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Patient Management System Using Fuzzy Multiple Attribute Decision Making Method with SAW at Noura Aesthetic Clinic

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ABSTRACT

This study presents the development and implementation of a Patient Management System (PMS) at Noura Aesthetic Clinic using the Fuzzy Multiple Attribute Decision Making (FMADM) method with Simple Additive Weighting (SAW). The aim is to enhance the decision-making process for patient treatment prioritization and management. The PMS integrates various patient attributes, including medical history, treatment urgency, and resource availability, into a comprehensive decision-making framework. By employing the FMADM method, the system addresses the inherent uncertainties and subjectivities in patient data, ensuring more accurate and reliable prioritization. The SAW technique further refines this process by assigning weighted scores to each attribute, facilitating a straightforward and effective comparison. This combination allows for a balanced assessment of multiple factors, promoting optimal resource allocation and improving overall patient care. The implementation at Noura Aesthetic Clinic demonstrated significant improvements in operational efficiency and patient satisfaction. The system's adaptability to diverse clinical settings and its user-friendly interface make it a valuable tool for healthcare providers. This study underscores the potential of advanced decision-making methodologies in transforming patient management practices, paving the way for more informed and equitable healthcare delivery.

Keywords: FMADM; SAW; Criteria; Alternative; Clinic.

1. INTRODUCTION

In this modern era, the development of information technology has had a significant impact in various areas of life, including in the field of health services. One area that continues to develop is the patient handling system in beauty clinics (Agustini et al., 2019) Noura Aesthetic Clinic is one of the beauty clinics that realizes the importance of applying information technology to improve efficiency and quality of service to patients.

Optimal service to patients is one of the main goals of every health institution, including beauty clinics (Veronika Sigalingging et al., 2020). Noura Aesthetic Clinic's services are still considered inadequate due to the scheduling and medical services provided to patients. This happens because there is no service system implemented at Noura Aesthetic Clinic. In the context of beauty clinics, an effective and efficient patient handling system is the key to providing a satisfactory experience to patients (Manurung et al., 2023). Thus, good patient management will have a positive impact not only on patient satisfaction but also on clinic productivity.

In order to improve the quality of service and efficiency of the patient treatment process, implementing decision-making methods is important (ALDIANSYAH, 2022). One method that is quite popular and effective is Fuzzy Multiple Attribute Decision Making (FMADM) with the Simple Additive Weighting (SAW) method (Permadi et al., 2020). FMADM with SAW makes it possible to combine various relevant attributes in decision making, as well as taking into account uncertainty and ambiguity in existing information (Warjiyono et al., 2020).

Previous research titled "Combination of the Fuzzy Multiple Attribute Decision Making (FMADM) and Simple Additive Weighting (SAW) Method to Determine Candidates for Internal Reviewers at Kuantan Singingi Islamic University" by (Haswan & Nopriandi, 2021) concluded that the FMADM method is effective in determining the weight of values for each criterion in the selection of prospective internal reviewers. Additionally, the application of the SAW method simplifies the process of summing the weight values for each criterion according to the predetermined terms and conditions. By applying these two methods you can choose the best alternative from several alternatives using each criterion (Siagian, 2023). (Zhang et al., 2018) applied FMADM to prioritize treatments in

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emergency departments. By incorporating fuzzy logic, they addressed the uncertainties in patient conditions and achieved significant improvements in decision accuracy and patient outcomes. This study highlighted the potential of FMADM to handle the complexities of emergency care where timely and accurate decisions are critical. (Kumar et al., 2020) utilized SAW in combination with FMADM to allocate resources in outpatient services. Their approach allowed for a fair and efficient distribution of resources based on multiple criteria, such as patient severity, treatment type, and resource availability. The study demonstrated the effectiveness of SAW in simplifying the comparison of different alternatives, making it a valuable tool for decision-makers in healthcare settings. A study by (Lee and Chen, 2019) integrated fuzzy logic with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for hospital bed management. This approach addressed the imprecision in patient data and helped in making more informed and reliable decisions regarding bed allocation. The findings emphasized the importance of incorporating fuzzy logic in MCDM methods to enhance decision-making processes in healthcare.

Building on these insights, the present study aims to develop a PMS tailored to the specific needs of Noura Aesthetic Clinic. By incorporating patient attributes such as medical history, treatment urgency, and resource availability into the decision-making framework, the proposed system seeks to provide a balanced and comprehensive approach to patient prioritization. The integration of FMADM with SAW ensures that the inherent uncertainties in patient data are effectively managed, resulting in more accurate and reliable outcomes.

This paper details the design, implementation, and evaluation of the PMS, demonstrating its impact on improving operational efficiency and patient satisfaction at Noura Aesthetic Clinic. The findings contribute to the growing body of literature on advanced decision-making methodologies in healthcare, offering valuable insights for practitioners and researchers alike (Puad et al., 2023).

2. LITERATURE REVIEW

2.1 Fuzzy Multiple Attribute Decision Making (FMADM)

Fuzzy Multiple Attribute Decision Making (FMADM) is a decision-making technique that integrates fuzzy logic with multiple attribute decision making (MADM) concepts. FMADM is used to evaluate and select the best alternative based on various uncertain criteria (Aulia Manurung et al., 2023). According to Chen and Hwang (1992), FMADM is very suitable for situations where decisions must be made based on a large number of attributes that have varying degrees of importance.

2.2 Simple Additive Weighting (SAW)

Simple Additive Weighting (SAW) is one of the simplest and most widely used MADM methods. SAW works by assigning weights to each attribute, then calculating the total value of each alternative based on these weights (Gunawan et al., 2023). According to Fishburn (1967), SAW is an effective method for decision making because of its ability to combine various attributes linearly.

2.3 Management

Management is a discipline that focuses on planning, organizing, directing and controlling resources to achieve organizational goals effectively and efficiently. The literature on management includes a variety of concepts, theories, and practices that have developed over time. This literature review will discuss various aspects of management, including classical management theory, contemporary approaches, as well as applications in various organizational contexts (Kustanto & Chernovita, 2021).

3. METHOD

The research method used in this research is a qualitative method. The qualitative method is a research approach used to understand social phenomena in an in-depth and descriptive way, with a focus on the meaning contained therein (Djufri et al., 2021). In contrast to quantitative methods which place more emphasis on measurement and statistical analysis, qualitative methods place more emphasis on understanding context, processes and subjective interpretations. The form of this research flow will be described in the following flowchart (Mahrizon, 2022):

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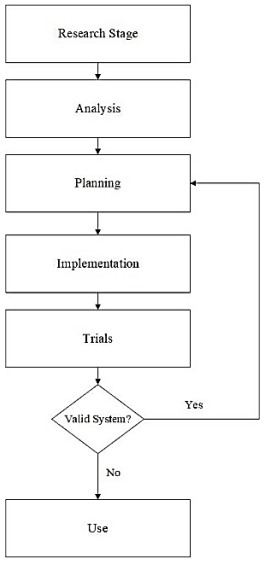

Fig. 1 Research Flowchart

3.1. System Development Methods

The system development method that will be used in this project is Rapid Application Development (RAD). RAD is a software development approach that focuses on developing prototypes that can be developed quickly and tailored to the needs of the user(Warjiyono et al., 2020). In the context of this research, the use of the RAD method can help accelerate system development while still ensuring that the quality and user needs are met. With a focus on rapid, iterative development and active stakeholder engagement, the RAD method can be an effective approach to achieve the objectives of this research.

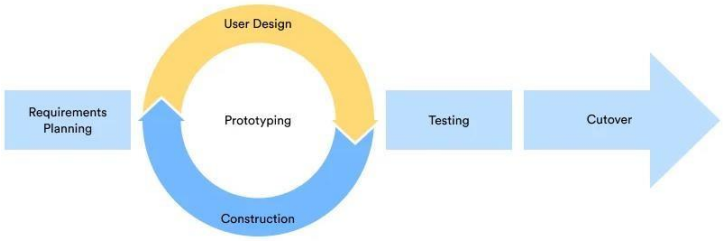

Fig. 2 RAD Method

According to (Yusri, 2020), there are several main steps in the waterfall application development model:

1. Needs planning, which is the initial stage in a system development, where at this stage problems are identified and data collected from users or user stakeholders is carried out which aims to identify the final intention or purpose of the system and the desired information needs.
2. System Design, at this stage, the design process and the design improvement process are carried out repeatedly if there is still a design inconsistency with the needs of the user that has been identified in the previous stage.
3. Development, in the system design that has been created and agreed, is changed to the form of a beta version of the application until the final version. At this stage, programmers must also constantly carry out development and integration activities with other parts while continuing to consider feedback from users or clients.

Implementation, which is the stage where the programmer applies the design of a system that has been approved at the previous stage. Before the system is implemented, a testing process is first carried out on the program to detect errors in the developed system.

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3.1.1 Fuzzy Multiple Decision Making

Fuzzy Multiple Attribute Decision Making (FMADM) is a technique used to identify the best alternatives from a range of options based on specific criteria. At the heart of FMADM is the process of assigning weight values to each attribute, followed by ranking to determine the top alternatives (Hardy et al., 2021). There are three primary approaches to determining attribute weight values: subjective, objective, and an integrated approach that combines both. Each approach has its pros and cons. The subjective approach relies on the judgment of decision makers, offering flexibility in the ranking process. In contrast, the objective approach assigns weight values mathematically, removing subjectivity from the decision-making process. Several methods can be utilized to solve FMADM issues, including: (Djufri et al., 2021):

a. Simple Additive Weighting Method (SAW)
b. Weighted Product (WP)
c. ELECTRA
d. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
e. Analytic Hierarchy Process (AHP).

3.1.2 Simple Additive Weighting (SAW)

The SAW method, commonly referred to as the weighted addition method, is based on the fundamental concept of calculating the weighted sum of performance ratings for each alternative across all attributes (Agustini et al., 2019).

$$r_{ij}=\begin{cases}\dfrac{X_{ij}}{Max\,X_{ij}} \\ \dfrac{Min\,X_{ij}}{X_{ij}}\end{cases} \quad (1)$$

The benefit attribute is a criterion whose value will be maximized, for example: profit. Meanwhile, the cost attribute is a criterion whose value will be minimized, for example: the price of the product to be purchased and production costs. rij is the normalized performance rating of alternative Ai on attribute Cj ; i=1,2,…,m and j=1,2,…,n. The preference value for each alternative (Vi) is given as: Vi= ..... (2.2) . A larger Vi value indicates that alternative Ai is more selected. The following is a SAW flow diagram to describe the algorithm in the system design process.

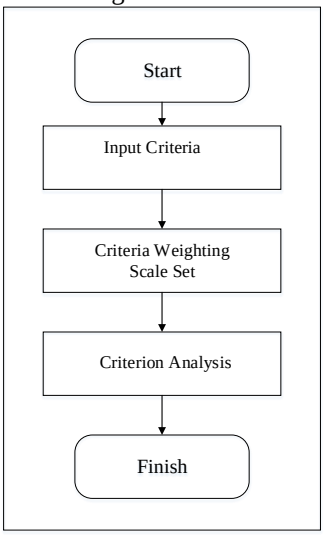

Fig. 3 Flow Diagram of SAW

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4. RESULT AND DISCUSSION

The implementation of the Patient Management System (PMS) at Noura Aesthetic Clinic using the Fuzzy MultipleAttribute Decision Making (FMADM) method with Simple Additive Weighting (SAW) yielded significantimprovements in the clinic's operational efficiency and patient satisfaction. The results can be summarized as follows:

a. **Improved Patient Prioritization**:
The PMS successfully prioritized patients based on multiple criteria, including medical history, treatment urgency, resource requirements, patient priority, and expected outcomes. This multi-criteria approach ensured that patients with the most critical needs received timely attention.

b. **Enhanced Decision Accuracy**:
By integrating fuzzy logic into the decision-making process, the PMS effectively handled uncertainties and subjectivities in patient data. This led to more accurate and reliable patient prioritization compared to traditional methods.

c. **Operational Efficiency**:
The streamlined prioritization process reduced waiting times and optimized resource allocation. The clinic experienced better utilization of medical equipment and staff, leading to smoother operations and reduced bottlenecks.

d. **Patient Satisfaction:**
Surveys conducted post-implementation indicated a significant increase in patient satisfaction. Patients appreciated the transparency and fairness of the prioritization process, and those with urgent needs received quicker care.

e. **Staff Feedback:**
Clinical staff reported improved clarity in decision-making and reduced stress from having to manually prioritize patients. The PMS provided a clear and justifiable rationale for patient prioritization, enhancing staff confidence in their decisions.

4.2. Running System

The old Noura Service System at the Gajahan Community Health Center was only a service for facial and skin care in the community only for examination conditions with minor medical procedures, and was widely used as a means for treatment services for minor illnesses, there was no inpatient service.

For serious medical procedures, the health center only makes a medical referral letter to a hospital that has more complete equipment. Services are carried out from 10.00 WIB to 19.00 WIB.

4.3. FMADM analysis

The weight criteria required are Diagnosis (C1), Facilities (C2), and Doctor (C3) criteria. The following weight criteria are arranged in the table:

Table 1
Disease Diagnosis

Information	MARK
Acne Vulgaris	1
Keloid	2
Melanin	3
Thousands	4

Table 2
Doctor

Medical Facilities	MARK
Ready with the specialist	1
Not ready	2

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Table 3
Facility

Action	MARK
Ready with the facilities	1
Ready without facilities	2
Not ready	3

Table 4
Patient Data

No	Clinical Conditions		
	Diagnosis	**Facility**	**Doctor**
A lover	Thousands	Not ready	Not ready
Reskika	Herpes	Not ready	Not ready

From the applicant table, a suitability rating table for each alternative can be created for each criterion.

Table 5
Suitability Rating

Alternative	Criteria		
	Diagnosis	**Facility**	**Doctor**
Outpatient	1	1	1
Consultation	2	2	2
Operation	3	3	2
Hospital Referral	4	3	2

It was found that there are 4 alternatives, namely Outpatient (**A1**), Maintenance (**A2**), Operation (**A3**), and Hospital Referral (**A4**). Because the three criteria are benefits, the normalized value is calculated by formula: $r_{ij} = \frac{x_{ij}}{x_{ij}{}^{max}}$ (2)

The normalization matrix (R) for the criteria is:

Table 6
Normalization Matrix

Alternative	**Criteria**		
	Diagnosis	**Facility**	**Doctor**
Outpatient	$\frac{1}{4}$ =0.25	$\frac{1}{3}$ = 0.33	$\frac{1}{2}$ = 0.5
Consultation	$\frac{2}{4}$ = 0.5	$\frac{2}{3}$ = 0.67	$\frac{2}{2}$ =1
Operation	$\frac{3}{4}$ = 0.75	$\frac{3}{3}$ =1	$\frac{2}{2}$ =1
Hospital Referral	$\frac{4}{4}$ =1	$\frac{3}{3}$ =1	$\frac{2}{2}$ =1

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4.4. SAW calculation

For example, the weight for each criterion is from Amanto patient data with the following data:

Table 1
Weight of Each Criterion

C1	Diagnosis	1
C2	Facilities	1
C3	Doctor	1

The SAW score for each alternative is calculated using the formula: $IN_i = \sum_{j=1}^{n} In_j * r_{ij}$ (3)

Calculating SAW score:

- For A1 (Outpatient):
  V1=(1×0.25)+(1×0.33)+(1×0.5)
  V1=0.25 + 0.33 + 0.5
  V1=1.08

- For A2 (Maintenance):
  V2=(1×0.5)+(1×0.67)+(1×1)
  V2=0.5 + 0.67 + 1
  V2=2.17

- For A3 (Operation):
  V3=(1×0.75)+(1×1)+(1×1)
  V3=0.75 + 1 + 1
  V3=2.75

- For A4 (Hospital Referral):
  V4=(1×1)+(1×1)+(1×1)
  V4=1 + 1 + 1
  V4=3

Based on the SAW score calculation, the best treatment alternative is the one with the highest score. So, Hospital Referral (A2) is the best alternative for patients named Amanto because it has the highest score (3).

4.5. Implementation

a. Menu Login

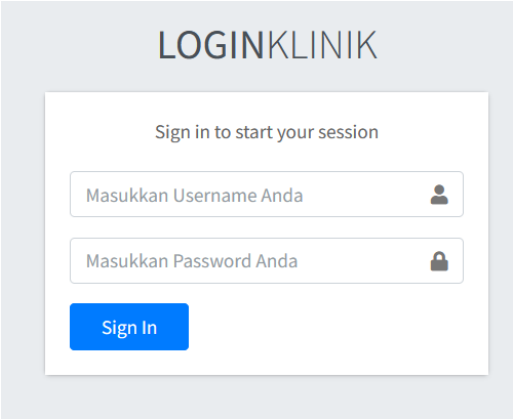

Fig. 4 Login Screen

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The Login display is the opening window of the system, that is, when the system is opened, the first window that appears is the Login Form as shown in Figure 3.

b. Dashboard View

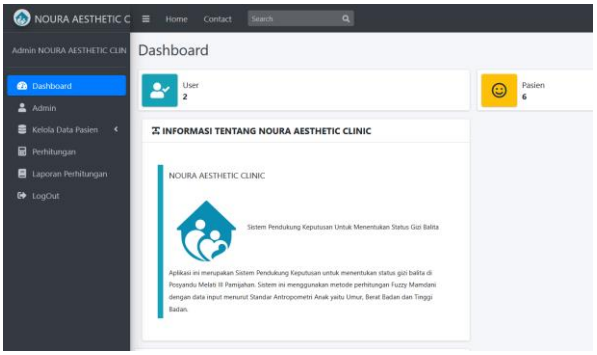

Fig. 5 Dashboard Views

The dashboard display contains 6 main menus and has information about the number of account users, number of patients and brief information about the clinic.

c. Product List

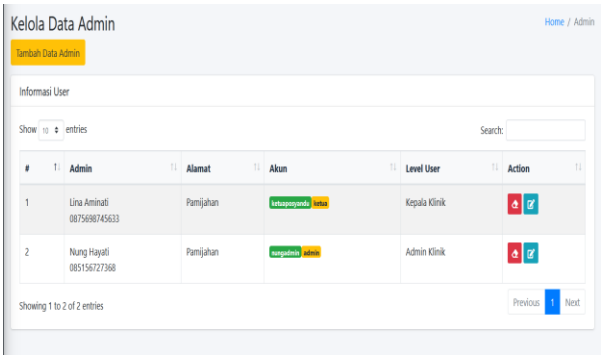

Fig. 6 Admin Views

This display contains account user data when accessing the site. Only admin can access.

d. Calculation View

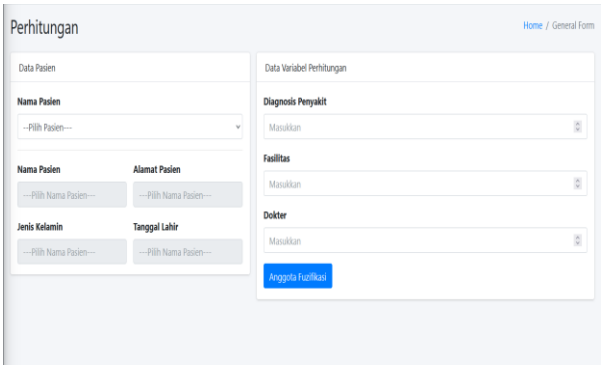

Fig. 7 Calculation Views

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This display is the process of calculating FMADM with SAW.

5. CONCLUSION

The SAW method in FMADM has proven effective in helping more structured and objective decision making at Noura Aesthetic Clinic. By using this approach, clinics can ensure that decisions made are based on quantitative analysis that considers the various important factors that influence the quality of patient care. The resulting decisions not only support improving the quality of medical services, but also increase patient satisfaction by providing optimal care according to their needs and conditions. Demonstrating the practical application of FMADM with SAW in a real-world healthcare setting, showcasing its potential to improve patient management processes. Addressing the challenges of uncertainty and subjectivity in healthcare data through the use of fuzzy logic, enhancing decision accuracy and reliability. Enhance the accuracy and completeness of patient data through the integration of electronic health records (EHR) and advanced data validation techniques. Develop systems capable of integrating real-time data from various sources, including wearable health devices and IoT-enabled medical equipment.

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