Critical Technology Implementing factors to Electronic Medical Record (EMR) implementation: Using AHP-TOPSIS Method

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*Abstract***:** Healthcare is recognized as one of humanity's most fundamental requirements. In underdeveloped nations, making low-cost healthcare services available to the general public is a huge difficulty, and technology can help to overcome this. As the healthcare industries generates enormous amounts of data, Electronic Health Record (EHR) becomes an indispensable part of quality healthcare. But this area is not focused upon for improving quality and efficiency of healthcare in developing countries due to the prevalence of various barriers and challenges. In order to overcome these differences, our study incorporates a systematic literature review of EHR adoption and thus identifies the critical success factors and ranks them by an integrated AHP-PROMETHEE approach. This study not only builds a theoretical foundation for various success factors for implementing EHR in India, but also can assist the policy makers to make data-driven decisions.

Keywords: Electronic Health Record (EHR), implementation, critical success factors, MCDM, AHP and PROMETHEE.

Received: March 27, 2022. Revised: November 15, 2022. Accepted: December 11, 2022. Published: February 3, 2023.

1. Introduction

As goes the famous saying “Health is wealth” which is as true as our life is. A good and healthy body not only keeps us happy but also gives us an internal feeling of complete well-being. "It is health that is genuine riches, not bits of gold and silver," Mahatma Gandhi had correctly stated. It is not just the healthy practices that keep us fit, but also a robust and properly managed healthcare system. [2] in their paper rightly state that a poorly managed healthcare system not only obstructs economic growth but most importantly directly affects the mortality rate of the people of that country. Hence, is an important aspect to be focused upon. Healthcare is recognised as one of humanity's most fundamental requirements. [27]. To optimize the quality of care the costs shoot up and then the affordability becomes a barrier in providing healthcare services. Thus, providing low-cost healthcare services accessible to the people is a major challenge in the developing countries. For this, technology can be used to enhance the reach of affordable, quality healthcare services [2,8,36,38]. The healthcare industry generates enormous amount of data from paper-based record-keeping, prescriptions, and patient-related data and medical reports [5]. The need for an electronic health record (EHR) arises in this situation. An electronic health record (EHR) is a computerised repository of a patient's prescriptions and data that allows authorised individuals to access information instantly and securely. Thus, it is an indispensable part of quality healthcare [14,23]. EHR frameworks have been implemented in most of the developed European countries but, similar implementations are in the nascent stage in the developing countries [2,3]. Also, the of use of ICT in healthcare in India is low as compared to many developing countries [9]. Unfortunately, this area is not focused upon for improving quality and efficiency of healthcare in developing countries due to the prevalence of various barriers and challenges [13,15,23]. To address the above

research gaps, the study states the following research objectives,

RO1: To identify critical success factors for the implementation of EHR in India.

RO2: To evaluate the rank according to their importance and relevance in Indian perspective using PROMETHEE.

RO3: To suggest managerial implications for successful implementation of EHR in India.

To address the above-mentioned objectives, the paper his study employs PROMETHEE method of MCDM to find the rank of importance of these various success factors for profound knowledge of these factors. In addition, this article lays the theoretical groundwork for numerous success criteria for deploying EHR in India, allowing policymakers and industry managers to make data-driven decisions. Our study incorporates a systematic literature review of EHR adoption and thus identifies the critical success factors for adoption of the same. Section 2 of the paper discusses the SLR of related work and further goes on to discuss the research gaps and proposes the research questions. The 11 identified factors are explained along with the 5 identified parameters. Further section proposes the research methodology and the approach adopted while the concluding sections present the results obtained and discussions along with the future scope of the work.

2. Literature Review

[2] highlighted the limited implementation of EHR in the case of Nigeria while [27] did in the case of Bangladesh. A similar work was conducted by [13] in the case of Philippines. The authors have described the current scenario of the country with respect to healthcare facilities and why the implementation of EHR is important. Several studies were conducted to identify the barriers in the implementation. For instance, [15,20,34] identified that Electronic Medical Record (EMR) hurdles and facilitators, as well as gaps in the real that increase efficiency and make care providing more convenient. In addition, [18] utilised idea mapping to identify the themes that healthcare professionals believe are critical to address throughout the adoption of a new EHR. Similarly, [11] identified the main determinants of physician's intention to use the EHR models by the physicians and explains the challenges faced in it with the help of path analysis and multiple linear regression analysis. Furthermore, [17] stated that EMRs have the capacity to improve the conditions of the care of people in the recent increase in urban slums, putting burden on the healthcare services. Health Information Systems (HISs) are considered extremely important for enhancing the efficiency and quality of health care. Thus, it becomes very important to study and analyse these barriers. On a similar note, the present study aims at finding the critical success factors for implementation of EHR in India. Thus, we propose the following research questions,

RQ1: What are the critical success factors for the implementation of EHR in India?

RQ2: What is the relative importance ranking of theses identified barriers?

RQ3: What are the managerial implications of this study to overcome hindrances in the EHR implementation?

An exhaustive literature analysis and comments from academic experts were used to identify 11 important success elements to meet the aforementioned research topics. This section contains a review of the literature relevant to this project. The rigorous literature survey enabled a better understanding of the fundamentals of Health 4.0. A total of

31 papers were analysed. They were selected by abstract reading and keyword search. This section of rigorous SLR is essential as this gives us a sound understanding of the research gaps of the current work and also shapes the direction of our further research. Our research identifies the following critical success factors:

2.1 IT infrastructure

One of the greatest factors is that the implementation of EHR is a complex process due to the nature of healthcare domain. It requires presence of information technology [8,16,30,31]. An IT infrastructure is essential for digitization of processes in healthcare in order to enable mobility and flexibility [17,29,39,41]. It establishes a link between all the systems in the healthcare domain and thus makes data sharing easy between them. This can prove beneficial in retrieving health information during an emergency case scenario, in turn saving time and the possible complications. But, the of use of ICT in healthcare in India is low as compared to many developing countries [9]. Thus, formation of a network of this data that can be securely accessed by any authorized healthcare professional is made possible by an IT infrastructure.

2.2 Acceptance of EHR and training

As we mentioned the most important factor to be the presence of an IT framework, it becomes very crucial to train the healthcare professionals about it. Due to the complexity involved in implementation along with the cost, there are certain barriers that exist which prevent the acceptance in the hospitals. For example, [11,13,19] stated in his work that there exists a resistance in the healthcare professionals to accept it. As a solution to it, importance was given to spreading awareness and knowledge about EMR and also providing the training to healthcare professionals. Furthermore, [15,22] stated that this resistance leads to technical challenges in HIS implementation in hospitals. The author addressed the possible solutions and one of them is identifying the issues in real time and formulation of a mechanism that will prevent technical difficulties and thus make the implementation more robust and thus improve the overall work efficiency. Also, [29] focused on the concept of shared responsibility among stake holders and this aims to increase the awareness and thus improve the efficiency and success of implementation of EHR. [23] analysed the potential of EHR technology and showed the future potential in careful implementation, simultaneously, it implies an insufficiency of socio-technical relationship between the doctor, patient and the technology as a barrier in the successful implementation.

2.3 Data management

Heterogeneous data causes interoperability concerns and further increases demand for more processing power [10,38,39]. Duplicated medical examinations reduce process efficiency and increase the cost of care [17,29]. An EHR gives the snapshot of the patient details including information about medical history and the past visits [35], and helps in preventing any duplicated data. This data should be easily accessible [2] and shall be available [16] in the least possible time. Also, the patient data shall be authentic [22] which makes it reliable for the doctors thus, ensuring that the information given about the patients is up to date. This makes clinical decision real time.

2.4 Security and Privacy

The next major difficulty is securing the data [2,3,28,41]. Unintended consequences and safety concerns are also becoming more prevalent [10,13,15]. Patients' faith in the protection of their privacy has been eroded as a result of data breaches in the health industry.

Making this sensitive data safe is critical to maintaining public trust and increasing healthcare service. [28] presented the Health IT Safety (HITS) measurement framework, which may provide as a theoretical foundation for measuring, monitoring, and improving patient safety. A control system is necessary to reduce resource wasting and so help the professional's tasks.

2.5 Decision making and risk prediction

Using EHR data in illness prediction is one of the most difficult tasks in health informatics [9,14,24,27,33,40]. Wherein minimal amount of research is conducted. Many authors have tried and integrated risk prediction with EHR [33]. But none have done it for developing countries using predicting a disease and its associated risk. For example, [9] proposed a fuzzy case-based reasoning (CBR) framework for early diagnosis and detection of a chronic disease to prevent further complications. While, [24] proposed an AI based model for the early diagnosis of another specific chronic disease. The studies concluded with a point that these techniques can be coupled with EHR to make a robust CDSS system.

2.6 Economic barriers

The continued cost burden [7,8,37] is leading to an increased pressure on the healthcare sector leading to compromising the quality due to the spiralling cost. [3,13,19] stated that the initial cost of EHR implementation is high and, in some cases, the maintenance costs also turn out to be high. Thus, it is imperative to properly allocate funds and enough capitals investments, specially at the beginning of the projects to overcome this barrier. Also, annual budgets of the hospitals shall be designed to equip them with the resources to carry out overall expenses without any burden. Many healthcare professionals consider EHRs to be helpful in improving medical practice managements. Because EHRs keep all of a patient's data in one place, there will be less time wasted ordering and evaluating the results of unneeded or redundant tests and medical procedures. Lower expenses are associated with lower usage.

2.7 Organizational issues

In many of the cases, the increased needs cannot be satisfied as the systems are old. Also, [6] said that the hospitals lack experience with respect to EHR implementations. [19] stated that in order to conform EHR specifications, it is vital for hospitals to redesign their medical and administrative procedures making it imperative for the successful implementation. As a result, developing strategic strategies for the adoption, deployment, and future development of EHRs is critical. Such plans should be formulated by hospital managements and shall be tested and evaluated time to time in order to gauge performance levels. If hospital management is unable to do so, it is advisable for them to enlist experts to the team or simply outsource the process.

2.8 Lack of administrative support and legal issues

[13] stated that little guidance is offered by the legal systems to direct the shift from paper-based to electronic records as they confide on past cases and thus, fall behind in adoption of new technologies [2,17,31]. For instance, clinicians can be held liable for negligence, in cases if they miss to consider a critical detail which impacts treatment decisions. While in some other cases, the institution they work in could be held liable. One of the most significant issues is the lack of regulations controlling EHR processes. EHR use should be governed by rules and regulations developed by the Ministry of Health. On similar lines, hospitals can also formulate their own laws for controlling the use EHRs

internally that would include privacy agreements.

2.9 Safety

The next important factor is the patient safety [29,30]. Safety can be associated with the prevention of harm to the patients. Increasing usage brings risks with it. However, it can be minimized by developing best practices for EHR design, usage, implementation and training. Hence, resource planning is important to get the full benefit of the investment and hence make sure that it is secure. Thus, a framework that minimizes the errors caused, and which learns from past errors is essential to be implemented. This involves participation from every element of the framework i.e., the organization, healthcare professionals as well as the patients.

2.10 Quality of care

Because of advancements in both acute and ambulatory care settings, long-term post-acute care (LTPAC) services are expected to rise. As a result, EHR systems are becoming increasingly crucial [6]. Access to health care services is a challenge for persons living in rural locations [2,9], owing to considerable distances to commute. Rural hospitals are sometimes the sole local source of care for patients who do not have access to experts. An EHR system can assist rural hospitals in increasing access [33] and thereby supporting remote diagnosis by providing them with immediate access to information that allows them to make timely, critical choices and save lives.

2.11 Power backup

As these systems are dependent upon electricity availability, it becomes necessary that an uninterrupted power supply is available that can provide emergency power [15,17,18,41] to the computer hardware for a small time period, if electricity is out. Also, data backup shall also be taken either cloud-based or on discs or tapes such that even if an event takes the main EHR out, it won't take out the backup system as well.

3. Research Methodology

This section proposes the use of a holistic AHP-PROMETHEE procedure in methodology for identifying the critical success factors for EHR implementation in India. For this, weights assigned for each parameter are calculated from which we ranking the factors. AHP evaluates the weights of parameters and then by PROMETHEE those weights are used to rank the factors. Analytical Hierarchy Process (AHP) aids decision analysts to analyse the relative importance of addressed elements [26]. An integrated PROMETHEE-AHP method provides a logical and sensible output that provides effective decision-making solution.

3.1 Analytical Hierarchy Process (AHP)

Pair-wise comparisons [Attribute versus Attribute] are used to compare alternatives with regard to numerous parameters and to evaluate their relative weights, allowing decision makers to easily assign importance to coefficients and compare alternatives. Because of its hierarchical nature, it may be utilised for any quantity of data to deal with decision-making challenges.

Step 1: Establishment of the hierarchical structure. A nine-point scale was used for making pair-wise comparisons between criteria of barrier and dimensions by the experts who were requested. The literature study yielded five indicators for rating the many essential success elements for EHR adoption in India, which were then evaluated through expert conversations. These identified barriers and barrier dimensions are made into hierarchical-level processes, that include four

levels namely (i) Analysis of parameters for hurdles for successful EHR implementation in India, (ii) Represent the priority of the determined parameters, (iii) The hierarchy constitutes the priority of parameters within dimension and (iv) Has relative weights for every parameter for evaluating the hurdles for successful EHR implementation in India.

Step 2: A pair-wise comparison matrix is created, and the pair-wise comparison matrix is constructed. After that, create a collection of pair-wise comparison matrices. This comparison matrix was solved using AHP approach to determine the relative relevance of the criteria.

Step 3: To confirm that the aforementioned conclusion is consistent, the largest eigen vector or relative weights are examined. The consistency index (CI) for each n-dimensional matrix is then determined using Eq (1). The consistency ratio (CR) is calculated using Eq. on the basis of the Random Consistency Index (RI) and the Confidence Interval (CI) (2). The following are the CI and CR:

$$CI = (\lambda \max - n)/(n-1) \quad (1)$$

The consistency ratio is hence evaluated using the formula

$$CR = CI/RI \quad (2)$$

Wherein, RI varies according the order of matrix.

Simultaneously the relative weights were found out. The severity of every attribute decided for each of the factor was first noted and we use PROMETHEE method of MCDM for analysis. The relative importance matrix was made with the help of expert opinion and we ranked each attribute according to the highest level of importance which we found out.

3.2 Preference ranking organization method for enrichment evaluation (PROMETHEE)

The PROMETHEE approach is simple to apply and does not need any assumptions about the proportionality of criteria. It employs preference ranking and can deal with ambiguous and hazy data. When crucial aspects of a choice are difficult to measure or compare, or when collaboration across departments or team members is limited by their distinct expertise or views, this strategy is utilised. It is necessary to state whether or not each criterion is of the benefit kind.

Step 1: Calculation of the preference function. The pairwise comparison of the alternatives, let $x_1, x_2, x_3, \ldots\ldots x_n$ with alternatives for each attribute, let $p_1, p_2, p_3, p_4 \ldots\ldots p_n$ is done. For 1st attribute p1, alternative vs alternative matrix is made. Let a correspond to the value of an alternative for a parameter where 'i' corresponds to the row number and 'j' corresponds to the column number. Binary logic follows. If $a_i > a_j$ then $a_{ij} = 1$ else $a_{ij} = 0$. In this way the attribute matrix is formulated. These are called as the preference functions.

Step 2: Calculation of the intensity for preference function. Using AHP the weight for every attribute is calculated. This weight is multiplied with all the values of the matrix. Then a cumulative matrix C is formulated whose aij is the sum of the a_{ij} of all the attributes. And for this matrix, the sum of every row and every column is calculated called as horizontal sum and vertical sum respectively. Then, the net flow is calculated which is the difference between the horizontal and the vertical sum for every alternative.

Step 3: Calculation of the rank. In PROMETHEE, the alternative with the lowest value of net flow has the highest preference i.e., the highest ranking.

3.3 Empirical Findings

According to the discussion with the experts the relative importance matrix was made and the weights were calculated. The 5 parameters identified are shown in table I. According to the data, the most important constraint was the accuracy (42%) followed by real time analysis (25%) and interoperability (15%) whereas cost and sustainability were the least relatively important factors. The cost was the non beneficial parameter and the rest were the beneficial parameters. Next a matrix consisting of the values of the factors obtained through expert discussions with respect to the parameters is made (table II).

TABLE I. PARAMETERS IDENTIFIED

	interoperability	accuracy	real time analysis	cost	sustainability	weights	Rank
interoperability	**1.00**	0.25	0.50	2.00	2.00	0.15	3
accuracy	4.00	**1.00**	2.00	3.00	4.00	0.42	1
real time analysis	2.00	0.50	**1.00**	4.00	2.00	0.25	2
cost	0.50	0.33	0.25	**1.00**	2.00	0.10	4
sustainability	0.50	0.25	0.50	0.50	**1.00**	0.08	5

TABLE II. FACTORS VS PARAMETERS

	interoperability	**accuracy**	**real time analysis**	**cost**	**sustainability**
IT infrastructure	1.5	34.5	847	1.76	H
Quality of care	0.027	36.8	834	1.75	A
Security and Privacy	0.037	38.6	827	1.74	H
Power backup	0.028	35.2	820	1.75	AA
Data management	0.032	38.2	839	1.68	H
Organizational issues	0.02	37.2	829	2.4	AA
Safety	0.036	35.4	824	1.59	H
Decision making and Risk prediction	0.029	38.4	825	2.21	H
Lack of administrative support and legal issues	0.01	37.9	816	2	AA
Economic barriers	0.02	37.9	816	2	AA
Acceptance of EHR and Training	0.5	38.9	817	3	AA

TABLE III. POINT SCALE

EXCEPTIONALLY LOW	EXL	0
EXTREMELY LOW	EL	0.1
VERY LOW	VL	0.2
LOW	L	0.3
BELOW AVERAGE	BA	0.4
AVERAGE	A	0.5
ABOVE AVERAGE	AA	0.6
HIGH	H	0.7
VERY HIGH	VH	0.8
EXTREMELY HIGH	EH	0.9
EXCEPTIONALLY HIGH	EXH	1

The subjective attributes were converted into objective numbers with the help of the following values (table III).

The next step is the calculation of the preference functions. The preference function for every attribute (parameter) is formed and then the matrix is multiplied by the respective weight. The cumulative matrix is thus formulated. After this the net flow is calculated. In PROMETHEE, the alternative (factor) with the lowest value of net flow has the highest preference i.e. the highest ranking. Table IV shows the values obtained of the cumulative matrix and thus the values of the net flow. Based on this, the various factors are ranked. According to the study priority of importance of the factory is topped by the presence of IT infrastructure (rank1). This was followed by acceptance of EHR and training (2), security and privacy (3), whereas the least 3 important factors were quality of care (9), safety (10) and finally power backup (11). The consistency ratio of the pairwise comparison of the parameters is 0.049 which is (< 0.1) and hence is highly acceptable.

4. Results and discussion

The research work incorporates a systematic literature review approach to identify and analyse the various barriers

TABLE IV. CUMULATIVE INTENSITY OF PREFERENCE FUNCTIONS AND RANKING OF THE FACTORS

	Decision making and Risk prediction	Economic barriers	IT infrastructure	Power backup	Security and Privacy	Organizational issues	Quality of care	Data management	Safety	Lack of administrative support and legal issues	Acceptance of EHR and Training	HORIZONTAL SUM		NET FLOW	RANK
Decision making and Risk prediction	0.000	0.416	0.416	0.416	0.416	0.518	0.416	0.518	0.518	0.518	0.518	4.670		-0.325	**5**
Economic barriers	0.584	0.000	0.645	0.229	0.898	0.601	0.229	0.747	0.601	0.601	0.747	5.883		1.867	**7**
IT infrastructure	0.500	0.355	0.000	0.102	0.253	0.355	0.000	0.102	0.102	0.102	0.663	2.533		-4.600	**1**
Power backup	0.584	0.669	0.898	0.000	0.898	0.771	0.898	1.000	0.518	0.518	0.663	7.418		5.272	**11**
Security and Privacy	0.500	0.102	0.663	0.102	0.000	0.102	0.145	0.518	0.102	0.102	0.663	2.998		-3.669	**3**
Organizational issues	0.482	0.399	0.645	0.145	0.898	0.000	0.229	0.645	0.416	0.416	0.663	4.940		0.359	**6**
Quality of care	0.500	0.771	0.916	0.102	0.771	0.771	0.000	0.771	0.518	0.518	0.663	6.301		2.937	**9**
Data management	0.399	0.253	0.815	0.000	0.399	0.355	0.145	0.000	0.000	0.000	0.663	3.029		-3.608	**4**
Safety	0.482	0.399	0.898	0.399	0.898	0.500	0.482	1.000	0.000	0.145	0.916	6.121		3.346	**10**
Lack of administrative support and legal issues	0.482	0.399	0.898	0.399	0.898	0.355	0.482	1.000	0.000	0.000	0.916	5.830		2.910	**8**
Acceptance of EHR and Training	0.482	0.253	0.337	0.253	0.337	0.253	0.337	0.337	0.000	0.000	0.000	2.589		-4.488	**2**

VERTICAL SUM		4.996	4.015	7.133	2.146	6.668	4.581	3.364	6.637	2.774	2.920	7.077

and factors for EHR implementation in India. These factors are then ranked using integrated AHP-PROMETHEE method of MCDM. Table IV shows the ranks obtained. The priority order of the factors is given as: (1) IT infrastructure-(2) acceptance of EHR and training-(3) security and privacy-(4) data management-(5) decision making and risk prediction– (6) organizational issues-(7) economic barriers-(8) lack of administrative support and legal issues-(9) quality of care-(10) safety-(11) power backup. An IT infrastructure is essential for digitization of processes in healthcare in order to enable mobility and flexibility [17,29]. It establishes a link between all the systems in the healthcare domain and thus makes data sharing easy between them. Resistance leads to technical challenges in HIS implementation in hospitals [15,22] and thus it becomes important to spread awareness and knowledge about EMR and also provide training to healthcare professionals. Patients' faith in the protection of their privacy has been eroded as a result of data breaches in the health industry. Making this sensitive data safe is critical to maintaining public trust and increasing healthcare service. Data should be easily accessible [2] and provided in the shortest time feasible [16]. Furthermore, the patient data must be legitimate [22], making it trustworthy for clinicians and guaranteeing that the information provided about the patients is current. One of the most challenging tasks in health informatics is using EHR data in illness prediction [9,14,24,33], which requires very little study. As a result, decision-making and risk prediction must be integrated into healthcare services. To combat the ongoing cost burden, it is critical to appropriately manage finances and make sufficient capital investments, particularly at the start of initiatives. The establishment of strategic plans for the adoption, deployment, and future development of EHRs is a critical step. One of the most significant issues is the lack of regulations controlling EHR processes. EHR use should be governed by rules and regulations developed by the Ministry of Health. An EHR system can assist rural hospitals in increasing access [33] and so enable remote diagnosis by providing them with immediate access to information that allows them to make critical choices. Resource planning is important to get the full benefit of the investment and hence make sure that it is secure. It becomes necessary that an uninterrupted power supply is available that can provide emergency power.

5. Conclusion and Future Scope

EHR frameworks have been implemented in most of the developed European countries but, similar implementations are in the nascent stage in the developing countries [2,3]. Also, the of use of ICT in healthcare in India is low as compared to many developing countries [9]. This requires further studies, reviews and clearer implications. In this study, we analysed the critical success factors for implementation of EHR in India. To analyse the further interrelation and importance, PROMETHEE method of MCDM was used. A ranking of the 11 factors was established (table IV). The 5 performance parameters selected were of both beneficial and non-beneficial type. The present research work is among the initial studies on the critical success factors for successful implementation in India. We used the AHP approach to establish the relative importance between the parameters and for this, expert opinions were taken into consideration. There can definitely be difference in the values from person to person. Sustainable frameworks and allied business models should be proposed which is in line with [22]. Further research can be directed in the way to reduce the impact of each of the 11 success factors as they can drastically affect the implementation of EHR in India. Academicians will be motivated to find out Industry specific barriers for EHR adoption. The policy makers can objectively evaluate hindrances for their initiatives like ‘Fit India Movement’ and organizations can develop efficient strategy to overcome these challenges, adopt EHR and improve quality of care.

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