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Decision Support System for Determining Vaccination Priorities Using the AHP TOPSIS Method

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ABSTRACT

Vaccination is the administration of vaccines to a living being to stimulate the formation of an immune system against a virus, while mass vaccination is the simultaneous administration of vaccines to a group in the form of organizations, companies, or the wider community to create *herd immunity*. However, with the limited number of vaccines available, it is not possible to carry out a thorough vaccination of a group with a very large number of members. It requires determining in advance who will be prioritized for the vaccine. The purpose of this study is to build a system that can automatically determine vaccination priorities to be more effective and efficient by implementing a decision support system using *the Analytical Hierarchy Process* (AHP) method and *the Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS). The result of this study is the formation of a *Web-based* decision support system application that *produces the output* of alternative *ranking* sequences as objects that will be prioritized for vaccines based on calculations against predetermined criteria.

1. Introduction

On 11 March 2020, *the World Health Organization* (*WHO*) has designated *coronavirus* (*COVID-19*) [1] as a global pandemic. This *COVID-19* virus was first discovered in Wuhan, China in December 2019. The *COVID-19* virus causes respiratory infections ranging from the common *cold* to more severe diseases such as *Middle East Respiratory Syndrome (MERS)*, and *Severe Acute Respiratory Syndrome (SARS)*. A person can be infected from a *person with COVID-19* through small *droplets (droplets*) from the nose or mouth when coughing or sneezing. *The droplets* then fall on surrounding objects. Then if someone else touches an object that has been contaminated with the *droplets*, then that person touches the eyes, nose or mouth (triangle of the face), then that person can be infected with *COVID-19*. Or it could be that someone is infected with *COVID-19* when accidentally inhaling *droplets* from the patient.

COVID-19 is growing rapidly in the world, including in Indonesia with infected cases reaching 2.07 million and deaths reaching 56,371 on June 27, 2021. With the number of cases that continue to increase every day, the government is socializing to the public to always maintain strict health protocols to combat the *COVID-19* virus. In the fight against *COVID-19*, maintaining endurance is important. Several things that can increase immunity[2] in people exposed to *COVID-19*, such as consumption of balanced nutrition, physical activity/light exercise, adequate rest, vitamin supplements, not smoking, and control of other comorbidities. Another way to obtain active immunity is by vaccination [3]. Vaccines help develop immunity by mimicking infections. Vaccines interact with the immune system and often produce an immune response similar to that produced by natural infections. After the artificial infection disappears, the body will remember how to fight the disease in the future.

After the discovery of vaccines developed by several countries in the world, *the World Health Organization* (*WHO*) recommended to all countries to vaccinate en masse. Indonesia through Presidential Regulation 99 of 2020 and Permenkes 2020 has poured it into a written regulation. The Indonesian government also urged businesses to vaccinate their workers en masse. In a large company that has hundreds to thousands of employees[4], it is not possible for the management to be able to vaccinate all its employees at the same time due to the limited availability of vaccines. It is necessary to determine who will be prioritized to be vaccinated first, especially for employees who are very vulnerable to exposure to *COVID-19*. This will certainly be difficult

to do if the vaccination priority determination is done manually. Moreover, the results of manual prioritization of vaccinations become non-objective and very ineffective in the process of determining them. Therefore, an automated [5] system is needed that can determine who will be prioritized to be vaccinated first according to the criteria specified in the company.

Pt. Tripacific Electrindo is a manufacturing company that produces home appliances that has been established since 1990, based in Jakarta, Republic of Indonesia, with the aim of facilitating and complementing consumer needs for quality home appliances. Pt. Pt. Tripacific Electrindo has a focus on becoming a leader in the field of household electronics and is able to provide products that are able to provide satisfaction to all its users.

Problems that occur in PT. Tripacific Electrindo related to the determination of vaccination priorities is currently the system used at PT. Tripacific Electrindo still uses the system manually, which is still determined manually by the relevant management. Vaccination prioritization is determined directly by the management by collecting employee data and choosing who will be prioritized to be vaccinated. This leads to ineffectiveness of the vaccination prioritization process and the results of such determinations become inconsistent. This problem can be solved by creating an automated system that can make it easier to prioritize vaccination by applying the concept of a decision support system. A decision support system is a system that supports *decision makers* in making decisions in a complex problem, which requires consideration of the many alternative options that exist. The methods used in the decision support system to be built are *the Analytical Hierarchy Process* (AHP)[5] and *the Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS)[5]. The system will be built based on *Web* applications[6] using the PHP programming language.

2. Method

2.1 Data Collection Methods

1. Literature Study

   Data collection is carried out by studying, researching, and understanding various literature from books, scientific journals, *internet* sites, and other readings related to the research carried out.

2. Observation

   Observations are carried out in the environment of research application, namely PT. Tripacific Electrindo to obtain criteria data for determining vaccination priorities.

3. Interviews

   Interviews are conducted in the environment involved, for example to any employee member who has a high risk of contracting *COVID-19*.

2.2 System Modeling Methods

To model the system design that will be made through the design stages using *the Unified Modeling Language* (UML) modeling language[7] which contains *use case diagrams, activity diagrams, sequence diagrams* and *class diagrams.*

2.3 System Design Methods

At this stage, a *Web-based* decision support system [8] is designed using the AHP (Analytical Hierarchy Process) and TOPSIS (Technique for Others Preference by Similarity to Ideal Solution) methods using the AHP (*Analytical Hierarchy Process*) and TOPSIS (*Technique for Others Preference by Similarity to Ideal Solution)* methods.).

2.4 Problems Encountered

In addition to the difficulty of determining vaccination priorities due to the large number of employees, there are other problems in the system that runs at PT. Electrindo's tripacific to the vaccination determination procedure. The problem is that the selection of employees to be used as a priority to be vaccinated is still carried out manually, so the selection process takes a long time and the selection results are not objective, making this running system ineffective and efficient.

2.5 Alternative Troubleshooting

Alternative problem solving of the running system of determining vaccination priorities in PT. Tripacific Electrindo, namely:

1. After employee data is collected, personnel input data through a system in the form of a *Web* application connected to the *internet*[8] so that the data is not messy and lost.
2. With the system created, the process of analyzing employee data and the selection process for determining employees who will be prioritized for vaccines are carried out automatically so that the determination of vaccination priorities becomes more effective and efficient and the results of the system are more objective than the manual method.

2.6 User Requirement [9]

Table 1. Final Stage Elicitation

Functional	
User Needs Analysis	
No.	**Information**
1	View employee data

2	View add-in employees
3	View employee edits
4	Remove an employee
5	Display criteria data
6	View added criteria
7	View edit criteria
8	Delete criteria
9	Display edit criteria weight values
10	View alternate data
11	View add-ins
12	View alternate edits
13	Remove an alternative
14	Display alternate weight value edits
15	Perform *automatic rankings*
16	Display *ranking* results
17	Print *ranking results*
18	Change *user password*
Non Functional	
I want the app to be able to	
1	Easy to use by *users*
2	View *logins* and *sign out*
3	Has a simple look

3. Result and Discussion

3.1 Proposed New Procedures

The decision support system for determining vaccination priorities is an application that will help provide decisions to determine who will be prioritized for vaccines at PT. Tripacific Electrindo. With this application, it is hoped that decision making will be more effective and efficient and more objective in determining who will be prioritized for the vaccine.

Through this application, the channeling department can input employee data, criteria data and alternative data via the web without installing the application, simply by accessing the web URL through a web browser[10].

After opening the application in the *web browser* the admin can *log into* the system, to add employee data, change the value of criteria and alternative data, to determine the priority of vaccination using the AHP method as a determination of the weight of the criteria to be used in the calculation stage of the TOPSIS method based on several predetermined criteria. Here the system will display employee data information, with weights on each of the criteria for the decision-making of vaccination prioritization.

3.2 Use Case Diagram

Here is the use case diagram of the system design to be created:

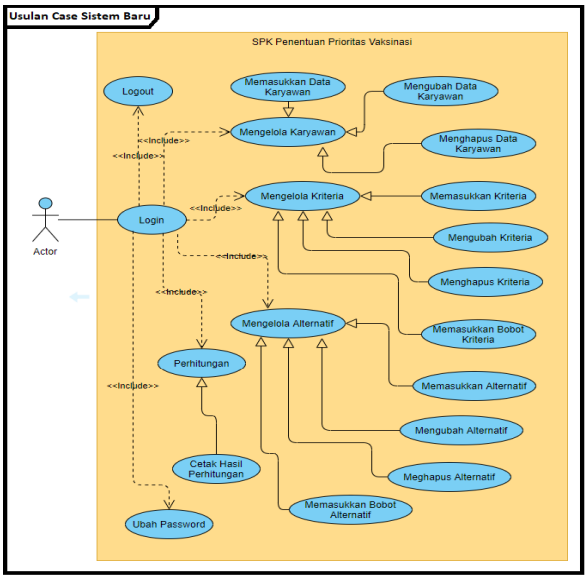

Figure 1. *Use Case Diagrams* of Proposed System

Based on the picture above, there is an actor who *acts* as a user as well as a system manager whose duties are unified and called an admin. Admins can perform several activities in the system when they have successfully *logged* into the system. Some of the activities contained in the system include:

1. Managing Employees
2. Managing Criteria
3. Managing Alternatives
4. Calculating the decision support system using the AHP TOPSIS method
5. Change the password
6. *Log out* to exit the system

3.3 Activity Diagram

Here are some of the activity diagrams of the newly created system:

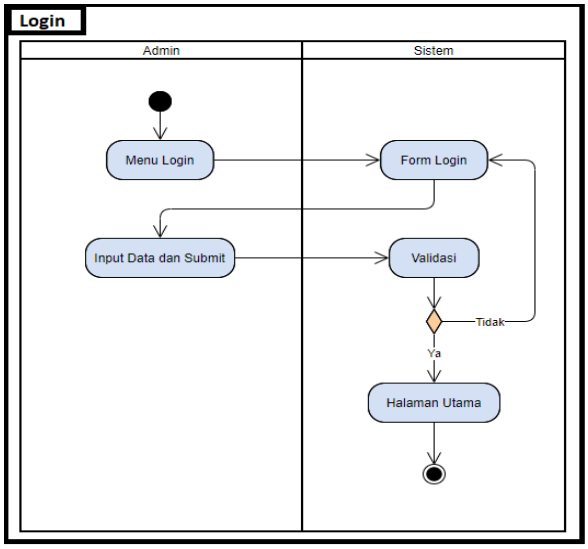

Figure 2. *Activity Login Diagram*

Based on the picture above, it shows *the login* activities carried out before entering the system. First the admin enters *the username* and *password* on *the login form*, after that click the *login* button to *submit*. Then the system validates whether the *username* and *password* correspond to the *database*. If appropriate and correct then the system displays the main page. If not, then the system returns to the *login form*.

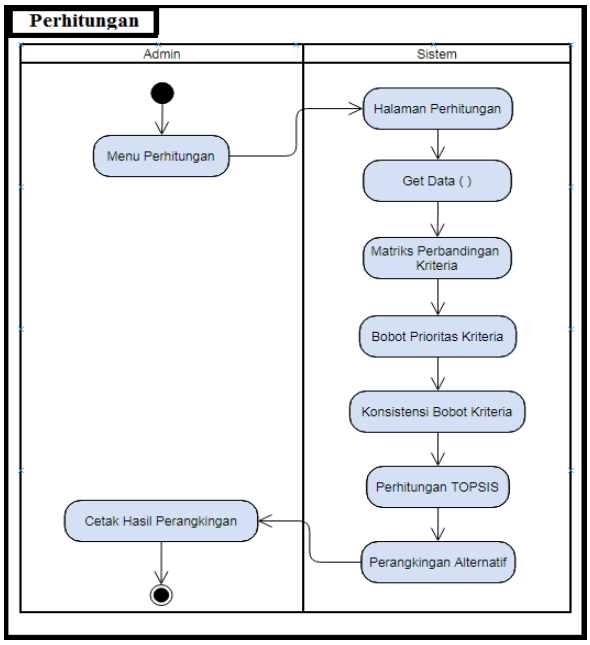

Figure 3. *Activity Diagram* Account

Based on the picture above, admins can see the CALCULATION OF AHP TOPSIS by selecting the calculation menu. Then the system will take criteria and alternative data as conditions in carrying out calculations. After that, the system displays a matrix of comparison of criteria then the AHP calculation is carried out on the weight of the criteria and then the results are ensured to be consistent. Then the system performs a ranking on each alternative using the TOPSIS method. Admins can also print *ranking* results by pressing the print button on the alternate *ranking* page.

3.4 Sequence Diagram

Here are some sequence diagrams of the newly created system:

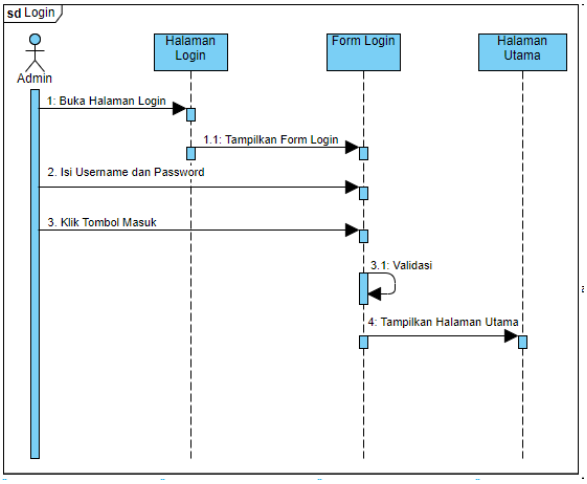

Figure 4. *Login Sequence Diagram*

Based on the picture above, it shows *the login* activities carried out before entering the system. First the admin opens *the login menu* to enter the *login form*, then the system displays *the login form*. After that, the admin enters *the username* and *password* on *the login form*, after that click the login button to submit. Then the system validates whether the *username* and *password* correspond to the *database*. If appropriate and correct then the system displays the main page. If not, then the system returns to the *login form*.

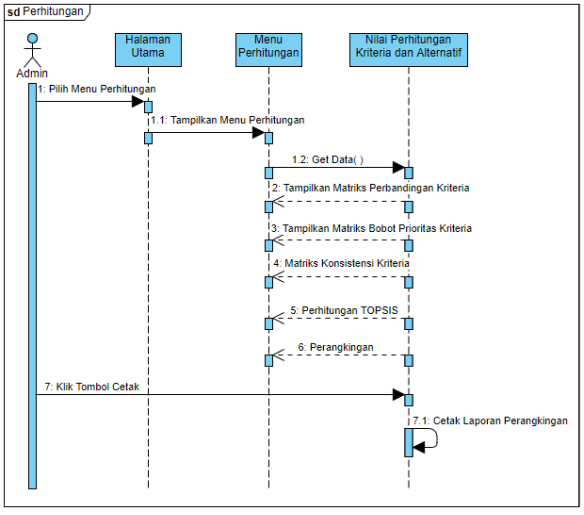

Figure 5. *Sequence Diagram* Account

Based on the picture above, admins can see the CALCULATION OF AHP TOPSIS by selecting the calculation menu on the main page. Then the system

will take criteria and alternative data as conditions in carrying out calculations. After that, the system displays a matrix of comparison of criteria then the AHP calculation is carried out on the weight of the criteria and then the results are ensured to be consistent. Then the system *ranks* each alternative with the TOPSIS method. After *the ranking* is carried out, the *ranking* result data can be printed by clicking the print button on the calculation menu page. Then the system will display a *ranking* report on determining vaccination priorities using the AHP TOPSIS method. And the admin clicks *print*, then the system will process the print of the report.

3.5 Class Diagram

The following is a *class diagram* on the system to be created, namely:

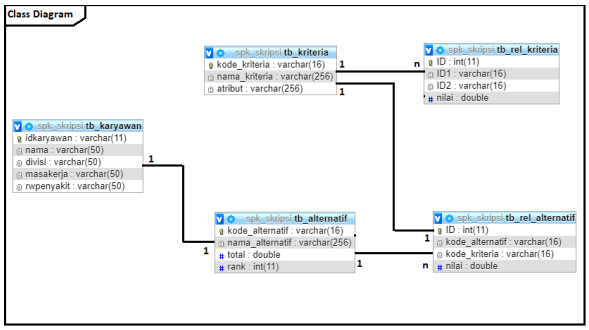

Figure 6. *Class Diagram*

Based on the figure above, the proposed *diagram class* is located:

1. Has 5 (five) *classes*, namely Employees, Criteria, Rel_Kriteria, Alternatives, and Rel_Alternatif.
2. Have 4 (four) *associations*, namely as relationships between tables in classes with the same operation.

3.6 System Display

The following are some views of the system implementation based on the design that has been made:

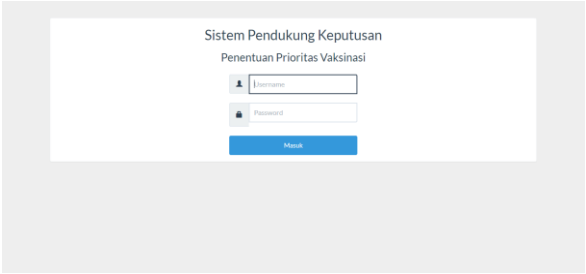

Figure 7. *Login* View

In figure 7, it *is a login* display before the *user* enters the system.

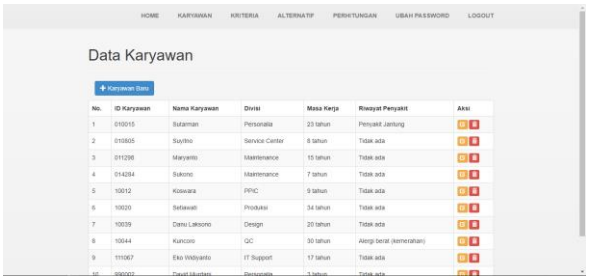

Figure 8. Employee *Menu* View

In figure 8, it is an employee *menu* display that contains employee *data*, *an* employee add menu, an employee *edit menu*, and an employee delete *menu*.

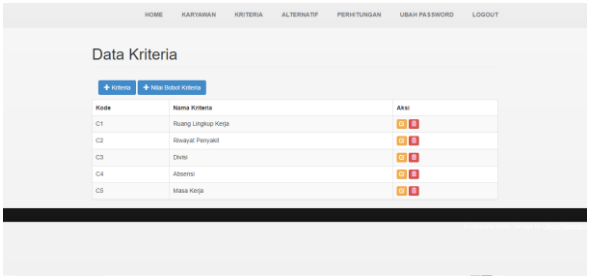

Figure 9. Criteria *Menu* Display

In figure 9, it is a display of the criteria *menu* containing criteria data, the add criteria *menu*, *the* edit criteria weight value *menu*, *the criteria edit menu*, and the criteria delete *menu*.

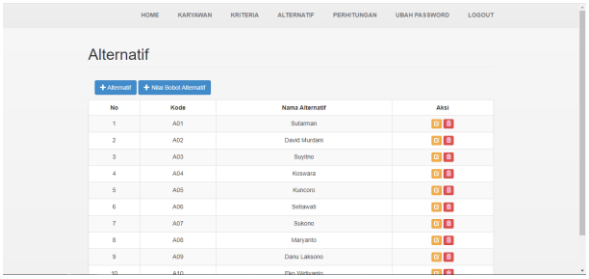

Figure 10. Alternate *Menu* Display

In figure 10, it is an alternative *menu* display that contains alternative data, an alternative add *menu*, an alternate weight value edit *menu*, an alternate *edit menu*, and an alternate delete *menu*.

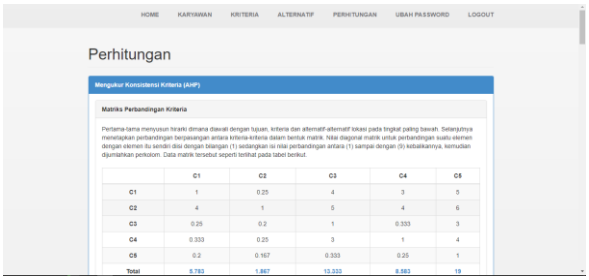

Figure 11. Calculation *Menu* Display

In figure 11, it is a display of the calculation *menu* which contains the calculation of the weight value of the criteria against each existing alternative using the

AHP TOPSIS method, *ranking* results from alternatives, and *a print menu* of alternative *ranking* results.

4. Conclusions and Suggestions

4.1 Conclusion

Based on the results of the research that has been carried out, several conclusions were obtained as follows:

1. This study aims to make it easier to determine who will be prioritized for vaccines in the work unit at PT. Electrindo's tripacifik and vaccination prioritization become more objective so that there is no fraud when determining vaccination priorities.
2. The decision support system is a system chosen to make it easier to determine who will be prioritized to be vaccinated in the work unit at PT. Tripacific Electrindo. This decision support system was chosen so that the results of the vaccination prioritization decision became more effective and efficient.
3. The methods used in this decision support system are AHP (*Analytical Hierarchy Process*) for calculating the specified criteria and TOPSIS (*Technique for Others Preference by Similarity to Ideal Solution*) for alternative calculations to the criteria in order to obtain ranking results from alternatives used to determine vaccination priorities.

4.2 Suggestion

Based on the results of the research that has been carried out, several suggestions were obtained as follows:

1. It is expected to add employee users to the system to fill in data independently because this system is still devoted to personnel as admins.
2. It is expected that the system can determine the value of each alternative automatically.
3. It is expected that this system will also be built on *a mobile* basis.

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