MOBILE HEALTH APPLICATIONS AND DISEASE HOTSPOT TRACKING SYSTEM: A PROPOSED SPATIAL ASSESSMENT TOOL FOR TUBERCULOSIS CONTACT TRACING IN MALAYSIA

MUHAMMAD AFFIN ROSMAIDI¹, ABDUL RAUF ABDUL RASAM¹, HAFISZAH ISMAIL², MOHAMAD SUIFAN HASIM³, FARIDAH MUHAMAD HALIL⁴, ROSMAIDI GHAZALI¹
¹Centre of Studies for Surveying Science and Geomatics
²Centre of Studies for Estate Management
³Centre of Studies for Building Surveying
⁴Centre of Studies for Quantity Surveying
Faculty of Architecture, Planning and Surveying,
Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
Corresponding Author Emails: rauf@uitm.edu.my, rosmadi@uitm.edu.my

ABSTRACT

Getting sick is one of the things that everyone does not want to have. To avoid getting sick, people have to be aware of their surroundings about the risk of being infected by many diseases. To determine the risk of getting infected, people usually have to search online about the illnesses. This could become a burden if the person did not have an internet connection. This paper focuses on detecting people, whether they have the risk of getting infected with Tuberculosis (TB) diseases or not. The risk can be known by developing a group of questions and the question given to the people who live around Shah Alam, Malaysia. From that, the risk (scale: 12) can be determined whether low risk (scale 4-6) medium risk (Scale 7-9) or high risk (10-12) using 4 main questions, namely the status of TB cases and contacts, surrounding crowdedness and housing areas. Previous data have also been used to detect the places that risky and that it can be known why that place become a hotspot of Tuberculosis diseases. The mobile application could be used as a medium to spread the questionnaire to assess the respondents’ risk level. The mobile application with an Android Studio and Proto.io has demonstrated its potential to detect the new or possible risk persons or contacts toward TB infections and diseases in the study area.

Keywords: Mobile Health Apps, Disease Surveillance, Contact Tracing, Tuberculosis Hotspot, Spatial Assessment

I. INTRODUCTION

Getting sick is one of the things that everyone does not want to have. By getting sick, it makes someone's life miserable, and it also affects their daily life. In 2018, a survey was done on the main causes of deaths in Malaysia, and the survey shows one (1) to five (5) of the main causes, 4 of them were from diseases. The diseases were Ischaemic heart diseases, Pneumonia, Cerebrovascular diseases and Chronic lower respiratory diseases. This survey has been done for several years, and the results were increasing every year. Dengue fever also records as one of the highest diseases in Malaysia. It hit nearly 8,0000 cases and 113 deaths reported from January 2019 until August 2019.

Although the world is more concerned about Covid-19, the diseases TB can also occur because it uses the same method as Covid-19 to spread. The World Health Organization (WHO) reported in 2010 that TB caused around 8.5-9.2 million cases and 1.2-1.5 million deaths worldwide. In research, low-income and emerging economies are the primary cause of the global distribution of TB cases in the years 2000 [1]. In Malaysia, it has a different pattern. The TB disease cases focus more on the urban area with a high population, low socioeconomic, and increased urbanisation.
Years ago, diseases data can only be obtained by watching the news on television and reading newspapers. There were also times when we got the data only by going to the hospital and asking about specific diseases. It requires the informer to provide the data to us and sometimes take a whole month to get the data. But moving along with the advancing technologies, the data can be obtained from some website and research that other researchers have made. The user can search for an entry by entering part of the browser's name, and the result will come out. It also provides suggestions to the user about the data that is similar to the chosen topic.

However, these kinds of medium require some time to be updated. Sometimes, it requires other researchers to do other research for the update. Some website that gives the data were not user-friendly. Some people just need the number of the data of a certain time, but it did not provide it with a simple format like in statistic or bar chart format. Through smartphone eras, more people will reach information into their pockets to obtain excess over the diseases. Benefits of the mobile application give the information on the hotspot of the diseases. The fast development of mobile health applications has met the requirements of the public health system for disease planning, surveillance, contact tracing, quarantine, and healthcare. Several experts [11][13][15] believed that this smartphone technology will influence the better quality management of COVID-19 pandemics delivery to patients across the condition, transmission and control, and potential sources [11-14][16]. [15] added how cell phone services, such as mobile apps, short message services (SMS), mobile phone monitoring info, phone camera, and mobile networking, are used against diseases. In terms of outcome dimensions such as efficiency, viability, acceptance, accessibility, prices, and efficacy, mobile phones have shown promising results.

Nowadays, detecting and tracking disease outbreaks, especially human TB [8] can be conducted in advanced ways, such as using GIS [17-19], mobile apps [3][5][16][20], big data analytics [2][7][10] and social media data [4][6][9]. [20] demonstrated that the mobile Health approach to TB contact tracing improved on the paper form-based approach used in Botswana because TB touch tracing was completed in less time on average, and data quality was improved. On the computer system usability questionnaire, the mHealth approach had also received favourable overall ratings, system effectiveness, knowledge quality, and interface quality.

In this study, To identify the early hotspot areas of TB diseases in Shah Alam using mobile applications. The study consists of three objectives, namely:

i. To identify the existing locations of TB cases in the study area using mobile mapping Apps.

ii. To determine the potential TB Cases based on the respondents’ condition feedback using mobile mapping Apps.

iii. To analyse the distribution of existing and potential TB cases using mobile mapping Apps

II. METHODOLOGY

The methodology that has been adopted in this research is divided into four (4) main methods that show detailed steps (refer to Figure 1 as research methodology). The procedure begins with research planning which is knowing the specified area for collecting data and the software that has been used. After that, data collection were obtained from mining social media and then data processing and going to the final step, which is getting the results. The overall steps of the methodology are outlined in Figure 1 and have guided throughout the research process.
2.1 Research Planning

In the planning phase, research goals were determined, and a high-level plan for the intended research was established. This phase explains the area of study and the software that was used for mobile application. The research is based in the area of Shah Alam City, Petaling. Petaling District is a district in Malaysia situated in the heart of Selangor. Established on 1 February 1974, the Petaling District has proclaimed a Federal Territory the same day as Kuala Lumpur. The region is situated near the capital, in the heart of the Klang Valley, and has undergone considerable urbanization. It is approximately 484.32 sq km. The town centre is split into Shah Alam, Petaling Jaya and Subang Jaya. ArcGIS Desktop, ArcGIS online platform, ArcGIS AppStudio used to develop the apps. This software was utilized in producing mobile application. The map made in ArcGIS Online was presented in a mobile application created by this software. Figure 2 shows the study area of section 7, Shah Alam.

2.2 Data Collection and Potential Risk Calculation

There were three data sets used in this study, including TB cases (2017), a base map of the study area and primary data of respondent’s feedback through questionnaires. TB cases were obtained from the Selangor State Health Department (JKNS), while the main shapefile base map was acquired from the ArcGIS platform (Figure 2). Google Form used to collect information about the potential risk people towards TB contacts and infection. The respondents answered the specific criteria of TB risk factors, including (i) personal address, (ii) health status (TB personal status) (iii) living conditions (crowded environment, TB contact), to assess their TB symptoms: high risk (Yes=3), medium risk (Maybe=2), or low risk (No=1). The total of risk (scale: 12) was determined whether low risk (scale 4-6) medium risk (Scale 7-9)or high risk (10-12) using the 4 main questions.
The first step is the data entry of the primary data. After the existing data had been filtered, the data were processed in ArcGIS Desktop for mapping purpose. The first thing to be done after opening the ArcGIS Desktop was to add the Shapefile data of Shah Alam. The function of this step was to ensure the study area was correct for processing the data and the base map did not open at another region. The Shapefile has to be edited because the Shapefile boundary only covers the large area of Shah Alam, and this study requires the boundary of each section. The data need to be key in manually in each row in the table format. The data covered the number of TB cases in the years 2017 in each boundary.

The second step is creating a map using ArcGIS Desktop. For making the map, visualize the data by symbolizing the data in symbology options. In this option, many types of symbology can be used. The choice was featured, categories, quantities, charts and multiple attributes. Select the best option to present the data. For this data, the quantity option has been used, and the symbology was in dot density.

The next step is the data entry and mapping of potential TB symptoms contacts. After the possible TB data had been analysed, the data were processed in ArcGIS Desktop for mapping purpose. The first step needs to be done after opening the ArcGIS Desktop and added the Shapefile data of Shah Alam. The function of this step was to ensure the study area was correct for processing the data and the base map. Like the data entry for existing data, the Shapefile needs to be edited because the Shapefile boundary only covers the large area of Shah Alam. However, this study requires the boundary for each section. The data need to be key in manually in each row. The data covered the number of TB cases with a high risk, medium risk and low risk from the survey in each boundary.

For making the map in ArcGIS point data, visualizing the data using symbology options. In this option, many types of symbology can be used. The option was featured, categories, quantities, charts and multiple attributes. Select the best option to present the data. For this task, the quantity option and the dot symbology were used for creating a map in ArcGIS Online. The Shapefile can be gotten by exporting the data used in the ArcGIS Desktop. The exported data have to be changed in .zip format. Then, select the drawing style. Depending on the attributes the option for the drawing style will be different with each attribute. After selecting the drawing style, click options to edit the symbol to present the data. Add all the Shapefile data to make a proper map that contains all the data needed.
After done creating the feature layer, the layer has appeared in the content. The first change the data collection in public so that everyone can use it without creating ID. Next for data collection, editing, go to Data and click Fields. Here, the developer can add and delete questions. For the original template chosen, it gave some question the developer can use. Delete the question and add other questions if there is no need by clicking the Add button and enter the question that wanted to ask.

The final step is mobile Application development using ArcGIS AppStudio. To start the program, click the New App button to choose the project. In the New App, ArcGIS Online gave many layouts to be used for the project. Some of the layouts can be used just by entering the data to be present and some of it has to be coded. The language for the coding is JavaScript. The templates were used is the Map Viewer. In the title, key in the study title. After done entering the title, the button of creating to continue the process and the setting button was selected. In the setting, many options will be shown on the left side of the windows. The first option was detailed. Here, the details of the application can be edited. The title of the app, summary, description, tags, access and use constraints and credits can be edited. The function of the edits so that users will know a little bit about the application. The next options were resources. In this option, developers can edit the app icon and launch the image.

Next was the properties. In properties, it has four sections which are Start Screen, a Form, Colours and Other Properties. On the start screen, it gave the developer to edit the first screen when the app was launched. It gave the developer the to change the background image of the start screen, the colour, the font size, title font, text font and entering feedback email. In the Form section, the thing that has to be edit was just the Web map ID and Feature service address. For the Web map ID, the developer just has to enter the id of the map that the developer has made earlier. The ID was at the above on the map. For the feature service address, it can get at the Overview. The developer has to scroll down until seeing URL word. Click the copy button and paste it into the empty box in the App Studio. After done entering the id, click the apply button. The developer has to publish the application so that other people can use the application.

III. RESULT AND DISCUSSION

3.1 Existing Hotspot of Tuberculosis cases

The existing distribution of TB cases that were collected at Jabatan Kesihatan Negeri Selangor (JKNS). This data tells about the TB patient locations and the number of patients at a certain place (refer to Figure 3). The data were transferred from the excel format into a visual format so that users can more understand the distribution of Tuberculosis cases throughout the years 2017.
After running a custom tool, the output released is Hotspot analysis. The data used in this process are in the form of random patterns. Through this output, the frequency of tuberculosis cases in Shah Alam (Refer Figure 4) is shown on a map. The most common areas are in the Section 24 area with 99% confidence level. We can also analyse that the majority of cases of tuberculosis cases occur are random.

Therefore, the authorities can plan to prevent this case so that it does not become a frequency of this case. Spatial statistics that have been applied in this custom tool can also help the authorities to carry out prevention, such as prioritizing patrols in areas where frequent tuberculosis cases occur.

Figure 3 Map of Recorded Tuberculosis Locations in Shah Alam
Measuring spatial autocorrelation based on feature locations is also conducted. After the report produced, the z-score is 0.05 which is in a range of -1.65 – 1.65 for a 90% confidence interval showing a relationship between pattern (refer to Figure 5). This report file from figure 5 shows that a pattern of Tuberculosis cases in Shah Alam is random. So that, the data has been confirmed that it is a random pattern that happened in Shah Alam based on tuberculosis cases.
3.2 Potential Tuberculosis Cases Hotspot based on the respondents’ feedback

A questionnaire has been made and been answered by some people that live around Shah Alam. Only 25 respondents respond to the questionnaire. The questionnaire consists of five (5) questions which are one (1) fill in the blank question and four (4) multiple choose a question. The questions were all above whether the respondent has a high risk, medium risk or low risk of getting Tuberculosis Diseases. The result of the risk was being gained by calculating the point. Each answer contains them at a point which is if the responsive answer 'Yes' is 3 points if 'No' is 1 point and if 'Maybe' is 2 points. The point will be summed up and the point collected will determine whether the respondents were high risk, medium risk or low risk.

The total sum of the point is classified into three groups which are 4/12 until 6/12 will be low risk (green), 7/12 until 9/12 will be medium risk (yellow) and 10/12 until 12/12 will be high risk (red). The result is presented in the table below. Question 1 asked about whether the respondent ever been infected with Tuberculosis. For question 2 it's about to do respondent lives in a crowded environment and question 3 asks whether the respondent ever heard peoples’ lives around their housing area being infected by Tuberculosis diseases. The last question is question 4, which asks about the possibility their housing area can be infected by Tuberculosis diseases.

Based on Table 1, not many respondents have experience infection by Tuberculosis diseases. From the address column, there was 8 respondent lives in Section 7, 5 respondent lives in Section 18, 5 respondent lives in Section 24 3 respondent lives in Section 8, 2 respondent lives at Section 20, 1 respondent lives in Section 17 and 1
respondent live in Section 19. Only 2 people have experienced infection by Tuberculosis diseases which is one live at Section 7 and the other one lives at Section 18. For question 2, 12 respondent respond ‘Yes’, 8 respondent respond ‘No’ and 5 respondent respond ‘Maybe’

Table 1. Table of Tuberculosis Data

<table>
<thead>
<tr>
<th>No.</th>
<th>Address</th>
<th>Question 1</th>
<th>Question2</th>
<th>Question 3</th>
<th>Question 4</th>
<th>Total point</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PKNS Section 7</td>
<td>No</td>
<td>Yes</td>
<td>Maybe</td>
<td>Yes</td>
<td>9/12</td>
</tr>
<tr>
<td>2.</td>
<td>Nilam Sari Section 7</td>
<td>No</td>
<td>Yes</td>
<td>Maybe</td>
<td>Maybe</td>
<td>8/12</td>
</tr>
<tr>
<td>3.</td>
<td>Section 18</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>6/12</td>
</tr>
<tr>
<td>4.</td>
<td>Blok 5 PKNS  Section 7</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>8/12</td>
</tr>
<tr>
<td>5.</td>
<td>Section 17</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>4/12</td>
</tr>
<tr>
<td>6.</td>
<td>Section 24</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>6/12</td>
</tr>
<tr>
<td>7.</td>
<td>Section 18</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Maybe</td>
<td>11/12</td>
</tr>
<tr>
<td>8.</td>
<td>Section 7</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>10/12</td>
</tr>
<tr>
<td>9.</td>
<td>Section 24</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>4/12</td>
</tr>
<tr>
<td>10.</td>
<td>Section 18</td>
<td>No</td>
<td>Yes</td>
<td>Maybe</td>
<td>Maybe</td>
<td>8/12</td>
</tr>
<tr>
<td>11.</td>
<td>Section 18</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Maybe</td>
<td>7/12</td>
</tr>
<tr>
<td>12.</td>
<td>Section 18</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Maybe</td>
<td>7/12</td>
</tr>
<tr>
<td>13.</td>
<td>Section 24</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Maybe</td>
<td>7/12</td>
</tr>
<tr>
<td>14.</td>
<td>Section 7</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>6/12</td>
</tr>
<tr>
<td>15.</td>
<td>Section 24</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Maybe</td>
<td>7/12</td>
</tr>
<tr>
<td>16.</td>
<td>Section 24</td>
<td>No</td>
<td>Yes</td>
<td>Maybe</td>
<td>Maybe</td>
<td>8/12</td>
</tr>
<tr>
<td>17.</td>
<td>Section 7</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>12/12</td>
</tr>
<tr>
<td>18.</td>
<td>Section 19</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Maybe</td>
<td>7/12</td>
</tr>
<tr>
<td>19.</td>
<td>Section 20</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>6/12</td>
</tr>
<tr>
<td>20.</td>
<td>Jalan Pualam  Section 7</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>5/12</td>
</tr>
<tr>
<td>21.</td>
<td>Section 7</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>4/12</td>
</tr>
<tr>
<td>22.</td>
<td>Section 20</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>4/12</td>
</tr>
<tr>
<td>23.</td>
<td>Section 20</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>6/12</td>
</tr>
<tr>
<td>24.</td>
<td>Section 8</td>
<td>No</td>
<td>Maybe</td>
<td>No</td>
<td>Maybe</td>
<td>6/12</td>
</tr>
<tr>
<td>25.</td>
<td>Section 8</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>5/12</td>
</tr>
</tbody>
</table>

For question 3, three respondents responded ‘Yes’, twelve respondents respond ‘No’ and ten respondents responded ‘Maybe’. For question 4, four respondents responded ‘Yes’, seven respondents responded ‘No’ and fourteen responded ‘Maybe’ (Refer to figure 6). To the total point, twelve respondents were classified as having low risk, ten respondents were classified as medium risk, and three were classified as high risk. From the data above, a map had been made to show the hotspot of respondents.
Map in Figure 7, the respondent came from different places. Many of the respondents came from Section 7 Shah Alam. From Section 7 Shah Alam, it said that it has 8 respondents with 3 of them have a low risk, 3 have a medium risk and 2 of them have high risk. In Section 18 Shah Alam, there were 5 respondents which 1 of them has a low risk, 3 have a medium risk and 1 have a high risk to be infected by TB diseases. In Section 24 Shah Alam, there were 5 respondents which 2 of them has a low risk and 3 have a medium risk. In Section 8 Shah Alam, there were 3 respondents and all of them has a low risk. For the other places, it either has 2,1 or 0 as predicted.
3.3 Mobile Application

This application was made for collecting TB data. In the Start Screen, it shows the title of the web application (Figure 8). For the user location, the user has to pin their location and the coordinates will be recorded when the user clicks the Next button (Figure 9). The map can zoom for the most accurate location position. To add the details, the user has to answer the question given. The questions were to help the developer detecting the possible tuberculosis diseases of the user based on the location and the details given by the user (Figure 10).
The developer processed the collected data, and the data are overlaid with the existing data of Tuberculosis, as shown in Figure 10. This Figure shows that the places that have high cases of TB have the potential of having a TB disease problem in the future. It can be seen that the high potential and medium potential cases located near to the existing hotspot cases that have been reported in years 2017. The developed mobile health applications could be used by the requirements of the local public health system for disease planning, surveillance, contact tracing, quarantine, and healthcare management [11][13][15].

Early detection of TB cases and contacts is a relevant idea for avoiding people from getting infected. It also can give awareness to people on how dangerous the Tuberculosis diseases. Therefore, communities might need an application that can be easily accessed and tell them a little bit of information about the disease other than having to google it. At the end of this study, the objectives are achieved by implementing the appropriate research methodology, including to identify the existing hotspots of the cases in Shah Alam using a map, to determine the potential TB hotspot based on the respondents’ health feedback, and to analyse the possible relationship between potential and existing TB hotspot. The hostpots are created by developing a map that contains both existing data and the respondent’s health feedback. The data were being differentiated by colour which the existing data that
have been collected from the JKNS were put in a black colour to represent the late cases record and the data that's been collected from respondents were being put with red, yellow and green colours which represent the risk of cases. The developed smartphone Apps demonstrates that areas with a large number of TB cases have a high risk of developing a TB disease problem in the future. It can be shown that the high-potential and medium-potential cases are clustered near the current hotspot cases identified in 2017. For outbreak planning, monitoring, and touch tracing, the proposed mobile health tools could be used to meet the needs of the local public health sector. The development of mobile apps using sophisticated evaluation techniques should be conducted for the next study.

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B. Conflicts of interest

The authors have no conflicts of interest to declare.

REFERENCE