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# Fuzzy Analytical Hierarchy Process for Evaluating Factors Influencing Covid-19 Vaccine Acceptance

**Norpah Mahat**
College of Computing, Informatics and Media, Universiti Teknologi MARA, Perlis Branch, Perlis, Malaysia
norpah020@uitm.edu.my

**Siti Sarah Raseli**
College of Computing, Informatics and Media, Universiti Teknologi MARA, Perlis Branch, Perlis, Malaysia
sitisarahraseli@uitm.edu.my

**Nur Izyan Nabilah**
College of Computing, Informatics and Media, Universiti Teknologi MARA, Perlis Branch, Perlis, Malaysia
2022550763@siswa.uitm.edu.my

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**ABSTRACT**

The global Covid-19 pandemic originated in China and has rapidly spread to over 180 countries, infecting millions of people. As vaccination efforts are underway worldwide, Malaysia has administered booster doses, but many Malaysians have yet to sign up for the Covid-19 vaccine. This study aims to identify the factors that influence the acceptance of the Covid-19 vaccine in Malaysia and formulate a model to rank these factors. Pearson correlation analysis was used to assess the relationship between variables. Additionally, the Fuzzy Analytical Hierarchy Process (FAHP) method was employed to rank the factors. Results from Pearson correlation analysis revealed that confidence in the safety and effectiveness of the vaccine was the most significant factor influencing vaccine acceptance, followed by education level, media messages, convenience, and religion. FAHP results also showed that confidence in vaccine safety and effectiveness was the top-ranking factor with the highest weight value, followed by education, media messages, convenience, and religion. This research contributes to the understanding of the factors influencing Covid-19 vaccine acceptance in Malaysia and provides valuable insights for decision-makers to improve vaccine distribution strategies.

***Corresponding Author:***
Norpah Mahat
College of Computing, Informatics and Media, Universiti Teknologi MARA, Perlis Branch, Perlis, Malaysia.
norpah020@uitm.edu.my

## 1. Introduction

The initial outbreak of Coronavirus disease (Covid-19) occurred in China and was caused by the SARS-CoV-2 virus. The Wuhan Municipal Health and Health Commission released an official document titled "emergency notice on reporting the treatment of pneumonia of unknown cause" [1], which was reported to the World Health Organization (WHO) in December 2019. In January 2020, WHO issued a preparedness warning to all countries and declared Covid-19 as a global health emergency or global health state of emergency.

The virus subsequently spread to neighboring countries such as Thailand, Malaysia, Korea, Japan, Europe, America, and Africa [2]. As of April 2020, there were over 2,400,000 reported cases and 170,000 deaths, making the Covid-19 pandemic a global health crisis that affects people in all countries. Within just over six months since the virus was first identified in mainland China, it had spread to more than 180 nations and infected over 18.4 million individuals, as recorded in August 2020 [3].

Referring to the Ministry of Health (KKM) report, Malaysia has been witnessing daily reports of new confirmed cases and new clusters. According to [4], the first case in Malaysia was reported



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on January 2020, and then positive cases gradually increased to 22 cases on February 2020, which remained plateau for nearly two weeks. Malaysia has recorded the highest number of Covid-19 cases in Southeast Asia, with 4817 cases and 77 deaths by April 2020. The distribution of Covid-19 cases during the third wave reached 83,142 cases in December 2020.

Due to the escalating number of new Covid-19 cases in Malaysia, as indicated by KKM, the government took proactive measures by implementing a Movement Control Order (MCO) from 18th March 2020 to prevent further spread of the virus and mitigate the surge in new cases. As per research conducted by [5], during the MCO period, all Malaysians were instructed to primarily stay indoors, with only the head of the family allowed to venture out for essential needs like groceries and food. Subsequently, on 4th May 2020, the government implemented the Conditional Movement Control Order (CMCO), followed by the Recovery Movement Control Order (RMCO) on 10th July 2020 [5].

In addition to the measures mentioned above, the Malaysian government has also been actively promoting Covid-19 vaccination as a key strategy to combat the spread of the virus. However, despite the government's efforts, vaccine acceptance has not been universally supported by all segments of the Malaysian population. The research was initiated in response to the problem of lower acceptance of vaccines in Malaysia, which has posed challenges to the national immunization program and efforts to control infectious diseases such as Covid-19. Recognizing the importance of understanding the factors that influence vaccine acceptance, the researchers undertook this study to provide evidence-based insights into the determinants of vaccine acceptance among Malaysians. The research aimed to fill the knowledge gap and contribute to the development of effective strategies to address vaccine hesitancy and promote vaccination uptake in the country.

## 2. Literature Review

The durable and infectious structure of the Covid-19 virus manifests in various forms, typically appearing as a spherical shape enveloped by a protective layer called a "glycoprotein". This glycoprotein facilitates the virus's ability to bind to human cells and weaken the immune system. At the core of the virus lies the viral nucleus, which contains RNA (Ribonucleic acid) that undergoes frequent mutations. This complex structure poses challenges to scientists in developing a vaccine to effectively eradicate the virus. However, this RNA structure also serves as a diagnostic tool for doctors in conducting specific tests to detect the presence of the virus in patients [6]. The understanding of the Covid-19 virus's structure and its RNA composition has been instrumental in the initiation of vaccine development efforts. Scientists and researchers have been leveraging this knowledge to create vaccines that can trigger the immune system to recognize and fight against the virus. Despite the challenges posed by the virus's complex structure, ongoing research and analysis of its components have led to significant progress in vaccine development, with several vaccines now available for administration worldwide.

The vaccination campaign against Covid-19 in Malaysia is a government-led effort aimed at preventing the spread of the disease and ultimately ending the pandemic in the country. This initiative is focused on achieving herd immunity among Malaysians and non-Malaysians alike. To oversee the program, the Malaysian Cabinet has appointed the Minister of Science, Technology, and Innovation as the coordinating minister. A special committee called the Covid-19 Vaccine Supply Access Guarantee (JKJAV) has also been established, co-chaired by the Health Minister and the Minister of Science, Technology, and Innovation, to ensure timely procurement of Covid-19 vaccines for the country. The immunization program, which began in February 2021, will be conducted in phases until February 2022. Notably, the Malaysian Prime Minister was among the first to receive the Covid-19 vaccine as a symbol of leadership and confidence in the vaccination campaign.

The involvement of the community and achieving high vaccine coverage are crucial in overcoming the Covid-19 epidemic. However, there is a concerning issue of low acceptance of the Covid-19 vaccine among the Malaysian population. Despite the provision of booster doses, there is a need for more Malaysians to sign up and accept the vaccination. It is evident that various factors may contribute to different acceptance rates of the vaccine among different populations, as highlighted by recent research [7]. Thus, the main objective of this study is to identify the factors that influence the acceptance of the Covid-19 vaccine in Malaysia, with a specific focus on determining and ranking the related factors that impact vaccine acceptance.

The Pearson correlation test can be utilized in this study to examine the strength and direction of the relationship between different factors and the acceptance of the Covid-19 vaccine among Malaysians. It can help identify if there are any significant correlations between variables

such as age, gender, education level, socioeconomic status, and vaccine acceptance. The results of the Pearson correlation test can provide valuable insights into which factors are positively or negatively correlated with vaccine acceptance, helping to better understand the underlying factors that influence vaccine acceptance in Malaysia.

Furthermore, the utilization of Fuzzy Analytic Hierarchy Process (FAHP) in this study can provide a robust decision-making approach for addressing hierarchical and ranking problems related to vaccine acceptance [8]. FAHP allows for interval decisions, which provide decision-makers with greater flexibility and confidence compared to fixed value judgments. Previous research has shown that FAHP has been effective in ranking problems and is in closer alignment with real-world situations [9]–[11]. The findings of this study make a significant contribution to the field of FAHP by demonstrating the relationship between the Pearson correlation and FAHP methods.

## 3. Methodology

### 3.1 The dataset

Data for this research was collected through a questionnaire administered via a Google Form, with the objective of identifying the acceptance of Covid-19 vaccine and its influencing factors, as well as conducting correlation analysis among these factors. The sampling method employed in this study involved random selection of individuals in Malaysia who were eligible for the Covid-19 vaccine and had access to the internet to fill the Google Form survey. A total of 171 participants took part in the survey. The questionnaire incorporated several factors to assess vaccine acceptance as described in Table 1. These factors were included in the survey to gather insights into their impact on individuals' acceptance of Covid-19 vaccine.

Table 1. Acceptance factors of Covid-19 vaccine

| Factors | Descriptions |
|---|---|
| *The message spread by media* | This factor aimed to understand the role of media in shaping individuals' perception of Covid-19 vaccine. |
| *Religion* | This factor sought to explore the influence of religious beliefs on individuals' acceptance of the Covid-19 vaccine. It examined whether religious beliefs or practices played a role in shaping their attitudes towards getting vaccinated. |
| *Education* | This factor aimed to assess the relationship between education level and vaccine acceptance. It explored whether higher education levels were associated with higher acceptance of the Covid-19 vaccine, considering the potential influence of education on health literacy and decision-making. |
| *Convinience* | This factor focused on the convenience of accessing the Covid-19 vaccine. It assessed the perceived ease of getting vaccinated in terms of availability, accessibility, and affordability of the vaccine, as well as the convenience of scheduling and receiving the vaccine. |
| *Vaccine safety and effectiveness* | This factor sought to understand the perception of vaccine safety and effectiveness among individuals. It assessed their concerns or confidence in the safety of the Covid-19 vaccine, including potential side effects, efficacy, and approval process. |
| Other | Other in this study refers to additional variables or factors that were not specifically included in the questionnaire. It is important to note that while the study examined several key factors, there may be other influential factors that were not explored or measured in the current research. Further investigation and exploration of these potential factors may be warranted in future studies to gain a more comprehensive understanding of the complexity of vaccine acceptance behavior |

In this study, SPSS (Statistical Package for the Social Sciences) was utilized to conduct the Pearson Correlation analysis. Pearson Correlation is a statistical method used to measure the strength and direction of the linear relationship between two variables. The correlation coefficients obtained from the analysis were interpreted according to the guidelines provided in Table 2, which lists the interpretation of correlation coefficients.

Table 2. Interpretation of Correlation Coefficients (CE)

| CE | Interpretation |
|---|---|
| 1 | Perfect (positive/negative) correlation |
| ±0.99 to ±0.99 | Very high (positive/negative) correlation |
| ±0.70 to ±0.90 | High (positive/negative) correlation |
| ±0.50 to ±0.70 | Moderate (positive/negative) correlation |
| ±0.30 to ±0.50 | Low (positive/negative) correlation |
| ±0.10 to ±0.30 | Very Low (positive/negative) correlation |
| ±0.00 to ±0.10 | Negligible (positive/negative) correlation |

The CE value ranges from -1 to +1, where -1 indicates a perfect negative correlation, +1 indicates a perfect positive correlation, and 0 indicates no correlation. A correlation coefficient of 0.00 to 0.10 is considered negligible or weak, while a correlation coefficient of 0.10 to 0.30 is considered a very low correlation. It is important to note that correlation does not necessarily imply causation and that other factors may be influencing the relationship between the two variables.

**3.2 Implementation of FAHP**

The primary data was collected at Dewan Apam Putra, Pasir Mas, Kelantan. The aim of collecting this data was to identify which factor influenced the most in accepting the Covid-19 vaccine according to rank. In general, the implementation of Fuzzy Hierarchy Process begins with the preparation of questionnaires and interviews with experts in the field. The questionnaire was prepared based on factors that have been identified through Pearson Correlation Analysis as having a relationship with the reason for receiving the vaccine. Then, the questionnaire was asked through an interview to the experts, that are, the doctors who are in charge of screening potential vaccine recipients at the vaccination centre. The respondents will be guided to determine the suitable Linguistic terms and their corresponding triangular Fuzzy numbers. The triangular scale is very useful to calculate the ranking factors by using Fuzzy Hierarchy Process.

The FAHP (Fuzzy Analytic Hierarchy Process) involves six essential steps as described in the literature [12]. These steps include: (1) identifying the factors using linguistic terms, (2) constructing the pair-wise comparison matrix, (3) calculating the fuzzy weights, (4) calculating the geometric mean of the fuzzy relation and criterion values, (5) calculating the fuzzy weight for each criterion, and (6) de-fuzzifying and normalizing the fuzzy weights. Details for each step are as the following.

Step 1: to identify the acceptance factors, the experts used linguistic terms and a corresponding scale outlined in Table 3 from the literature [13] to compare each factor and identify acceptance factors. If the expert deemed "Factor 1" less important than "Factor 2," they used the corresponding fuzzy triangular scales of (2,3,4), and if "Factor 1" was moderately or fairly important, they used the scales of (4,5,6). In the first case, the pairwise contribute matrix of the criteria compared "Factor 2" to "Factor 1" using the fuzzy triangular scale figure of (1/4, 1/3, 1/2), while in the second case, the fuzzy triangular scale figure of (1/6, 1/5, 1/4) was used. The same method was applied when comparing "Factor 1" with "Factor 3", "Factor 4", and "Factor 5".

Table 3. The Linguistic terms and the Corresponding Triangular Fuzzy Numbers

| Scale | Definition | Triangular Fuzzy Scale |
|---|---|---|
| 1 | Equally important to both factors | (1,1,1) |
| 3 | Weakly important | (2,3,4) |
| 5 | Fairly important | (4,5,6) |
| 7 | Strongly important | (6,7,8) |
| 9 | Absolutely important | (9,9,9) |
| 2 | The intermittent levels of importance among two adjacent scales | (1,2,3) |
| 4 | | (3,4,5) |
| 6 | | (5,6,7) |
| 8 | | (7,8,9) |

Step 2: to construct the pair-wise comparison matrix, $\tilde{A}^{k}$ . By referring to Table 2, the pair-wise comparison matrix is structured in Equation (1). Each criteria alternative's score relates to each criterion and is defined as $d_{ij}^{k}$, which referred to the $K^{th}$ EXPERT Selection of $i^{th}$ factor over $j^{th}$ factor.

$$\begin{bmatrix} d_{11}^{K} & d_{12}^{K} & \dots & d_{1n}^{K} \\ d_{21}^{K} & \dots & \dots & d_{2n}^{K} \\ \dots & \dots & \dots & \dots \\ d_{n1}^{K} & d_{n2}^{K} & \dots & d_{nn}^{K} \end{bmatrix} \quad (1)$$

Step 3: to calculate the fuzzy number of factors by using the formula in Equation (2).

$$D_{ij} = \frac{\sum_{k=1}^{k} d_{ij}^{k}}{K} \quad (2)$$

where k = number expert and $(d_{ij}^{k})$ = average expert preference.

Step 4: to calculate the geometric mean of the fuzzy relation and the values of each criterion Using the formula in Equation (3), where n from pair-wise comparison matrix at Equation (2) which is the number of factors.

$$\bar{r}_1 = \left(\prod_{j=1}^{n} d_{ij}\right)^{\frac{1}{n}} \quad (3)$$

where $i = 1,2,3 \dots . n$

Step 5: to calculate the fuzzy weight for each criterion. To begin, compute the vector summation $d_i$ for each $\bar{r}$ by using Equation (4). Find the (-1) power of the summation vector and replace the fuzzy triangular number to make it in increasing order.

$$D_{1=(t_1 \oplus t_2 \oplus \dots . t_n)} \quad (4)$$

Then, to calculate the fuzzy weight of criterion, $w_i$ and multiply each $i$ with the reverse vector. The formula for $w_1$ is shown in Equation (5).

$$W_1 = \bar{r}_1 \otimes (\bar{r}_1 \oplus \bar{r}_2 \dots . \bar{r}_n)^{-1} = lw_1, mw_1, uw_1 \quad (5)$$

The variable $l$ is refer to the lower number of increasing orders of $d_i$, $m$ is refer to the median number of increasing orders of $d_i$ , and $u$ is refer to the upper number of increasing orders of $d_i$ .

Step 7: to de-fuzzify and normalise the fuzzy weight. By using the centre of area defuzzification, the fuzzy weight, $w_i$ need to be defuzzified since they are still fuzzy triangular numbers by applying Equation (6). Then, it needs to be Normalized using Equation (7).

$$M_i = \frac{lw_i + mw_i + uw_i}{3} \quad (6)$$

$$N = \frac{M_i}{\sum_{i=1}^{n} M_I} \quad (7)$$

## 4. Results and Discussion

Based on the findings presented in Figure 1, the results indicate that the "Confidence in vaccine safety and effectiveness" factor had a statistically significant positive correlation with vaccine acceptance, as evidenced by a p-value < α (0.000 < 0.01) and an r-value of 0.469. Additionally, the "Education" factor showed a statistically significant impact on vaccine acceptance with a low positive correlation (r-value of 0.262) and a p-value < α (0.003 < 0.01). On the other hand, the "Message spread by media" factor did not demonstrate statistical significance as the p-value (0.03) was greater than α (0.01), and the correlation was very low (r-value of 0.234) indicating rumors spread by media had minimal influence on vaccine acceptance. Similarly, the "Convenience" factor showed a very low correlation (r-value of 0.195) and no statistical significance (p-value of 0.111 > α of 0.05). The "Religion" factor, on the other hand, was found to be statistically significant (p-value of 0.02 = α) with a very low positive correlation (r-value of 0.18) with vaccine acceptance. Finally, the “Other” factors had negligible positive correlations (r-value of 0.100) with vaccine acceptance.

In conclusion, the results indicate that the primary factor influencing vaccine acceptance was the "Confidence in vaccine safety and effectiveness," followed by the "Education" factor. The impact of “Message spread by media”, “Convenience”, “Religion”, and “Other” was relatively minimal.

| | | Convenience | The messages spread by the media | Confidence of vaccine safety and effectiveness | Education | Religion | Other | Accept the vaccine |
|---|---|---|---|---|---|---|---|---|
| Accept the vaccine | Pearson Correlation | .195* | .234** | .469** | .262** | .180* | .100 | 1 |
| | Sig. (2-tailed) | .011 | .002 | .000 | .001 | .020 | .197 | |
| | N | 169 | 169 | 169 | 169 | 168 | 169 | 169 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 1. Results from Pearson Correlation

Furthermore, the result obtained by the FAHP method was evaluated based on the factors influencing the acceptance of the Covid-19 vaccine. In this stage, the weight of each criterion was determined based on linguistic term and corresponding fuzzy number.

The average fuzzy number was calculated once the first two steps of the process have been completed. The average of each criterion was calculated based on their preferences. Based on the Pearson Correlation result, the five vaccine acceptance factors included in this study are listed in Table 4.

Table 4. Factors of Vaccine Acceptance

| No | Factors |
|---|---|
| 1 | Religion |
| 2 | Education |
| 3 | Convenience |
| 4 | The message spread by media |
| 5 | Confidences of vaccine safety and effectiveness |

Each criteria alternative's score relates to each criterion, $d_{ij}$ were calculated with Equation (2) and presented in Table 5. The column titled "No" denotes the factors that are listed in Table 4.

Table 5. Alternative's Score, $d_{ij}$

| No | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | (1,1,1) | (0.45,0.47,0.55) | (1.49,1.21,1.07) | (1.12,0.81,0.53) | (0.27, 0.39,0.73) |
| 2 | (3.33,4,4.66) | (1,1,1) | (2.08,1.44,0.88) | (1.78,1.5,1.33) | (1.73,1.41,1.11) |
| 3 | (2.5,3.11,3.75) | (1.33,1.33,1.56) | (1,1,1) | (2.19,1.94,1.83) | (0.24,0.33,0.57) |
| 4 | (2.66,3.17,3.78) | (0.83,1.11,1.42) | (1.08,1.23,1.5) | (1,1,1) | (1.38,1.06,1.4) |
| 5 | (2.33,3.33,4.33) | (1.5,1.78,2.08) | (2.17,2.78,3.42) | (2.33,2.5,2.78) | (1,1,1) |

Based on the criteria alternative's score, the geometric mean of the fuzzy comparison will be calculated by using Equation (8), that shows the overview of computation for the "Confidences of vaccine safety and effectiveness" factor. Before determining the value of each criterion's fuzzy weight, the vector summation must be computed and power with -1. As a result, the geometric mean of fuzzy comparison values is shown in Table 6.

$$\tilde{r}_{confidences\ of\ vaccine\ safety}$$
$$= [(\ 2.333x1.500x2.167x\ 2.333x1)^{\frac{1}{5}}, (3.333x1.778x2.500x2.778x1)^{\frac{1}{5}}, (4.333x2.083x3.417x2.778x1)^{\frac{1}{5}}\ ]$$
$$= (1.777,\ 2.103,\ 2.435) \quad (8)$$

The fuzzy weight of each factor will be calculated in the fifth step. As a result, Equation (9) indicates the relative fuzzy weight for the criteria "Confidences of vaccine safety".

$$w_{Confidences\ of\ vaccine\ safety} = (1.777,\ 2.103,\ 2.435)\ \text{x}\ (0.152,\ 0.168,\ 0.180)$$
$$= [(1.777\ \text{X}\ 0.152),\ (2.103\ \text{X}\ 0.168),\ (2.435\ \text{X}\ 0.180)]$$
$$= (0.270, 0.353, 0.438) \quad (9)$$

The non-fuzzy weight was de-fuzzified and Normalized as in sixth step. As a result, the fuzzy weight for the criterion "Confidences of vaccine safety and effectiveness" was de-fuzzified with Equation (10).

$$M_{confidences\ of\ vaccine\ safety} = \frac{0.270+0.353+0.438}{3} = 0.354 \quad (10)$$

Finally, for the "Confidences of vaccine safety and effectiveness" factor, the Normalized weight was obtained by using Equation (11).

$$N_{confidences\ of\ vaccine\ safety} = \frac{0.354}{0.122+0.271+0.211+0.238+0.354} = 0.296 \quad (11)$$

By following the six steps provided, the criterion with the highest score was suggested as the most essential factor. Table 6 shows the results of geometric mean fuzzy comparison value and Table 7 shows the relative fuzzy weight value for all factors.

Table 6. Geometric Mean of Fuzzy Comparison Value

| Factors | Geometric Mean | | |
|---|---|---|---|
| Religion | 0.728 | 0.715 | 0.743 |
| Education | 1.845 | 1.651 | 1.419 |
| Convenience | 1.121 | 1.219 | 1.434 |
| The message spread by media | 1.272 | 1.356 | 1.622 |
| Confidences of vaccine safety and effectiveness | 1.777 | 2.103 | 2.435 |

Table 7. Relative Fuzzy Weight

| Factors | Fuzzy Weight | | |
|---|---|---|---|
| Religion | 0.111 | 0.120 | 0.134 |
| Education | 0.280 | 0.277 | 0.255 |
| Convenience | 0.170 | 0.205 | 0.258 |
| The message spread by media | 0.193 | 0.228 | 0.292 |
| Confidences of vaccine safety and effectiveness | 0.270 | 0.353 | 0.438 |

Finally, Normalized weight for all factors were calculated. Table 8 shows the value of De-fuzzified and Normalized fuzzy weight.

Table 8. De-fuzzied and Normalized Fuzzy Weight

| Factors | De-fuzzied Fuzzy Weight | Normalized Fuzzy Weight |
|---|---|---|
| Religion | 0.122 | 0.101 |
| Education | 0.271 | 0.226 |
| Convinience | 0.211 | 0.177 |
| The message spread by media | 0.238 | 0.199 |
| Confidence of vaccine safety and effectiveness | 0.354 | 0.296 |

The value of fuzzy weights, normalized weight and ranking for all factors influencing acceptance vaccine of Covid-19 are presented in Table 9. The factor with highest fuzzy weight value ranked as the most related factors influence acceptance of vaccine Covid-19.

Table 9. Fuzzy Weight, Normalized Weights and Ranking of Acceptance Factors

| Factors | *M* | *N* | Rank |
|---|---|---|---|
| Confidence of vaccine safety and effectiveness | 0.354 | 0.296 | 1 |
| Education | 0.271 | 0.226 | 2 |
| The message spread by media | 0.238 | 0.199 | 3 |
| Convenience | 0.211 | 0.177 | 4 |
| Religion | 0.122 | 0.101 | 5 |

According to the findings in Table 9, the factor with the highest contribution to the acceptance of Covid-19 vaccine was the "Confidence of vaccine safety and effectiveness". The weight value of this factor was 0.296, which was higher than the weight values of other factors. The "Education" factor had a weight value of 0.226, "The message spread by media" had a weight value of 0.199,

"Convenience" had a weight value of 0.1777, and "Religion" had a weight value of 0.101. The order of priority for the factors was "Confidence of vaccine safety and effectiveness" as the first rank, followed by "Education" as the second rank, "The message spread by media" as the third rank, "Convenience" as the fourth rank, and "Religion" as the fifth rank.

Based on the findings, it is evident that the public's trust in vaccine safety and effectiveness is critical in ensuring high vaccine acceptance rates. This highlights the importance of providing accurate and transparent information regarding the safety and efficacy of the Covid-19 vaccine to the public. Moreover, the results suggest that education also plays a significant role in vaccine acceptance. Therefore, targeted educational campaigns aimed at addressing the concerns and misconceptions regarding the vaccine can positively impact vaccine acceptance rates.

Additionally, the findings indicate that the spread of misinformation through the media can have a negative impact on vaccine acceptance rates. Therefore, it is essential to have a reliable and trustworthy source of information to combat misinformation and promote accurate information about the vaccine.

Lastly, the study shows that convenience and religion also have a small but noteworthy impact on vaccine acceptance rates. Thus, policymakers and healthcare providers must consider the convenience of vaccine access and the cultural and religious beliefs of the community when promoting vaccination campaigns.

The results of both the FAHP method and correlation analysis are comparable, as demonstrated by the findings. Both the methods have corroborated the fact that the factor of “Confidence in vaccine safety and effectiveness" is the most critical factor that influences the acceptance of Covid-19 vaccine.

Additionally, this study has focused on the proposed factors affecting the acceptance of the Covid-19 vaccine based solely on individual opinions, rather than taking into account all perspectives such as those of the government and the community.

## 5. Conclusion

The factors that influence the acceptance of the Covid-19 vaccine have been thoroughly investigated and evaluated in this study. The Pearson Correlation method was used to determine that the confidence in vaccine safety and effectiveness is the primary factor affecting vaccine acceptance, followed by education, message spread by media, convenience, religion, and other factors. The Fuzzy Analytic Hierarchy Process (FAHP) method was also employed to rank the relative importance of these factors, and the results confirm that confidence in vaccine safety and effectiveness is the most influential factor in vaccine acceptance, followed by education, message spread by media, convenience, and religion.

The study's objectives have been successfully achieved by identifying and ranking the factors that influence Covid-19 vaccine acceptance, as well as demonstrating the relationship between the FAHP and SSPS methods. The research findings provide valuable insights into Covid-19 vaccine acceptance and highlight the need for targeted interventions to increase vaccine acceptance. However, it is important to note that this study only considered individual opinions, and other factors such as government and community perceptions should also be taken into account.

Future research can build on these findings by exploring additional factors that inform effective vaccination strategies. Overall, this study emphasizes the importance of understanding the factors that influence Covid-19 vaccine acceptance to develop effective vaccination campaigns and combat vaccine hesitancy.

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## Conflict of Interest

The authors declare no conflict of interest in the subject matter or materials discussed in this manuscript.

## References


[1] S. Kannan, P. Shaik Syed Ali, A. Sheeza, and K. Hemalatha, "COVID-19 (Novel Coronavirus 2019) - recent trends," *Eur Rev Med Pharmacol Sci*, vol. 24, no. 4, 2020, doi: 10.26355/eurrev_202002_20378.

[2] R. Pal, A. A. Sekh, S. Kar, and D. K. Prasad, "Neural network based country wise risk prediction of COVID-19," *Applied Sciences (Switzerland)*, vol. 10, no. 18, 2020, doi: 10.3390/APP10186448.

[3] R. P. Rajkumar, "Ayurveda and COVID-19: Where psychoneuroimmunology and the meaning response meet," *Brain, Behavior, and Immunity*, vol. 87. 2020. doi: 10.1016/j.bbi.2020.04.056.

[4] N. F. C. Mat, H. A. Edinur, M. K. A. A. Razab, and S. Safuan, "A single mass gathering resulted in massive transmission of COVID-19 infections in Malaysia with further international spread," *J Travel Med*, vol. 27, no. 3, 2020, doi: 10.1093/jtm/taaa059.

[5] N. A. Aziz, J. Othman, H. Lugova, and A. Suleiman, "Malaysia's approach in handling COVID-19 onslaught: Report on the Movement Control Order (MCO) and targeted screening to reduce community infection rate and impact on public health and economy," *Journal of Infection and Public Health*, vol. 13, no. 12. 2020. doi: 10.1016/j.jiph.2020.08.007.

[6] H. S. Rahman *et al.*, "The transmission modes and sources of COVID-19: A systematic review," *International Journal of Surgery Open*, vol. 26. 2020. doi: 10.1016/j.ijso.2020.08.017.

[7] A. A. Azlan, M. R. Hamzah, T. J. Sern, S. H. Ayub, and E. Mohamad, "Public knowledge, attitudes and practices towards COVID-19: A cross-sectional study in Malaysia," *PLoS One*, vol. 15, no. 5, 2020, doi: 10.1371/journal.pone.0233668.

[8] A. Rahman and Md. G. Muktadir, "SPSS: An Imperative Quantitative Data Analysis Tool for Social Science Research," *International Journal of Research and Innovation in Social Science*, vol. 05, no. 10, 2021, doi: 10.47772/ijriss.2021.51012.

[9] S. Nazari, M. Fallah, H. Kazemipoor, and A. Salehipour, "A fuzzy inference- fuzzy analytic hierarchy process-based clinical decision support system for diagnosis of heart diseases," *Expert Syst Appl*, vol. 95, 2018, doi: 10.1016/j.eswa.2017.11.001.

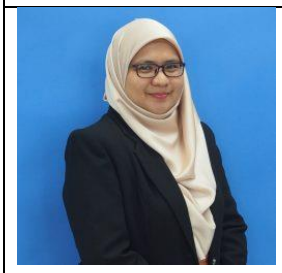
[10] H. S. Loh, K. F. Yuen, X. Wang, E. Surucu-Balci, G. Balci, and Q. Zhou, "Airport selection criteria of low-cost carriers: A fuzzy analytical hierarchy process," *J Air Transp Manag*, vol. 83, 2020, doi: 10.1016/j.jairtraman.2019.101759.

[11] A. Khashei-Siuki, A. keshavarz, and H. Sharifan, "Comparison of AHP and FAHP methods in determining suitable areas for drinking water harvesting in Birjand aquifer. Iran," *Groundw Sustain Dev*, vol. 10, 2020, doi: 10.1016/j.gsd.2019.100328.

[12] N. Mahat and N. F. Zulkofli, "Fuzzy Analytic Hierarchy Process to Solve the Child Abuse Problem," *Journal of Computing Research and Innovation*, vol. 5, no. 4, 2020, doi: 10.24191/jcrinn.v5i4.166.

[13] M. K. Othman, N. S. F. Abdul Rahman, A. Ismail, and A. H. Saharuddin, "Factors contributing to the imbalances of cargo flows in Malaysia large-scale minor ports using a fuzzy analytical hierarchy process (FAHP) approach," *Asian Journal of Shipping and Logistics*, vol. 36, no. 3, 2020, doi: 10.1016/j.ajsl.2019.12.012.

**Biography of all authors**

| Picture | Biography | Authorship contribution |
|---|---|---|
|  | Norpah Mahat is a senior lecturer from Department of Mathematics and Statistics, Universiti Teknologi MARA Perlis branch. She graduated with a Master's degree in Mathematics from Universiti Sains Malaysia. Her expertise is in the field of Fuzzy and Neural Networks. | Data analysis, interpretation and drafting article. |
|  | Siti Sarah bt Raseli is currently serving as a senior lecturer at Universiti Teknologi MARA Perlis branch in the field of mathematics since 2007. She hold a Master's Degree in Mathematics from University of Science Malaysia and a Bachelor of Mathematics from Universiti Teknologi MARA Shah Alam. She involved in writing many articles in national and international journals. | Drafting article. |
|  | Nur Izyan Nabilah with Bachelor of Science (Hons.) Management Mathematics from Faculty of Computer and Mathematical Sciences, Universiti Teknologi Mara Perlis Branch. | Data collection. |