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RESEARCH

Multi-Criterial Based Feature Selection for Health Care System

Habib Ullah Khan[1] · Nasir Ali[1] · Shah Nazir[2] · Abdulatif Alabdulatif[3] · Mohammad Arif[4]

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Abstract

Health is the basis of a happy and successful living, and modern people have significantly benefited from medical advancements. More information is available to analyze the difficulties that affect our well-being with each new technology. Researchers may be able to answer previously inaccessible health problems due to analyzing and sequencing health data. Data in health care system is rapidly rising due to information of data analyzed with the help of IoT medical devices, availability of data in clinics and health care facility centers and with various Electronic Health Records (EHRs). Healthcare is a significant sector that deals with a variety of multi-objective and many-objective dilemmas. Quantum computing addresses specific objectives within an ideal timeframe by simultaneously working on numerous features and distinct processes. The proposed technique is a multi-criteria-based quantum health feature selection system for offering the optimum health care facilities to patients in the healthcare sector. The features are grouped into various criteria based on their applicability during a literature assessment. With the help of the Entropy technique, weight has been allocated to these selected features. To evaluate these features, the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) strategy was adopted, in which the features were ranked to find the most suitable features among a group of features. This mechanism employs methods for weighting criteria and evaluating the most appropriate quantum features to be used by the healthcare industry and practitioners in improving patient care in health facility units.

Keywords Health care · Quantum health · Feature selection · Decision making · Disease detection · IoHT

✉ Mohammad Arif
mohammadarif911@gachon.ac.kr

Habib Ullah Khan
habib.khan@qu.edu.qa

Nasir Ali
nasirali1993aaa@gmail.com

Shah Nazir
shahnazir@uoswabi.edu.pk

Abdulatif Alabdulatif
ab.alabdulatif@qu.edu.sa

1 Department of Accounting and Information Systems, College of Business and Economics, Qatar University, Doha, Qatar

2 Department of Computer Science, University of Swabi, Swabi, Pakistan

3 Department of Computer Science, College of Computer, Qassim University, Buraydah 51452, Saudi Arabia

4 Department of Computer Engineering, Gachon University, Seongnam-si 13120, Republic of Korea

1 Introduction

Healthcare technology is a significant utilization and assimilation of various knowledge for enhancing, supporting, and sustaining the health of mankind [1]. The modern era is concerned with data extraction and retrieval, as well as the transformation of this data into useful and predictable information. Traditional health care and medicinal facilities are being transformed into digital and smart sectors as advancement in technology and scientific theory. Smart healthcare is more than simply a technology improvement; it is a multilevel transformation. This shift is manifested in improvements to medical modelling, the development of information, medical management, and preventative and therapeutic paradigms [2]. The rapid evolution of society are forcing organizations especially health care systems to enhance the quality of life [3]. Researchers and organizations are motivated towards enhancing healthcare facilities in order to improve people's quality of life [4]. Provider organisations offer health care services to individuals in order to enhance their health [5].

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The improvement of industrial applications to medical technologies has a significant financial, technical, and cultural value. Sensors are increasingly being incorporated into many applications in our daily lives as computer technology, digital signal processing, and automation improve. Sensor data can help medical practitioners detect sensitive situations faster and more precisely and urge patients to be more conscious of their illnesses and alterations. Diseases control is becoming increasingly important as the number of chronic disease patients increases and the population ages. Prevention is defined as maintaining a healthy lifestyle via physical activity, food, and periodic preventative tests, and avoiding chronic conditions from progressing. Indeed, the growing rates of severe illnesses and the scarcity of healthcare services to meet patient care expectations have raised the need for healthcare sector innovation [6].

Healthcare systems have been among the most important aspects of our daily lives, resulting in an exponential rise in medical data such as medical pictures and patient information, necessitating increased computational capacity to handle and preserve the confidentiality of this data [7]. In recent years, most healthcare data has been gathered via IoT devices, mobile adhoc networks [8, 9] and sensor networks [10] connected via the internet through fiber optic for fast speed [11]. In a traditional IoT system, tools and sensors are the fundamental components that interact and modify as necessary. In an IoT system, data is gathered from devices, preprocessed, and sent for informed decision or service. Many gadgets and things are considered part of medical technology, such as healthcare wearables and remote monitoring [12]. Administrative responsibilities substantially hamper the work of doctors, caregivers, and technologists in healthcare. Medical procedures (for example, lab tests and imaging encounters) must be planned and prepared, appointments with various service providers must be scheduled, specimens or patients must be moved, visits from doctors to other departments must be arranged, and reports must be documented, forwarded, and examined [13]. IoT-enabled healthcare system that connect smart health gadgets is represented in Fig. 1.

However, it is impractical to perform the complicated data analysis necessary to arrive at answers when this huge amount of data is scattered out with restricted access, is in formats not suitable to sharing, cannot be simply organized for computational procedures, and therefore does not exists as a detailed history [14]. With diagnoses and treatment precision becoming more important for excellent care, quantum computing provides unbeatable processing speed and power. The technique improves the analysis of massive amounts of health information as well as care delivery. Using quantum computing concepts, doctors may find correlations and offer appropriate diagnosis or therapies [15]. Quantum computing can revolutionize drug discovery, genome sequencing, in vitro medical studies, cloud-based healthcare, and health data prediction, expanding researchers understanding in heredity, biochemistry, pharmacology, and other sectors.

- The features are grouped into various criteria based on their applicability during a literature assessment. With

Fig. 1 IoT-enabled smart healthcare system

the help of the Entropy technique, weight has been allocated to these selected features.
- To evaluate these features, the TOPSIS strategy was adopted, in which the features were ranked to find the most suitable features among a group of features. This mechanism employs methods for weighting criteria and evaluating the most appropriate quantum features to be used by the health care industry.

The paper is organized into various section. Section 1 Introduction briefly provides and overview of the research topic, Section 2 Literature Review describes existing research work carried out by researchers and practitioners in this domain. Section 3 Methodology represents the overall approaches used carrying out this research work. Section 4 Experimental setup and results shows the results obtained by using the proposed methodology. Conclusion Section 5 concludes the overall research.

2 Literature review

The socialization of medical services is constantly evolving. Physicians, engineers and technologists must be able to realize the modification in perspective that is attempting to drive it [16]. The healthcare facility system both saves lives and enhances wellbeing of individuals. Over the last two decades, the average lifetime has improved by five years [17]. With its emphasis on non-deterministic thinking, quantum and relativistic physics can provide a useful framework for comprehending the abstraction layers of healthcare system their interposition and interrelation. Utilizing analytical approach might lead to innovative treatments (including physicians, patients, and payers) that address issues at several locations in the system at the same time [18]. Healthcare facilities in the digital era are more effective, flexible, and customized as the intelligent medical system uses various gadgets and tools to detect and diagnose diseases, increasing the quality of patient life [19]. Technological advancements have contributed to much more reliable monitoring systems, which generally permit the synchronized acquisition of a variety of physiological data, including blood pressure, respiration, heartbeat, pulse rate, and many more [6]. A continuous patient monitoring system is especially helpful for analyzing patients' actions and behavior. Wearable sensor technologies used in patient monitoring have consistently produced massive amounts of data. The amount of data collected by IoT-based patient monitoring is significant. These technologies are thriving in every industry, from individual to institutional. The increased number of devices necessitates the development of more efficient technologies to allow the system to run more smoothly [20].

A large number of electronic devices are linked to the Internet. These electronically linked devices capture and send data and respond to any incoming actions. Hospitals can use medical sensors to incorporate medical diagnosis (MD) in the healthcare ecosystem [21]. To ensure enhanced treatments, the growth of healthcare data necessitates precise analysis of disease identification, treatment, and real-time supervision [22]. Figure 2 shows the general conception of the Internet of things, where many gadgets are connected to provides various services to people.

Quantum computing, in conjunction with artificial intelligence, can be used to analyze medical images. Not only will picture detail be greatly increased but the doctor will be supported in interpreting data since excellent machine learning could retrain a quantum computer to detect pathological observations more precisely than the human eye [23]. The quantum computer revolution has accelerated healthcare in diabetes mellitus and COVID-19 diagnosis. It may now be used to offer advance indication of infections as well as rehabilitation for patients [24]. Quantum computing may involve rapid drug discovery process, comprehensive genome sequencing and processing, in vitro medical studies with virtual humans modeled 'live,' healthcare relocation to the cloud, and predicted safety and wellbeing of health data via quantum superposition. It's really hard to imagine the relevance of the Quantum Computer in medical services, but it can be a best tool for expanding our understanding and knowledge of heredity, biochemistry, pharmacology, and other social and healthcare sectors [25].

Quantum medicine is an advanced therapeutic approach based on a combination of all latest developments in quantum theory and the most recent data on the profound reality of the living with decades of eastern healthcare experience, or with the real knowledge of a biological entity. Quantum treatment is based on the use of energetic quanta, or minute doses of electromagnetic energy, for the diagnosis, treatment, and prevention of numerous diseases, ultimately promoting human health rehabilitation. In this situation, electromagnetic waves are equivalent to natural levels and is meant to improve the activities of cells, tissues, organs, systems, and the entire body. Although quantum medicine is still in its early stages, it promises to transform the preponderance of ways for ensuring human wellbeing in future [26]. The quantum technology in personalized medicine gives clinicians a thorough understanding of the sickness. Using this information, they can administer medications which are most effective when gender, ethnicity, genetic composition, and other patient variables are taken into account. Drug development is one probable application sector where these technological solutions will uncover numerous implications [27]. Quantum dots (QDs) are widely used in biological imaging for the identification of toxins and pathogens. Because of the expensive cost, detection of limit concerns, and a lack of

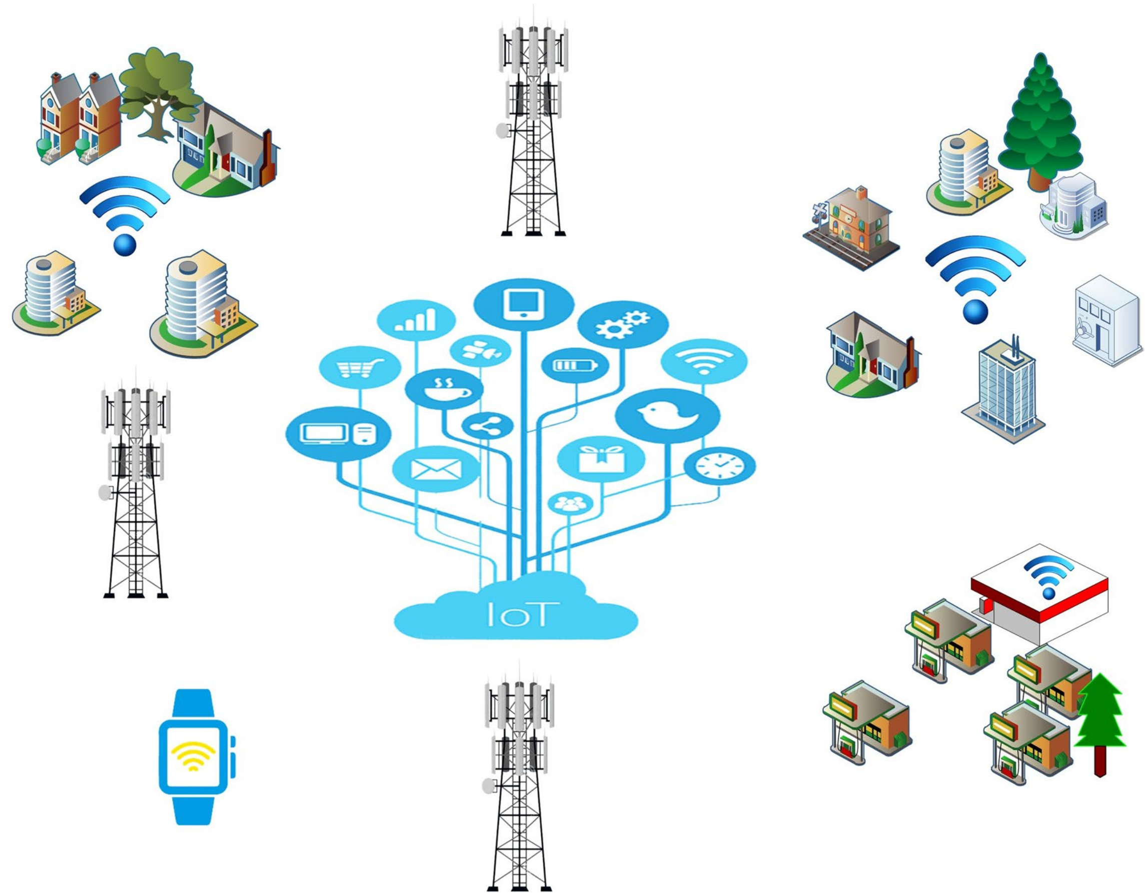

Fig. 2 Internet of things conception

sufficient data on health consequences, their usage as surrogates to research the origin and transit of non-fluorescent nanostructures [28].

The formation of the eukaryotic organisms and the appearance of the mitochondrial matrix, which both boosted energy output per cell and expanded the capacity to access, store, and make use of information, were important aspects in this evolutionary process. According to recent studies, life has always welcomed quantum phenomena like 'tunneling' and 'coherence,' with competition and stressful environments serving as a persistent push for biological evolution. The basal adaptable stress response characterized by hormesis–a mechanism that gathers information to facilitate flexibility is essential to this entire process. Significantly, hormesis may boost mitochondrial quantum yield, hence increasing the ATP/ROS ratio, but an inflammatory response, which is closely linked to the ageing process, may do the reverse. All of this indicates that in order to attain maximum health and good ageing, the system must be sufficiently stressed to maintain peak mitochondrial activity, which might reflect the selection of best performance at the quantum level [29].

Psychopathology is the condition in which daily life is disrupted by a divergence from what is normally expected. The essential of them are statistical deviations from usual, abnormalities in social connections, disruptions in reality vision, and restlessness. Their significance stems not from the fact that they occur infrequently or infrequently, but from their recurrence and the identification of illness. This approach accepts more ordinary action as ideal. According to a more systematized diagnosis, a pathological mental health disorder must deviate from the notions of feeling, emotion, and behavior patterns, be associated to negative emotions, disrupt essential routine, and pose a real threat to the individual or those around them. The physiological approach reduces psychopathologies to nerve cells, neural nets, synapses, and neurotransmitters. But nevertheless, the basis of neuropsychiatric disorders can now be indicated at much deeper layers. When these deeper patterns are considered, a new perspective arises, which might be referred to as the quantum psychopathological approach [30].

Since quantum AI and quantum ML are enabling technologies, it is essential to conduct a formative evaluation of both from the perspective of practical quantum information processing. Many sectors are demanding unprecedented amounts of change in the present healthcare climate. Among these influences are shifting demographics, higher customer expectations, increased competitiveness, and increased government pressure. Meeting these issues will need significant changes in healthcare organizations as well as a continuing search for new methods to produce future value [31].

3 Methodology

Decision support system (DSS) is an information system discipline that supports and enhances an institution's decision-making process. Because quantum computing includes a lot of aspects in health, decision-makers find it difficult to communicate their opinions. DSS is used in healthcare systems to assist decisions when dealing with large volumes of health data [32]. The integration of data, analytical models, and user-friendly interfaces in the Decision Support System (DSS) facilitates the decision-making process across multiple domains. Decision Support Systems have a broad scope and are applied across various domains, including commerce administration, financial analytics, healthcare provision, logistics supervision, developmental schematics, and ecological blueprinting. These systems impart a crucial impetus to strategic forecasting, hazard appraisal, capital allotment, output assessment, and other pivotal decision-making protocols, thereby endowing organizations with the ability to navigate themselves towards prudent and productive outcomes. Decision Support Systems (DSS) are responsible for the integration and management of voluminous data from a diverse range of sources, both internal and external, including real-time data feeds. The system makes sure the data is accurate, trustworthy, and easily accessible to support good decision-making. DSS uses mathematical, statistical, and analytical models to aid decision-making, ranging from straightforward calculations to sophisticated simulation models, optimisation algorithms, forecasting approaches, and data mining techniques. DSS offers a user-friendly interface that enables interaction, criterion entry, data analysis, and outcome visualisation for decision-makers. It has visualisation techniques, optimisation algorithms, and decision tree analysis as well as dashboards, reports, charts, and graphs. The Decision Support System (DSS) offers a platform that makes it easier for decision-makers to share information, exchange ideas, and analyse and evaluate choices individually. The system thus promotes interaction among decision-makers. The DSS is meticulously designed to be highly flexible and adaptive to evolving decision contexts and requirements, thereby affording users the ease of modifying decision criteria, input assumptions, models, and scenarios. This flexibility confers decision-makers with the ability to explore multiple options and respond effectively to dynamic situations. Moreover, the DSS can seamlessly integrate with other information systems and databases, thereby granting access to relevant data. It can interact with enterprise resource planning (ERP) systems, customer relationship management (CRM) systems, data warehouses, and other external sources, thus providing comprehensive decision support.

To support the digital care system decision making, an essential step is taken to aid patients, clinicians, and other health-related organizations in carrying out necessary processes to make healthcare successful [33]. To decrease computation time and effort, decision-makers employ a selection approach for the type of decision aids [34]. The decision is carried out on selecting appropriate features of things, people, and devices, or they may be made on various criteria adopted [35]. We have collected various features from the literature review to select appropriate quantum features to enhance health care operations.

3.1 Feature selection

Features are unique attributes of objects, entities or a person. Feature selection is a crucial process that involves identifying and selecting a subset of pertinent features or variables from a larger pool of available features. This step is imperative in both machine learning and data analysis for a multitude of reasons: To avoid overfitting, it is important to exclude non-essential or superfluous attributes from the model, as they may introduce noise or irrelevant patterns. By opting for exclusively pertinent features, we can diminish the intricacy of the model and enhance its ability to generalize, thereby leading to superior performance on unobserved data. Understanding and explaining the connections between the characteristics and the objective variable is crucial in numerous applications. The selection of characteristics can assist in recognizing the most impactful features, amplifying the model's interpretability, and furnishing comprehension into the fundamental data patterns. Having a reduced set of features can diminish the computational expenses incurred during the model training process, which consequently results in heightened speed and efficiency of the model. This notion is particularly critical when dealing with intricate models or voluminous datasets, as the process of reducing the number of features can substantially hasten the training and prediction procedures. Feature selection is a valuable technique that aids in the identification and elimination of noisy or irrelevant features. This approach proves particularly advantageous when dealing with low-quality or incomplete data. By prioritizing the most informative features, the impact of noise can be mitigated, thereby resulting in an overall improvement in the quality of data utilized for modeling.

In real-world learning problems, data representation frequently employs a large number of characteristics, only a subset of which may be connected to the target idea. In this case, feature selection is crucial for accelerating learning and improving idea quality [36]. In application domains where datasets containing several thousands of variables are present, feature selection has become a matter of major research. Device selection, text recognition, effective people selection, gene expression, and so on are examples of feature selection domains [37]. As a data preparation method, feature selection is effective and successful in data preparation (particularly high-dimensional data) for different statistics and machine-learning concerns.

3.2 Searching libraries

Searching through digital libraries can prove to be a commendable methodology in aiding the process of selecting suitable features for a given task or problem. By providing access to an extensive collection of research papers, articles, and various scholarly materials, digital libraries offer valuable insights and guidance on feature selection techniques and best practices. Digital repositories such as IEEE, Springer, ACM, Wiley, and Science Direct were properly checked to collect features relevant to healthcare. These features were then properly analyzed to remove duplication or irrelevant features.The goals of feature selection include creating easier and more intelligible models, enhancing high throughput, and providing intelligible data [38]. The most appropriate features are selected from the large set and are fed to statistical or machine learning algorithms [39] to classify, arrange and to rank them according to their likeliness or preferences. The literature study is deeply analyzed to collect various features related to healthcare. Figure 3 represents searching various libraries for health-related studies and selecting appropriate features from these articles. Table 1 represents the collected features based on which the decision will be carried out.

Table 1 Features analyzed

No	Features	Citations
1	Portability	[27]
2	Tolerance	[40]
3	Predictability	[41]
4	Durability	[42]
5	Integrity	[42]
6	Reliability	[43]
7	Energy efficiency	[44, 45]
8	Flexibility	[46]
9	Real-time	[46]
10	Immutable	[46]

The figure shows various appropriate features analyzed during the literature review. This will assist organizations to focus on these features to enhance care facilities in healthcare systems (Figs. 4 and 5).

3.3 MCDM approach for evaluating and ranking features

Multi-Criteria Decision Making (MCDM) is a systematic method for assessing and ranking characteristics or options based on a number of criteria or goals. By considering multiple factors at once, it assists decision-makers in making good choices.

When utilizing the entropy technique to evaluate features, you usually want to determine the relevance or significance of each characteristic based on its capacity to offer details and reduce ambiguity throughout the decision-making process. Here is an in-depth explanation of assessing features using the entropy method. Clearly state the decision-making dilemma and the features that need to be evaluated. Decide the decision criteria by Determining the critical decision criteria or goals for the decision-making situation. The decision-making process should be compatible with these criteria, making them valuable. Set the criterion weights to reflect each one's individual importance. These weights can be determined by discussions with relevant parties, professional counsel, or other procedures for making decisions. Measure each criterion's uncertainty or information content by computing its Entropy. The Entropy of the criterion's values is a measure of how random or disorderly they are. Usually, the probability distribution of the criteria values serves as the basis for the formula for calculating Entropy. The entropy value is a number between 0 (no uncertainty) and 1 (highest uncertainty). Determining the information gain for each feature is based on how effectively each feature can make the selection criteria less ambiguous. Information gain measures the entropy decrease brought about by considering a certain characteristic. Arrange the features in descending order according to their information gain scores. A higher information gain suggests a more important or beneficial trait for the decision-making problem. In light of the degree of uncertainty and valuable information connected with each criterion, it facilitates in determining which of the most beneficial and pertinent factors influence the decision-making process. Using the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) technique, it is also possible to rank characteristics according to their effectiveness or attractiveness.

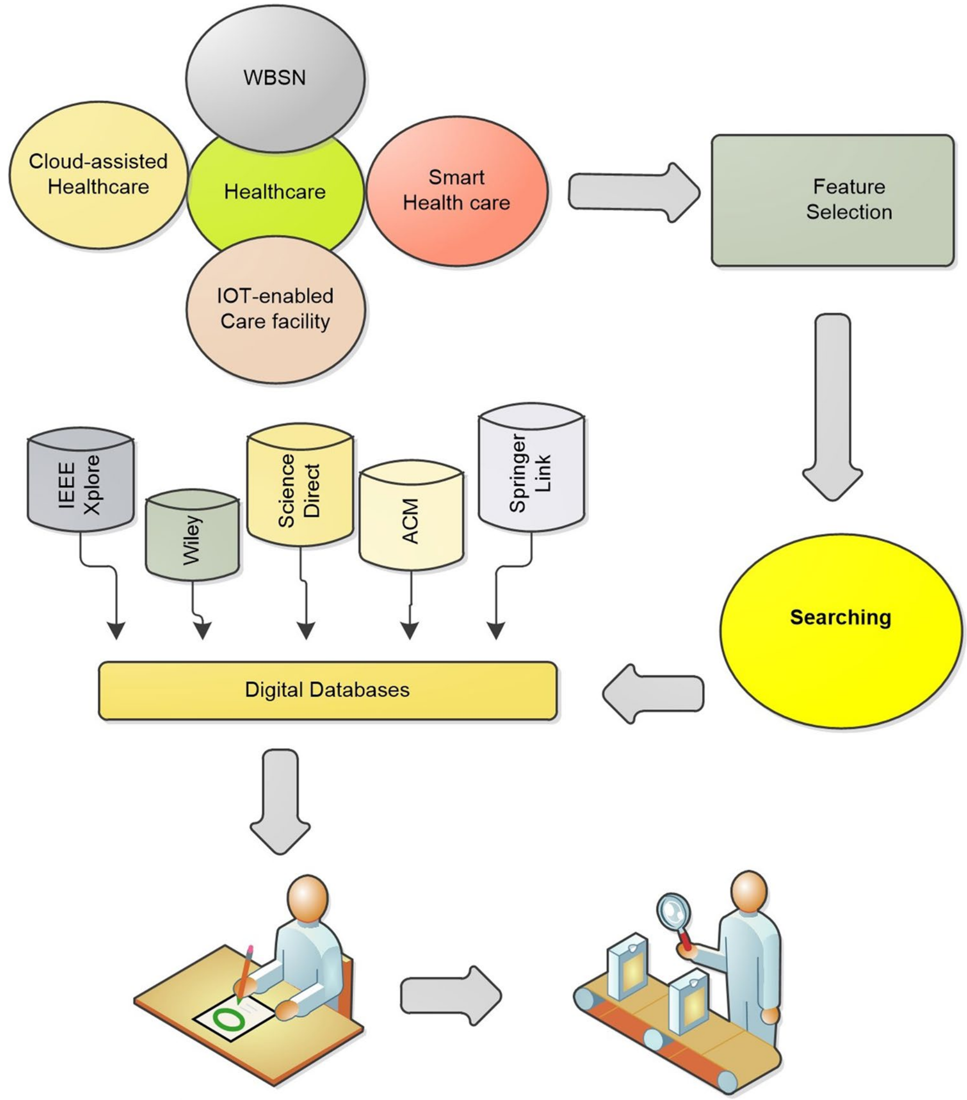

Fig. 3 Selection of relevent features from literatures studies

The details explanation and stages of the proposed methods are explained in Section 4.

4 Experimental setup and results

In a broad sense, decision-making is the desire of humans to make "calculated" actions in the context of various options. In scientific words, it is the objective to build mathematical modeling techniques that consider various options with different criteria. Due to socio-economic sector changes, multi-criteria decision-making has become a fast-growing field in recent decades. Decision makers want to get judgment guidance to help them choose amongst options, particularly to overcome less desirable alternatives swiftly. Decision-making approaches have gained widespread popularity with the use of computers in all aspects of decision-making procedures. Since MCDM has gained popularity in disciplines such as combinatorial optimization and operational research, the field has developed a number of approaches. Because most of the approaches are associated with sophisticated calculations, the use of the MCDM methods approach has proven significantly simpler for users and decision-makers in recent years, especially as computer usage has expanded dramatically. The key issue for the decision aid in discrete alternative multi-criteria choice problems is to pick the best options among a collection of solutions, ranking options according to their relevance, finding the best one according to its ranking, and concluding the results [47]. In this study the entropy method is used to weight the various numbers of criteria and the TOPSIS method is used to rank the criteria for selecting the most appropriate one among group of

Fig. 4 Features selected from various articles

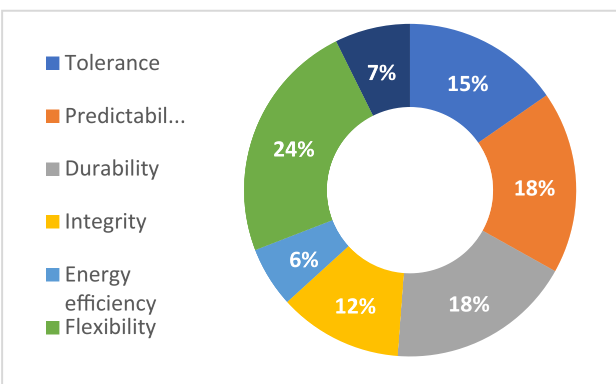

Fig. 5 Representation of quantum features weightages

criteria. The details procedures of each MCDM approach is given in subsections.

4.1 Entropy method

Entropy in information theory assesses how much data a source delivers or determines the degree of uncertainty in a particular problem [48]. Let's assume that we have events e1, e2, …, en; with their probability p1, p2,…, pn for a problem with X, These probabilities indicate the degree of uncertainty in the occurrence of the following event. As a result, if all pi criteria are satisfied, we have the maximum level of uncertainty for that occurrence (Table 2).

The weights of the criteria in the decision matrix may be determined using the entropy approach, and the final result

Table 2 Decision matrix

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	8	6	7	5	9	4	8
QH2	6	8	4	7	8	5	9
QH3	7	4	8	6	6	5	7
QH4	6	7	5	7	8	4	9
QH5	4	8	6	9	7	8	6

Table 3 Summation of values

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	8	6	7	5	9	4	8
QH2	6	8	4	7	8	5	9
QH3	7	4	8	6	6	5	7
QH4	6	7	5	7	8	4	9
QH5	4	8	6	9	7	8	6
SUM	**31**	**33**	**30**	**34**	**38**	**26**	**39**

Table 4 Normalize decision matrix

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	0.258064516	0.181818182	0.233333333	0.147058824	0.236842105	0.153846154	0.205128205
QH2	0.193548387	0.242424242	0.133333333	0.205882353	0.210526316	0.192307692	0.230769231
QH3	0.225806452	0.121212121	0.266666667	0.176470588	0.157894737	0.192307692	0.179487179
QH4	0.193548387	0.212121212	0.166666667	0.205882353	0.210526316	0.153846154	0.230769231
QH5	0.129032258	0.242424242	0.2	0.264705882	0.184210526	0.307692308	0.153846154

Table 5 Finding entropy of criteria's

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	-0.349560171	-0.309954199	-0.339567021	-0.281900384	-0.34113827	-0.287969566	-0.324947714
QH2	-0.317850529	-0.343531156	-0.268653736	-0.325386842	-0.328030446	-0.317049736	-0.338385477
QH3	-0.3360174	-0.255783418	-0.352468224	-0.306106069	-0.29144632	-0.317049736	-0.308296423
QH4	-0.317850529	-0.328914603	-0.298626578	-0.325386842	-0.328030446	-0.287969566	-0.338385477
QH5	-0.264218431	-0.343531156	-0.321887582	-0.351830104	-0.311624528	-0.362663076	-0.287969566

Table 6 Calculating sum (sum----> ∑ *r* * *ln (r)*)

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	-0.349560171	-0.309954199	-0.339567021	-0.281900384	-0.34113827	-0.287969566	-0.324947714
QH2	-0.317850529	-0.343531156	-0.268653736	-0.325386842	-0.328030446	-0.317049736	-0.338385477
QH3	-0.3360174	-0.255783418	-0.352468224	-0.306106069	-0.29144632	-0.317049736	-0.308296423
QH4	-0.317850529	-0.328914603	-0.298626578	-0.325386842	-0.328030446	-0.287969566	-0.338385477
QH5	-0.264218431	-0.343531156	-0.321887582	-0.351830104	-0.311624528	-0.362663076	-0.287969566
Sum	-1.585497061	-1.581714532	-1.581203142	-1.59061024	-1.600270009	-1.572701679	-1.597984657

can be used to determine the overall rating of each alternative (Table 3).

Normalized decision matrix is one in which each column's values are divided by the total of those values. Normalizing the criteria ensures that all receive the same amount of weight in the decision-making process, regardless of their scale or measuring units. The matrix is normalized by dividing each value by the total of the corresponding column in each column. The values in each column are now relative to one another and each one is added to each column as a result, it is less complicated to evaluate alternatives based on how satisfactorily they perform against each criterion (Table 4).

$$\text{Calculate h} = 1/\ln(m) = 1/\ln(5) = 1/1.6094379 = 0.6213349$$
$$\text{Compute} \ ---> \ r * \ln(r)$$

Entropy is a measurement of how uncertain or diverse a set of values for a criterion are, which is useful in decision-making. The fraction of each value must be calculated to determine the criteria's Entropy. More varied or unpredictable conditions exist when the entropy value is greater. The criteria has more consistent or uniform values when the entropy score is low (Table 5).

After calculating Entropy of each criteria, summation is caried out. The summation of these criteria is represented in Table 6.

The weight of each criterion is multiplied by the value it represents in the decision matrix in the next step of a decision support system (Table 7).

Diversification in the context of decision-making refers to how much distinct choices in a decision matrix differ from one another in terms of certain criteria. The weight of a criteria refers to its relative importance or influence to a choice (Table 8).

Each criterion in the decision matrix is given a relative weight through the use of a weight vector, or vector of weights. By dividing the normalized decision matrix by the weight vector, one may utilize the weight vector to get the overall score of each alternative. By dividing the normalized decision matrix by the weight vector, we can utilize this weight vector to get the total score of each alternative (Table 9).

Each criterion is evaluated during the decision-making process in a decision support system to establish its importance or worth. The relative importance of each criterion in comparison to the other criterion(s) is indicated by its weight. Each criterion for making decisions must

Table 7 Multiplying sum

Sum ($\sum$ r * ln (r)) by -h to calculate Entropy (e) = -h $\sum$ r * ln (r)

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	-0.349560171	-0.309954199	-0.339567021	-0.281900384	-0.34113827	-0.287969566	-0.324947714
QH2	-0.317850529	-0.343531156	-0.268653736	-0.325386842	-0.328030446	-0.317049736	-0.338385477
QH3	-0.3360174	-0.255783418	-0.352468224	-0.306106069	-0.29144632	-0.317049736	-0.308296423
QH4	-0.317850529	-0.328914603	-0.298626578	-0.325386842	-0.328030446	-0.287969566	-0.338385477
QH5	-0.264218431	-0.343531156	-0.321887582	-0.351830104	-0.311624528	-0.362663076	-0.287969566
e	**0.985124658**	**0.982774441**	**0.982456696**	**0.988301655**	**0.994303606**	**0.97717444**	**0.992883637**

Table 8 Calculating diversification

Calculate diversification d = 1 - e, and Sum it

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	-0.349560171	-0.309954199	-0.339567021	-0.281900384	-0.34113827	-0.287969566	-0.324947714
QH2	-0.317850529	-0.343531156	-0.268653736	-0.325386842	-0.328030446	-0.317049736	-0.338385477
QH3	-0.3360174	-0.255783418	-0.352468224	-0.306106069	-0.29144632	-0.317049736	-0.308296423
QH4	-0.317850529	-0.328914603	-0.298626578	-0.325386842	-0.328030446	-0.287969566	-0.338385477
QH5	-0.264218431	-0.343531156	-0.321887582	-0.351830104	-0.311624528	-0.362663076	-0.287969566
e	0.985124658	0.982774441	0.982456696	0.988301655	0.994303606	0.97717444	0.992883637
d = 1 - e	**0.014875342**	**0.017225559**	**0.017543304**	**0.011698345**	**0.005696394**	**0.02282556**	**0.007116363**

Table 9 Computing weight vector W

W = (1 - e) / ($\sum$ (1 - e)) = d / $\sum$ d

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	-0.349560171	-0.309954199	-0.339567021	-0.281900384	-0.34113827	-0.287969566	-0.324947714
QH2	-0.317850529	-0.343531156	-0.268653736	-0.325386842	-0.328030446	-0.317049736	-0.338385477
QH3	-0.3360174	-0.255783418	-0.352468224	-0.306106069	-0.29144632	-0.317049736	-0.308296423
QH4	-0.317850529	-0.328914603	-0.298626578	-0.325386842	-0.328030446	-0.287969566	-0.338385477
QH5	-0.264218431	-0.343531156	-0.321887582	-0.351830104	-0.311624528	-0.362663076	-0.287969566
e	0.985124658	0.982774441	0.982456696	0.988301655	0.994303606	0.97717444	0.992883637
d = 1 - e	0.014875342	0.017225559	0.017543304	0.011698345	0.005696394	0.02282556	0.007116363
W = d / $\sum$ d	**0.153384297**	**0.177618119**	**0.180894484**	**0.12062529**	**0.058737295**	**0.235361472**	**0.073379041**

Table 10 Calculating weightages

	W	W in %
Tolerance	0.153384297	15.33842967
Predictability	0.177618119	17.76181194
Durability	0.180894484	18.0894484
Integrity	0.12062529	12.06252896
Energy efficiency	0.058737295	5.873729536
Flexibility	0.235361472	23.53614719
Real-time	0.073379041	7.337904082

be assigned a level of importance or relevance in order to calculate weights in a decision support system. Entropy-based, equally weighted, or ways based on entropy can all be used to calculate the weights. These methods can be either objective or subjective. We may order the alternatives based on how well they perform overall by averaging the criteria values for each choice and adding the weights (Table 10).

Various quantum features were weighted according to specific criteria, these evaluation is carried out for the purpose to rank appropriate healthcare features [49].

4.2 TOPSIS method for ranking criteria

The second most popular and frequently used MCDM approach, after the Analytic Hierarchy Process, was the creation of the TOPSIS technique by Yoon and Hwang in 1981. This is because it's user-friendly and flexible enough to accommodate different requirements and choices. The TOPSIS calculation involves a number of steps, including vector normalisation of the decision matrix, calculation of the weighted normalised decision matrix, identification of the positive ideal solution (PIS) and negative ideal solution (NIS), computation of the distance between each alternative and the PIS and NIS, determination of the ranking index, and finally ranking of the preference order [50].

Each criterion for the TOPSIS decision matrix was scored on a scale of 1 to 10, as shown in Table 11. The choice matrix is created by combining several criteria and alternatives in a matrix. As illustrated, a matrix with "n" choices and criteria may be formed (1).

$$D = \begin{matrix} A_1 \\ \vdots \\ A_n \end{matrix} \begin{bmatrix} C_1 & \cdots & C_n \\ Z_{11} & \cdots & Z_{1n} \\ \vdots & & \vdots \\ Z_{m1} & \cdots & Z_{mn} \end{bmatrix} \quad (1)$$

A_1, A_2, ……. A_n are representing the alternatives while the C_1, C_2……. Cn are showing the criteria.

To create a decision matrix, one must first identify the decision criteria and the alternatives. Choose the problem or decision that has to be made. Decide what needs to be accomplished in terms of objectives or goals. Decide which decision criteria are important for attaining the goals. These requirements must be verifiable and applicable to the choice being made. Determine the options you are analyzing. These options must be feasible and relevant to the decision-making process. Organize the options into rows and the deciding criteria into columns to create the decision matrix. Assign values to each choice criterion in the decision matrix to show how well each alternative performed against that criterion. The values in the decision matrix should indicate how each

Table 11 Decision Matrix

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	8	6	7	5	9	4	8
QH2	6	8	4	7	8	5	9
QH3	7	4	8	6	6	5	7
QH4	6	7	5	7	8	4	9
QH5	4	8	6	9	7	8	6

Table 12 Normalized decision matrix

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	0.039800995	0.026200873	0.036842105	0.020833333	0.030612245	0.02739726	0.025723473
QH2	0.029850746	0.034934498	0.021052632	0.029166667	0.027210884	0.034246575	0.028938907
QH3	0.034825871	0.017467249	0.042105263	0.025	0.020408163	0.034246575	0.022508039
QH4	0.029850746	0.030567686	0.026315789	0.029166667	0.027210884	0.02739726	0.028938907
QH5	0.019900498	0.034934498	0.031578947	0.0375	0.023809524	0.054794521	0.019292605

alternative performed in relation to each choice criterion and should be measurable.

A decision matrix that has been normalized is one in which an appropriate weight or significance factor has split each value. Normalization is crucial in the decision-making process because it enables a fair comparison of options across several criteria with varying scales or units of measurement. The normalized decision matrix can be calculated by using the given formula (2) and the matrix is shown in Table 12.

$$\overline{X_{ij}} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^{n} X_{ij}^2}} \quad (2)$$

For the purpose of finding the weighted normalized decision matrix, the criteria weights obtained by the implementation of AHP are multiplied with each criteria of the normalized decision matrix as shown in the Table 13.

$$V = \begin{bmatrix} V_{11} & \cdots & V_{1n} \\ \vdots & \ddots & \vdots \\ V_{m1} & \cdots & V_{mn} \end{bmatrix} \text{where } V_{ij} = W_j \times R_{ij} \quad (3)$$

In a multi-criteria decision support system, the ideal solution serves as a benchmark for assessing and ranking the decision matrix's possibilities. The best feasible combination of criteria values for each criterion in the decision matrix is what is referred to as an ideal or perfect answer. In multi-criteria decision-making, two sorts of ideal solutions are frequently employed. Ideal positive response: This is the ideal set of criterion values for each criterion in the decision matrix. Choose the highest value possible for each decision matrix criterion to get it. Ideal negative solutions: This is the worst feasible combination of criterion values for each criterion in the decision matrix. It may be found by choosing the lowest value for each decision matrix criterion.

The ideal solutions can be calculated using Eqs. (4) and (5).

$$V_j^+ = \{(\max i(V_{ij}) \; if \; j \, \mathcal{E} J); (\min i(V_{ij}) \; if \; j \mathcal{E} J^/)\} \quad (4)$$

$$V_j^- = \{(\min i(V_{ij}) \; if \; j \, \mathcal{E} J); (\max i(V_{ij}) \; if \; j \, \mathcal{E} J^/)\} \quad (5)$$

Beneficial parameters are denoted by J, while non-beneficial are denoted by $J^/$. The results are presented in Table 14.

The following equations are utilized to measure ideal and non-ideal solutions.

$$S^+ = \sqrt{\sum_{J=1}^{n} (V_{ij} - V^+)^2} \quad (6)$$

$$S^- = \sqrt{\sum_{J=1}^{n} (V_{ij} - V^-)^2} \quad (7)$$

Once the ideal positive and negative solutions have been determined, they may be utilized to determine how far apart each alternative is from the ideal solutions. The sum of the squared differences between the alternative and ideal positive values is used to assess how far away the solution is from being ideal.

Table 13 Weighted normalized matrix

Weightage	0.153384297	0.177618119	0.180894484	0.12062529	0.058737295	0.235361472	0.073379041
	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	0.006104848	0.00465375	0.006664534	0.002513027	0.00179808	0.00644826	0.001887564
QH2	0.004578636	0.006205	0.003808305	0.003518238	0.001598294	0.008060324	0.002123509
QH3	0.005341742	0.0031025	0.00761661	0.003015632	0.00119872	0.008060324	0.001651618
QH4	0.004578636	0.005429375	0.004760381	0.003518238	0.001598294	0.00644826	0.002123509
QH5	0.003052424	0.006205	0.005712457	0.004523448	0.001398507	0.012896519	0.001415673

Table 14 Ideal solution (best, worst)

	Tolerance	Predictability	Durability	Integrity	Energy efficiency	Flexibility	Real-time
QH1	0.006104848	0.00465375	0.006664534	0.002513027	0.00179808	0.00644826	0.001887564
QH2	0.004578636	0.006205	0.003808305	0.003518238	0.001598294	0.008060324	0.002123509
QH3	0.005341742	0.0031025	0.00761661	0.003015632	0.00119872	0.008060324	0.001651618
QH4	0.004578636	0.005429375	0.004760381	0.003518238	0.001598294	0.00644826	0.002123509
QH5	0.003052424	0.006205	0.005712457	0.004523448	0.001398507	0.012896519	0.001415673
Vj+	0.006104848	0.006205	0.00761661	0.004523448	0.00179808	0.012896519	0.002123509
Vj-	0.003052424	0.0031025	0.003808305	0.002513027	0.00119872	0.00644826	0.001415673

Similarly, with the signs of the differences switched around, the distance from the ideal negative solution is determined. The relative proximity of each option to the ideal solutions is then determined using the distance from the ideal positive solution and the distance from the ideal negative solution. The ideal positive and negative solutions are calculated from eqs. (6) and (7) for ranking the alternatives, as shown in Table 14.

5 Conclusions

Technological advancement has revolutionized and enhanced the overall quality of people's lives. Numerous IoT devices collect the person information, which is then processed and stored on various systems and servers for further uses. The data can be categorized into various forms that is then used for prediction purposes to save time and to overcome the computation complexity. This article describes how the quantum computing method is being utilised to improve the operational efficiency and effectiveness of the healthcare institution. In the literature review, significant quantum computing characteristics are analysed. An entropy method is utilised to weigh each of these features, and an MCDM TOPSIS-based strategy is used for selecting the features that would improve the patient care system. The study will assist the health organization and researchers working to implement a model and framework based on quantum computing conception for making the lives of people easier and happier one.

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Declarations

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