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Implementation of the TOPSIS Method in Recommendations for Selecting Facial *Sunscreen* Based on a *Decision Support System*

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ABSTRACT: Choosing the right sunscreen for your skin type can be challenging due to the wide variety of products available and differences in skin types among users. This study aims to develop a web-based Decision Support System (DSS) to recommend the right sunscreen product using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. This system uses five criteria, namely: Broad Spectrum Protection, SPF Value, Skin Compatibility, Comfort of Use, and Skin Safety. The TOPSIS method is applied to perform normalization, weighting, calculation of ideal solutions, and ranking of alternatives. The results of the study show that the system is able to provide objective sunscreen recommendations based on user preferences, thereby helping users make more accurate and structured decisions.

KEYWORDS: Decision Support System, Sunscreen, TOPSIS, Ranking, Recommendations.

I. INTRODUCTION

Indonesia is a tropical country located on the equator, so its people are often exposed to sunlight throughout the year. According to the *American Cancer Society*, exposure to *ultraviolet* (UV) rays is carcinogenic and can cause redness, burns, loss of elasticity, and can even trigger skin cancer. Therefore, having clean and well-maintained skin is important for some people to boost their self-confidence. One way to care for the skin is by using skincare, which is a series of skin treatments aimed at maintaining health, cleanliness, and improving skin condition by using skincare products that are safe and suitable for your skin type [1]. The *World Health Organization* (WHO) recommends the use of *Sunscreen* to protect the skin from the harmful effects of sunlight. Broad-spectrum *Sunscreen* with an SPF of at least 15 can protect the skin from UVA and UVB rays [2]. UVA (320–400 nm) can penetrate the skin and cause premature aging and increase the risk of skin cancer. UVB (290–320 nm) can lead to sunburn and DNA damage in the skin [3].

Sunscreen is a substance that protects the skin from UV exposure, especially UVA and UVB rays that can damage the skin. Sunscreen is available in various forms such as lotion, cream, gel, ointment, and spray that can be applied to the skin [4]. *Sunscreen* consists of three types, namely physical, chemical, and hybrid. Physical *Sunscreen* reflects UV rays, chemical *Sunscreen* absorbs UV rays and converts them into heat, while hybrid is a combination of both that provides double protection and is suitable for sensitive skin [5][3]. *Sunscreen* is essential for protecting the skin from the negative effects of UV rays. However, the abundance of sunscreen products on the market with various criteria and benefits makes it difficult for consumers to choose the sunscreen that suits their skin's needs [6]. There are generally five types of facial skin: normal, oily, dry, sensitive, and combination. Each skin type has different needs, so choosing the wrong *Sunscreen* can cause skin problems [7].

Based on an interview i conducted on Halodoc with a dermatologist and venereologist (Sp.KK), Dr. Aurelia Stephanie Sp.D.V.E, the use of *Sunscreen* for facial skin health is very important, essential, and irreplaceable. Every day, there are 5-6 patients who have facial skin problems due to the products they use. The most common effects found in patients who do not use *Sunscreen* regularly are hyperpigmentation (*dark spots*) and premature aging, followed by sensitive/irritable skin. This condition shows that people still often have difficulty and make mistakes in choosing *Sunscreen* for themselves. This is a pattern that is encountered almost every day, both in practice and in teledermatology. To support this research, the author distributed a questionnaire to 233 students aged 18-25 years, which found that the majority of *Sunscreen* users are women (77.68%) and (83.69%) use it regularly. As many as 68.67% of respondents considered *Sunscreen* to be very important, but only 29.61% correctly understood its function, while 62.23% still lacked understanding. In addition, 43.78% of respondents had difficulty choosing *Sunscreen* according to their skin type, and 52.36% had experienced skin problems due to improper use of *Sunscreen*. Based on the data obtained, there is a need for a *decision support system* to help choose the appropriate sunscreen. *Decision Support Systems* (DSS) help consumers choose products by processing relevant information data, so that decisions are more objective and tailored to individual needs [8]. A *Decision Support System* (DSS) is a system that assists in decision-making for both

structured and unstructured problems. According to Moore and Chang, DSS supports data analysis, decision modeling, and planning for specific situations, with the goal of helping users make better decisions [9]. The method used in this decision support system is the *Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS), which is a multi-criteria decision-making method. TOPSIS works based on the principle that the best alternative is the one closest to the positive ideal solution and furthest from the negative ideal solution, which is calculated using Euclidean distance. The calculation results produce a priority order for each alternative. This method is widely used because its concept is simple, easy to understand, efficient in calculation, and effective in determining the best decision [10] [11].

II. RESEARCH METHOD

To achieve the predetermined research objectives, systematic and structured steps are required. Therefore, this research was conducted through several interrelated stages, starting from problem identification to system testing and evaluation. The research methods used can be explained as follows.

A. Research Stages

This study uses a structured method to ensure that the process runs systematically and produces valid results, with the research stages beginning with problem identification and ending with conclusions, as shown in the following figure:

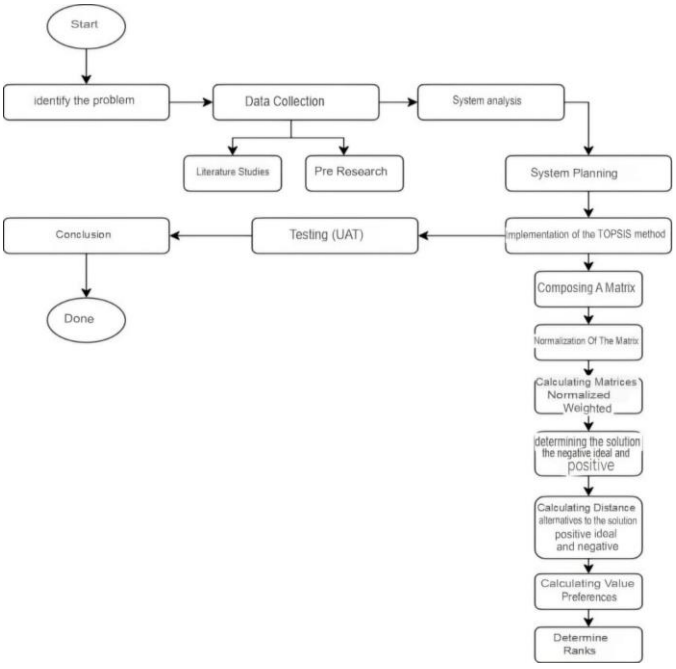

Figure 1 Research stages

B. Problem identification

This research began by identifying the difficulties users face in determining the appropriate sunscreen product amid the many choices available. To solve this problem, the TOPSIS method was used as a decision support system approach to rank *Sunscreens* based on specific criteria.

C. Data Collection

Data collection was carried out through a literature study of journals, books, and previous studies discussing decision support systems and the TOPSIS method. In addition, data was also obtained through the distribution of questionnaires to 233 respondents aged 18–25 years to identify problems and determine the criteria and subcriteria based on the recommendations of dermatology organizations and scientific literature in the selection of *Sunscreen*.

D. System Analysis

System analysis was conducted to understand the requirements for a web-based decision support system for sunscreen selection. This analysis included functional requirements such as data management, TOPSIS method calculations, and recommendation presentation, as well as non- functional requirements such as ease of use, speed, and system security.

E. System Design

The system design aims to describe the form and workflow of the *Sunscreen* selection decision support system. The system is designed to be able to process product data and user criteria using the TOPSIS method and display the results of recommendations in the form of *Sunscreen* rankings.

F. System Testing (User Acceptance Testing)

System testing was peformed using the *User Acceptance Testing* (UAT) method to determine the level of user acceptance of the system. This test assessed the ease of use, suitability of system functions, and user satisfaction with the recommendations generated by the system.

G. Implementation of the TOPSIS Method

The calculation process is carried out through several systematic stages as follows:

a. Compiling the decision matrix
The initial stage of TOPSIS is to compile a decision matrix containing the values of each alternative for each criterion. This can be seen in equation (1) [12].

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{\mathrm{mn}} \end{bmatrix} \quad (1)$$

b. Normalization of the decision matrix
The normalization process is carried out so that data from various scales can be compared using the same scale. This can be seen in equation (2) [13].

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (2)$$

c. Forming a weighted normalization matrix
The normalization results are then multiplied by the weight (w) of each criterion. This can be seen in equation (3) [14].

$$y_{ij} = w_j \cdot r_{ij} \quad (3)$$

d. Determining the positive ideal solution and the negative ideal solution. This can be seen in equations (4) and (5) [15].

- Positif Ideal Solution (A^+)

$$A^+ = \{y_1^+, y_2^+, \dots, y_n^+\} \quad (4)$$

With :

$$y_j^+ = \begin{cases} max(y_{ij}), j \text{ is a benefit criterion} \\ min(y_{ij}), j \text{ is a cost criterion} \end{cases}$$

- Negative Ideal Solution (A^-)

$$A^- = \{y_1^-, y_2^-, \dots, y_n^-\} \quad (5)$$

With :

$$y_j^- = \begin{cases} min(y_{ij}), j \text{ is a benefit criterion} \\ max(y_{ij}), j \text{ is a cost criterion} \end{cases}$$

e. Calculate the alternative distance to the positive and negative ideal solutions. This can be seen in equations (6) and (7) [16].

- Alternative distance to the positive ideal solution:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_j^+)^2} \quad (6)$$

- Alternative distance to the negative ideal solution:

$$D_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_j^-)^2} \quad (7)$$

f. calculating preference values (Vi)

Preference values are calculated to determine the ranking of each alternative. This can be seen in equation (8) [11].

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (8)$$

The advantage of TOPSIS lies in its ability to handle criteria in a structured manner and provide clear evaluations, thereby assisting in making the right decisions based on the closest distance from the positive ideal solution and the furthest distance from the negative ideal solution [10] [17].

III.RESULT AND DISCUSSION

A. Alternatives Data

TOPSIS calculations were performed to ensure that the recommendation process was carried out according to theory, by calculating the criteria values for each alternative to produce a final ranking of *Sunscreen* products. The alternative data in this study consisted of *Sunscreen* products recommended to users. The alternatives were determined based on the research criteria and products available at beauty outlets and official websites, with a total of 10 samples used and presented in Table 1.

Table 1 Alternatives Data

Alternatives	Code
Biore UV Aqua Rich Watery Essence SPF50+	A1
Wardah UV Shield Active Protection Serum SPF50+	A2
Azarine Hydrasoothe *Sunscreen* Gel SPF30	A3
Skintific Ceramide Serum *Sunscreen* SPF50+	A4
CeraVe Hydrating Mineral *Sunscreen* SPF30	A5

B. Criteria Data

The criteria data for this study were used as the basis for decision making in selecting sunscreen using the TOPSIS method. The criteria were determined based on interviews conducted with Dr. Aurelia Stephanie Sp.D.V.E and classified as benefits or costs with subcriteria converted to numerical values to facilitate calculation. The criteria data used are presented in Table 2.

Table 2 Criteria Data

Code	Criteria	Weight	Attribute
C1	Broad Spectrum Protection	0.33	Benefits
C2	SPF Value	0.27	Benefits
C3	Suitable for skin	0.20	Benefits
C4	Comfortable on the skin	0.13	Benefits
C5	Safe for skin	0.07	Benefits

Table 2 summarizes the five criteria used in selecting *Sunscreen*. These criteria were established based on recommendations from experts, namely dermatologists and venereologists, who stated that broad spectrum protection, SPF value, skin compatibility, skin comfort, and skin safety are the main factors in determining the effectiveness and safety of *Sunscreen*. These five criteria consist of benefit attributes. All criteria are categorized as benefits because each represents the level of effectiveness, safety, and quality of *Sunscreen*, where a higher value indicates better protection performance, so there are no cost attributes in this study.

C. Subcriteria Data

Subcriteria data are used as a numerical rating scale for each alternative based on each criterion. The rating uses a scale of 1–5, where 5 indicates the best condition, and this data forms the basis for the decision matrix in the TOPSIS calculation. The criterion values are shown in Table 3.

Table 3 Subcriteria Data

Broad Spectrum Protection	Score
UVA & UVB Protection	5
Not Broad Spectrum	4

SPF Value	Score
SPF >50	5
SPF >30	4

Suitable for skin	Score

Does not cause acne	5
Does not cause itching	4
Does not sting	3

Comfortable to wear	**Score**
Non-sticky	4
No white case	5

Safe for skin	**Score**
Fragrance-free	5
Non-comedogenic	4

The table explains the subcriteria used in evaluating sunscreen products and the score for each indicator. The evaluation is based on UV protection, SPF level, skin compatibility, comfort of use, and ingredient safety. The scores are used as the basis for the TOPSIS method calculation to determine the best sunscreen alternative.

D. Application of the TOPSIS Method

In developing this decision support system, calculations were performed using the TOPSIS method. The following are the steps involved:

1. Creating the decision matrix: The first step in this calculation is to determine the alternative values for each criterion. Alternative values are obtained from information available on official websites or listed on the packaging of sunscreen products that are alternatives. The decision matrix is shown in Table 4.

Table 4 Decision Matrix

Alternative	**Criteria**				
	C1	C2	C3	C4	C5
A1	5	5	4	5	5
A2	5	5	4	4	4
A3	5	4	4	5	4
A4	5	5	5	4	5
A5	5	4	5	4	5

2. Determining the normalized decision matrix (R): The second step in the TOPSIS method is to normalize the decision matrix, which aims to standardize the value scale for each criterion so that they can be compared fairly. The normalization process is carried out by dividing each element of the decision matrix by the square root of the sum of the squares of the values in the same criterion. This process is stated in Equation (1).

   Normalized decision matrix results:

   - Criteria C1

$$x_1 = \sqrt{5^2 + 5^2 + 5^2 + 5^2 + 5^2} = 11{,}18$$

$$r_{11} = \frac{5}{11{,}18} = 0{,}447$$

$$r_{21} = \frac{5}{11{,}18} = 0{,}447$$

$$r_{31} = \frac{5}{11{,}18} = 0{,}447$$

$$r_{41} = \frac{5}{11{,}18} = 0{,}447$$

$$r_{51} = \frac{5}{11{,}18} = 0{,}447$$

$$R = \begin{bmatrix} 0{,}447 & 0{,}483 & 0{,}404 & 0{,}505 & 0{,}464 \\ 0{,}447 & 0{,}483 & 0{,}404 & 0{,}404 & 0{,}464 \\ 0{,}447 & 0{,}386 & 0{,}404 & 0{,}505 & 0{,}371 \\ 0{,}447 & 0{,}483 & 0{,}505 & 0{,}404 & 0{,}464 \\ 0{,}447 & 0{,}386 & 0{,}505 & 0{,}404 & 0{,}464 \end{bmatrix}$$

3. The third step in the TOPSIS method is to form a weighted normalized decision matrix (Y). This stage is carried out by multiplying each value in the normalized matrix by the previously determined criteria weight. The weighted normalization matrix is the result of combining the normalization results and the weight of each criterion. This stage is carried out to ensure that each criterion contributes according to its level of importance in the decision-making process. The calculation of the weighted normalization matrix is stated in Equation (3), and the results of the equation Y are shown below:

   - Normalized values for the Wardah UV Shield Essential Gel Sunscreen Serum (SPF35 PA+++) alternative

$$y_{11} = 0{,}33 \times 0{,}447 = 0{,}147$$
$$y_{12} = 0{,}27 \times 0{,}483 = 0{,}130$$
$$y_{13} = 0{,}20 \times 0{,}404 = 0{,}080$$
$$y_{14} = 0{,}13 \times 0{,}505 = 0{,}065$$
$$y_{15} = 0{,}07 \times 0{,}464 = 0{,}032$$

$$Y = \begin{bmatrix} 0{,}148 & 0{,}130 & 0{,}080 & 0{,}065 & 0{,}032 \\ 0{,}148 & 0{,}130 & 0{,}080 & 0{,}052 & 0{,}025 \\ 0{,}148 & 0{,}104 & 0{,}080 & 0{,}065 & 0{,}025 \\ 0{,}148 & 0{,}130 & 0{,}101 & 0{,}052 & 0{,}032 \\ 0{,}148 & 0{,}104 & 0{,}201 & 0{,}052 & 0{,}032 \end{bmatrix}$$

4. The next step in the TOPSIS method is to determine the positive ideal solution (A^+) and negative ideal solution (A^-) based on the weighted normalized matrix. The positive ideal solution represents the best condition for each criterion, while the negative ideal solution describes the worst condition. For benefit criteria, the A^+ value is obtained from the maximum value and A^- from the minimum value in each column of the matrix. Conversely, for cost criteria, the A^+ value is taken from the minimum value because a smaller value is more desirable, while A^- is taken from the maximum value. Mathematically, the positive and negative ideal solutions are formulated in Equation (4) and Equation (5). Thus, the results obtained from the positive ideal solution and the negative ideal solution are as follows:

$$A^+ = \{0{,}147; 0{,}130; 0{,}101; 0{,}065; 0{,}032\}$$
$$A^- = \{0{,}147; 0{,}104; 0{,}080; 0{,}052; 0{,}025\}$$

5. After the positive and negative ideal solutions are determined, the next step is to calculate the distance of each alternative from both solutions. This calculation aims to determine the proximity of the alternative to the best condition (D^+) and its distance from the worst condition (D^-). A good alternative has a small D^+ value and a large D^- value. The distance to the positive ideal solution is calculated using Equation (6), while the distance to the negative ideal solution is calculated using Equation (7). Thus, the results obtained from the positive ideal solution and the negative ideal solution are as follows:

$$D^+ = \{0{,}020; 0{,}024; 0{,}033; 0{,}013; 0{,}029\}$$
$$D^- = \{0{,}029; 0{,}026; 0{,}013; 0{,}033; 0{,}021\}$$

6. Calculating preference values (Vi) The final stage in the TOPSIS method is to calculate the preference values (Vi) for each alternative. Preference values are used to indicate the degree of closeness of an alternative to the ideal solution, taking into account the distance to the negative ideal solution and the total distance to both ideal solutions. The greater the value of V_i, the better and more recommended the alternative is. The calculation of preference values is stated in Equation (8). After calculating the preference values, the alternatives are then ranked from the largest to the smallest V_i value to determine the final ranking. The results of the ranking can be seen in Table 5 below:

Table 5 Ranking Result

Code	Name Product	Preference Value (V_i)	Ranking
A1	Biore UV Aqua Rich Watery Essence SPF50+	0,597	2
A2	Wardah UV Shield Active Protection Serum SPF50+	0,527	3
A3	Azarine Hydrasoothe *Sunscreen* Gel SPF30	0,280	5
A4	Skintific 5x Ceramide Serum *Sunscreen* SPF50+	0,719	1
A5	CeraVe Hydrating Mineral *Sunscreen* SPF30	0,420	4

Based on the TOPSIS method calculation, A1 (Skintific 5x Ceramide Serum *Sunscreen* SPF50+) is the best alternative with a score of 0,719. This is because alternative A1 is the most recommended *Sunscreen* product based on protection criteria, SPF value, skin compatibility, ease of use, and ingredient safety. The main ingredients received high scores as subcriteria that users can consider. Meanwhile, the alternative with the lowest score is A5 (Azarine Hydrasoothe *Sunscreen* Gel SPF30) with a score of 0,280. This indicates that the product's performance is inferior to other alternatives based on the research criteria.

E. User Acceptance Testing (UAT)

User Acceptance Testing (UAT) was peformed to ensure that the decision support system for selecting *Sunscreen* using the TOPSIS method could run according to user requirements. Based on the test results conducted on 15 respondents by trying out all the main features by the admin and users, the system ran well and was able to display *Sunscreen* recommendations according to the calculations. Therefore, the system was declared feasible and acceptable for use. Below are the results of the UAT test :

The calculations for the total responses above are as follows:

a.	Strongly Agree (SS)	= 5 x 47	= 235
b.	Agree (S)	= 4 x 68	= 272
c.	Quite Agree (CS)	= 3 x 39	= 117
d.	Disagree (KS)	= 2 x 1	= 2
e.	Strongly Disagree (TS)	= 1 x 0	= 0
	Total score		**= 626**

Then, the maximum score is calculated as follows: Maximum score

Maximum Score = Number of responses x Highest score
= 155 x 5 = 775

After that, the UAT percentage was calculated as

Percentage $= \frac{Total\ Score}{Maximum\ score}$ x 100%

$= \frac{626}{775}$ x 100% = 80, 77%

The following table shows the range that can be seen as a conclusion of the UAT percentage that has been calculated.

Table 6 UAT Range

No.	Description	Range
1	Strongly Disagree	0% - 20%
2	Disagree	21% - 40%
3	Quite agree	41% - 60%
4	Agree	61% - 80%
5	Strongly Agree	81% - 100%

Based on the result of User Acceptance Testing (UAT), the system obtained a percentage score of 80.77%, which falls into the Agree category. This shows theat the *Sunscreen* selection decision support system using the TOPSIS method is acceptable to users and suitable for use.

IV.CONCLUSIONS

According to the results of the system implementation and testing, the *Sunscreen* selection decision support system using the TOPSIS method can run well and produce objective recommendations. The calculation results show that Skintific 5x Ceramide Serum *Sunscreen* SPF50+ obtained the highest preference value of 0,719, while Azarine Hydrasoothe *Sunscreen* Gel SPF30 had the lowest preference value of

0,280. These results prove that the TOPSIS method is capable of providing a systematic and easy-to-understand ranking of alternatives, so that the system can help users determine the *Sunscreen* that suits their facial skin needs. Additionally, the results of the *User Acceptance Testing* (UAT) involving 15 respondents showed an acceptance rate of 80.77%, which falls into the "agree" category Therefore, it can be concluded that the system is well-received by users in terms of ease of use, system functionality, and the recommendations generated. For further development, this system can still be improved by adding more sunscreen product options and more detailed criteria so that the recommendations generated are more in line with user needs. Additionally, the system can be developed into a mobile version for easier access, and other methods can be added as comparisons to strengthen the recommendation results.

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