

The Intersection of Health Policy and Technology: Applying Quantum Computing for Optimizing Healthcare System Simulations and Predictions

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ABSTRACT

The convergence of fitness coverage and generation is a vital frontier in present-day healthcare, giving probabilities for innovation and optimization that have no means to visible earlier. The cause of this paper is to research the capacity for quantum computing to enhance computer simulations and forecasts of healthcare systems. To revolutionise customized medication processes, provided a progressive approach that everybody termed Efficient Personalised Medicine through Quantum Machine Learning Analysis (EPM-QMLA). This approach combines the abilities of quantum computing with device learning. The significance of this work is living inside the fact that it has the potential to substantially beautify the results of healthcare by way of making it possible to expand remedy plans which are greater correct and individualized. Nevertheless, there are limitations, inclusive of the fact that quantum computing programs in healthcare are still in their infant degrees, which necessitates the introduction of stable infrastructure and algorithmic advancements. The modern capacity of EPM-QMLA is verified through simulated analyses in a lot of healthcare situations. This demonstrates the capability of EPM-QMLA to optimise useful resource allocation, predict infection progression, and personalize remedies to particular patient profiles. Through this examine, the promise of quantum computing as a sturdy device for advancing healthcare coverage and exercise is highlighted. This will pave the manner for a healthcare device this is greater efficient and targeted on the patient.

1. Introduction

Improving forecasts and simulations of healthcare structures is a big capacity final results of the convergence of fitness policy and generation, specifically with the help of quantum computing [1]. The fantastic processing ability of quantum computers permits for the examination of sizeable and complex datasets, which in turn allows for the fast and correct modelling of complicated healthcare situations [2]. Better healthcare demand forecasting, aid allocation, and coverage alternate impact tests are all made possible with this functionality, making it an important device for health policymakers [3]. Policymakers can enhance healthcare transport and effects by using the use of quantum computing to plot greater powerful techniques [21]. Big boundaries exist, despite the fact that, whilst looking to comprise quantum computing into healthcare systems [5]. Significant investments in infrastructure and specialised expertise are required for the reason that era is still in its early stages [6]. Due to the sensitive nature of sufferers' clinical facts and the extreme consequences that might result from information breaches [20], protecting their privacy and security is of paramount importance [8]. Furthermore, policymakers, healthcare carriers, laptop scientists, and quantum physicists need to paintings together in an interdisciplinary effort [9] for the implementation to be a success [22]. To integrate quantum computing's theoretical advances into healthcare's actual international, this partnership is vital [11]. To similarly guarantee moral norms and affected person safety, thorough regulatory frameworks are required to manipulate the utility of quantum computing to healthcare [12]. Although there are a few barriers, quantum computing has the potential to significantly improve healthcare via remodelling how people understand and control health structures [23]. Better fitness consequences for populations round the sector can be ours when people use this state-of-the-art technology to make healthcare shipping greater green, powerful, and equitable [14]. Examine the potential of quantum computing to improve healthcare management and policy by increasing the precision and velocity of healthcare simulations and projections [10]. The EPM-QMLA method combines machine learning with quantum computing to generate accurate, personalised treatment programmes; it needs to be developed and reviewed [4]. Optimise resource allocation, anticipate illness development, and customise treatments to distinct patient profiles with EPM-QMLA. Improve healthcare efficiency and patient outcomes. Here is the organised outline of the study papers continue for the following section: Section II delves into the topic

of health policy and technology nexus, specifically how to optimise simulations and predictions of healthcare systems through the application of quantum computing. Effective Quantum Machine Learning Analysis for Individualised Health Care (EPM-QMLA) is the subject of Section III. Results and comparisons to previous methods are given in Section IV of the full assessment [7]. The Results Summary is found in Section V.

2. Literature Review

The potential for quantum computing to revolutionise numerous medical applications has made its way into the healthcare industry in recent years. The possibility of Quantum computing in healthcare (QCP-H) is thoroughly examined in the research of Ur Rasool et al., [15] with an emphasis on computationally demanding medical applications such as personalised medicine and drug development. This is helpful for identifying opportunities in the current state of affairs and developing useful quantum healthcare applications. This dynamic relationship has been studied by Ahmadi, A., [24], who explains that industries could be revolutionized by Quantum Computing and Artificial Intelligence (QC&AI) like encryption and pharmaceutical research. Its benefits are discussed; challenging issues it throws at us, as business people dealing with intricate questions; what it would mean for us if we were to engage in such a venture; and some of the ethical considerations arising from these interventions. Thus, based on Sharma et al.'s [17] findings Quantum Computing (QC) will provide an analysis of dense genetic information which will lead to personalized medicine revolution[13]. It also looks forward to defining better treatment outcomes with fewer adverse events associated with reduced side effects; designing personalized prevention plans; and making new drug development easier for implementation under personalized health care through QC. For instance, Innovative Teaching Methods (ITM) that are interactive simulations designed to enhance quantum literacy skills among public health practitioners have been endorsed by VanGeest et al., 2019 [26]. Public health practitioners will need to educate their staff for them not to be disrupted by quantum so that they use these technologies for surveillance of diseases prognosis as well as health records analysis. To achieve explainable AI in healthcare Zhou et al. [25] proposed Quantum Optical Neural Networks QONNs. First step is pre-processing for securing and validating medical data after which QONNs are designed using optical components and qubits while Improved Genetic Algorithms are used to optimize them[16].” There would be expert opinion surveys conducted alongside comparative analysis that were meant for informed decision-making on top of improved health analytics”[18]. These advancements demonstrate how disruptive quantum technologies are in shaping the future of public health towards data-driven efficiency but also in terms of personalized medicine or treatment efficacy[19].

3. Methodology

A holistic approach to healthcare advancement that incorporates data preparation, simulation, individualized treatment planning, computational machine learning and health analysis of policies. The goals of this framework are to enhance patient care, optimize resource allocation and influence evidence based health policy through different sources of knowledge and advanced technologies.

Quantum Computing Healthcare Applications

Personalized medicine based on genetic analysis, drug development, and healthcare logistics optimization are some of the potential uses of quantum computing in healthcare, according to a taxonomy of these applications. By improving mathematical models for disease development and treatment efficacy and speeding up simulations, quantum algorithms can transform medical study and therapeutic methods via the solution of complicated computing issues.

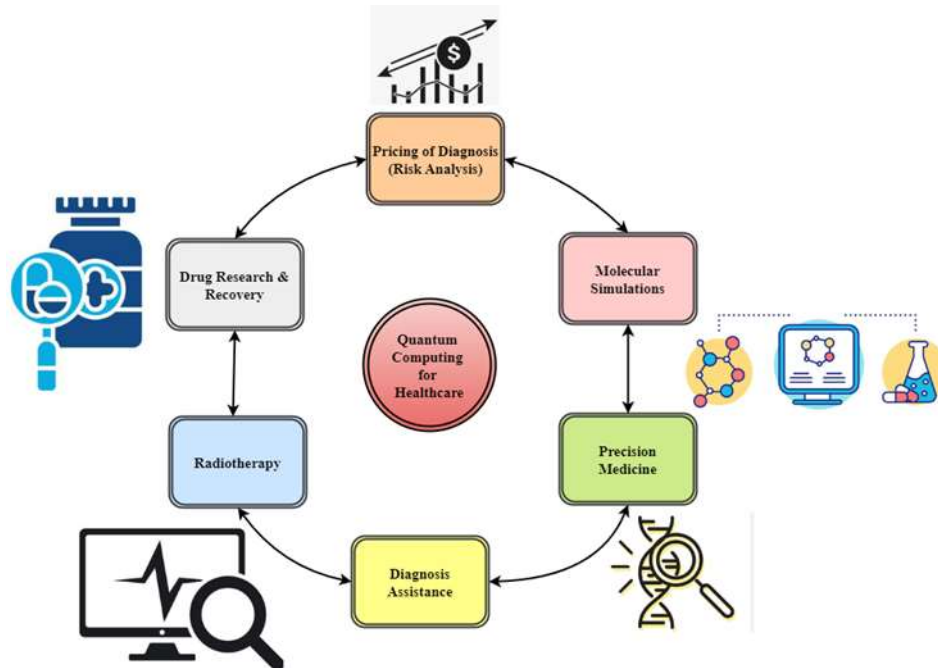


Figure 1. A taxonomy of possible healthcare applications using quantum computing

The benefits of quantum computing over traditional computer systems have recently been shown in Figure 1. Disease detection and treatment are both made incrementally faster by quantum computing, which, in some applications, may dramatically shorten calculation times from millennia to minutes. It inspires novel approaches to achieving superior competence in certain domains, as well as fresh frameworks and methods. Consequently, healthcare service providers and the health industry as a whole stand to benefit greatly from the use of quantum computing in several contexts, including but not limited to optimized pricing, tailored therapy, and expedited diagnosis. The availability and accessibility of health-relevant data sources on a global scale have greatly improved, leading to a noticeable uptick in the usage of classical modeling and quantum-based techniques, according to a literature review. In this part, the developers will discuss many possible healthcare uses of quantum computing; Figure 1 shows one of these applications in action.

Cohort Multi-modal Data Outline

The first of several critical stages in identifying a cohort utilizing multi-modal data is integrating multiple data sources such as genetic data, wearable sensors, and Electronic Health Records (EHRs). Second, make sure the data is consistent and high-quality by preparing it with cleaning, standardization, and integration. The last step is to use sophisticated analytics and machine learning methods to divide the population into subsets defined by common traits this will allow for more precise studies or treatments depending on individual patients' requirements.

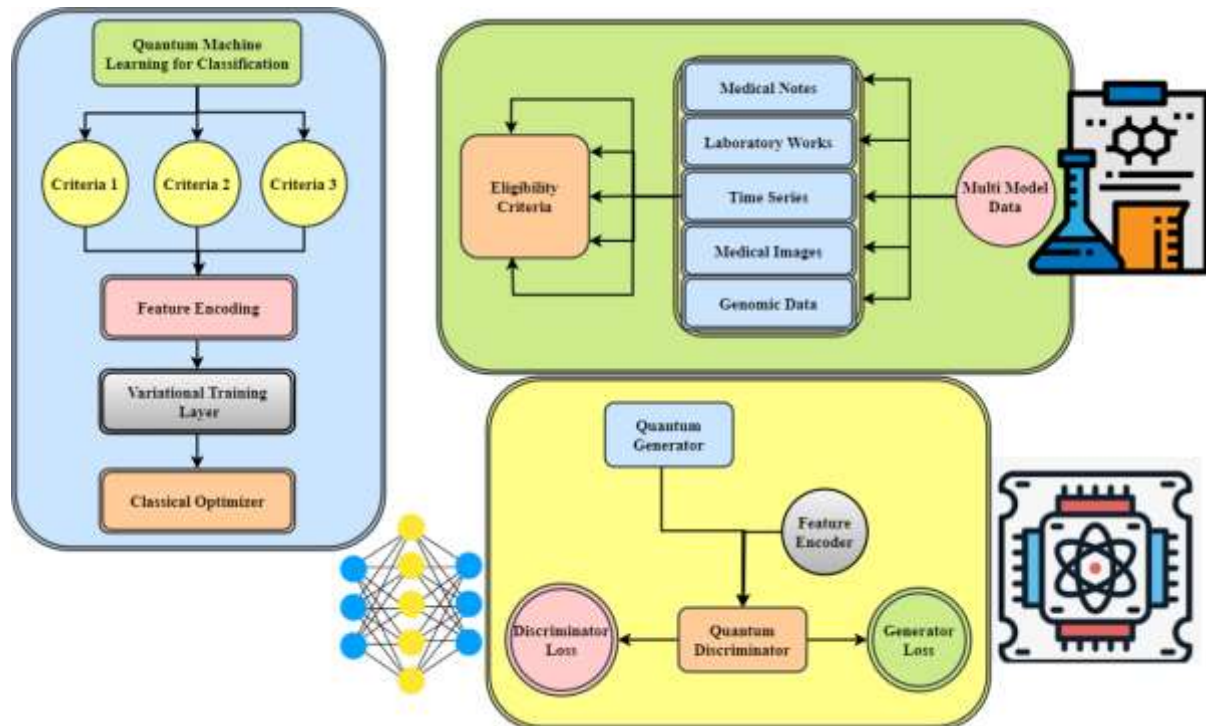


Figure 2. An outline of the steps involved in identifying a cohort using multi-modal data

Among the many applications of Quantum Neural Networks (QNNs) in machine learning, has recently attracted a lot of attention for its distinct benefits is shown in figure 2. To address these issues with conventional QNN has been suggested. For example, it has been shown that can generate robust models with minimal training data. Many variants exist, including hybrid models that combine quantum generators with classical discriminators and complete quantum versions that use QNNs for both tasks. The QNN shows a distinct advantage in fully quantum settings when optimizing both the generator and the discriminator as part of a linear programming problem. Practical applications of complete quantum QNN include the creation of basic synthetic pictures using the dataset, and the synthesis of random distributions via the use of hybrid versions including both quantum generating and classical discriminators. Consequently, these configurations may serve as a synthetic controlled arm for clinical trials by generating complicated distributions that match distributions from actual patient biological data with far less training data, utilizing either a complete quantum version.

Healthcare Analytics and Management Assistance

Healthcare delivery may be optimized with the help of a coordinated system that blends state-of-the-art analytics technologies with management support systems. To improve the treatment of patients and operational efficiency, it uses data from several sources, like as EHRs and continuous monitoring devices, uses predictive modeling to allocate resources, and gives decision-makers practical insights. The overarching goals of this system are to facilitate evidence-based decision-making in healthcare settings, enhance clinical outcomes, and standardize healthcare operations.

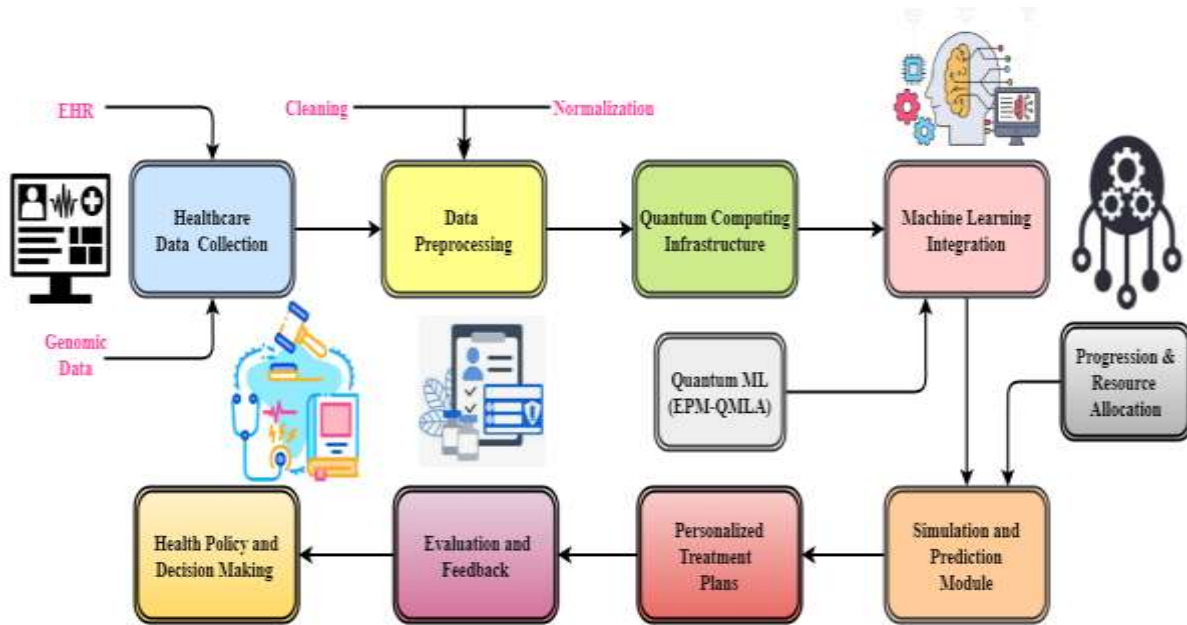


Figure 3. An Interconnected Structure for Advanced Medicine Insights and Administrative Support

As illustrated in figure 3, this is how it is shown that the data-driven healthcare approach supports systematicness using modern technology. Firstly, information is collected from various sources such as electronic health records (EHRs), genomics and wearables. These are key sources for advanced analytics since they offer comprehensive patient histories and real-time health indicators. Additionally, the collected data should be made ready for analysis by processing through cleaning, normalizing and integrating of the same. The first step to ensure all requirements are met is to prepare the data for upcoming healthcare applications and purposes. Furthermore, at this level, machine learning based on quantum computing algorithms combines traditional training models with quantum; Thus, allowing for complex computation through quantum hardware treatments, increased analytical capabilities to support diagnostic and predictive modeling, personalized treatment protocols facilitated by this holistic approach have improved how health care decisions are made. Conversely, treatments can be individualized as simulation and prediction models will help to utilize individual-specific information but also reallocate resources more efficiently. Finally, positive global public policy on health care delivery can lead to a change path focused on improving the quality of medical care delivery, supporting evidence-based policy benefits of experts in the health sector.

Feasibility determination with mathematical calculations

One could therefore apply mathematical representations to evaluate quantifies if the method is practical against measures like computational efficiency, prediction accuracy and resource optimization. As a result of running these computations, we would test scalability of quantum computing techniques together with machine learning algorithms when dealing with massive datasets from hospitals sourced out there. The goal of the framework's evaluation of these measures is to show that it can successfully improve decision-making and patient outcomes.

$$gcr + fx + J(\cos Sx) = (cot - r(n + x))^{ikq-s} = hg_{zq}^{t+1} \quad (1)$$

The equation 1 (EPM-QMLA) method factors in healthcare system modeling are likely indicated by gcr , fx , and $J(\cos Sx)$, while forecasting algorithms or computational outcomes enhanced by quantum computers and algorithmic learning could be represented by $J(\cos Sx)$, $kq - s$ and hg_{zq}^{t+1} .

$$C.\nabla\exists c = F \frac{ag}{t^2 DG} + \frac{d_2 D(a+r)}{cxr^2} - \frac{1}{tanxkl^2} (l - kf) \quad (2)$$

Equation 2 does depict a mathematical model of $C.\nabla\exists c$ the dynamics and interconnections $F \frac{ag}{t^2 DG}$ in biological or healthcare systems. This model might be relevant $d_2 D(a+r)$ to computational models

cxr^2 of illness development, $\frac{1}{\tan xkl^2}$ optimization of resource allocation, or medication customization according to patient profiles within the framework $(l - kf)$ of EPM-QMLA.

$$\frac{e^2s}{\omega tc_2} = \left(vs^2 + \frac{\omega g}{1 - C(s - \rho\phi)} \right) + \frac{(q - pr) + qz(s - t)}{\cos(r - q) + 1} - \frac{1}{\cos(\epsilon - \gamma)} \quad (3)$$

This Equation is optimized using quantum computing methods ωg . It involves many parameters, including $\frac{e^2s}{\omega tc_2}$. By integrating these models vs^2 to EPM-QMLA, it may improve $1 - C(s - \rho\phi)$ healthcare results through the use of cutting-edge computational approaches by simulating healthcare situations, allocating resources optimally $(q - pr) + qz(s - t)$, and tailoring therapies $\cos(r - q) + 1$ to individual patients based $\cos(\epsilon - \gamma)$ on their unique data.

$$\frac{f^2z}{st^2r} = \left(v^2 + \frac{g \propto}{1 - (x + tq)} \right) + \frac{(1 - qi)}{1 + \cos(r - s)} - \frac{1}{n - sq} \quad (4)$$

The given equation 4 may be written as intricate, including factors that might be associated with healthcare-simulated settings. Within the framework of EPM-QMLA, this expression $1 - (x + tq)$ may stand for a model that combines v^2 the computational capacity of quantum computing denoted by f^2z , st^2r with the characteristics $\frac{(1 - qi)}{1 + \cos(r - s)}$ of the healthcare system $1 - qi$, $\frac{1}{n - sq}$.

$$cxt \sim fxq = 8gj q + \frac{1}{2}([tv - ph]) - \cos + \frac{1}{2}(v + \partial x) \quad (5)$$

Equations 5 represent the intricate interactions and optimizations found in quantum algorithms which also pertain to healthcare. Here, cxt could stand for a computational state, fxq for particle impacts and the context like $8gj q$ and $([tv - ph]) - \cos$ for particular data modifications or computational $\frac{1}{2}(v + \partial x)$ processes within this quantum artificial intelligence framework.

$$\int_h^{(i-x)} (1 + Cx) + kZ(q - r) = \int_{Gt}^2 xq - vj(q - 1) \quad (6)$$

Equation 6 when applied to provide a mathematical framework $(i - x)$ for healthcare system optimization $1 + Cx$ of resource allocation or progressive prediction of sickness. As a means to improve healthcare $kZ(q - r)$ outcomes and individualized $xq - vj$ treatment plans, quantum machine learning methods like EPM-QMLA seek to use superior computing capabilities $q - 1$ to solve such complicated equations more effectively.

$$g(e - q) = \frac{1}{nkf} - \sum_{q=1}^g \frac{i(q - x)}{r + qk} - (q - 1) + Iq(z - gi) \quad (7)$$

The Equation 7 may stand in for a computer model that optimizes resource allocation, predicts illness development, $g(e - q)$ or uses patient data $r + qk$ to personalize $(q - x)$ therapies using Resource allocation analysis. Its components presumably deal with parameters such as patient data $\frac{1}{nkf}$, medication factors $q - 1$, and prediction results $Iq(z - gi)$.

$$g = S_t R \log \left(1 - \frac{[R_{s-1}] - B_{n.R} + S}{Q_1 - F(\vartheta_2 R)} \right) - T_x(o - 1) \quad (8)$$

Equation 8 is associated to g an optimization function or dynamic model S . The calculation stands $B_{n.R}$ in for a computer model that efficient analysis of resources $S_t R \log$, outcomes for patients $T_x(o - 1)$, and the effectiveness of treatments $[R_{s-1}]$.

The suggested integrated framework uses advanced data approaches and technology to tackle the

complexity of contemporary healthcare. To ensure that quality high-quality data is obtained during preprocessing stage, the architecture begins with strong data collection from such sources as EHRs, genetic information or wearable devices. Advanced analytics for modeling predictions and individualized treatment planning are made possible by the combination of a quantum computing infrastructure with machine learning infrastructure framework aims to enable informed decision-making using simulations and policy analysis, to improve healthcare management and resource allocation. This method highlights how data-driven insights might revolutionize healthcare delivery and policymaking.

4. Results and discussion

Quantum Computing (QC) is an innovator in the healthcare industry, especially for evaluating efficiency and allocating resources

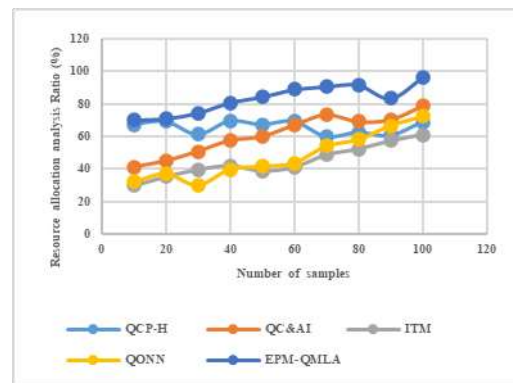


Figure 4. Resource allocation analysis

In the above figure 4, healthcare administration requires efficient resource allocation; which quantum computing can improve. EPM-QMLA analyses huge datasets at unprecedented speeds and precision to facilitate asset allocation using quantum computing. This technique forecasts impacted person needs and illness trends using predictive analytics to shift resources in real time. To prepare for emergencies, EPM-QMLA can predict hospital admission surges and mobilise staff, beds, and medication sooner. EPM-QMLA can identify high-quality treatment regimens for certain groups based on patient records, helping allocate resources to therapies with the highest promise. This personalised approach optimises resource use and patient outcomes. This generation of healthcare statistics requires quantum infrastructure spending and complicated algorithms. Quantum physicists, statistics scientists, and healthcare experts must collaborate to scale computational discoveries globally. Quantum computing resource allocation optimisation may be advantageous despite these challenges. Agility and performance can help healthcare devices adapt to changing needs and improve care produces 96.2%. EPM-QMLA improves performance, efficacy, and fairness at the health policy-era crossroads, a major healthcare aid allocation breakthrough.

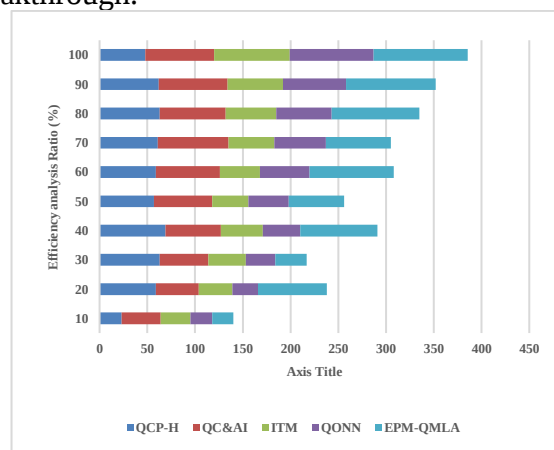


Figure.5 Efficiency analysis

In the above figure 5, performance evaluation is needed to comprehend quantum computing's expanding impact on healthcare device modelling and forecasting. Quantum computing, notably EPM-QMLA, enhances processing speed and statistics management. Increased computing capability allows complex datasets to be examined quickly, improving healthcare models. Disease modelling, treatment result prediction, and how to allocate resources can be done faster and more efficiently with EPM-QMLA. Infection development modelling can be computationally and time-consuming. Quantum computing may update and make decisions exponentially faster. EPM-QMLA's ability to analyse genetic and patient health records allows for a fully customised pharmacological strategy. This extensive analysis guarantees that treatment plans are customised to each patient and created quickly by removing guesswork and maximising efficiency produces 98.7%. Allocating resources based on accurate estimates helps healthcare providers be greener and save money. Quantum computing in healthcare demands advanced infrastructure, skilled staff, and algorithms. Despite these challenges, quantum computing's efficiency promises a more sensitive, flexible, and green healthcare equipment that better meets patient and healthcare corporate needs. When applied to healthcare, quantum computing will accompany in a new era of optimal use of available resources. Incorporating quantum technologies has the potential to revolutionise healthcare delivery, leading to more efficient, long-lasting, and fair healthcare systems worldwide.

5. Conclusion and future scope

Finally, a revolutionary strategy for enhancing healthcare machine forecasts and simulations is to combine quantum computing with fitness policy. The consequences of this study exhibit how EPM-QMLA has the ability to completely rework the field of personalised medicinal drug. Through the utilisation of quantum computing and machine mastering, EPM-QMLA gives a modern method to developing unique and customized treatment programmes. The effectiveness of EPM-QMLA in optimising resource allocation, forecasting illness development, and adapting remedies to precise affected person profiles has been tested with the aid of the simulated analyses across numerous healthcare situations. By improving remedy efficacy and personalisation to each affected person's wishes, this has the ability to greatly enhance healthcare outcomes. Nonetheless there are loads of boundaries that want to be overcome earlier than quantum computing may be fully utilised in healthcare. These include creating strong infrastructure and complex algorithms. While exploring the ability of quantum computing in healthcare, it is crucial to spend heavily and paintings together across disciplines to shut the distance between principle and exercise. In spite of those boundaries, EPM-QMLA has undeniable capacity as a mighty instrument for improving healthcare policy and practice. This research suggests the vital position of quantum computing in defining the future of healthcare by using paving the way for a greener device that centres around patients. This look at its effects assist in addition research and funding into quantum computing era within the pursuit of a universally handy, fantastic healthcare gadget that is additionally extra efficient, individualised, and honest.

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