Determination of Hospital Rank by Using Technique For Order Preference by Similiarity to Ideal Solution (TOPSIS) and Multi Objective Optimization on the Basis of Ratio Analysis (MOORA)

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Abstract— **Health services are one type of public service, which is essential in the development of public health and has a significant role in accelerating the improvement of public health status. Hospital is a health service facility that is full of technology, capital, works and experts. In this era of globalization, many hospitals, both government and private, have been built to meet public health needs and services. To find out which hospitals have public health service provisions, researchers need ranking hospitals. This paper compares three methods, which are TOPSIS, MOORA and the combination of those two methods. The study was conducted based on six criteria, namely Hospital Registration, Payment, Outpatient, Inpatient, Emergency and Pharmacy. The results show that the combination method, MOORA, and TOPSIS determine the same hospitals for the 1st rank until 7th rank. Then, for 8th rank until 10th rank, TOPSIS method get different results from other methods. The result of the analysis in this research can be used as a recommendation for the government and hospital managers to improve the quality of public health services.**

Keywords—Decision Support System, MOORA, Hospital, TOPSIS

I. INTRODUCTION

Health is an essential thing for humans to be able to survive and carry out activities. The importance of this health encourages governments and the private sector to establish health services so that people can access health needs. Health services are one type of public service, which is essential in the development of public health and has a critical job in quickening the improvement of public health status. This is also supported because the population is increasing, so many local and private governments have established health services such as regional public hospitals, private public hospitals, and clinics [1].

A hospital is an organization carried out by professional medical personnel well organized from medical facilities permanent, medical services, ongoing nursing care, diagnosis and treatment of diseases suffered by patients [2].

Decision support system (DSS) are systems that can solve problems with semi-structured and unstructured conditions. Some methods that can be used with a decision support system are MOORA and TOPSIS [3].

TOPSIS [4]–[7] s a decision-making method based on alternative choices, which contain the nearest good ways from a positive perfect arrangement and has the most expanded range from the ideal negative arrangement [3]. Related research using TOPSIS as a decision support model was carried out by Khosravi in the selection of rice milling systems [8].

MOORA is a multi-objective system that optimizes two or more conflicting attributes simultaneously. This method is applied to solve problems with complex mathematical calculations [9]. The MOORA method has flexibility and convenience to be understood and separated from the individual piece of an approval procedure [10]–[14] into decision weighting criteria with several decision maker attributes [15]–[18]. This way is chosen because it can select alternatives from several alternatives based on predetermined criteria. So that people can find out which hospital is suitable to be a place for healing in their health.

II. LITERATURE REVIEW

A. Decision Support System

Decision Support System (DSS) is a method that can assist in making decisions based on data and models to solve problems. DSS consist of three main components, namely model management, data management, and interface. There are four phases in the construction of a decision support system, namely intelligence, design, choice, and implementation [8].

B. Technique For Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS is a strategy for decision making dependent on elective decisions, which can give the best arrangement by computing the closeness between the separation of the perfect arrangement from positive and negative qualities [3]. Following are the steps analysis in TOPSIS method:

1. Normalization of the decision matrix

Normalize each element in the D matrix so that a normalized R matrix is formed. Every normalization of the value of *rij* can be calculated as in the following Equation (1):

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

where i=1,2,3,…,m;
j=1,2,3,…,n

2. Weighting the normalized matrix is given the weight W = (*w1, w2, ..., wn*), so that the weighted normalized matrix V can be generated as in equation (2):

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$$V = \begin{bmatrix} w_{11}r_{11} & \cdots & w_{1n}r_{1n} \\ \vdots & \ddots & \vdots \\ w_{m1}r_{m1} & \cdots & w_{mn}r_{mn} \end{bmatrix} \quad (2)$$

with i=1,2,3,…,m dan j=1,2,3…,n

3. Determine positive ideal solutions and negative ideal solutions

The positive ideal solution is denoted by A + and the negative ideal solution is denoted by A-, as in the following equation (3):

$$A^+ = \{(\max v_e \mid j \in J)(\min v_e \mid j \in J'), i = 1,2,3,\ldots,m\} = \{v_1^+, v_2^+, \ldots, v_m^+\}$$
$$A^- = \{(\max v_e \mid j \in J)(\min v_e \mid j \in J'), i = 1,2,3,\ldots,m\} = \{v_1^-, v_2^-, \ldots, v_m^-\} \quad (3)$$

where :
v_{ij} = matrix element V row i and column j
J ={j=1,2,3,…,n and j due to benefit criteria }
J' ={j=1,2,3,…,n and j due to cost criteria }

4. Calculating Separation Measure

This separation measure is an estimation of good ways from an option in contrast to a perfect positive arrangement and a negative perfect arrangement. The numerical count is as in the accompanying Equation (4, 5):

Separation measure for positive ideal solutions

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \text{ dengan i = 1,2,3,…,n} \quad (4)$$

Separation measure for begative ideal solutions

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \text{ dengan i = 1,2,3,…,n} \quad (5)$$

5. Calculate relative proximity to positive ideals

The relative proximity of the alternative A + to the ideal solution A- is represented in the following equation (6):

$$C_i = \frac{S_i^-}{S_i^- + S_i^+} \quad (6)$$

with 0<C, <1 dan i = 1,2,3,…,m

6. Sort Option

Options can be positioned dependent on the request for Ci. In this way, the best option is one that is the briefest separation to the perfect arrangement and the most remote separation with a negative perfect arrangement.

C. Multi Objective Optimization On The Basic Of Ratio Analysis (MOORA)

The MOORA technique is a multi-target framework that enhances at least two clashing properties at the same time. This technique is connected to tackle issues with complex numerical computations. The MOORA [19] strategy is generally connected in fields, for example, the board, building, contracting, street structure, and financial matters. This strategy has a decent degree of selectivity in deciding an option. The methodology taken by MOORA is characterized as a procedure at the same time to advance at least two duplicates which repudiate a few imperatives.

The MOORA technique has adaptability and comfort to be comprehended and isolated from the emotional piece of an assessment procedure into choice weighting criteria with a few leader traits [18]. This method has a good level of selectivity in determining an alternative [20]–[22] where the criteria are beneficial (benefit) or that do not have a profit (cost).

a. Make a decision matrix, which is described in Equation (7).

$$\mathbf{X} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{mn} \\ X_{21} & X_{22} & \cdots & X_{mn} \\ \cdots & \cdots & \cdots & \cdots \\ X_{n1} & X_{n2} & \cdots & X_{mn} \end{bmatrix} \quad (7)$$

b. normalize the matrik x, which is explained in Equation (8).

$$X*_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}^2} \quad (8)$$

c. Determine the weighted normalization matrix, which is described in Equation (9).

$$W_j * X_{ij} \quad (9)$$

d. Determine preference results, which is explained in Equation (10).

$$Y_i = \sum_{j=1}^{g} w_j X*ij - \sum_{j=g+1}^{n} w_j X_{ij} \quad (10)$$

D. Hospital

According to [23], clinic as one of the health service has a key job in making quality HR as a push to quicken the improvement of wellbeing status in an exhaustive, fair, moderate and adequate way to the whole network. This strategic role is obtained because the Hospital is a health service facility that is full of technology, capital, work and experts. Today the role is increasingly prominent given the emergence of changes in disease epidemiology, demographic structure, the development of science and technology, the socio-economic structure of society, which requires services that are more qualified, friendly and able to meet their expectations, desires and needs.

III. Research Method

A. Data Types and Sources

The types of data collected and analyzed are primary data sourced from hospital simulation data in the form of Hospital Registration, Payment, Outpatient, Inpatient, Emergency and Pharmacy.

B. Step analysys

The steps of analysis in this study are as follows.

1. Model the hospital process
2. Perform simulations
3. Get the event log
4. Perform analysis of event logs with two methods, namely
   a. TOPSIS
   b. MOORA
5. Get hospital rankings
6. Conclusion

The analysis step can be recorded in the flow diagram shown in Figure 1 as follows.

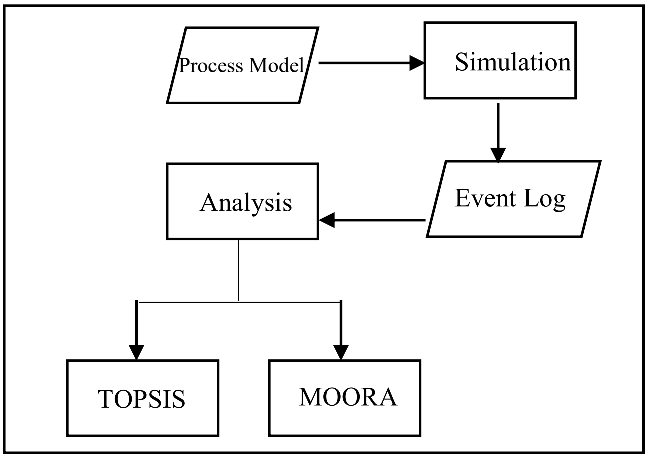

Figure 1. Flowchart

C. Knowledge Base Management

Hospital ranking is done by looking at the service time for each process in the hospital. From the time of service, the weighting is based on criteria and alternatives. Below is a table of criteria and alternatives that will be tested in the TOPSIS and MOORA methods so that they get the highest alternative. The criteria table and alternatives are described in TABLE I and TABLE II.

TABLE I. Criteria

Code	Criteria
K1	Payment
K2	Road Prone Modules
K3	Hospital Registration
K4	Pharmacy Model
K5	Inpatiet
K6	Emergency Module

TABLE II. Alternatif

Code	Alternatif
A1	Hospital 1
A2	Hospital 2
A3	Hospital 3
A4	Hospital 4
A5	Hospital 5
A6	Hospital 6
A7	Hospital 7
A8	Hospital 8
A9	Hospital 9
A10	Hospital 10

IV. RESULT AND ANALYSIS

In this chapter, we will explain the results and discussion about the best ranking using the TOPSIS and MOORA methods.

A. Determining Hospital Rank by using TOPSIS

The first step in TOPSIS is normalization of decision matrix. The calculation result is shown in Table III. Next, do the weighting normalized matrix. The calculation results is shown in Table IV.

TABEL III. Normalization of Decision Matrix

Alter native	**Criteria**					
	I1	**I2**	**I3**	**I4**	**I5**	**I6**
H1	0.36	0.18	0.30	0.35	0.36	0.47
H2	0.48	0.22	0.37	0.46	0.27	0.47
H3	0.11	0.43	0.18	0.12	0.17	0.12
H4	0.14	0.26	0.23	0.15	0.25	0.14
H5	0.16	0.18	0.26	0.19	0.51	0.14
H6	0.12	0.39	0.17	0.19	0.29	0.11
H7	0.55	0.32	0.44	0.27	0.19	0.49
H8	0.41	0.47	0.49	0.41	0.39	0.43
H9	0.20	0.24	0.32	0.13	0.22	0.15
H10	0.18	0.27	0.19	0.52	0.31	0.14

TABLE IV. Weighted Normalization of Decision Matrix

Alter native	**Criteria**					
	I1	**I2**	**I3**	**I4**	**I5**	**I6**
H1	1.1	0.72	0.90	1.43	1.47	2.37
H2	1.45	0.89	1.12	1.87	1.10	2.38
H3	0.34	1.72	0.55	0.48	0.71	0.60
H4	0.44	1.07	0.70	0.62	1.02	0.72
H5	0.48	0.73	0.78	0.76	2.05	0.72
H6	0.37	1.58	0.51	0.76	1.17	0.58
H7	1.65	1.31	1.32	1.11	0.76	2.48
H8	1.24	1.89	1.47	1.66	1.56	2.15
H9	0.62	0.96	0.98	0.55	0.91	0.76
H10	0.53	1.10	0.57	2.08	1.25	0.72

Then, determine the ideal positive solution (A +) and the ideal negative (A-) can be seen in TABLE V.

Tabel V. Calculation of Positive and Negative Ideal Solutions

A+	A-
0.34	1.65
0.72	1.89
0.51	1.47
0.48	2.08
0.71	2.05
0.58	2.48

After that, a calculation is performed to find a positive separation measure (Si +) and a negative separation measure (Si-). The next stage then calculates the relative proximity of the alternative A+ with the ideal solution A-. The results of the calculations is shown in Table VI. The result of the ranking of the TOPSIS is shown in Table VII.

TABLE VI. Calculation of Separation Measure

S+	S-	C
2.32	1.66	0.41
2.63	1.45	0.35
1.00	3.23	0.76
0.55	2.99	0.84
1.40	2.83	0.66
1.01	2.96	0.74
2.59	1.71	0.39
2.77	0.82	0.22
0.65	2.95	0.81
1.74	2.53	0.59

Tabel VII. Results of the TOPSIS Method Order

Result	Alternative	Ranking
0.41	H1	4
0.35	H2	2
0.76	H3	8
0.84	H4	10
0.66	H5	6
0.74	H6	7
0.39	H7	3
0.22	H8	1
0.81	H9	9
0.59	H10	5

From the results of calculations using the TOPSIS, it was found that the highest ranking hospital was Hospital 8, and the hospital with the lowest rating was Hospital 3.

B. Multi Objective Optimization on the Basis of Ratio Analysis (MOORA)

The first step in MOORA is to normalize the decision matrix. The calculation results is shown in Table VIII.

TABLE VIII. Normalize Decision Matrix MOORA

Alter natif	**Criteria**					
	I1	**I2**	**I3**	**I4**	**I5**	**I6**
H1	0,,.36	0,,.18	0,,.30	0,,.35	0,,.36	0,,.47
H2	0,,.48	0,, ,,.22	0,,.37	0,,.46	0,,.27	0,,.47
H3	0,,.11	0,,.43	0,,.18	0,,.12	0,,.17	0,,.12
H4	0,,.14	0,,.26	0,,.23	0,,.15	0,,.25	0,,.14
H5	0,,.16	0,,.18	0,,.26	0,,.19	0,,.51	0,,.14
H6	0.12	0.39	0.17	0.19	0.29	0.11
H7	0.55	0.32	0.44	0.27	0.19	0.49
H8	0.41	0.47	0.49	0.41	0.39	0.43
H9	0.20	0.24	0.32	0.13	0.22	0.15
H10	0.18	0.27	0.19	0.52	0.31	0.14

Next, do the weighted normalization matrix. Normalization of the weighted matrix is obtained by multiplying the weight of the criteria that have been obtained using TOPSIS with the normalization matrix is shown in Table IX.

TABLE IX**.** Normalize Decision Matrix Weighted MOORA

Alter Native	**Criteria**					
	I1	**I2**	**I3**	**I4**	**I5**	**I6**
H1	-0.48	-0.31	-0.39	-0.62	-0.64	-1.03
H2	-0.63	-0.39	-0.48	-0.81	-0.48	-1.03
H3	-0.15	-0.75	-0.24	-0.21	-0.31	-0.26
H4	-0.19	-0.46	-0.30	-0.27	-0.44	-0.31
H5	-0.21	-0.32	-0.34	-0.33	-0.89	-0.31
H6	-0.16	-0.69	-0.22	-0.33	-0.51	-0.25
H7	-0.72	-0.57	-0.57	-0.48	-0.33	-1.07
H8	-0.54	-0.82	-0.64	-0.72	-0.68	-0.93
H9	-0.27	-0.42	-0.42	-0.24	-0.39	-0.33
H10	-0.23	-0.48	-0.24	-0.90	-0.54	-0.31

Next step is calculating preference values, benefit attributes will be summed with other benefit attributes. The cost attribute will be summed with other cost attributes. The value of yi is obtained by subtracting from the sum of benefits and costs. Because in this case a hospital that has an attribute in the form of service duration is worth the cost. So the value is obtained is shown in Table X.

TABLE X. Preference Result MOORA

Alternative	Result (yi)
H1	3.48
H2	3.84
H3	1.92
H4	2.00
H5	2.41
H6	2.17
H7	3.76
H8	4.34
H9	2.09
H10	2.72

The final step is determining ranking. Ranking seen from the yi values obtained. Hospitals which are the best alternative to become outstanding best hospital is shown in Table XI.

TABLE XI. Preference Value MOORA

Alternatif	Rank
H8	1
H2	2
H7	3
H1	4
H10	5
H5	6
H6	7
H9	8
H4	9
H3	10

From the results of calculations using the MOORA, it was found that the highest ranking hospital was hospital 8, and the hospital with the lowest rating was hospital 3.

C. Combined Rank Between TOPSIS and MOORA

The way to get a combined rating is by calculating the average value between TOPSIS and MOORA is shown in Table XII.

TABLE XII. The Combination Result of TOPSIS and MOORA

Alternative	**Value**	**Rank**
H8	2,28	1
H2	2,095	2
H7	2,075	3
H1	1,945	4
H10	1,655	5
H5	1,535	6
H6	1,455	7
H9	1,45	8
H4	1,42	9
H3	1,34	10

V. CONCLUSION

This paper determines the hospital rank by using the combination of MOORA and TOPSIS. The result shows that the combination method, MOORA, and TOPSIS determines the same hospitals for the 1st rank until 7th rank. Then, the 8th rank until 10th rank produced by the combination method and MOORA are identical, but TOPSIS get different results in 8th rank until 10th rank. The conclusion is the rank results are mostly the same.

For the next development, it is better if the hospital ranking is added to the hospital variable so that the difference in the results of the analysis of the two methods is more visible. Then, the analytical method can be added to determine better ways.

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REFERENCES

[1] M. Sholihin, N. Fuad, and N. Khamiliyah, “Sistem pendukung keputusan penentuan warga penerima Jamkesmas dengan metode Fuzzy Tsukamoto,” *J.*

Tek. Vol, vol. 5, no. 2, 2013.

[2] S. Supartiningsih, “Kualitas Pelayanan an Kepuasan Pasien Rumah Sakit: Kasus Pada Pasien Rawat Jalan,” *Jurnal Medicoeticolegal dan Manajemen Rumah Sakit*, vol. 6, no. 1, pp. 9–15, 2017.

[3] V. L. Sauter, *Decision support systems for business intelligence*. John Wiley \& Sons, 2014.

[4] U. Yudatama and R. Sarno, “Evaluation Maturity Index and Risk Management for IT Governance Using Fuzzy AHP and Fuzzy Topsis,” *International Seminar on Intelligent Technology and Its Applications*, pp. 323–328, 2015.

[5] D. N. Ghosh, “Analytic hierarchy process \& TOPSIS method to evaluate faculty performance in engineering education,” *Dipendra Nath Ghosh et al UNIASCIT*, vol. 1, no. 2, pp. 63--70, 2011.

[6] Y. D. Harja and R. Sarno, “Determine the best option for nearest medical services using Google maps API, Haversine and TOPSIS algorithm,” in *2018 International Conference on Information and Communications Technology (ICOIACT)*, 2018, pp. 814–819.

[7] G. Sophia and R. Sarno, “AHP-TOPSIS for analyzing job performance with factor evaluation system and process mining,” *Telkomnika*, vol. 17, no. 3, pp. 1344–1351, 2019.

[8] J. Khosravi, M. A. Asoodar, M. R. Alizadeh, and M. H. Peyman, “Application of multiple criteria decision making system compensatory (TOPSIS) in selecting of rice milling system,” *World Applied Sciences Journal*, vol. 13, no. 11, pp. 2306–2311, 2011.

[9] W. K. M. Brauers and others, “Multi-objective contractor’s ranking by applying the MOORA method,” *Journal of Business Economics and management*, no. 4, pp. 245–255, 2008.

[10] K. R. Sungkono and R. Sarno, “CHMM for discovering intentional process model from event logs by considering sequence of activities,” in *2017 4th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)*, 2017, pp. 1–6.

[11] R. Sarno and K. R. Sungkono, “Coupled Hidden Markov Model for Process Mining of Invisible Prime Tasks,” *International Review on Computers and Software (IRECOS)*, vol. 11, no. 6, pp. 539–547, 2016.

[12] K. R. Sungkono, R. Sarno, and N. F. Ariyani, “Refining business process ontology model with invisible prime tasks using SWRL rules,” in *2017 11th International Conference on Information & Communication Technology and System (ICTS)*, 2017, pp. 215–220.

[13] K. R. Sungkono and R. Sarno, “Constructing Control-Flow Patterns Containing Invisible Task and Non-Free Choice Based on Declarative Model,” *International Journal of Innovative Computing, Information and Control (IJICIC)*, vol. 14, no. 4, 2018.

[14] R. Sarno and K. R. Sungkono, “Hidden Markov Model for Process Mining of Parallel Business Processes,” *International Review on Computers and Software (IRECOS)*, vol. 11, no. 4, pp. 290–300, 2016.

[15] V. K. Mittal, R. Sindhwani, P. L. Singh, V. Kalsariya, and F. Salroo, “Evaluating significance of green manufacturing enablers using MOORA method for Indian manufacturing sector,” in *Proceedings of the International Conference on Modern Research in Aerospace Engineering*, 2018, pp. 303–314.

[16] M. Chand, N. Bhatia, and R. K. Singh, “ANP-MOORA-based approach for the analysis of selected issues of green supply chain management,” *Benchmarking: An International Journal*, vol. 25, no. 2, pp. 642–659, 2018.

[17] S. K. Sahoo, S. S. Naik, and J. Rana, “Experimental Analysis of Wire EDM Process Parameters for Micromachining of High Carbon High Chromium Steel by Using MOORA Technique,” in *Micro and Nano Machining of Engineering Materials*, Springer, 2019, pp. 137–148.

[18] A. Arabsheybani, M. M. Paydar, and A. S. Safaei, “An integrated fuzzy MOORA method and FMEA technique for sustainable supplier selection considering quantity discounts and supplier’s risk,” *Journal of cleaner production*, vol. 190, pp. 577–591, 2018.

[19] Y. Dong, Y. Liu, H. Liang, F. Chiclana, and E. Herrera-Viedma, “Strategic weight manipulation in multiple attribute decision making,” *Omega*, vol. 75, pp. 154–164, 2018.

[20] M. K. Sagar, P. Jayaswal, and K. Kushwah, “Exploring fuzzy SAW method for maintenance strategy selection problem of material handling equipment,” *International Journal of Current Engineering and Technology*, vol. 3, no. 2, pp. 600–605, 2013.

[21] A. Cahyapratama and R. Sarno, “Application of Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) Methods In Singer Selection Process,” in *International Conference on Information and Communications Technology (ICOIACT) Application*, 2018, no. Mcdm, pp. 234–239.

[22] A. F. Apriliana, R. Sarno, and Y. A. Effendi, “Risk analysis of IT applications using FMEA and AHP SAW method with COBIT 5,” in *2018 International Conference on Information and Communications Technology (ICOIACT)*, 2018, pp. 373–378.

[23] F. Fauziah, E. Surachman, and A. Muhtadi, “Integration of service quality and quality function deployment as an effort of pharmaceutical service improvement on outpatient in a referral Hospital, Karawang, Indonesia,” *Journal of Advanced Pharmacy Education & Research| Apr-Jun*, vol. 9, no. 2, 2019.