.

Scores per questions
The maximal score, i.e. the score for answering 'yes', has been listed in table 4. The maximal score for each question was set at 1 for all, except for the questions concerning fever. This was done because fever has been considered to be the main symptom of dengue (doctor Razitasham, personal communication) and determines the pathology to a certain extent. On top of that, the presence of fever indicates an infection while this is not the case for the other symptoms.

Adding and rating "don't know"
Since users might not understand the meaning of some questions or they might not be able to assess if a symptom is present (i.e. due to lack of measure equipment or because a symptom is experienced to a small extent), it was decided to add a 'don't know' button. Both reasons to press the 'don't know' button indicate that the symptom cannot be excluded or included entirely. Therefore, it was decided to apply a score of 0.5 times the score of 'yes'.

Normalizing score

To calculate the final score, it was decided to use absolute scores instead of normalize the score to the number of symptoms. This was done because, if the score was normalized, adding a new question about a symptom would decrease the score while the amount of 'positive' symptoms remains the same.

5.3.3. Decision tree

In order to decide what advice the user should get, a decision tree was created. The score per question, structured per layer and topic, is listed in table 4. Based on the sum of scores per question, the total score is calculated for each layer, according to the following rules:

Score layer 1 = Sum of symptoms layer 1 * ((sum of risks layer 1 / 2) + 1)
Score layer 2 = Score layer 1 + (sum of symptoms layer 2)
Score layer 3 = Sum of symptoms layer 3

Layer 1

```
If score layer 1 == 0:
      'You probably don't have dengue. Keep taking precautions to  prevent
       mosquitoes'
Elseif score layer 1 < 3:
      'Take it easy and answer the questions again tomorrow! Keep  taking
      precautions to prevent mosquitoes'
Else:
      [proceed to layer 2]
```

Layer 2

```
If score layer 2 < 5:
      'Take it easy and answer the questions again tomorrow! Keep  taking
precautions to prevent mosquitoes.
      To be sure, answer the questions in layer 3'
Else:
      [proceed to layer 3]
```

Layer 3

```
If score layer 3 == 0:
      'You may have dengue. Try to make an appointment with the doctor to
      confirm this. Take rest, make sure you drink enough water and
take precautions such that you will not be bitten by a mosquito.'
Else:
      'Don't hesitate to visit a doctor immediately!
      In the meanwhile, drink enough water and don't use medicines other
than paracetamol.'
```

Table 4. Score and formulation per question ordered by layer.

Symptom/Risk	Formulation of question	Score
Layer 1		
Symptoms		
Fever	Do you have a fever?	2
Headache	Do you have a headache?	1
Joint/muscle pain	Do you have muscle and/or joint pain?	1
Skin rash	Do you have any kind of rash?	1
Vomiting	Have you been vomiting in the past 2 days?	1
Risk		
Direct environment	Are there people in your direct environment (e.g. family or friends) that recently suffered from dengue?	1
Live in risk area	Do you live in a risk area or has there recently been fogging in your area?	1
Job outside	Do your working activities mostly take place outside (for more than 5 hours)?	1
Layer 2		
Sudden fever	If you have a fever, was it sudden?	2
Difficulty breathing	Is it difficult to breathe?	1
Mild bleeding manifestation	Did you experience mild bleeding manifestations? (such as bleeding nose/gums or easy bruising)	1
Symptoms > 2 days	Have you not been feeling well for two or more days?	1
Nausea	Are you feeling nauseous?	1
Swollen lymphs	Are your lymphs swollen?	1
Pain behind eyes	Do you experience pain behind the eyes?	1
Red spots on skin	Do you have red spots and/or patches on your skin?	1
Layer 3		
Severe abdominal pain	Do you have severe abdominal pains?	1
Vomiting blood	Have you been vomiting blood in the past 2 days?	1
Persistent vomiting	Do you experience persistent vomiting in the past 2 days?	1
Bleeding gums or nose	Have you had a spontaneously bleeding nose or gums in the past 2 days?	1
Internal bleeding	Do you have spontaneous internal hemorrhage (ecchymosis)?	1
Black tarry stools	Do you have black/tarry stools?	1
Had dengue before?	Have you had dengue before?	1
Joins risk group?	[This will be questioned in the follow-up email] Risk groups are: diabetes, asthma, cardiac diseases, ..	1

5.3.4. Usage scenario

As can be seen in the scenario below, based on the symptoms, four possible outputs can be generated. For each pathology and input, the output given by the system is listed in table 4.

Table 5. Possible scenarios of usage of the application.

Pathology	Input	Output
Person doesn't show any symptoms	Layer 1: – Person answers all questions in layer 1 with 'No'	'You probably don't have dengue. Keep taking precautions to prevent mosquitoes'
Person shows some symptoms, but not enough to diagnose dengue.	Layer 1: – Person has high risk, but only has one symptom and no fever – Person has low risk, has only two symptoms and no fever – Person has low risk and has only fever Layer 2: – Person has only one of the symptoms of layer 2 and no sudden fever.	Take it easy and answer the questions again tomorrow! Keep taking precautions to prevent mosquitoes'
Person is likely to have dengue but not severed Dengue	Layer 3: – Person has no symptoms of layer 3, and has at least sudden fever or two symptoms of layer 2.	You may have dengue. Try to make an appointment with the doctor to confirm this. Take rest, make sure you drink enough (see table) and take precautions such that you will not be bitten by a mosquito.
Person is likely to have severe Dengue (DHF) or DSS	Layer 3: – Person has one or more symptoms of layer 3.	Don't hesitate and visit the nearest government clinic immediately! (If it is at night, go to the emergency clinic in the hospital as soon as possible).

6. Sustainability analysis

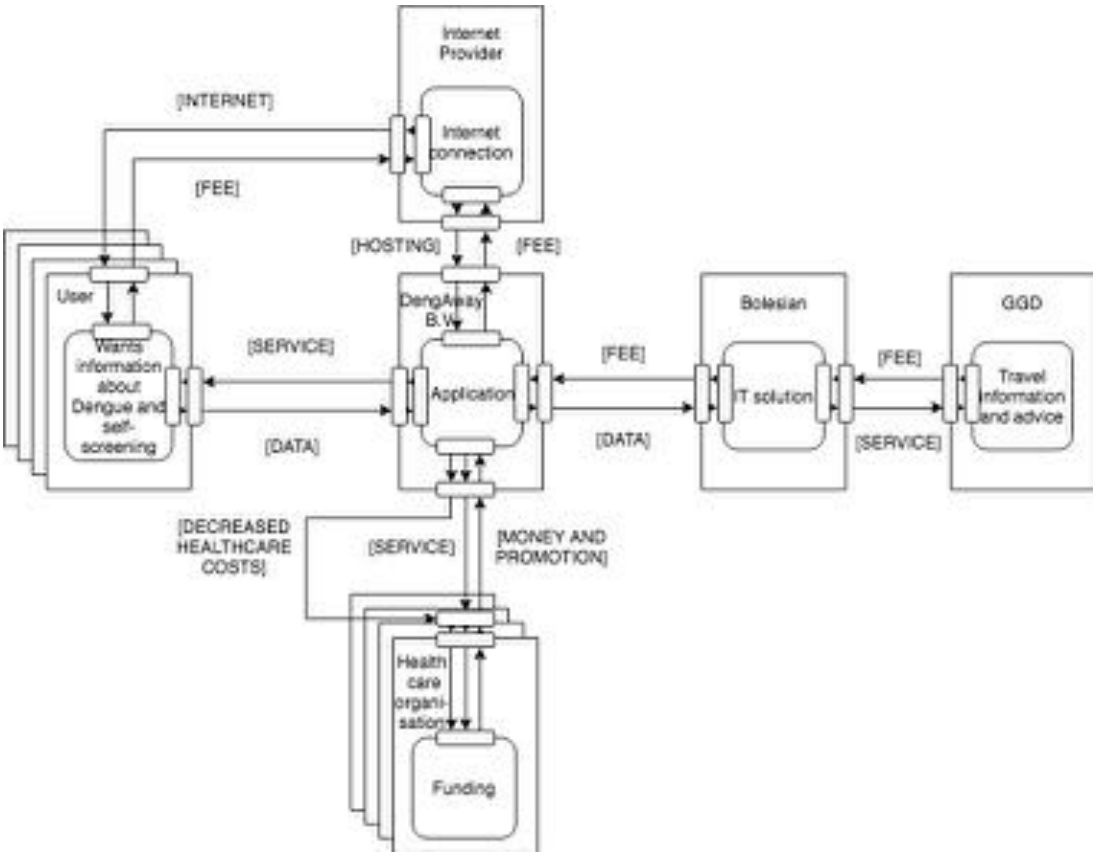


Figure 22. An e3-value model evaluating the sustainability of the application.

This e3-value model indicates the interactions needed to ensure the sustainability of our application. Users will provide the application with data, namely information on the symptoms they are experiencing. In return, they receive the service of the application by getting advice on what their next steps should be, the prevention of dengue, and some general information about the disease. Since the application is web-based, the user needs to pay a fee to the internet provider in order to have an internet connection. The application also has to pay a fee to the internet provider in order to host the application on the internet. The application will eventually be funded by a healthcare organisation, which is most likely to be a part of the government health department. By giving the company that owns the application, in this case DengAway B.V., money and promotional material that can be integrated in the app, the app will provide them with a service in the form of giving them some insights in for example areas in which the app is often used, symptoms that are common and results of the follow-up email of actual diagnoses. Additionally, the app can result in earlier diagnosis, which decreases health care costs for the organisation. In order to continuously keep the application sustainable, companies could be included in the model. At first, the idea was to include Bolesian as a support by using a domain provided by them. However, for the current application there would not yet be enough benefits for them to provide the application with such things. An independent company, here called DengAway B.V., could provide the domain itself. However, a processed form of the data could be sold to companies such as Bolesian. In exchange for a fee, they can receive processed data. However, this data will have to be anonymized before being sold. In turn, companies such as Bolesian can use this data to develop IT solutions for their customers like the GGD (Dutch healthcare institution) and offer them the service of these solutions in exchange for a fee.

7. Scope and Fidelity

We have succeeded in implementing all the must-haves stated in the MoSCoW table (table 3). This implies that the application contains the following:
-Homepage
-Information page with basic information
-Information page about the prevention of dengue
-Self-screening tool with questions about symptoms
-Formula calculating risk
-Advice based on the risk calculated by the formula
-Page on which the hotspot map can be placed in a later stadium
-Button that opens a window with extra information on the current question in the screening tool
-The application is in both English and Malay.

Furthermore, the following should and could haves were also implemented:
-Suitable for both smartphones and laptops
-Tested and evaluated by potential users
-User friendly interface to change the content to other languages/symptoms including a manual
-Link to iDengue

Unfortunately, due to the constraint in time, we were not able to implement the following features:
-Option to enter email for follow-up email
-Follow up email to get information on 'action of user', what they did with the advice, and the eventual diagnosis
-Indication of the location of the nearest clinic
-Map hotspot areas
-Crawling information from other sources
-Learning algorithm to predict next outbreak
-Hotspot area notifications and warnings
-Offline availability
-Extension to other diseases
-Collection of data on usage and symptoms

Crawling data from other information sources was not implemented since it is very hard to get permission from the local governmental health department to view and use this data. If we were to able to include tracking of the user's location by using a devices location tracker, it would be possible to map the hotspot areas. Additionally, we could then indicate the nearest clinics on that same map. This way, the real time location could also enable the application to send alerts when entering a hotspot area, or when a new case has been confirmed in your proximity. It could then also be implemented to use the hotspot map in combination with crawled data to predict next outbreaks by using learning algorithms.

Adding the option to enter your email address in order to send a follow-up email in which the user is asked how he/she proceeded after receiving in-app advice and what the eventual diagnosis was, will enable us to collect data on the usage of the app, the symptoms, and related diagnoses. Offline availability would mostly be convenient for less connected kampungs. Extension of the application to other diseases is something that could be considered after implementing all the above.

8. Evaluation and discussion

8.1 User evaluation methods

For the evaluation of our application, we visited Kampung Pinggan Jaya on 29 June 2019. We conducted the evaluation in the community house on two laptops. Here, we only evaluated the self-screening part. Potential users between the ages of 9 and 60, with an average age of 35.4 years, participated in the evaluation. They were presented with the application and concurrently were given a scenario by the group members. In each group, there was a translator since most Kampung inhabitants do not master the English language sufficiently. As they proceeded through the application, they were given hints about how they could possibly feel and what symptoms they might or might not experience. This way, we could observe whether they were able to proceed through the application and find buttons for specific functions, such as 'go back' or 'more information'. Additionally, it allowed us to evaluate whether the potential users understood the terminology that we used in both English and Malay. After reaching the advice page of the application, the participants were asked to complete an evaluation form, which assessed the design, value, comprehensibility, and improvement points. The evaluation form can be found in appendix 2.

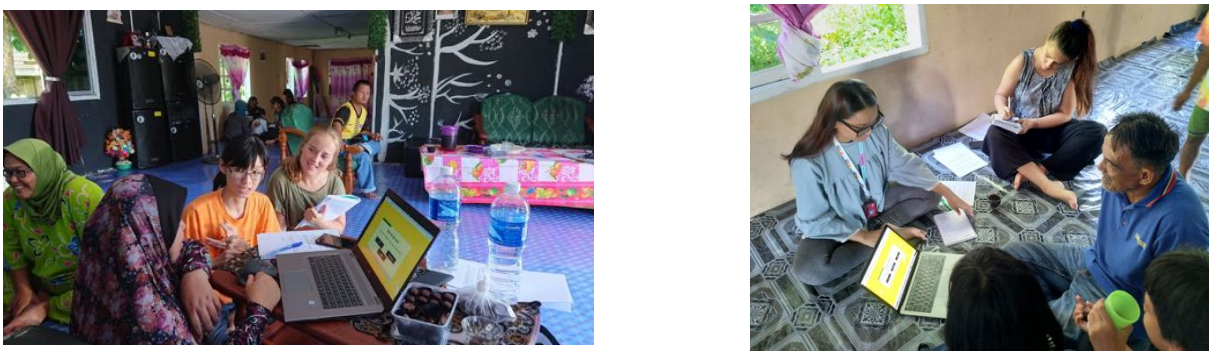


Figure 23. Evaluation session in the community house in Kampung Pinggan Jaya.

8.2 User evaluation results

Table 6. Average scores of the application.

Category	Average	Average Female	Average Male
Design	8.2	8.25	8
Value for the community	9.3	9.5	8.5
Understandability	7.6	7.5	8

Table (..) shows the average scores for the categories 'design', 'value for the community', and 'understandability' based on a scale of 1 to 10. As can be seen, female participants rated the value for the community higher, but male participants found the application more comprehensible. We observed that almost all participants had difficulties with understanding how to go back to a previous question.

Some of the critical feedback from the villagers was:
-The question about internal bleeding is hard to understand
-The fontsize of the 'more information' section is too small
-Not everyone knows what paracetamol is

-The questions should be simpler
-The question about rash is hard to understand
-There are too many questions
-Add more information about the disease

Some positive feedback was:
-The advice that are given are good
-The application is easy to use
-It is good that the application is available in two languages
-The design is nice and bright

8.3 Discussion

From the evaluation result we can conclude that the application is already very useful for the people from Kampung Pinggan Jaya. The advice that was given was useful and clear to the villagers and since the application is available in two languages, it is easy to use. Additionally, they liked the design since the combination of the white and yellow is bright, which they liked. One person rated the design slightly less since he did not like the color yellow. The feedback was put into practice immediately after the evaluation. For example, the fontsize of the 'more information' sections of the questions in the self-screening tool was increased to make it more legible. All questions were revised and made easier if necessary. This was done for both the English and Bahasa Malay version. Since paracetamol was not known to everyone, it was added that this often is named 'Panadol'.

Multiple participants also mentioned that they thought there were too many questions. A possible solution for this would be to implement that when a user reaches the threshold for going to the next layer in the self-screening tool, he/she proceeds immediately without having to fill in the other questions of the current layer. Furthermore, the participants had difficulties with understanding the 'back' button. This could possibly be solved by adding the word 'back' to the button. Some participants had some difficulties with using the application, but this was mostly due to difficulties with using a laptop and not with the application itself.

Unfortunately, we were not able to go back to the Kampung due to time constraints. If we would have had more time, we could have gone back to test the application again after implementing the adjustments based on the feedback. The participants also indicated a need for more information on the disease itself and prevention. However, this was already the plan, but it was not yet connected to the self-screening tool. It would have been very interesting to see whether the application would then provide for all their needs.

The general conclusion from the user evaluation is that the people from Kampung Pinggan Jaya think an application like DengAway is very much needed in their community, both to aid diagnosis of the disease and to raise awareness since it is a realistic threat. This implies that the application is a valuable addition to the community.

9. Conclusions and future work

DengAway could be a valuable platform for the local population in Sarawak, Malaysia, and other countries that are dealing with mosquito-borne viruses. The application has been designed to be as simple as possible to ensure it could be used by anyone. Even though the design is simple and user-friendly, it still contains the essential information about both the disease itself and prevention. If the application were to be approved by the government, it could be a great addition to the program for raising awareness about dengue and its risks. Additionally, it hopefully would aid early diagnosis of the disease, which could in turn lead to an improvement of the quality of the treatment of infected

people and. Control of outbreaks could possibly also be made easier since there will be more insight in the actual number of cases if the follow-up email were to be implemented. The application has a cost-effective design which makes it sustainable in the long run. The application, even though there are a lot of additions that could be made, is ready to be used and the next step would be making it accessible to the wider public.

9.1 Future work

Even though the current application is a good foundation for one that could really have an impact on the world, there is still a lot that could be implemented. For example, it would be convenient if users could give the application permission to access their location. This way, the application could have a hotspot area tool in which hotspots can be shown on a map. The user would then be able to easily identify whether he/she is in a hotspot area or close to one. Based on their location, the application could also indicate where the nearest medical clinics are. If it were to be combined with real time information on the local time, the indication could be adapted so that only the clinics that are open at that specific time are shown.

The location services could also be compared with existing data on dengue cases and hotspot areas. This combination could in turn be used for creating a learning algorithm that could possibly predict the next outbreak or the likelihood that an area will become a hotspot area. A different learning algorithm could also be implemented to improve the screening tool. By sending a follow-up email to determine the eventual diagnosis, this learning algorithm could combine the diagnosis with the symptoms that the user entered and the advice they received to adjust the weights of the symptoms. This way the screening-tool could become increasingly accurate. Collecting this data, and some additional data such as age and chronic illnesses, could also be beneficial for the health department of the Malaysian government. For example, the application could send them an update each month. This update could inform the health department of the number of people that used the self-screening tool, what their symptoms were, and what the eventual diagnosis was. This could in turn be used for monitoring the disease and maybe help them to prevent and manage outbreaks. Before all these features were to be implemented, local and international privacy regulations should be taken into account. These privacy regulations would have to be reviewed thoroughly to create a suitable privacy statement that users have to agree to before the application can actually use their data.

In order to make the application even more user friendly, the self-screening tool could be fine tuned. For example, excessive questions could be avoided by adding a feature which causes the user to proceed to the advice and possibly the next layer whenever the threshold is reached. This would imply that if a user has enough symptoms he or she proceeds automatically and thus skips the rest of the questions. Furthermore, images should be added to the more information sections of the questions.

The application could also be extended for use by different parties, such as medical specialists. This extension could for example contain more in depth questions about additional symptoms or enable specialists to suggest other screening symptoms. The application could then also be used as a professional sharing platform on which medical specialists can inform each other of unusual symptoms of dengue or sudden rises in the number of cases in their area. This extension and the application itself could also have better language compatibility. This would enable the application to be used by everyone around the world that is able to read.

Lastly, the application could also be made more elaborate. Instead of only screening for dengue, other mosquito-borne diseases could also be included. This way, the screening tool would not only

give you advice based on the probability that you have dengue, but it would also give you the probabilities of the risk that you have been infected with another mosquito-borne virus.

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11. Appendix 1

14/06/2019 Interview with dr. Jane from UNIMAS
During this interview we pitched our two ideas to dr. Jane.
Both ideas are to raise awareness and to detect cases earlier on.

The first idea is to create a hotspot map. This detects where you are and sends you an alert when you enter a hotspot area or when there is a new case of dengue in your area. This could be an alert, sms, or whatsapp message. The second idea is a self-diagnosis application. This is to check symptoms from patients, but also to raise awareness and ensure early detection. It then gives advice on how to proceed. This is not available in Malay yet, so we would want to implement it in both English and Malay.

We only have two weeks to make a prototype. The dr. indicates that it depends on your background what is possible. We do not have a lot of experience in mapping, but we do have experience in AI and web development. For AI we will need data. We should get the data from for example iDengue, but that is not all to accurate. The dr. tells us about EpidNews, where they publish data on diseases not only Dengue but also other cases. A case should be confirmed first before it is published anywhere. A case comes in, then they check and diagnose suspected dengue. Until it is confirmed it will not be published. The authorities always confirm Dengue when it is suspected by sending samples to a lab.

If we would be making an application with data from actual cases, we would only be able to use data from cases that have been confirmed by the NS1 test. If we do the hotspot mapping, we will need to get access to this information. In the self-diagnosis app, we could also take risk areas into account. So when you're in a hotspot area, the advice to go to a doctor will be given sooner. We would then still need data.

Bolesian is also working on this, and they might have some data. If you use location, you will also be able to determine what the circumstances are at that area, such as weather, humidity etc. This could then be used in making an estimation of the risk. People are currently looking at construction sites as risk areas. These areas can have stagnant water. There is data available on the drainage system, but the dr. is not sure about data on construction areas. From her research, they concluded that altitude also plays a role. Within a certain range, there is an increased chance of Aedes mosquito. This is both for tall buildings and mountains and such.

The dr. indicates that for the general public, the self-diagnosis will be more beneficial compared to the hotspot mapping. The hotspot is more interesting for the public health officer. If you're able to determine the hotspot, it is easier to send interventions to that specific area. Travellers might also benefit from this. If it would give alerts, it might be useful for the general public as well.
If we wanted to do the hotspot mapping, we would have to use fake data to run it. We could then demonstrate that it works before adding the real data. Might be a motivation to share the data as well.

Hotspot area mapping project from dr. Jane is aimed at public health department. This is based on additional data on for example where the patient has travelled in the past two weeks. However, only they can use this data for their research. If multiple people with Dengue have been in the same area, this is marked as a hotspot area. It does not so much concern locations abroad. From the selected areas, they will figure out the weather at that point of time. Then use a formula to calculate a probability of infection, and rank these with an algorithm to determine the top 5 locations that are marked as hotspot areas.

There is a high probability of infection around stagnant water. The lake of UNIMAS however is flowing slowly, so not very dangerous. Furthermore, don't stay outside too much around certain times. We wanted to know the difference between hotspots, localities and clusters on iDengue, but this is only known by the public health department.
We were hoping to talk to a person from Bolesian in order to see what kind of data they could provide us with. We asked for permission to share the information we got from dr. Jane with them. She gave this since the information is published in anyway.

14/06/2019 Dr. Razitasham from the department of public health at the medical faculty of UNIMAS

Self-diagnosis tool

This tool/application could be very helpful in outbreak areas. For example, Kuching is an outbreak area at the moment.
The symptoms of Dengue are very general and thus it is a disease that is hard to diagnose. Additionally, currently the Aedes mosquito is not only active during dusk and dawn (as is normal for this type of mosquito) but also during the first few hours of the day, approximately until 10-11 a.m.
A way to determine whether you are in a Dengue area is to check for a history of fogging. Fogging is the process of spreading smoke with chemicals in it that will extinguish the mosquitos. However, this cannot be done during the rain season (or rainy periods outside of this season) because the rain will wash the chemicals away. Wind is also a factor that will determine the fogging results because it can blow the chemicals away from the Dengue area.

Hotspot mapping

This has been tried before and the doctor thinks it will be very difficult to achieve this. One of the reasons for this is the permission that is needed for linking to the telephone service to determine someone's location and send alerts. This is feasible, but not within the two weeks that we have to develop the application. However, Whatsapp alerts might be possible since this goes via an internet connects rather than a cell service.

Other diseases

Other diseases that can be found in the area are Japanese Encephalitis and Leptospirosis. These diseases have similar symptoms to Dengue fever and thus these are hard to distinguish. One way to determine the disease is a blood test. Additionally, you have to think about the family history of a person and where this person has travelled to in order to determine the most likely disease.

Diagnosis

The usual symptoms of Dengue are fever, rash, bodyache, and headaches. Using an immunological test named NS1 it can be determined if it is actually a case of dengue. This diagnosis is used for iDengue. This implies that the cases reported on this approved website are certain cases. However, most cases of Dengue are asymptomatic. The most dangerous variant is hemorrhaging Dengue. This variant causes nausea, vomiting, and even internal bleedings. If a person has (suspected) Dengue,

he/she should drink a lot of water and stay at home as much as possible. Using platelet count, Dengue can also be diagnoses. If there is a trend of increasing platelet count, the patient can often be discharged and return to the clinic for a check up after a certain period.

Serotypes

There are four serotypes of Dengue. All four types occur in Malaysia, making it extra dangerous. If you have already had the one variant, the next infection is even more dangerous because of the created antibodies from the first infection. However, a person is resistant for that specific type then. A second infection is also dangerous for people who had an asymptomatic first infection. The danger lies in the fact that the second infection leads to a higher risk of hemorrhagic fever.

Other

Outdoor jobs increase the risk of getting Dengue. This should be considered in the self-diagnosis as well. We do not have to collect data on external conditions since these could be used retrospectively in the analysis (e.g. check what the specific conditions where in the period that there was a spike in Dengue activity.).
External conditions are for example rain, since it attracts mosquitos, and hot weather, since it makes the mosquitos reach maturity sooner.
Doctors communicate cases of Dengue to the head office by e-notice. This contains all the information from the doctors, from symptoms to travel history. This is done for any disease, but Dengue cases are sent through to iDengue.
Epidlink: family history of Dengue + fever → scares people that it is Dengue immediately. The awareness does cause people to have an early referral to a doctor, which is better than no referral at all. Some risk factors are: decreased immune system, living/working in high risk areas, and pre-existing medical problems.

17/06/2019 Interview with a patient

Male- 37 years old, from Amsterdam, The Netherlands.
The patient also has a severe form of asthma, this is also one of the complications for dengue.

1) What symptoms did you have?
It started with headaches, and high fever. The fever was very sudden. He went to the doctor at UNIMAS and got prescribed paracetamol. After that, the fever dropped and went away on the second day. Later on he also got diarrhea. On the third day the fever returned, combined with difficulty breathing and muscle pains. Day one he already had some muscle pain, but by day three he could barely walk up the stairs anymore. Additionally, he was very tired.

In the beginning he did not really have a rash. At day 3 it started to show on his head.

He did not very much experience nausea, but when he went to the ER on the 3rd day they found out that his blood pressure was very low. That also caused him to get dizzy. The lower blood pressure is also a symptom of dengue.
He did not necessarily experience pain behind the eyes, but he did have a headache somewhat around the eyes.
He did not check for swollen lymphs, but his temperature was 39.5 degrees Celsius and occasionally rose to almost 40 degrees. He did not have any mild bleeding manifestations.

2) How long from the onset of symptoms until you realize that you need to go to the hospital?

After three days he realized he had to go to the hospital. The fever kept rising and dropping, which is a typical symptom of dengue. It might have had something to do with the paracetamol, but it also occured when he did not take the paracetamol.

There were no people in his close environment that were suffering from dengue or recently suffered from it.

The patient kept his windows open at night since it was very warm and there was no air conditioning. He thinks that he would have identified the dengue sooner if he would have had more information. An app would be useful, but it would be best to include multiple tropical diseases and not just dengue.

4) Do you wear long sleeve clothes at night?
He did not wear long pants during the night since the room did not have air conditioning. He did spray with DEET 2-3 times a day.

5) Do you wear dark colored clothes?
Shirts I do sometimes black. Shorts also.

8) Where have you travelled/visited in the past two weeks?
Abu Dhabi, and kuala lumpur 1 night. And then UNIMAS.

Other things to advise?
Visit a doctor as soon as possible if you suspect dengue.

Did you know this was a high risk area?
They said that unimas area was totally clear, but it turned out that there were some cases already in the environment. I would have wanted to know it.

9) How long until the dengue fever subsides?
It lasted for 4 days and then it stopped, and then still 2 days in critical phase. So it was around 5 days until the fever subsided.
He drank a lot of water in the hospital since dengue dehydrates you. Additionally he received around 2,5 litres of fluid a day via IV. The doctors did a blood test every day. The body temperature was checked very often.

He thinks that the first doctor at UNIMAS should have recognized the dengue since he had a very specific headache, muscle pain and a fever. On top of that, he was living in a neighbourhood with multiple cases. Nonetheless, he was satisfied with the doctors that have treated him.

The patient mentioned that he will probably never return to Malaysia since he will be at great risk if he would get infected with dengue again.

21/06/2019
Interview with Dr. Razitasham at Ella's house to review our layer system and terminology

The idea is to create a diagnosis application. We want to make three layers so that not everyone has to answer all questions when a person is not at risk of dengue. The first layer determines if there is a

risk. In case of a risk → go to layer 2. We use typical symptoms to establish this like fever. In the third layer we diagnose the severe dengue and give the advice to visit doctor immediately.

Layer 1
5 questions about basic symptoms and 3 questions about risk factors. The doctor mentions that community often does not know that they are in a risk area. It might be a better idea to ask if there is a history of fogging in their area. The more information button should also contain a lot of information in order to make it clear for the people whether they are in a high risk area. Some kampungs are also identified as high risk areas. Can be found on iDengue, but the doctor says that people will not look at it. They sometimes scare people with information about high risk via whatsapp or facebook. Only then people will realise. Advice: keep taking precautions.

Layer 2
If score of layer 1 is higher than 4, then proceed to layer 2. Questions like difficulty breathing, temperature above 38 degrees and was it sudden, for how many days, etc. Swollen lymphs, they will not know so we better ask do you have swelling in your neck and behind your ears?
If the score is 2 or higher → go to layer 3.
Lower → take it easy and answer the questions again tomorrow. Since you passed layer 1, the risk is already taken into account.

Layer 3
If someone has 1 or more of these symptoms then go visit a doctor immediately. If not, it is probably mild dengue. It should be spontaneous bleeding gums or nose. Red spots and rashes can also occur in level 2. Maybe include pictures so that it is clear for people what it should look like. Layer 1 rash should be flared up/irritated skin, layer three should be patches/spots (ecchymosis).
You could tell people to take only paracetamol, but it is more important to visit a doctor. We should ask people if they have had dengue before in this layer as well.

The doctor likes the idea of the layer system. For layer 1, it can be dengue if there is no fever at that moment. Fever in the past 2-3 days might also indicate Dengue. Natural history of disease means what the presentations are when it starts and why these. This explains a lot about how we should divide the layers and why. Ask if someone already took paracetamol since this lowers fever and thus might influence the result. Don't only ask if they have a fever yes/no.

To test our application, we should first ask people if it is understandable and if it works. Then for a second testing round ask people in risk areas. We would need 30 or more persons. The application is not diagnosis, but only screening and giving advice. We could use Ella's students to test the application.

We need people their address to see if they live in a risk area. Asking permission to use location is easier. Might be an issue if someone does the test at hospital/other house/school.
Muscle pain can also be from exercising. To distinguish this we have to ask the patient if it is from exercising or not, and combine it with other symptoms.
People most often know when they have a fever, so we do not have to take into account that they might not have a thermometer and such.

As a doctor you want people to visit you early on in the disease. Most of the time they are aware of Dengue, but not of the consequences. The community should know more about the signs and symptoms of (severe) dengue.

When people go to the doctor they only pay 2 rm. This is because it is most often a government clinic. Treatment for diseases is free in Malaysia. They have the NS1 test. For mild Dengue also go to a doctor. They want to do a blood test to be able to control Dengue, keep track of cases, and initialize fogging.

The don't know button is because yes indicates that you certainly have it, no indicates that you certainly have not. The doctor is doubting about this and says that it might be better to leave it out.

If our application indicates that it is severy dengue, people should go to the doctor immediately. Otherwise it might lead to dengue shock syndrome. Government clinics during the day, ER during the night. Private clinics do not have the NS1 test. It might be a good idea to create a page with the available clinics/hospitals. However, most people know where the clinics are.
Stating 'you might have dengue' is good, even though we are not clinicians. The aim of this application is screening, so not diagnosing.

12. Appendix 2

DengAway Evaluation

Age:

…..……

Kampung:

…..……

1. What do you like about the application?

2. Who don't you like about the application

3. How useful do you think this application could be in the area where you live?

1	2	3	4	5	6	7	8	9	10

Remarks:

4. On a scale of 1 to 10, 10 being perfect, what rating would you give the design of the application? Please elaborate on your answer.

1	2	3	4	5	6	7	8	9	10

Remarks:

5. On a scale of 1 to 10, with 10 being very good and 1 being not at all, how well do you understand the application? Please elaborate on your answer

1	2	3	4	5	6	7	8	9	10

Remarks:

6. How could we improve our application?