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Android Application Development with Multi Criteria Decision Making (MCDM) to distinguish Covid-19, Influenza and Cold infections

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Abstract:

Infection symptoms are physical or mental characteristics that indicate a disease condition, especially those visible to the patient. The World Health Organization (WHO) issued a document containing symptoms of infection by the Covid-19 virus, including fever, dry cough, fatigue, and shortness of breath. These symptoms have similarities with illnesses caused by Influenza and Cold viruses, and it is difficult for most people to distinguish the differences between them. We proposed a Research and Development (RnD) study, developing an android app that embeds a Simple Additive Weighting (SAW) algorithm. However, this article will not cover the development process of the android app, but mostly on how the algorithm works. This study aims to help people differentiate Influenza, Cold, and Covid-19 virus infections based on their symptoms through an Android-based application. We used weights, provided by WHO and several related studies, to be processed by the SAW decision-making algorithm, one of the Multi-Criteria Decision Making (MCDM) algorithms, a method that makes decisions based on multiple conflicting criteria. By entering the symptoms, the user can get the most similar type of infection. The app showed its potential in achieving research objectives and the feasibility of being applied in the community..

Keywords: Covid-19 Symptom, Simple Additive Weighting (SAW), Multi-Criteria Decision Making (MCDM).

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Introduction

World Health Organization (WHO) mentions several symptoms of Covid 19 infection such as fever, cough, fatigue, breathlessness, sore throat, diarrhea, and runny nose. Studies by (Niu et al., 2020) and (Yang, Liu, Tao, & Li, 2020) show similar symptoms if people are infected by the Covid-19 virus. Some symptoms are easy to recognize as specific symptoms for Covid 19 infections. However, there are symptoms similar to other viruses such as Cold and Influenza, and infection by Cold and Influenza viruses are even more familiar among people.

In a normal situation, before the Covid 19 pandemic, there was no sense of urgency to recognize the symptoms of Influenza and Cold. However, as the Covid 19 has a higher fatality rate, people need to know its symptoms as soon as possible when the indication of infections has arisen. Moreover, people need to distinguish between a Covid 19 infection and the harmless viruses, Influenza and Cold. People need to know right away after the infection of Covid 19 and further action to medical services. Thus, the problems come because of

1. It is difficult for ordinary people to memorize all Covid 19's symptoms,
2. There are similar symptoms between Covid 19 and Influenza, either Cold,
3. Every symptom can be categorized based on how often the symptom appearance and each kind of virus has a different number of appearances, thus making it is harder to memorize and distinguish them.

Beyond those three points, people are getting infected by Covid 19 without any symptoms, known as asymptomatic. This study will exclude the asymptomatic from the research goals.

Based on Centers for Disease Control and Prevention (CDC) (CDC, 2020) and WHO (WHO, 2020) we can summarize the symptoms and its number of appearances that categorized as frequently, sometimes, little, rare, and never, as shown on Table 1.

Table 1.Covid 19 Symptoms

Covid-19	Influenza	Cold
frequently		
Cough	Cough	Runny Nose
Breath-lessness	Fever	Sore Throat
Fever	Headache	Body Aches
-	Body Aches	Sneeze
-	Fatigue	-
sometimes		
Sore Throat	Runny Nose	Fatigue
Fatigue	Sore Throat	-
Body Aches	Diarrhea	-
little		
Runny Nose	-	Cough
Diarrhea	-	-
rare		
Sneeze	-	Fever
-	-	Headache
never		
-	Breath-lessness	Breath-lessness
-	Sneeze	Diarrhea

We can use Table 1 as a weight value to determine the type of viruses that make the infection. We proposed a simple additive weighting (SAW) algorithm as a decision support system to decide the kind of infection using the symptoms as weight value. SAW is one of the Multi-Criteria Decision Making (MCDM) algorithms, a method that makes a decision based on multiple conflicting criteria (Xu & Yang, 2001)(Chen, 2011). We will embed the algorithm into a mobile app to help people to determine the viruses based on those weighting values.

Related Work

Weighting methods such as MCDM are usually used for helping the policymaker to make a decision, without any additional need from the experts to help (Wang, Zhu, & Wang, 2016). We can mention some examples for MCDM implementation, such as for helping the water treatment stakeholder decide a policy (Shahdany & Roozbahani, 2016), to choose the best agricultural management (Javidi Sabbaghian et al., 2016), to determine marine protected areas to conserve marine biodiversity (Habtemariam & Fang, 2016), and to make a decision in a pre-construction stage of a building project on campus (Abraham, Lepech, & Haymaker, 2013).

As seen in many studies, a few studies use MCDM in a small scope, such as for personal use (not organization nor institution). Moreover, using the MCDM in a mobile app is rare in studies we had found. We found a study by (Goodridge, Bernard, Jordan, & Rampersad, 2017) that uses MCDM for personal use, which is to diagnose a disease in a plant; yes, the goal is similar to our study. However, the method is used in personal computers and a web-based app. We do more progression, using the mobile app, the user will gain the flexibility as we can bring the mobile phone anywhere and anytime. Moreover, the most important is that almost everybody has a mobile phone.

Research Method

This study took six stages, (i) define the alternative (Ai), i.e., influenza, cold, and covid-19, (ii) define the criteria (Cj), i.e., all the symptoms used (10 symptoms), (iii) create the decision matrix or determine the value for each criterion for each alternative, (iv) do normalization to decision matrix using two formulations as shown in equations (a) and (b). We use Equation (a) if the j is a benefit; otherwise, we use Equation (b) if the j is a cost. In the next stage (v), we put the weight based on the user input. In this study, the weight means how badly the user feels the symptoms. The last step (vi) is deciding with Equation (c) for every alternative of Vi. The highest value becomes the chosen decision.

$$r_{ij} = \begin{cases} \dfrac{X_{ij}}{Max\ X_{ij}} & (a) \\ \\ \dfrac{Min\ X_{ij}}{X_{ij}} & (b) \end{cases}$$

$$V_i = \sum_{j=1}^{n} w_j\, r_{ij} \qquad (c)$$

Result and Analysis

Result

We used ten symptoms to build the decisions matrix, as shown in Table 2. Each symptom is then assigned a weight. The more often it occurs, the greater the weight. Each symptom may have a different weight for each type of virus; thus, overall symptoms and their weight will show the characteristics for each type of virus.

Table 2. Criteria

No	Nama Kriteria
1	Cough
2	Fever
3	Runny Nose
4	Sore Throat
5	Breathlessness
6	Headache
7	Body Aches
8	Sneeze

9	Fatigue
10	Diarrhea

The value 0 means the symptoms never show, and the values 1,2,3,4 respectively mean rare, little, sometimes, and frequently. It can be seen in Table 3 the symptoms and their weight for Covid-19, Influenza, and Cold.

Table 3. Initial decision matrix

Criteria	Covid-19	Influenza	Cold
Cough	4	4	2
Fever	4	4	1
Runny Nose	2	3	4
Sore Throat	3	3	4
Breathlessness	4	0	0
Headache	3	4	1
Body Aches	3	4	4
Sneeze	1	0	4
Fatigue	3	4	2
Diarrhea	2	3	0

The next step is to normalize the weight using equation (1) to produce a normalized decision matrix, and we got the result as shown in Table 4.

Table 4. Normalized decision matrix

Criteria	Covid-19	Influenza	Cold
Cough	1	1	0.5
Fever	1	1	0.25
Runny Nose	0.5	0.75	1
Sore Throat	0.75	0.75	1
Breathlessness	1	0	0
Headache	0.75	1	0.25
Body Aches	0.75	1	1
Sneeze	0.25	0	1
Fatigue	0.75	1	0.5
Diarrhea	0.66667	1	0

In the last step, using equation (3), we can get the preference value for each type of infection symptom. Suppose the user enters the symptom value according to Table 5, then the preference value for similarity to Cold infection can be calculated as follow:

Cold = (11.76x0.5) + (0x0.25) + (17.65x1) + (23.53x1) + (0x0) + (17.65x0.25) + (5.88x1) (23.53x1) + (0x0.5) + (0x0.00) = 80.88.

In the same way, we can count the preference value for the Covid-19 to become 61.76 and the Influenza become 66.18. Because Cold gets the highest number, Cold is the most likely the virus that infects the user.

Table 5 Sample the user input and the normalization result

Criteria	User Input	Description	Normalization
Cough	2	Little	11.76
Fever	0	Never	0.00
Runny Nose	3	Sometimes	17.65
Sore Throat	4	Frequently	23.53
Breathlessness	0	Never	0.00
Headache	3	Sometimes	17.65
Body Aches	1	Rare	5.88
Sneeze	4	Frequently	23.53
Fatigue	0	Never	0.00
Diarrhea	0	Never	0.00

Analysis

We split the discussion into two parts. First, we will discuss the app development result, how the app work, how the user puts the data, and how the app shows the result. Secondly, we discuss how we evaluate the app. We created three scenarios with specific inputs for Covid symptoms, Influenza symptoms, and Flu symptoms. Because the input symptoms are specific to one type of virus, if the application runs well, the results should match the specific symptoms entered.

The app has two main pages, a page for inputting the symptoms (Figure 1) and a page to display the results (Figure 2). We use Bahasa Indonesia as the app language as we are targeting the user from Indonesian people. On the input page, the user enters each symptom, with a choice starting from "none" if the user does not experience the symptom to "severe" if the user badly experiences the symptoms. In the background, the app will convert into a weighted number starting 0 for "none" to 4 for severe symptoms. The result of the preference value is displayed on page 2, as can be seen in Figure 2..

Figure 1. Page for input the symptoms

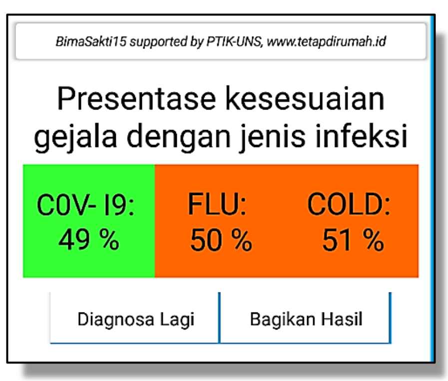

Figure 2. Result page

Scenario-based testing is considered successful if the preference results conform to the specific type of symptom given. Specific symptoms are symptoms that have a significant weight in one type of virus, but on the contrary, minor or rarely occurs for two other viruses. For example, a specific symptom of a cold is sneezing. Sneezing is a specific Cold symptom because it rarely occurs in Covid-19 and Influenza infections. The specific symptom of Covid-19 is shortness of breath, and these symptoms are rare in

Influenza and Cold. So if specific flu symptoms are given, then the tool is considered successful if the preference calculation results show the Flu as the highest value.

When this article was written, some Covid-19 sufferers experienced other specific symptoms such as loss of sense of taste and smell. However, because it has not been written in the official WHO documents, it is not included in the weighting process. So there are three scenarios, people with a tendency for Covid-19 symptoms, a tendency for Influenza symptoms, and a tendency for Cold symptoms. Table 4 shows the specific symptoms according to each scenario.

Table 4. Input with specific symptoms for each virus

Criteria	Scenario 1: Covid-19	Scenario 2 Influenza	Scenario 3: Cold
Cough	4	4	0
Fever	4	4	0
Runny Nose	1	0	4
Sore Throat	4	0	4
Breathlessness	4	0	0
Headache	1	3	0
Body Aches	2	3	4
Sneeze	1	0	4
Fatigue	1	3	1
Diarrhea	2	3	0

With specific symptoms, as seen in Table 4, we can get the results in Table 5.

Table 5 Scenario-based testing result

Scenario	Covid-19 (%)		Influenza. (%)		Cold (%)	
	App	Manual	App	Manual	App	Manual
1	**84**	**83.68**	74	73.96	49	48.96
2	84	83.75	**100**	**100**	41	41.25
3	57	57.35	65	64.71	**97**	**97.06**

Further results show that symptoms tend to Covid-19 (scenario 1), the highest preference number is acquired by Covid-19, which is 84%, and for Influenza and Cold are 74% and 49%, respectively. For specific Influenza symptoms (Scenario 2), the Influenza gets 100%, followed by Covid-19 84% and Cold 41%. Scenario 3 for Cold also shows relevant results, Cold gets 97%, followed by Influenza and Covid-19 at 65% and 57%, respectively. All scenarios successfully show us that the app and SAW can differentiate kinds of virus infection. Looking further at the second scenario, the preference number between Covid-19 and Influenza does not have a significant gap, and this small gap shows many similarities symptoms between the two viruses. Without using the app, we may say that the two will be difficult to distinguish.

Conclusion

The developed app with an embedded SAW algorithm has been shown to determine the kind of infection by inputting the weight of the symptoms. Covid-19 and Influenza infections have many symptoms that are similar in weight, so the SAW algorithm gives preference values with minor distinction. Over time, there are new symptoms of Covid-19 acknowledged; it opens the potential for further research by adding the types of symptoms and their weight and implementing other algorithms.

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