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An integrated multi-criteria approach to formulate and assess healthcare referral system strategies in developing countries

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ABSTRACT

This study aims to identify challenges in implementing a quality healthcare referral system in developing countries and explore the strategies to overcome these challenges. Data for this study were collected through consultations with experts in the field. We introduce a novel hybrid method called Criteria Importance Assessment (CIMAS) and Alternative Ranking Order Method Accounting for Two-Step Normalization (AROMAN). CIMAS determines the relative importance of criteria, and AROMAN is employed to rank the strategies. The primary challenges identified include inadequate infrastructure facilities and deficient health information systems. The most appropriate strategy involves focusing on improving infrastructure facilities. We also carry out comprehensive sensitivity and comparative analyses to validate the applicability of the proposed model. This study identifies and elucidates the challenges of establishing a high-quality healthcare referral system in developing countries and substantially contributes to the existing body of knowledge by effectively delineating and prioritizing the strategies to tackle these challenges.

1. Introduction

The World Health Organization (WHO) Framework for Action outlines six critical health system components, including health service delivery. A functional referral system relies on integrating into a well-operating health system, as outlined in the health system requirements of the Kenya draft Referral Strategy and Investment Plan for Health Services (RSPHS) 2012–2017 [1]. Successful referrals necessitate accessible care facilities, well-trained staff, economically viable services, and the availability of essential equipment and drugs. The caretaker's approval and submission of the referral suggestion often determine the success of referral care, influenced by factors such as the perceived necessity of the referral.

In many nations, health facilities are divided into primary care and hospitals. Ideally, healthcare systems promote starting with primary care and then, if needed, moving to higher-level services to minimize costs for caretakers [2]. Yet, individuals often skip primary care and head straight to hospitals, straining resources and increasing costs for caretakers and the healthcare system [3]. Securing the fundamental human right to the highest attainable standard of health [4] requires a robust referral system in a hierarchical health setup. This system ensures continuity of care across primary, secondary, and tertiary levels. Unfortunately, in numerous developing nations, weak referral systems compromise overall health system performance, leading to adverse health outcomes.

Kenya's healthcare system consists of six levels organized into four tiers, depending on the services' scope and complexity. The Ministry of Health in Kenya discovered that the distance of healthcare facilities from

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the population directly impacts service utilization. The research suggests that the closer one is to a health facility, the more likely they are to use its services.

Counties must provide health services and manage referrals in their health facilities and pharmacies. The Kenya Health Policy 2012–2030 emphasizes the necessity of strengthening the referral system to enhance the efficiency of the health system and improve health outcomes [5]. Critical investment priorities outlined in Kenya Health Sector Strategic and Investment Plan (KHSSP) 2012–2018 involve updating referral tools and guidelines, orienting management teams on referral responsibilities, and providing tools for expertise movement and travel allowances. The health sector has formulated a referral strategy, along with standard guidelines and forms, to direct the establishment of an effective system that addresses the demands of rural and economically disadvantaged populations. Kiambu county (Kenya), with a population exceeding 2.5 million, grapples with unequal ratios of doctors, nurses, and clinical officers to patients [6]. Although the government has endeavored to enhance the referral system in Kenya for improved health system efficiency and outcomes, the results are unsatisfactory due to numerous challenges.

Numerous studies highlight challenges in implementing a quality healthcare referral system in Kenya. For instance, Nguru and Ireri [7] examined the factors affecting the establishment of the system in a specific county in Kenya. Their study focused on the lack of alignment between communication, healthcare worker capacity, and knowledge regarding this establishment. They employed a cross-sectional design, using questionnaires to survey health sector workers. The results indicated that the communication gap is the system's most significant factor. Nango [8] conducted a cross-sectional survey to assess how certain factors affect a functional referral system. Data was gathered through questionnaires and interviews, then analyzed using statistical methods. The study found that the main characteristics of health facilities significantly impacted the referral system and suggested improving the supply of drugs and quality of service to attract more patients. Wallenius [9] studied how factors affect the referral chain. The data is collected via survey and examined using content analysis to establish an optimum referral chain model. The results emphasized facilitating current referral chain systems to diminish errors. Kimathi [10] argued in favor of decentralizing the health sector to empower county governments to develop new frameworks that cater to their specific health requirements. This approach would promote adequate citizen engagement and enable independent, swift decision-making on the mobilization and administration of resources. Ajwang [11] sought to determine how referral services affect household access to healthcare. Data was collected through surveys and interviews and then analyzed using statistical methods. The study provides several insights for healthcare planning and offers suggestions to enhance healthcare access. Osoro [12] identified what determines upward referral systems for over 500 patients in different hospitals. Data was collected through interviews and questionnaires and then analyzed statistically. The study found that proximity to the referral hospital was the sole significant factor affecting the implementation of upward referral systems. It indicated that health facilities enhance communication systems, and organizing workshops and seminars will promote awareness of referral system guidelines among healthcare workers. Akwanalo et al. [13] attracted stakeholders in patient referrals, leading to authorization for research and collaboration in updating care protocols for timely and appropriate referrals. Gichuki [14] investigated health from a public health and human rights perspective and analyzed the law and policy framework governing the health sector and its main issues. Njanwe, Marete and Ayaya [15] studied how well national healthcare referral instructions are followed and the instantaneous results for children at an advanced teaching hospital. They found that adherence to these instructions was low among children treated at the second-biggest national hospital. Kamau, Osuga and Njuguna [16] addressed issues in establishing a high-quality referral healthcare system. However, none of these studies have evaluated or developed strategies to address the most significant challenges facing the healthcare referral system. To fill these gaps, a comprehensive managerial perspective is needed for an effective strategy for a well-functioning referral system. This approach should consider multiple criteria for better decision outcomes [17,18]. Multi-criteria decision-making (MCDM) techniques, known for handling complex problems and diverse criteria, are well-suited for this purpose [19].

1.1. Objectives

The main goal of this study is to examine and assess the challenges faced by an efficient healthcare referral system and to suggest strategies for overcoming these challenges. In pursuit of this objective, a hybrid approach that combines the criteria importance assessment (CIMAS)-method with the alternative ranking order method accounting for the two-step normalization (AROMAN) technique will be utilized for the first time. The adoption of this hybrid method is motivated by identifying the optimal strategy for an effective healthcare referral system by assigning diverse weights to different criteria.

1.2. Contributions

The contributions of this research can be summarized as follows:

(i) Introducing a novel hybrid approach for identifying an effective strategy for a quality healthcare referral system at the county level in developing countries.
(ii) Pioneering the application of the CIMAS-AROMAN method in the literature, incorporating hybrid elements for enhanced applicability.
(iii) Providing recommendations for devising strategies to address the existing challenges in Kiambu county's current state regarding the healthcare referral system.

1.3. Motivations of CIMAS-AROMAN application

Previous studies on Kenya's healthcare referral system have found a lack of information regarding the most critical challenges and how to assess and formulate appropriate strategies to overcome them. There is a research gap in an extensive study incorporating the MCDM approach and qualitative methods to address uncertainty. This study aims to fill this gap by introducing a CIMAS-AROMAN hybrid method to assist Kiambu county in determining an effective strategy for a well-functioning referral system.

The CIMAS method provides various advantages over other criteria weighting approaches. It helps managers and decision-makers determine weights for each criterion and rank them in descending order. CIMAS relies on the essential knowledge and experience of experts during its implementation. However, it exclusively depends on expert knowledge and experience for the final criteria ranking, which could be a drawback if less-experienced experts are involved in decision-making.

The AROMAN method offers advantages over other alternative ranking methods. It can evaluate alternatives quantitatively and qualitatively, employs dual normalization processes for improved normalization and sensitivity analysis, uses a straightforward ranking approach to avoid complex calculations, and differentiates between cost and benefit evaluation criteria.

The rest of the paper is organized as follows: Section 2 provides a literature review, while Section 3 gives a methodology. Section 4 offers an application, while Section 5 gives a sensitivity analysis. Section 6 provides a comparison analysis. Section 7 presents some findings and discussion, while Section 8 provides some concluding remarks.

2. Literature review

This section includes two sub-sections.

2.1. Overview of approaches related to the healthcare referral system

Research on healthcare systems, specifically focusing on referral systems, has been carried out in numerous countries worldwide [20,21]. For instance, Eskandari, Abbaszadeh and Borhani [22] outlined the barriers to the healthcare process within rural societies. Oluseye et al. [23] evaluated how healthcare workers in specific primary healthcare (PHC) centers understand and use the referral system. Abrahim et al. [24] studied how people seek initial care before reaching health facilities, a vital aspect of the primary healthcare unit's referral system. Diba et al. [25] examined the challenges recognized by staff in the referral systems of maternal healthcare facilities. Afolaranmi et al. [26] examined the degree of referral practice and the factors impacting it among health workers in PHCs. Alkinaidri et al. [27] examined the use of Lean Six Sigma to enhance the healthcare referral system. Handayani et al. [28] established a model for user acceptance of the health referral system in Indonesia. Doumouras et al. [29] investigated the effects of transitioning from a fax-based referral system to an online system on referral rates for bariatric surgery. Their study revealed a substantial increase in referrals following the adoption of the online system. Dogba et al. [30] investigated how the referral system's entry point and the quality of human resources impacted maternal mortality and stillbirths. They discovered that accessing the referral system through the regional hospital was linked to a significant survival percentage for both mothers and newborns. Fernández-Méndez et al. [31] examined how the introduction of a web-based electronic referral system using a service-designed form affected the waiting time and the information's completeness. Give et al. [32] investigated the factors affecting referrals in complicated compatible health frameworks and recommended enhancing community health by dealing with these factors and improving referral system efficiency. Chitsa [33] studied factors affecting the referral system management in primary healthcare and suggested resource availability improvement (proficient personnel) as a recommendation for the government. Daniels and Abuosi [34] found obstacles in referring urgent obstetric cases to the main national center and suggested improving transportation. Masaba et al. [35] reviewed Kenya's devolved healthcare system, noting improved health infrastructure.

2.2. Implementation of MCDM in the healthcare sector

The healthcare and medical fields play a crucial role in elevating living standards and improving the overall quality of human life [36, 37]. Decision-making in the healthcare domain is often complex and poses significant challenges due to its profound impact on the quality of individual lives [38–40]. The primary aim of these decisions is to maximize health benefits, minimize health risks, empower patient choice, promote physical engagement, address resource limitations, and uphold principles of fairness and equity [41–43]. For instance, Debnath et al. [44] proposed a procedure for selecting suppliers for healthcare testing facilities. KhanMohammadi, Talaie and Azizi [45] assessed hospital service quality. Akter et al. [46] investigated the critical risk factors influencing the supply chain of emergency life-saving drugs. Chakraborty et al. [47] employed a method to tackle the issue of healthcare supplier selection. Ecer and Pamucar [48] identified the priority ranking of insurance companies within healthcare services. Torkayesh et al. [49] allocated weights to healthcare parameters, evaluating healthcare performance in different countries. Yazdani et al. [50] employed a method to determine the locations for healthcare waste disposal. Puška et al. [51] proposed a model for choosing incinerators to manage healthcare waste. Pamučar et al. [52] investigated the choice of an effective treatment method for handling healthcare waste. Mishra et al. [53] focused on evaluating healthcare in the context of hazardous waste recycling. Pamucar et al. [54] addressed supplier selection issues during the COVID-19 pandemic. Shih, Kasaie and Rajendran [55] formulated a strategy for managing platelet inventory within the blood supply chain. Tavana et al. [56] presented a framework for evaluating the performance of medical equipment suppliers. Chakraborty et al. [57] introduced a method to address supplier selection challenges in India's healthcare. Selamzade et al. [58] assessed the effectiveness of countries in combating the COVID-19 pandemic at various points in time. Görçün et al. [59] developed a method for healthcare policymakers to optimize service provider choice. Swarnakar et al. [60] explored prosperous parameters for effectively implementing durable Lean Six Sigma in healthcare. Krishankumar et al. [61] introduced an approach for choosing an appropriate blockchain service provider, contributing to blockchain technology. Saha et al. [62] devised a model for choosing a healthcare supplier that offers increased versatility and workability in addressing problems. Al-Jedai et al. [63] evaluated the viability of adopting a model for the evaluation of health technology of orphan drugs. A summary of the MCDM approaches within the healthcare sector is presented in Supplementary Material.

3. The CIMAS-AROMAN methodology

The CIMAS method, as presented by Bošković et al. [64] in addressing supplier selection challenges, offers a fresh perspective by methodically gauging the significance of criteria in decision-making through expert assessments. An essential aspect of this method is its acknowledgment of experts' knowledge and experience, giving weight to the years they have dedicated to the relevant field. Since its inception, this approach has primarily been utilized in addressing supplier selection challenges.

The AROMAN method is a novel approach designed to enhance decision-making in multi-criteria settings. It utilizes a two-step normalization process and ensures impartial comparisons among alternatives [65]. AROMAN produces a thorough ranking order by factoring in the importance of criteria and their respective weights. Despite its recent inception, this method has garnered considerable attention and found diverse applications, including assessing sustainability in rural postal networks [66], selecting professional drivers [67], choosing cargo bike delivery concepts [68], evaluating durable competitiveness levels [69], and comparing electric vehicles [70].

The CIMAS-AROMAN method facilitates the assessment of alternative options by methodically gauging the significance of criteria in the decision-making process through expert evaluations. This method involves two phases, totaling 17 steps. In the first phase, the CIMAS method's eleven steps are applied to ascertain criteria weights, and in the second phase, the six steps of the AROMAN method are employed to rank the alternatives. The sequential steps in applying this method are below:

First phase: The CIMAS method is performed in 11 steps. These steps are as follows:

Step 1. Criteria definition assessment: The first step is to delineate the criteria for assessing importance. These criteria can be determined through a literature review or expert consultation.

Step 2. Expert's number assessment: The decision-maker assesses the experts' numbers in the field and gathers data on their experience length.

Step 3. Experience of expert assessment: The experts detail their field experience in years, and the decision-maker determines their significance.

Step 4. Expert significance calculation: In a typical scenario, the significance of the expert can be computed (Eq. (1)):

$$W^{E_i} = \frac{E_i}{\sum_{i=1}^{q} E_i}, i = 1, 2, \ldots, q. \quad (1)$$

Step 5. Input data matrix formulation: During this step, an input decision-making matrix is established (see Appendix B1).

Step 6. Input-data matrix normalization: Following the creation of the input data matrix, step 6 involves data normalization (see Appendix B2). In this process, the normalization technique is done by applying Eq. (2).

$$x^*_{ij} = \frac{x_{ij}}{\sum_{i=1}^{q} x_{ij}}, i = 1, 2, \ldots, q;\ j = 1, 2, \ldots, p. \quad (2)$$

Step 7. Expert weight matrix calculation: The normalized input data undergoes multiplication with the weights assigned to experts in Step 4 (see Appendix B3). The computation is carried out using Eq. (3):

$$\widehat{x^*}_{ij} = x^*_{ij} \cdot W^{E_i}, i = 1, 2, \ldots q; j = 1, 2, \ldots, p. \quad (3)$$

Step 8. Maximum and minimum value of each criterion calculation: The maximum ($R_{j\ max}$) and minimum value ($R_{j\ min}$) of each criterion (see Appendix B4) are assessed by using equation (4) and **5.**

$$R_{j\ max} = \max_i \left[\widehat{x^*}_{ij}\right], j = 1, 2, \ldots, p, \quad (4)$$

$$R_{j\ min} = \min_i \left[\widehat{x^*}_{ij}\right], j = 1, 2, \ldots, p. \quad (5)$$

Step 9. Minimum and maximum difference values calculation: This difference (B_j) between the minimum and maximum values from the antecedent step is computed using Eq. (6).

$$B_j = R_{j\ max} - R_{j\ min}, j = 1, 2, \ldots, p. \quad (6)$$

Step 10. The final rank formula application is done (Eq. (7)).

$$L_j = \frac{B_j}{\sum_{j=1}^{p} B_j}, j = 1, 2, \ldots, p. \quad (7)$$

Step 11. Reliability Index (RI) Check

When using subjective methods like CIMAS, ensuring the reliability of expert responses is crucial. Unlike the analytical hierarchy process (AHP) method, which measures inconsistency rates, CIMAS employs an alternative approach [67] to assess reliability. This involves a second round of interviews where experts, unaware of the first-round results, assign percentage importance to criteria on a scale of 0–100%. Suppose we use cap P sub j as the responses from the second round of interviews and cap L sub j or the previously acquired CIMAS weights. In that case, the reliability index (RI) can be calculated through Eq. (8).

$$RI = \frac{\sum_{j=1}^{n} \left| F_j * 100 - P_j \right|}{100}. \quad (8)$$

Second stage: The AROMAN method is conducted in six steps as follows.

Step 12. In this phase, a decision-making matrix Y_{mxn} with the input data $y_{11}, \ldots, y_{2j}, \ldots, y_{mn}$, is formulated (Eq. (9)):

$$Y = \begin{bmatrix} y_{11} & \cdots & y_{1j} & \cdots & y_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ y_{21} & \cdots & y_{2j} & \cdots & y_{2n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ y_{m1} & \cdots & y_{mj} & \cdots & y_{mn} \end{bmatrix}. \quad (9)$$

Step 13. Upon establishing the decision-making problem matrix, the subsequent phase involves normalizing the data. The AROMAN method integrates two normalization techniques, namely linear (Eq. (10)) and vector (Eq. (11)), to produce an aggregated normalized matrix (Eq. (12)).

$$P_{ij} = \frac{y_{ij} - \min_i [y_{ij}]}{\max_i [y_{ij}] - \min_i [y_{ij}]}, \quad (10)$$
$$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n,$$

$$P^*_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{m} y^2_{ij}}},\ i = 1, 2, \ldots, m; j = 1, 2, \ldots, n, \quad (11)$$

$$P^{norm}_{ij} = \frac{1}{2}\left[\mu P_{ij} + \left(1 - \mu\right) P^*_{ij}\right],\ i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n. \quad (12)$$

where P^{norm}_{ij} is the aggregated averaged normalization and μ is the weighting factor changing from 0 to 1. In our case, $\mu = 0.5$.

Step 14. Eq. (13) calculates this phase.

$$\widehat{P_{ij}} = W_{ij} \cdot P^{norm}_{ij},\ i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n. \quad (13)$$

Step 15. Obtention of a sum of the normalized weighted values calculated (Eq. (14) and Eq. (15)), respectively:

$$D_i = \sum_{j=1}^{n} \widehat{P_{ij}}^{(min)},\ i = 1, 2, \ldots, m, \quad (14)$$

$$U_i = \sum_{j=1}^{n} \widehat{P_{ij}}^{(max)},\ i = 1, 2, \ldots, m. \quad (15)$$

Step 16. The sum of D_i and U_i values are raised to δ and $1 - \delta$levels, respectively.

$$D_i^{\hat{}} = D_i^{\delta} = \left(\sum_{j=1}^{n} \widehat{P_{ij}}^{(min)}\right)^{\delta}, i = 1, 2, ..., n, \quad (16)$$

$$U_i^{\hat{}} = U_i^{1-\delta} = \left(\sum_{j=1}^{n} \widehat{P_{ij}}^{(max)}\right)^{1-\delta}, i = 1, 2, ...n, \quad (17)$$

where δ is the coefficient level framed in [0,1].

Step 17. Thedifference between the values $U_i^{\hat{}}$ and $D_i^{\hat{}}$ are computed. The final ranking equation S_i is applied as follows:

$$S_i = e^{U_i^{\hat{}} - D_i^{\hat{}}}, i = 1, 2, ..., n. \quad (18)$$

4. Application

Our investigation identifies challenges associated with the quality healthcare referral system and alternatives through a synthesis of past studies [71] and consultations with experts. To establish a dependable

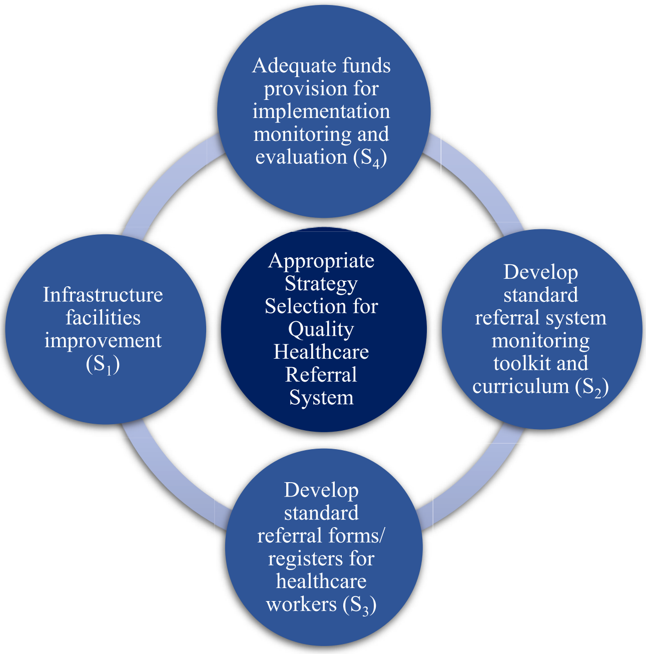

Fig. 1. Strategies for quality healthcare referral system.

evaluation, interviews were conducted with five experts carefully chosen based on particular criteria, including their skill and extensive understanding of the field.

4.1. Criteria and alternatives characterization

The challenges along with alternatives have been defined in **Appendix C1**. The potential strategies to handle these most critical challenges are shown in Fig. 1.

4.2. Criteria weights determination

This section showcases the CIMAS method's application in evaluating criteria for selecting an appropriate strategy for a quality healthcare referral system. Four criteria were identified: one costly type (C_4) and three beneficial types (C_1, C_2, and C_3). Five experts participated in the assessment, ranking the importance of each criterion on a one-to-ten-point scale. Expert weights were determined based on their field experience. The generated data from this case study were processed using the CIMAS method (see **Appendices C2**-**C4**), The criteria rankings are visualized in Fig. 2.

The assessment results for determining an optimal strategy for a quality healthcare referral system are ranked as follows: inadequate infrastructure facilities received the highest importance, followed by deficient health information systems, insufficient healthcare worker capacity, and insufficient financial resources, respectively. A second round of interviews with experts collected information on the percentage distribution of criteria importance to confirm the result reliability. The results in Table 1 show a consistency rate below 0.1 (RI0.0931), indicating satisfactory reliability.

4.3. Ranking quality healthcare referral system strategy

The available alternatives are appraised based on predetermined criteria, with evaluations conducted using a scale from one to ten points. The opinions of the five experts are shown in the form of an appendix (see **Appendix D**).

Table 2
Initial decision-making matrix.

	C_1	C_2	C_3	C_4
S_1	6	6	5	4.2
S_2	2.6	5.8	6	4
S_3	2.8	6.6	4.6	3.8
S_4	3.6	5.4	5	6

Table 3
Linear normalization of the initial decision-making matrix.

	C_1	C_2	C_3	C_4
S_1	1.0000	0.5000	0.2857	0.1818
S_2	0.0000	0.3333	1.0000	0.0909
S_3	0.0588	1.0000	0.0000	0.0000
S_4	0.2941	0.0000	0.2857	1.0000

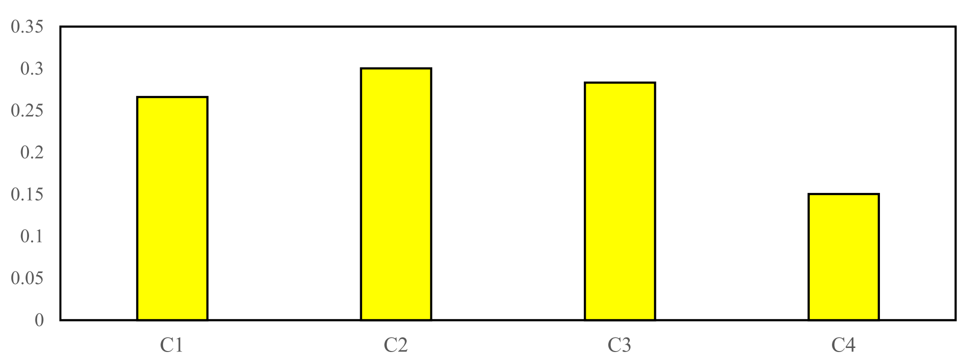

Fig. 2. Rank of the criteria.

Table 1
RI calculation.

	L_j	E_1	E_2	E_3	E_4	E_5	Average P_j	$\lvert F_J * 100 - P_j \rvert$	RI
C_1	0.2661	25	28	25	30	25	26.6	0.0143	0.0001
C_2	0.3002	35	32	33	30	35	33	2.9769	0.0298
C_3	0.2832	30	35	27	28	30	30	1.6774	0.0168
C_4	0.1504	10	5	15	12	10	10.4	4.6400	0.0464
									0.0931

Table 4
Vector normalization of the initial decision-making matrix.

	C_1	C_2	C_3	C_4
S_1	0.7526	0.5029	0.4830	0.4580
S_2	0.3261	0.4861	0.5796	0.4362
S_3	0.3512	0.5532	0.4444	0.4144
S_4	0.4516	0.4526	0.4830	0.6543

Table 5
Aggregate average normalization (β = 0.5).

	C_1	C_2	C_3	C_4
S_1	0.4381	0.2507	0.1922	0.1600
S_2	0.0815	0.2049	0.3949	0.1318
S_3	0.1025	0.3883	0.1111	0.1036
S_4	0.1864	0.1131	0.1922	0.4136

Table 6
Aggregated average weighted normalized matrix with summarized criterion types.

	C_1	C_2	C_3	C_4
S_1	0.1166	0.0753	0.0544	0.0241
S_2	0.0217	0.0615	0.1118	0.0198
S_3	0.0273	0.1166	0.0315	0.0156
S_4	0.0496	0.0340	0.0544	0.0622

The input-data matrix is formulated and presented in Table 2 by employing the assessments.

After creating the initial decision-making matrix, the input data is normalized. The resulting normalized values have been computed and indicated in Tables 3–**5**.

Following that, the subsequent step included the multiplication of the aggregated averaged normalized decision matrix by the criteria weights (see Table 6).

With $\lambda = 0.5$, the calculations for L_i and A_i values are carried out. The ultimate ranking is then computed as follows: S1>S2>S3>S4; the findings are depicted in Fig. 3 and Table 7.

5. Sensitivity analysis

A sensitivity analysis was performed by incrementally adjusting the threshold value in increments of 0.2, from 0 to 1. The final ranking results are detailed in Table 8.

The findings indicate that regardless of the value of λ, the overall ranking of alternatives remains consistent. A graphical representation of alternative rankings is depicted in Fig. 4.

6. Comparative analysis

A comparison is made using a well-known MCDM method, such as the Additive Ratio Assessment (ARAS) method [72]. The results of this comparison are presented in Fig. 5.

The results of the comparative analysis revealed that the applied CIMAS-AROMAN is compatible with the CIMAS-ARAS. Both methods obtained the following ranking order: S1>S2>S3>S4. We can conclude with a high level of confidence in the applied method.

7. Findings and discussion

After thoroughly examining existing literature and consulting experts, it is clear that multiple challenges impede the quality of the healthcare referral system, with their significance evaluated on a scale from one to ten. Experts have emphasized the significant challenge of inadequate infrastructure facilities, echoing Kamau, Osuga and Njuguna [16], which identifies insufficient transport as a critical obstacle in achieving child and maternal health targets in many developing African countries. Another report from the WHO underscores the impact of deficient transport, particularly in rural areas with limited healthcare facilities and transportation options. Therefore, it is crucial to advocate for the accessibility of essential transport facilities throughout the referral phases, encompassing patient transport, client variables, specimens, and experts at referral hospitals.

The second major challenge revolves around deficient health information systems, aligning with Hussein et al. [73], which points out the weaknesses in health information systems for capturing referral data. Most health facilities lack standardized referral documents. Prompt communication of patient information during specialty referrals is indispensable to ensure adequate consultations and harmonized, safe patient care. Establishing mandatory communication to service users

Table 7
L_i and A_i values, differences, and final rank.

L_i	A_i	A_i-L_i	Rank
0.1551	0.4963	0.3412	1.4062
0.1408	0.4416	0.3009	1.3510
0.1248	0.4187	0.2939	1.3416
0.2494	0.3715	0.1221	1.1298

Table 8
Sensitivity analysis outcomes.

λ	0	0.2	0.4	0.6	0.8	1
S_1	0.4706	0.8619	1.2290	1.5905	2.0236	2.6762
S_2	0.4471	0.8302	1.1813	1.5295	1.9694	2.6649
S_3	0.4383	0.8297	1.1765	1.5159	1.9544	2.6536
S_4	0.4223	0.6916	0.9758	1.3020	1.7586	2.5543

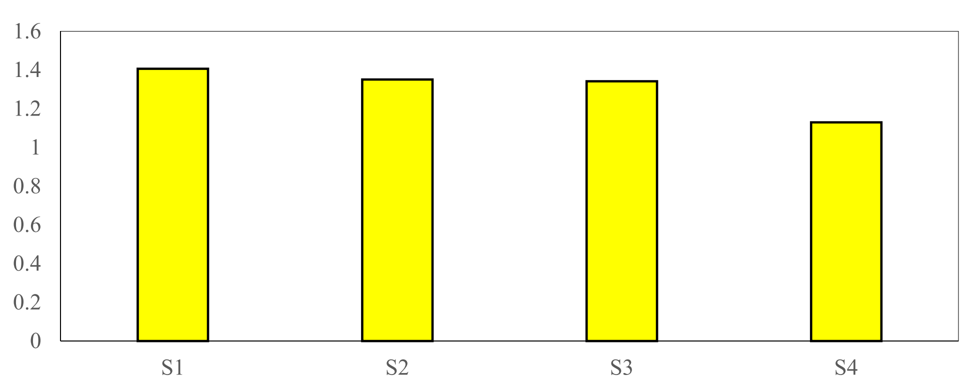

Fig. 3. Final rank of alternatives.

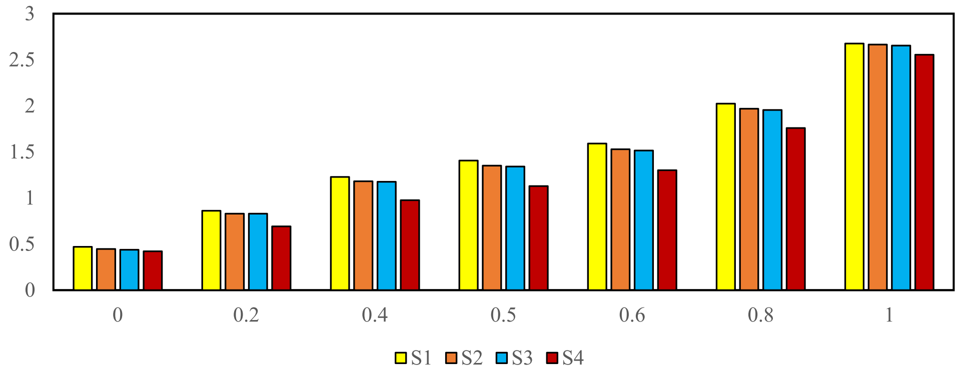

Fig. 4. Sensitivity analysis results.

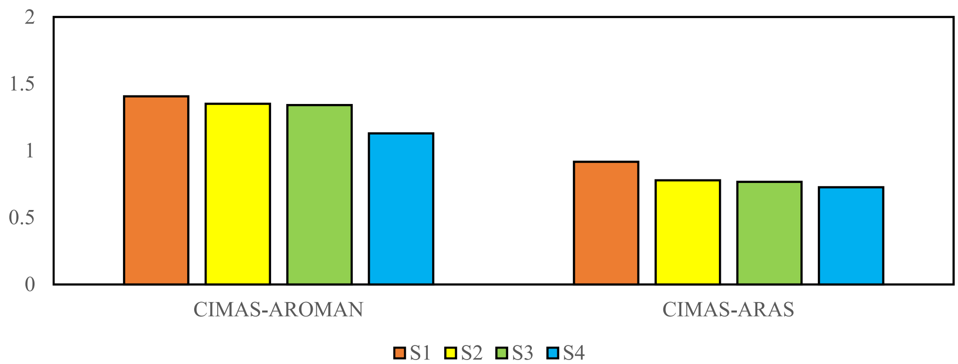

Fig. 5. Comparative analysis with the ARAS method.

and their families is crucial when referrals associated with the users are made to different service levels. Using locally systematized referral letters is essential for conveying clinical data in the referral chain. Implementing web-based referral systems is necessary to enhance the efficiency of email communication regarding referrals and improve scheduling benefits.

Our methodology emphasizes addressing key challenges affecting the healthcare referral system in Kiambu county, with a primary focus on enhancing infrastructure facilities. This entails proactively promoting public-private partnerships to attract investments in different health service areas. Priority initiatives should involve operationalizing dysfunctional facilities, building and improving existing ones, and implementing new facilities as required. Implementing effective policies for equipment maintenance and procurement is crucial. Establishing an operational transport management system for emergencies and effectively address shortages is essential. Hospitals need to procure necessary equipment and eliminate inactive assets.

8. Conclusion

The research introduces the innovative integrated methodology to identify an effective strategy for a high-quality healthcare referral system at the county level. This hybrid approach minimizes uncertainties and simplifies computations when compared to alternative methods. Its advantage lies in employing two normalization methods simultaneously for dataset normalization and proposing solutions for strategy ranking. However, the hybrid method introduces restrictions by selecting vectorial and linear normalization techniques for normalization processes. To improve the method further, incorporating different normalization techniques could be considered.

This research focused on identifying an appropriate strategy for a high-quality healthcare referral system in developing countries, especially Kiambu county, and has made significant contributions to the academic field on multiple fronts. Firstly, creating an integrated methodology constitutes an original and valuable scientific contribution to the existing healthcare referral system research literature. Secondly, the research has brought attention to local healthcare authorities and the Ministry of Health in Kenya, highlighting the need to improve infrastructure facilities. Thirdly, it has laid the groundwork for implementing an appropriate strategy for the healthcare referral system, thereby contributing to informed decision-making at the county level. Lastly, the research offers decision support, enabling academics and practitioners to deepen their understanding of the healthcare referral system and make more well-informed decisions.

Finally, this research has a few limitations. Firstly, it focuses exclusively on the healthcare referral system at the Kiambu county level, neglecting the examination of referral systems in other counties. Secondly, the study involved only a limited number of experts. Future studies should address these limitations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.health.2024.100315.

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