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## DIGITAL TRAINING RECOMMENDATIONS FOR ENHANCING HEALTHCARE HUMAN RESOURCE COMPETENCE USING THE SIMPLE ADDITIVE WEIGHTING ALGORITHM

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### ABSTRACT

*The main challenge in digital transformation within the healthcare sector lies in the limited mapping of human resources' (HR) readiness toward information technology. This study aims to evaluate the digital readiness level of healthcare human resources using a data-driven approach. The Simple Additive Weighting (SAW) method was applied, utilizing six variables whose weights were determined through expert discussions.*

*The results show that respondents' digital readiness scores range from 0.800 to 0.858. The highest score was achieved by R011 (Doctor, Outpatient Department) with a score of 0.858, indicating excellent digital literacy and effective utilization of information systems. A score of 0.828 was obtained by R032 (Medical Records Administration, ICU), R035 (Midwife, Polyclinic), and R025 (Doctor, Outpatient Department), suggesting relatively even readiness levels. The lowest score, 0.800, belonged to R026 (Laboratory Analyst, Polyclinic), which still falls within the high-readiness category but indicates the need for improvement in health data analysis skills. The overall average score was 0.828, confirming that the majority of healthcare personnel demonstrate good digital readiness.*

*These findings highlight the effectiveness of the SAW method in providing data-driven recommendations for digital capacity development. Moreover, the results can serve as a foundation for designing more targeted and efficient training programs. Overall, this study demonstrates that SAW-based mapping can effectively support strategic decision-making in the digital transformation of healthcare services.*

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### KEYWORDS

Digital Readiness, Healthcare Human Resources, Simple Additive Weighting (SAW), Digital Transformation, Training Recommendations

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## INTRODUCTION

Healthcare human resources (HRH) are one of the most crucial elements in determining the quality of healthcare services within a country (Haakenstad et al., 2022). The success of healthcare systems—whether in hospitals, community health centers, or other medical institutions—highly depends on the competence of the healthcare professionals involved (Hannawa et al., 2022). However, the rapid advancement of technology in the digital era has introduced new challenges for healthcare workers (Isidori et al., 2022). The demand for healthcare professionals who possess not only strong clinical expertise but also digital skills is steadily increasing (Ferreira et al., 2025). Digital transformation in healthcare, including the implementation of electronic medical records (EMR), hospital information management systems (HIMS), telemedicine, big data analytics, and the utilization of artificial intelligence (AI), requires healthcare professionals to adapt to a work environment that is increasingly dependent on information technology (Iyanna et al., 2022).

However, a significant challenge remains: the competency gap between the technological demands of the healthcare sector and the digital skills possessed by many healthcare workers (Navarro-Martínez et al., 2023). Many healthcare professionals—including doctors, nurses, and administrative staff—have not received adequate training in digital technologies. Some face difficulties operating patient management systems, interpreting data from electronic medical records, or optimizing the use of telemedicine platforms (Bekele et al., 2024). This competency gap can have serious implications for service effectiveness, operational efficiency, and even patient safety (Khan et al., 2025).

Additionally, healthcare training programs are often not data-driven (Amri & Abed, 2023). Many healthcare institutions still adopt a generic training approach, providing the same program to all healthcare personnel regardless of their specialization, experience, or digital proficiency levels (Zhang & Wang, 2024). As a result, training sessions are frequently ineffective, cost-inefficient, and fail to significantly improve competency (Månsson et al., 2022). This highlights the need for a system capable of generating personalized training recommendations based on each healthcare worker's competency profile (Martin-Sanchez et al., 2023).

In this context, the application of data mining techniques can make a significant contribution (Martin-Sanchez et al., 2023). Data mining enables the analysis of healthcare professionals' skills, work experience, and training needs to produce more accurate and targeted training recommendations (Kaul et al., 2023). One suitable method for this purpose is the Simple Additive Weighting (SAW) algorithm, a multi-criteria decision-making (MCDM) technique that is simple, effective, and widely used across various domains to generate recommendations and rank alternatives based on multiple criteria (Van Dua, 2023).

Using the SAW algorithm, each healthcare worker can receive personalized digital training recommendations tailored to their specific needs (Sahal et al., 2022). For example, a healthcare professional proficient in using electronic medical record systems but lacking expertise in health data analytics may be recommended to attend big data or AI training (Seth et al., 2023). Conversely, a worker struggling with patient management applications could be directed toward basic health information system training (Feroz et al.,

2021). This approach ensures that training programs are no longer uniform, but rather personalized, adaptive, and precisely targeted.

Implementing a SAW-based recommendation system in healthcare training planning will not only enhance the individual competencies of healthcare professionals but also positively impact organizational performance (Galih Adi Nugraha et al., 2025). Healthcare services can become more effective, efficient, and aligned with the demands of the digital era. Furthermore, digitally competent healthcare workers enable hospitals and medical institutions to adapt faster to technological advancements, improve service quality, and better address global healthcare challenges (Aldhi et al., 2025).

Therefore, this research is highly relevant in supporting the digital transformation agenda of the healthcare sector, both in Indonesia and globally. The main objective of this study is to develop a digital training recommendation system for healthcare professionals using the Simple Additive Weighting (SAW) algorithm. By doing so, the research aims to enhance healthcare human resource competencies and better prepare them to face the ongoing digital transformation in the healthcare sector.

## **RESEARCH METHOD**

The research method employed in this study is a multi-criteria decision-making (MCDM) model using the Simple Additive Weighting (SAW) algorithm. The study began with data collection through questionnaires and interviews with healthcare professionals to identify their needs and priorities for digital training. The research variables were determined based on the core competencies required, including digital literacy, medical technology skills, and health data management. The collected data were then analyzed using the SAW method to provide personalized training recommendations based on the assigned weights and scores of each criterion. The findings of this study are expected to produce an applicable and accurate recommendation model that can effectively support digital competency development among healthcare professionals.

## **RESULT AND DISCUSSION**

### **1. Criteria Determination**

This study utilizes seven interrelated variables to describe the readiness and capability of healthcare human resources in facing digital transformation within the healthcare sector. The first variable, digital literacy, serves as the foundation as it encompasses an individual's ability to understand, access, and effectively utilize technology. The second variable, Health Information System (HIS) usage, plays a significant role in ensuring that healthcare services become more integrated, accurate, and efficient. Data management and security represent another critical variable, as maintaining the confidentiality and accuracy of patient data is essential to comply with ethical standards and regulatory requirements. The fourth variable, digital medical technology skills, focuses on the ability of healthcare professionals to operate technology-based medical devices effectively. Additionally, health data analysis is crucial for supporting evidence-based decision-making through more comprehensive and targeted data processing. The sixth variable, digital collaboration, emphasizes the importance of teamwork among healthcare professionals by leveraging digital platforms that facilitate fast, effective, and cross-disciplinary communication. Finally, technology innovation adaptation serves as a key factor in sustaining transformation, as the ability to adopt and implement new technologies enhances the competitiveness of healthcare institutions. By integrating these seven

variables, this study aims to provide a comprehensive assessment of digital readiness in the healthcare sector.

## 2. Criteria Weight Determination

The determination of criteria weights in this study was established through expert discussions to ensure a balanced proportion according to the level of importance of each variable. The total weight was set to 1.0, with the following distribution: digital Literacy 0.15, Health Information System (HIS) Usage 0.15, Data Management and Security 0.15, Digital Medical Technology Skills 0.15, Health Data Analysis 0.15, Digital Collaboration 0.15, Technology Innovation Adaptation 0.10. This proportional weighting reflects the strategic priorities in supporting digital transformation within the healthcare sector.

## 3. Constructing the Decision Matrix

The decision matrix is a crucial initial stage in the implementation of the Simple Additive Weighting (SAW) method, as it serves as the foundation for subsequent calculations and analysis. In the decision matrix, each respondent (alternative) is evaluated based on several predetermined criteria, including digital literacy, Health Information System (HIS) usage, data management and security, digital medical technology skills, health data analysis, digital collaboration, and technology innovation adaptation (Poot et al., 2023). The numerical values presented in the table represent the measured scores or assessments that reflect each respondent's ability or competency level for each criterion. For example, respondent R001, a midwife working at the polyclinic, obtained a score of 4 in digital literacy and 5 in data management. This structured approach facilitates an objective comparison between respondents. Thus, the decision matrix not only presents raw data but also functions as a key instrument that transforms the data into a standardized format for further computation and analysis. The following table presents the decision matrix data used in this study.

Table 1. Decision Matrix

Respondent ID	Role	Unit	Digital Literacy	HIS Usage	Data Management & Security	Digital Medical Tech Skills	Health Data Analysis	Digital Collaboration	Technology Innovation Adaptation
R001	Midwife	Polyclinic	4	4	5	4	4	2	3
R002	Doctor	Inpatient	3	4	4	5	3	3	4
R003	Midwife	Polyclinic	2	3	5	4	2	2	3
R004	Midwife	Inpatient	5	3	3	4	4	1	4
R005	Midwife	Emergency	3	2	4	4	3	3	3
:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:	:
R045	Midwife	Emergency	4	4	4	3	3	4	3
R046	Lab Analyst	Inpatient	4	5	5	2	4	2	4
R047	Doctor	Inpatient	3	4	4	4	4	3	4
R048	Midwife	Inpatient	4	3	4	3	2	5	5
R049	Lab Analyst	Pharmacy	4	4	3	3	4	4	4
R050	Nurse	Emergency	4	3	3	3	5	4	4

#### 4. Matrix Normalization

Matrix normalization is the process of converting the values in the decision matrix into a uniform scale so that they can be compared objectively across criteria with different measurement units. In the Simple Additive Weighting (SAW) method, normalization is performed by dividing the value of each alternative for a given criterion by the maximum value of that criterion (for benefit criteria) or by dividing the minimum value by the alternative value (for cost criteria). This process produces normalized values ranging from 0 to 1, ensuring that no criterion becomes disproportionately dominant due to differences in measurement scales. Consequently, normalization guarantees fairness, balance, and consistency in the final computation. Since all the criteria used in this study are benefit criteria, the following formula is applied:

$$r_{ij} = \frac{x_{ij}}{\max(x_j)}$$

The implementation of the calculation for respondent R001 on the Digital Literacy criterion is as follows

$$r_{11} = \frac{4}{5} = 0.8$$

#### 5. Calculating the Preference Value (SAW Score)

In the Simple Additive Weighting (SAW) method, the final and most critical stage is calculating the preference value, which serves as the basis for decision-making. This preference value represents the importance level or final score of each alternative based on the predefined criteria. After the decision matrix normalization process is performed to ensure a uniform data scale, the weights of each criterion are then applied to provide a proportional contribution to the evaluation of each alternative. This calculation ensures that the assessment results are more objective, transparent, and comparable across all alternatives. The formula for calculating the preference value in the SAW method is expressed as follows:

$$V_i = \sum (w_j \times r_{ij})$$

The calculation of the preference value (SAW Score) for respondent R001 is as follows.

Table 2. SAW Score Calculation for R001

Digital Literacy	$0.15 \times 0.8 = 0.12$
HIS Usage	$0.15 \times 0.8 = 0.12$
Data Management	$0.15 \times 0.8 = 0.12$
Medical Technology	$0.15 \times 0.8 = 0.12$
Data Analysis	$0.15 \times 0.8 = 0.12$
Collaboration	$0.15 \times 0.4 = 0.06$
Adaptation	$0.10 \times 0.6 = 0.06$
Total Score R001	0.75

The preference score calculation for R001 shows that the largest contributions come from five main criteria: Digital Literacy, Health Information System (HIS) Usage, Data Management, Medical Technology, and Data Analysis, each contributing 0.12 (weight 0.15 × normalization 0.8 from a score of 4/5). This indicates that R001 possesses solid fundamental and technical digital competencies. Digital Collaboration contributes the least at 0.06 (0.15 × 0.4; score 2/5), making it the weakest area. Technological Innovation Adaptation contributes 0.06 (0.10 × 0.6; score 3/5), reflecting a moderate level of adaptive readiness. The total score of 0.75 indicates a relatively high level of digital readiness, with training priorities focusing on enhancing cross-unit collaboration and strengthening innovation practices to ensure a more balanced impact of digital transformation.

## 6. Ranking

Based on the calculation of the overall scores, the top five highest scores are as follows:

Table 3. Overall SAW Score Calculation

Respondent ID	Role	Unit	SAW Score
R011	Doctor	Outpatient	0,858
R032	Admin Medical Recorsd	ICU	0,828
R035	Midwife	Polyclinic	0,828
R025	Doctor	Outpatient	0,828
R026	Laboratory Analyst	Polyclinic	0,8

The results in Table 3, calculated using the Simple Additive Weighting (SAW) method for 50 respondents, show that the recommendation system can objectively map the level of digital readiness among healthcare human resources based on seven key variables. The highest SAW score is achieved by R011 (Doctor, Outpatient) with a score of 0.858, indicating an excellent level of readiness in digital literacy, utilization of health information systems, and digital medical technology skills. Meanwhile, several other respondents, such as R032 (Admin Medical Recorsd, ICU), R035 (Midwife, Polyclinic), and R025 (Doctor, Outpatient), each scored 0.828, suggesting a high level of readiness but with a need for improvement in health data analysis and digital collaboration. Respondent R026 (Laboratory Analyst, Polyclinic) scored 0.800, placing them in the moderate readiness category and therefore recommended for intensive training in data management and security. Overall, respondent scores range from 0.800 to 0.858, with an average score of 0.828, indicating that the digital readiness level of healthcare human resources is within the relatively high category.

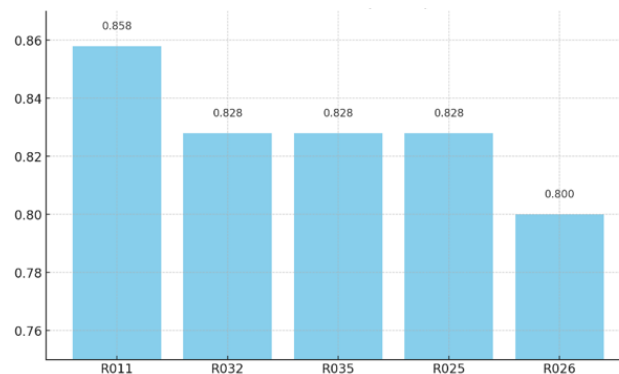


Figure 1. Human Resources Training Recommendations

Figure 1 presents the graphical results of the SAW score calculations for five respondents, illustrating variations in scores that reflect differences in roles and work units within the hospital. Respondent R011, a doctor in the Outpatient Unit, achieved the highest score of 0.858, indicating a comparatively stronger contribution and performance than the other respondents. Three respondents — R032 (medical records administration in the ICU), R035 (midwife in the Polyclinic), and R025 (doctor in the Outpatient Unit) — each obtained an identical score of 0.828, suggesting a comparable level of readiness and performance across both medical and non-medical personnel in different units. In contrast, R026, a laboratory analyst in the Polyclinic, recorded the lowest score of 0.800. These variations highlight the unique characteristics and differing levels of contribution associated with each role within the healthcare system. Overall, this graph provides a valuable basis for further analysis in evaluating performance, ensuring fairness, and assessing the relevance of the indicators applied in the Simple Additive Weighting (SAW) method.

## CONCLUSION

This study aims to assess the digital readiness of healthcare human resources in facing technological transformation by employing the Simple Additive Weighting (SAW) method. The analyzed variables include digital literacy, health information system utilization, data management and security, digital medical technology skills, health data analysis, and digital collaboration, with weights determined through expert discussions. Data were collected using questionnaires distributed to healthcare professionals and processed using the SAW method to generate final scores. The results indicate that the respondents' digital readiness scores range between 0.800 and 0.858, with an average score of 0.828. The highest score was achieved by Respondent R011 (Doctor, Outpatient Unit) with a value of 0.858, while the lowest score was recorded by Respondent R026 (Laboratory Analyst, Polyclinic) with 0.800. Overall, these findings suggest that the digital readiness level of healthcare human resources is relatively high, and the SAW method proves effective in providing objective recommendations to support training strategies and capacity-building policies based on information technology. For future research, it is recommended to integrate the SAW method with other data mining techniques, such as Principal Component Analysis (PCA) or K-Means clustering, to generate training recommendations that are more accurate, adaptive, and aligned with the specific needs of healthcare institutions."

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