

PERFORMANCE EVALUATION OF MEDICAL UNITS FROM A PRIVATE HEALTHCARE NETWORK USING MULTI-CRITERIA DECISION MAKING

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ABSTRACT: When assessing the performance of medical units, both the optimization of resources and the improvement of services offered to patients must be considered. This paper proposes an approach based on Multiple-Criteria Decision Analysis (MCDA) to identify the most performant medical unit within a private healthcare network in Romania. The analysis considers the conversion rate of patient visits from ambulatory consultations to surgical interventions, as well as factors such as conversion rate per doctor, duration between first visit and intervention, types of medical specialties, and resource utilization rate. Data was extracted from the internal operational database of a private healthcare network, processed, and analyzed using a data visualization tool. Multi-Criteria Decision Making (MCDM) was applied to weight criteria and correlate operational factors with clinical efficiency. The results reveal significant variations between medical units, identifying best practices leading to superior conversion outcomes. The methodology provides a structured decision-making framework for health managers to optimize resource allocation and improve operational flows. The findings confirm that units balancing conversion efficiency and resource utilization achieve superior overall performance, validating the initial research hypothesis.

KEYWORDS: conversion rate, healthcare, data analysis, MCDM, operational efficiency

Introduction

Performance evaluation brings significant benefits, especially in the context of rapid and unpredictable changes in economic, technological, organizational, social, and political environments. As external conditions evolve, organizations must remain agile and responsive. Moreover, organizations are increasingly required to innovate, reconfigure structures, and rethink traditional practices to remain competitive. By consistently assessing performance, they can better understand internal capabilities and external pressures, allowing for quick and informed responses [1].

This research was undertaken to enhance the decision-making process with the long-term objective of improving operational management within private healthcare networks. Its primary aim is to identify underperforming medical units and to analyze the critical factors influencing their performance. This investigation is driven by several key motivations, including the optimization of resource allocation, the improvement of healthcare service quality, and the promotion of data-driven decision-making in both operational and strategic management contexts. The literature emphasizes the importance of multidimensional performance assessment to avoid limited interpretation based on only one metric, as health systems usually involve multiple stakeholders, such as doctors, patients, clinicians, public [1].

Evaluating the performance of medical units is essential in a private healthcare network due to competition and financial pressure from external and internal factors and looking at classic indicators separately (costs, number of patients) offers a fragmented point of view. There is a need for a multidimensional approach with the purpose of integrating operational, clinical and financial performance as there is no standardized tool for comparison between medical units based on more than one factor at the same time.

In this paper, the main objective is to apply Multi-Criteria Decision Making for the comparison of the performance of medical units using six criteria that define the healthcare industry: conversion rate, total number of patients, number of active doctors, average cost per patient, average income generated per patient, utilization rate. The values are normalized to calculate the utility score for each medical unit. The central hypothesis of this study posits that medical units exhibiting higher conversion rates and a balanced ratio between total costs and utilization rates are likely to achieve superior overall

utility. The objective of the research was to identify the most efficient medical unit by conducting a performance evaluation that simultaneously considers multiple key performance indicators.

Literature review

In today's world, healthcare plays an essential role in the quality of life and wellbeing of the population, as healthcare systems have the duty to ensure access to efficient, safe and fair. medical services. There is a constant demand for medical services since the population is getting old and suffering from chronic illnesses. On top of that, people have limited resources, and that is the reason why medical services need to be maintained under controlled costs. Performance reflects the capacity of the medical system to offer efficient, accessible, qualitative services and it includes financial indicators such as cost-efficiency and clinical indicators such as results for patients and patient satisfaction.

Multi-Criteria decision making

In the last decades, Multi-Criteria Decision Making (MCDM) has become one of the most dynamic and important research areas in making decisions. The decision-making process evolved from single-criterion decision-making (for example profit) to complex cases where multiple criteria and perspectives are involved. In theory, there are two big ways of MCDM: Multi-Objective Decision Making and Multi-Attribute Decision Making. The first one, Multi-Objective Decision Making is focused on continuous solutions and optimal compromises using mathematical programming models. This approach is mostly theoretical and less applicable. Meanwhile, Multi-Attribute Decision Making is centred on discrete decision spaces, in which the scope is to create a rank of the existent alternatives depending on multiple criteria. While more applicable to real-world cases, MADM suffers from limited method availability and validation challenges [2].

The real problems of making decisions are often too complex and poorly structured to be resolved using only one criterion. This kind of unidimensional approach excessively simplifies reality and can lead to taking wrong or incomplete decisions. Multi-Criteria Decision Making is an advanced branch of operational research used as a tool for complex situations with multiple criteria that are usually in conflict [3].

Applications of MCDM in healthcare

Making decisions in healthcare is a subject of major importance, given the complexity, uncertainties and the necessity of integration of preferences and values of interested parts [4]. In this context, methods of multi-criteria decision analysis became more and more used in supporting decision-making processes as they combine both qualitative and quantitative approaches for evaluating more factors.

One of the most known methods in MCDM is Analytic Hierarchy Process and it was developed in the 1970s by Thomas Saaty. AHP helps decision factors to structure complex problems in a clear hierarchy of objectives, criteria, sub criteria and other alternatives. AHP allows calculation of relative weights of the criteria involved in the decision, obtaining a hierarchy of alternatives based on how good they fulfill the chosen criteria [5]. *Liberatore & Nydick* (2008) realizes a reference paper which analyses the method AHP in making decision in health care. Their study unites a series of applications in various domains of medicine such as selection of medical treatments where AHP is used for comparison of therapeutic options according to criteria such as efficacy, costs, secondary effects and patient preferences. Another application of AHP is for prioritization of clinical interventions, especially when resources are limited (for example, transplants, and expensive oncology treatments). This method allows making decisions in a transparent and justified way [6]. While AHP has been widely used in healthcare prioritization, other methods such as MAUT offer complementary advantages when decision-makers face conflicting trade-offs across quantitative criteria.

Multi-Attribute Utility Theory

Multi-Attribute Utility Theory was used for solving real problems in different domains, domains where decisions imply more than one conflictual criterion. MAUT offers a logical framework for solving problems with conflictual objectives. Even though simulation is efficient for modelling complex systems, the integration of MAUT is necessary for optimizing and selecting alternatives. MAUT is a fundamental tool used in decision analysis [7]. This technique helps when evaluating alternatives and also identifies alternatives that perform well on most of the criteria. The process starts with developing a

matrix, where rows represent the alternatives, and the columns represent the performance measurements. Each cell reflects the performance of each alternative for one criterion. Utility functions are defined for each attribute, scaling performance values on a range from 0 to 1. If certain independence conditions are met, these functions can be mathematically combined into a multi-attribute utility function [8].

One study proposes an approach based on utility functions used for planning complicated cases in the hospital, taking into account perspectives and preferences of different decision factors. This method facilitates allocation of intra-hospital resources to different operational units and offers a better allocation of capacity and mix of medical cases. Through utilization of utility function, compromises between different objectives can be evaluated and they can model different values of output. This analysis offers valuable information to planners and hospital managers [9]. A notable limitation of MAUT lies in its assumption of independence between attributes, which can be problematic in the healthcare context, where criteria are often interdependent. For instance, the cost of a treatment might influence how its effectiveness is perceived, while side effects can significantly impact the patient's quality of life.

Methodology

Multi-Attribute Utility Theory (MAUT) is a structured decision-making methodology that is used for evaluating and comparing alternatives based on multiple, often conflicting criteria. The scope of the method is to assign utility values to each chosen attribute, reflecting preferences of the decision maker and then aggregating them into a single unique score for each attribute. This methodology is effective in the context where both quantitative and qualitative alternatives must be considered. MAUT offers a mathematical foundation by incorporating utility functions to match the attitudes and value judgements of the decision-maker [10].

The dataset used in this analysis originates from the internal clinical and operational database of the healthcare network, which records information related to patient activity, medical procedures, financial indicators, and resource utilization. Data was extracted through the network's business intelligence system, ensuring consistency and accuracy across all medical units. Only aggregated and anonymized records were used, without any personally identifiable patient information. The dataset covers the full operational activity of the five selected units during the year 2024 and was validated in collaboration with the network's data management department to ensure completeness and reliability.

This study adopts a quantitative approach based on Multi-Attribute Utility Theory (MAUT) to evaluate and rank the performance of medical units within a private healthcare network. The analysis aims to integrate both operational and economic criteria to establish a comprehensive and justifiable framework for decision-making. The objective of the research is to create a ranking of medical units based on six criteria: conversion rate, patient volume, number of active doctors, average cost / patient, average income / intervention, utilization rate. Criteria chosen are defining the medical industry. The data used in this study comes from an internal clinical and operational database from the healthcare network. Data processing and normalization were performed using Microsoft Excel, which allowed for efficient calculation of normalized values, utility functions, and the final performance scores.

To make the performance indicators comparable across medical units, the raw values were normalized using the Min-Max normalization method. This method was used for the following indicators: patient volume, number of active doctors, utilization rate, case mix index. A high patient volume indicates attractiveness and intense utilization of the medical services that are provided for the population. Having a high number of active doctors suggests a greater operational capacity and diversity of services. A high utilization rate reflects efficiency in the use of available resources (operating block, use of the emergency room, equipment). Last but not least, a high case mix index indicates more complex treatments, therefore a hospital with a more important role and advanced expertise. This technique transforms the data into a [0, 1] range, ensuring comparability. The Min-Max normalization formula is as follows:

$$U_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)} \quad (1),$$

It was also used Max-Min normalization method for indicators such as average cost / patient (reduced costs indicate a better operational efficiency and optimal allocation of resources), average income / patient (a minimal income/patient points to better accessibility to services) and conversion rate (surgery should represent the final step in the patient pathway, only when strictly necessary, therefore a lower conversion rate may reflect better clinical screening and adherence to conservative treatment protocols) using the following formula:

$$U_{ij} = \frac{\max(X_j) - X_{ij}}{\max(X_j) - \min(X_j)} \quad (2),$$

Where:

- U_{ij} represents the normalized value of indicator i for medical unit j ,
- X_{ij} is the raw value of indicator i for medical unit j ,
- $\max(X_j) - \min(X_j)$ are the minimum and maximum values of indicator i across the entire dataset.

To assess the performance of each medical unit, linear utility functions were used. These functions assume a proportional relationship between the indicator value and the associated utility. These indicators are expected to exhibit a linear relationship, where increases in the indicator value directly correspond to increases in utility, with no diminishing or accelerating effects. The linear utility function is given by the formula:

$$U_j(x) = \frac{x - x_{min}}{x_{max} - x_{min}} \quad (3),$$

Where:

- $U_j(x)$ is the utility for medical unit j for indicator x ,
- x is the value of indicator x for medical unit j ,
- x_{max} and x_{min} are the maximum and minimum values of indicator xxx across the entire dataset.

In this context, linear functions were chosen because they reflect a direct proportional relationship, which is justified for the selected indicators (e.g., cost per patient, average price per intervention), where no saturation or accelerated growth trends are expected.

To obtain a global performance score, the utility functions for each criterion were aggregated using the weighted arithmetic mean. The formula for calculating the final score of a medical unit is:

$$U_i = \sum_{j=1}^n (w_j * U_{ij}) \quad (4),$$

Where:

- U_i is the final utility of medical unit i ,
- w_j represents the weight assigned to criterion j ,
- U_{ij} is the utility for medical unit iii for criterion j ,
- n is the total number of criteria.

In this case, equal weights were assigned (1/6 for each criterion), as no preferences were expressed. This assumes that each criterion contributes equally to the final score.

The last step is for comparison of overall utility scores for each medical unit and ranking creation. The medical units were ranked based on their global utility scores, which allow for an objective and comparative evaluation based on the indicators presented above.

In contrast to the present study, a comprehensive analysis conducted in 2001 explored multi-criteria decision-making within the private healthcare sector, integrating both qualitative and quantitative data for the evaluation of medical technologies. The authors highlighted the significance of accounting for diverse factors such as cost-effectiveness and resource allocation in the decision-making process. Their findings support the application of Multi-Attribute Utility Theory (MAUT) as a suitable method for assessing the performance of medical units [11].

Results and further discussions

Located in Bucharest, A is a private medical facility that serves the northern part of the city with the main focus being of maternity, obstetrics-gynecology, pediatrics. B is situated in Braşov, a central Romanian city. It provides inpatient and outpatient services in the central region of Romania and is known for general surgery, internal medicine and diagnostic imaging capabilities. C is located in Cluj-Napoca, and it is a major academic and medical hub in north-western region of Romania. It is a multi-disciplinary hospital, and it benefits from proximity to medicine universities and research institutions, contributing to its high-quality standards. D is based in Bucharest and its focus falls on minimally invasive surgery and gynecology. Also located in Bucharest, E is a private flagship hospital recognized for its bariatric surgery and robotic-assisted procedures. It also functions as a multidisciplinary center and is accredited as a teaching hospital. The selection was based on three main criteria: (1) comparable service portfolios and patient structures, (2) availability of complete and consistent operational data for the year 2024, and (3) geographic distribution to ensure regional diversity.

The primary objective of this study was to evaluate the performance of five private-sector medical units using the Multi-Attribute Utility Theory (MAUT), a structured approach within the broader framework of multi-criteria decision-making (MCDM). To enable an objective and comprehensive comparison, six key indicators of operational performance were analyzed: conversion rate, patient volume, number of active physicians, average cost per patient, average income per patient, and utilization rate. In the applied model, each criterion was assigned an equal weight of 1/6, reflecting a balanced contribution to the overall performance assessment.

In the medical industry, the conversion rate refers to the percentage of patients who go from one clinical state to another. This study considers patients who showed up in the ambulatory or emergency room of a hospital and had undergone an intervention after. The patient volume is a fundamental indicator of activity evaluation of a medical unit because it reflects the number of services provided and the impact on population's overall health state. The number of active doctors is an essential factor for measuring the capacity of providing medical services [12]. This reflects the accessibility and availability of care for patients. Average cost per patient is a key indicator for healthcare providers, measuring the efficiency of resource use [13]. It helps identify opportunities to reduce costs and improve operational efficiency. The average price per intervention reflects the cost associated with delivering a specific medical service. It is essential for evaluating the financial sustainability and profitability of healthcare units. Utilization rate measures the frequency of medical services used, indicating their efficiency and accessibility [14]. A high utilization rate suggests effective use of resources and patient satisfaction. The case mix index (CMI) is a standard indicator of hospital disease severity all over the globe. CMI is designed to calculate the complexity of interventions that are done in the hospital [15].

Data was extracted from operational internal sources and reflect the real performance of those five medical units in the year 2024.

Table 1: Data used in research

Medical Unit Id	Conversion rate [nr.]	Patient volume [nr.]	Active doctors [nr.]	Average cost/patient [m.u.]	Average income/patient [m.u.]	Utilization rate [nr.]	Case mix index [nr.]
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A	34.4%	21,342	200	318	743	58%	1.36
B	10.0%	42,057	182	198	326	46%	2.59
C	12.7%	63,284	381	114	224	52%	1.50
D	6.4%	47,436	125	254	399	42%	1.62
E	13.5%	66,696	323	468	834	43%	1.77

Source: Authors' own research.

To bring all criteria on a comparable scale from 0 to 1, specific formula for normalization was applied. For maximization criteria, the following formula was applied:

$$x_{norm} = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad (5),$$

For minimization criteria, the following formula was applied:

$$x_{norm} = \frac{X_{max} - X_i}{X_{max} - X_{min}} \quad (6),$$

After the normalization process, the matrix of normalized data was created, where each medical unit could be evaluated and a comparison based on the numbers could be performed.

Maximization criteria: patient volume, active doctors, utilization rate, case mix index.

Minimization criteria: average cost per patient, average income per patient, conversion rate.

Table 2: Normalized data matrix

Medical Unit Id	Conversion rate [nr.]	Patient volume [nr.]	Active doctors [nr.]	Average cost/patient [m.u.]	Average income/patient [m.u.]	Utilization rate [nr.]	Case mix index [nr.]
A	0.00	0.00	0.29	0.42	0.15	1.00	0.00
B	0.87	0.46	0.22	0.76	0.83	0.21	1.00
C	0.77	0.92	1.00	1.00	1.00	0.63	0.11
D	1.00	0.58	0.00	0.60	0.71	0.00	0.21
E	0.75	1.00	0.77	0.00	0.00	0.04	0.33

Source: Authors' own research.

A global utility score was calculated as the arithmetic mean of the six normalized values due to the fact that all evaluation criteria were assigned to equal importance.

Table 3: Global utility for each medical unit

Medical Unit Id	Global utility
C	0.78
B	0.62
D	0.44
E	0.41
A	0.27

Source: Authors' own research.

Based on the overall utility scores, a performance ranking was created for allowing a comparative evaluation of the units. The overall results obtained confirm the applicability of this method, MAUT, in the context of evaluating the performance of private medical units, offering an objective analysis. In specialized literature, similar approaches have been applied through AHOP or TOPSIS, which are other MCDM techniques. However, the chosen method for this paper, MAUT, stands out for simplicity in interpretation and capability of integration of both quantitative and qualitative data.

When looking at the normalized data, several targeted improvement directions can be identified for each medical unit. Medical Unit A, despite having a high utilization rate, performs poorly across all other criteria, including zero patient volume and case complexity. Improvement strategies should focus on increasing patient intake, attracting more complex cases, and expanding the medical team. Medical Unit B shows strong performance overall and has the highest case mix index yet suffers from high average costs and low utilization. To enhance performance, it should focus on reducing operational inefficiencies, optimizing resource use, and reassessing its care pathways to ensure appropriate treatment intensity, especially given the high conversion rate. Medical Unit C stands out with excellent scores in most dimensions, but its low case mix index suggests a predominance of simple cases. The unit could improve its service by attracting more diverse and complex patient cases to better utilize its robust infrastructure and personnel. Medical Unit D presents a mixed profile: it has a high conversion rate and case complexity but lacks active doctors and has a utilization rate of zero, possibly indicating data inconsistencies or operational bottlenecks. Priority actions include staffing medical positions, improving resource utilization, and increasing patient throughput. Lastly, Medical Unit E registers the highest patient volume and a solid number of active doctors yet yields low financial returns and handles relatively simple cases. The unit should work on attracting more complex cases, improving service pricing, and enhancing resource use to convert volume into higher value care.

The main contribution of this paper is that the application of this method was performed on real operational data from a private healthcare network in Romania, which bring practical relevance to the domain. Moreover, the model can be further adapted to include differentiated weights according to strategic priorities, allowing a better alignment between operational processes and financial goals. This way, the results obtained can support decision-making process and managers in identifying top-performing units, set targets for improvement, and allocate resources more efficiently and effectively. The analysis highlights the need to balance patient volume with operational efficiency (costs, income and utilization rate). These results confirm the initial hypothesis: hospitals balancing conversion rate and operational efficiency attain superior performance.

Some limitations that may impact the result are about the lack of qualitative data. The analysis does not take into account qualitative factors such NPS (net promoter score), doctor tenure, service quality and that could impact overall performance. Another limitation could be the variation of case volume, because some medical units may have a much larger patient volume than another and can influence result for indicators such as „patient volume” or „utilization rate”.

Conclusion

This paper demonstrates the applicability of Multi-Attribute Utility Theory for evaluation of operational performance in private healthcare. The proposed model allows an objective ranking of medical units based on six key performance indicators. Future research could enrich the model by introducing qualitative data, adjusting criteria weights based on input of the stakeholders and extending the analysis to broader healthcare systems.

This study addresses the critical need for reliable and objective methods to evaluate operational performance within private healthcare units. Given the complexity of healthcare services and the multitude of factors influencing outcomes, traditional single-criterion assessments often fall short. By applying Multi-Attribute Utility Theory (MAUT), this research integrates six key performance indicators—conversion rate, patient volume, active doctors, average cost per patient, average income per patient, utilization rate, and case mix index—into a comprehensive framework. This allows for a nuanced and balanced evaluation that reflects both efficiency and service quality dimensions.

The results demonstrate the effectiveness of MAUT in providing an objective ranking of the presented medical units, highlighting variations in performance and identifying areas for improvement. Such insights can inform managerial decisions and strategic planning to optimize resource use and enhance patient care. Future research could enhance the model by incorporating qualitative factors, involving stakeholders to refine criteria weighting, and expanding the analysis to include public healthcare institutions or larger networks, thereby increasing the model's applicability and impact.

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