

Enhancing the Efficiency of Health Care Industry by the Implementation of Maintenance Quality Function Deployment

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Abstract: In today's rapidly evolving healthcare landscape, the efficient operation of healthcare facilities is paramount to ensure optimal patient care, cost-effectiveness, and overall organizational success. However, traditional maintenance approaches often fall short in addressing the diverse needs and priorities of stakeholders, resulting in inefficiencies and suboptimal outcomes. Hence, there is a pressing need for innovative methodologies to align maintenance practices with the diverse needs of healthcare stakeholders. This paper proposes a Maintenance Quality Function Deployment (MQFD) for enhancing the efficiency of health care Industry. Initially the data is collected from "Hospital ratings" dataset. Then; the data is fed into Analytic Hierarchy Process (AHP) used to prioritize various service-quality dimensions of healthcare services. Then the SERVQUAL used to analyse the assumption that a customer has certain expectations from the service provider. Finally the Interpretive Structural Modelling (ISM) method used to maintain the customer expectations. The proposed method demonstrates a higher service ranking based on the analysis of the Hospital ratings dataset.

Keywords: Hospital, Healthcare, Customer, patient, Analytic Hierarchy Process (AHP), Interpretive Structural Modelling (ISM), Management

1. Introduction

In the contemporary healthcare landscape, the relationship among transparency in the hospital sector and satisfaction of patient are emerging as a critical focal point [1,2]. As people become more involved in their healthcare journeys, healthcare facilities must adopt a communicative and transparent approach [3]. This paradigm change emphasizes the need to inform people in addition to offering superior medical treatment and participating in their treatment procedures [4,5]. The transparency of a hospital's operations, rules, and results has a major impact on patient satisfaction [6,7]. In an age where information is widely available, patients desire clarity on medical procedures, charges, and overall service quality [8,9]. Hospitals that stress transparency in these areas not only educate patients but also build trust, establishing a pleasant and collaborative patient-provider relationship

[10]. Patient satisfaction, a multidimensional indicator that includes factors such as communication, trust, and perceived quality of care, is inextricably linked to transparency [11]. Hospitals that are open about their performance statistics, treatment alternatives, and patient results are more likely to receive positive feedback from patients who feel educated and involved in their healthcare decisions [12,13]. This dynamic interplay between patient satisfaction and transparency emphasizes the need for healthcare facilities to adopt open practices [14]. As we go more into the subtleties of this connection, it becomes critical to examine the methods and problems of establishing openness in the healthcare sector [15]. Finally, the synergy between patient satisfaction and transparency influences

the healthcare experiences of people while also laying the groundwork for a more accountable and patient-centred healthcare system (HCS) [16]. Major contribution of this research work is as follows:

- The manuscript introduces the novel combination of improve the hospital management quality using AHP, ISM and SERVQUAL methods.
- Dataset are collected from the "Hospital Rating Data Set".
- Healthcare services' several service-quality dimensions are ranked using the AHP technique.
- The SERVQUAL technique is employed to examine the presumption that a client has specific demands from a service supplier.
- ISM method used to maintain the customer expectations
- Rest of the manuscripts is arranged as below: The literature review presented in sector 2, proposed methodology presented in sector 3, result and discussion described in sector 4, conclusion presented in sector 5.

2. Recent Research Works: A Brief Review

Many studies that have already existed in this brief review about the recent work in Enhancing the Efficiency of Health Care Industry are analysed here.

Dutta et al.,[17] have investigated the critical roles of ML and AI in healthcare research. The research, which emphasizes the vast breadth of AI, dives into the use of computer algorithms to analyse large datasets to categorize, forecast, and generates meaningful findings. Within this arena, machine learning (ML) emerges as a cornerstone, including the creation of statistical models based on real-world data to anticipate outcomes and categorize observations. A future in which AI and machine learning make important contributions to increasing the quality and quantity of EMR data, enhancing register data, and standardizing research methodologies.

Rubinger et al., [18] have explored the pivotal role of AI and ML in healthcare research. Emphasizing the broad scope of AI, the study delves into the application of computational algorithms to analyse extensive datasets, aiming to classify, predict, and derive valuable conclusions. Within this realm, ML emerges as a cornerstone, involving the construction of statistical

models based on real-world data to forecast outcomes and categorize observations. A future where AI and ML contribute significantly to enhancing the quantity and quality of EMR data, thereby improving registry data and standardizing research protocols and outcomes.

Cutillo et al.,[19] described how Machine Intelligence (MI) was quickly becoming an essential technique in clinical research, biomedical discovery, precision medicine, and medical diagnostics/devices. With the use of these technologies, patients, researchers, and physicians may be able to take advantage of new opportunities and make better decisions. These methods, when applied in healthcare settings, have the potential to improve patient care quality and the efficacy and efficiency of the health research and care network. This whitepaper highlights key issues that, if addressed appropriately, could expedite advancement in the field efficiently, ethically, and transparently. It reports on key issues related to MI that were specific to healthcare applications, finds opportunities for improving MI systems in the healthcare setting and offers paths and fixes for these problems.

Thach Phuonga et al.,[20] have created a patient satisfaction scale to assess PS and identify related characteristics in numerous Vietnamese hospitals. To identify characteristics that were connected with patient satisfaction levels, the multivariate linear regression was used. A remarkable 0.9400 indicated the reliability of the internal consistency. 64.8% of respondents said they were completely satisfied with this item, which was followed by "Transparency of information and procedure" and "Attitude and capabilities of health professionals." Compared to other patients, outpatients who utilized on-demand services, lived in remote provinces, and couldn't afford service charges expressed lower levels of satisfaction. The difficult issues include improving the standard of administrative processes, utilizing information technology to

raise hospital standards, and guaranteeing that all patient groups receive healthcare equally.

Mutiarasari et al., [21] have investigated the level of satisfaction with care received in Central Sulawesi's public and private hospitals. Ten hospitals in Central Sulawesi were the subject of this cross-sectional, analytical observational study. In each institution, there were 1070 samples, which corresponded to 107 patients. The 38 closed items on the Community Happiness Index (CSI) Questionnaire, was used to gauge the level of patient happiness. Patients seeking care at private hospitals were more satisfied than those at public hospitals in all categories.

Liu et al., [22] have created an interpretable machine learning system that tackles the problem of patient satisfaction as a supervised learning task and uses a mixed-integer programming model to determine which elements are most significant. The proposed method incorporates variable selection, coefficient learning, and feature transformation into the optimization process and transforms heterogeneous data into features that can be understood by humans.

Abu-Rumman et al., [23] have investigated if a large Jordanian hospital's implementation of the King Abdullah II Award for Excellence (KAIIE) customer outcomes criterion was linked to excellent patient satisfaction ratings. A pragmatic theoretical approach and mixed methodology were used to conduct a satisfaction survey to patients receiving in-patient care from a variety of disciplines to get feedback on various aspects of their care.

2.1 Background of the Research Work

A recent study on improving the efficiency of the healthcare business includes a variety of approaches and their accompanying limitations. A combination of the Internet of Things (IoT) aims to increase efficiency and transparency in healthcare delivery by deploying IoT infrastructure, evaluating real-time data, and involving stakeholders. However, important disadvantages include privacy issues, problems with data standards and interoperability, high implementation costs, possible opposition to technology change among healthcare personnel, and inequities in areas with poor internet access. Another study focused on constructing a patient satisfaction measure in Vietnamese hospitals, finding elements such

as health professional attitudes and information openness. Lower satisfaction ratings for various patient groups necessitate improvements in administrative procedures as well as the use of information technology to provide equal healthcare delivery. A study of service satisfaction levels in private and public hospitals in Central Sulawesi found that private hospitals had better satisfaction, although possible discrepancies in healthcare quality amongst sectors pose a barrier. The study, which used the Community Satisfaction Index (CSI) Questionnaire, may have difficulties in generalizing its findings. Furthermore, research on the role of AI and ML in healthcare research stresses their extensive breadth while raising issues about ethics and data standards. The interpretability of machine learning frameworks for patient satisfaction is a unique approach; nonetheless, significant hurdles include guaranteeing model interpretability and real-world application. The use of ML in healthcare presents exciting opportunities, but it requires resolving critical challenges such as efficiency, transparency, and ethical considerations. Finally, comparing the KAIIE criterion to patient satisfaction in a large Jordanian hospital highlights the possible advantages of quality awards for enhancing patient experience, but there may be challenges with self-assessment accuracy and total impact assessment. These difficulties and concerns have encouraged me to do this investigation.

3. Proposed Methodology

The proposed EHCIMQ-AHP-SERVQUAL-ISM method based to Maintenance Quality Function Deployment (MQFD) is for Enhancing the Efficiency of Health Care Industry. Initially the data is collected from Hospital ratings dataset. The information is then entered into AHP, which is used to rank the many aspects of healthcare services' service quality. Next, the SERVQUAL was utilized to analyze the presumption that a client has particular demands of a service provider. Finally the

Interpretive Structural Modelling ISM method used to maintain the customer expectations. Fig. 1 shows that Block Diagram of Proposed EHCIMQ-AHP-SERVQUAL-ISM method.

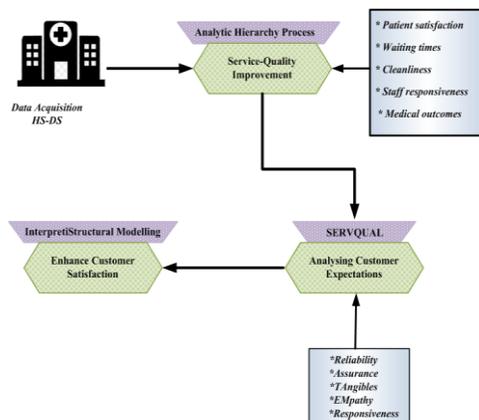


Fig 1: Block Diagram of Proposed EHCIMQ-AHP-SERVQUAL-ISM method

3.1 Dataset Description

The data is collected from “Hospital Ratings” Dataset (HR-DS) [24]. On the Medicare.gov Hospital Compare website, the Centres for Medicare & Medicaid Services uses several official datasets. You can use these data to compare the standard of care provided by more than 4,000 Medicare-certified hospitals nationwide.

The Hospital Ratings Dataset provides comprehensive information about the performance and quality of healthcare institutions across various parameters. It typically includes data on factors such as patient outcomes, safety measures, efficiency of care, patient satisfaction, and adherence to clinical guidelines. This dataset is valuable for healthcare administrators, policymakers, researchers, and patients alike, as it allows for comparisons between hospitals, identification of areas for improvement, and informed decision-making regarding healthcare providers. Variables in the dataset may encompass metrics like mortality rates, readmission rates, infection rates, patient experience scores, and hospital accreditation status. Analysing this dataset can shed light on the effectiveness of healthcare delivery systems, assist in allocating resources effectively, and ultimately contribute to enhancing the overall quality of healthcare services. Moreover, it can empower patients to make more informed choices about where to seek medical treatment based on transparent and reliable

information about hospital performance.

3.2 Service-Quality Improvement by using Analytic Hierarchy Process (AHP)

Thomas L. Saaty invented the AHP decision-making technique in 1980 [25]. This approach is commonly used to describe difficult decision-making problems and has numerous 119 qualities. It works by breaking down the amorphous problems under consideration into hierarchical components. A hierarchical system must have the main aim, the criterion (and sub-criterion) that impacts the objective, and the options of the problem.

Hospital administration is one of the many industries that have effectively used the AHP as a decision-making tool to raise service standards. Here's how AHP can help you increase service quality in hospital management. Begin by defining critical aspects of service quality in the context of hospital management. This may include elements like satisfaction with patients, wait times, staff attentiveness, cleanliness, medical results, and so forth. Divide each service quality component into specific criterion and sub-criterion. For example, factors for patient satisfaction might include empathy, communication, and information offered. A critical feature of AHP is the pairwise comparison process, in which each criterion is systematically compared to each other, and stakeholders provide preference or significance ratings. This stage not only determines the relative relevance of criteria, but also guarantees that judgments are consistent. The built-in mechanisms of AHP consistency tests assist in confirming the trustworthiness of these pairwise comparisons. Let's denote the priority or importance of criterion i with respect to criterion j as a_{ij} , the reciprocal equation is follow below,

$$a_{ij} = \frac{1}{a_{ji}}$$

(1)

The matrix A is formed with elements a_{ij}

representing the pair wise comparison judgments. A consistency vector w is computed, and the following formula is used to get the consistency index (CI): equation (2)

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (2)$$

Here, λ_{\max} is denoted as the maximum eigen value of matrix A , n is represent as the number of criteria or alternatives.

The subsequent calculation of weighted scores for each criterion enables a quantitative analysis of their respective impacts on the overarching goal of service-quality improvement. The aggregation of scores up the hierarchy allows for a holistic evaluation of alternative solutions. The option that scores the highest overall is the one that is best suited for implementation.

To ensure the consistency of judgements, a consistency ratio (CR) is calculated by diving (CI) by a random index (RI) derived from statistical, if CR is below a predefined threshold, the judgements are considered consistent. Equation (3)

$$CR = \frac{CI}{RI} \quad (3)$$

This consistency checking helps ensure the reliability of the pairwise comparisons. Once consistency is verified, the weights or priorities of criteria and alternatives are determined based on the principal eigenvector of matrix A equation (4)

$$w_i = \frac{1}{n} \sum_j^n a_{ij} \quad (4)$$

The relative significance of each criterion or option in the decision-making process is represented by these weights. The normalized weights provide a basis for making informed decisions regarding service-quality improvement in hospital management. The context of hospital management quality improvement with specific parameters, equation (5)

$$Q = \sum_{j=1}^i w_i \cdot P_i \quad (5)$$

where Q represent the overall quality of hospital management, and P represent a set of parameters contributing to this quality, n is the number of parameters contributing to hospital management quality, P_i represents the value or performance of parameter i . w_i is represents the weight or priority of parameter i obtained through AHP. AHP facilitates a systematic approach used to evaluating and improving hospital management quality.

3.3 Analysing Customer Expectations with SERVQUAL Method

SERVQUAL is a technique for evaluating service quality created by Parasuraman, Zeithaml, and Berry [26]. It entails assessing the differences between consumer expectations and perceptions across five dimensions: dependability, certainty, empathy, tangibles, and responsiveness. The approach uses a Likert scale poll to gather customer feedback, allowing firms to find areas for improvement in service delivery. SERVQUAL is frequently used to improve customer satisfaction and total service quality in a variety of sectors. The last gap on the list, number five, is referred to as the SQ method. It integrates service quality design from the customer's perspective in situations when the client is also the service provider. Utilizing a survey tailored to this methodology and regarded as a measuring instrument, the service is evaluated.

The 44 questions on the SERVQUAL scale are designed to aid in the assessment of the discrepancy between expectations and perceptions. A second series of 22 questions asks about the client's impressions of the service they received, while the first 22 questions deal with the expectations of the consumer. The Liker scale is used to present the answers to the questions; 1 represents a definite dissatisfaction and 5 represents a definite satisfaction. Using the formula below, the difference between the ratings of customers' perceptions and expectations is

then used to generate the service quality rating equation (6)

$$SQ = P - E$$

(6)

where SQ is indicated as the overall service quality, P is represent as perception of service quality provided, E is indicated as the expected service quality.

The client's expectations have been fulfilled when the gap is positively assessed, meaning that the client has a very high opinion of the services. Conversely, if the gap score is negative, it indicates that the customer's view of the services is inadequate because they did not live up to their expectations. Based on the aforementioned, it would appear reasonable to utilize a service quality evaluation method, like the SERVQUAL model, that is used in the medical sector to monitor the quality of medical services supplied.

SERVQUAL method helps hospitals assess and improve service quality by comparing customer expectations to actual experiences across key dimensions. Closing these gaps enhances patient satisfaction and contributes to overall healthcare quality. Regular application ensures on-going alignment with patient needs.

3.4 Interpretive Structural Modelling used to Enhance Customer Satisfaction

ISM technique is interpretative, as the judgment groups determine if and how the variables are connected. The set of complicated variables is transformed into an overarching structure through reciprocal interactions [27]. ISM is a method for analyzing complicated interactions between variables, ideas, or elements in a system. It aids in comprehending the hierarchical structure and interdependencies between various pieces. In the context of meeting the expectations of customers, ISM may help determine and arrange the aspects that impact customer satisfaction and assist strategic decision-making.

The first stage in ISM is to identify the major elements that impact customer expectations in the context of a certain service or product. This might include service quality, responsiveness, communication, dependability, and other criteria related to the business, like hospitality, healthcare, or retail. ISM then

develops links between these components, resulting in a structural model that shows how each factor is related to the others. This model aids in visualizing the hierarchical structure and determining which aspects are more significant and reliant. ISM assists in differentiating between driving and dependent elements. Driving variables have a significant amount of effect and play an important part in determining other elements. Understanding these driving variables is critical for prioritizing efforts and resources to meet and exceed consumer expectations. Once the ISM model is built, it offers information about the critical areas that require attention. Organizations can then devise action plans and strategies to improve or sustain the identified driving variables that substantially influence consumer expectations.

In conclusion, employing ISM enables firms to completely analyse and comprehend the numerous elements influencing customer happiness. This technique provides systematic knowledge, allowing for the development of successful strategies and plans to better satisfy consumer expectations.

4. Result and Discussion

This section outlines the performance of proposed approach based on the simulation outcome. Table 1 shows

Table 1: Analysis of the Performance of Proposed Method Service Ranking

Sl.No	Services	Ranking
1	Registration Admission service	/ 9.4
2	Doctor's care	9.8
3	Nursing care	9.5
4	Timely availability of reports	8.2
5	Courtesy of staffs	8
6	Pharmacy service	8.6

7	Billing service / Payment advises	9.5
8	Housekeeping / cleanliness	7.2
9	Patient education by doctors / staffs	9.6
10	Surgical / Procedural services	8
11	Response to request	7
12	Dietary advises / charts	8.7
13	Cafeteria / Canteen services	9
14	Counselling approach	8.5
15	Maintenance activities	9.2
16	Waiting time for appointment	8.4
17	General comfort	8
18	Level of respect received	9.4
19	Facilities for complaints	9.6
20	Overall performance	9.4
21	Any violation of rights- Yes / No If Yes, please write details:	No

A comprehensive analysis titled "Analysis of the Performance of Proposed Method Service Ranking" sheds light on patient satisfaction with various hospital services. The table 1 showcases a ranking system, presumably based on patient surveys or administrative data, where scores range from 1 to 10, with 10 reflecting the highest satisfaction. Patients expressed the greatest satisfaction with aspects like doctor's care (9.8), patient education provided by doctors and staff (9.6), and facilities for addressing complaints (9.6). However, areas like housekeeping/cleanliness (7.2), response to requests (7.0), and general comfort (8.0) received lower scores, indicating potential areas for

improvement. While the average score suggests a generally positive sentiment, the table highlights specific aspects where the hospital can enhance patient experience and satisfaction.

5. Conclusion

The effectiveness of the proposed EHCIMQ-AHP-SERVQUAL-ISM method is used to Maintenance Quality Function Deployment (MQFD) for Enhancing the Efficiency of Health Care Industry. The "Hospital ratings" dataset, the integration of Analytic Hierarchy Process (AHP), SERVQUAL, and Interpretive Structural Modelling (ISM) provides a robust methodology for enhancing the efficiency of the healthcare industry. AHP's role in prioritizing service-quality dimensions ensures a targeted and informed decision-making process that aligns with the diverse needs of stakeholders. The incorporation of SERVQUAL allows for a nuanced analysis of customer expectations, recognizing the pivotal role of patient satisfaction in organizational success. Furthermore, the strategic use of ISM facilitates a systematic understanding of interrelationships, enabling the development of tailored strategies to meet and surpass customer expectations. By adopting the MQFD framework, healthcare facilities can transcend conventional maintenance approaches, addressing inefficiencies and fostering optimal outcomes for patient care and organizational effectiveness.

Ethical Approval and Consent to participate:

This article does not contain any studies with human participants performed by any of the authors.

Human and Animal Ethics: Not Applicable

Consent for publication: Not Applicable

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