

Role of Cloud Computing in Healthcare Systems

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ABSTRACT

The healthcare industry is complex because it is so vast in terms of the processes involved and the amount of private and sensitive information it needs to deal with. The industry's complexity often leads to two major challenges – increased operational cost (including data storage cost) and difficulty in building a self-sufficient health ecosystem. Technology has always been the savior that workarounds for overcoming major healthcare industry challenges. One such technology is cloud computing. It has been in use in the healthcare industry for several years and continuously evolving with industry changes. Cloud computing is transforming the healthcare industry at different levels with features like collaboration, scalability, reachability, efficiency, and security.

The on-demand computing feature of the cloud adds value, especially when healthcare institutes and care providers need to deploy, access and handle network information at the drop of a hat. With the rise in demand for data-based security, there needs to be a shift in the creation, usage, better storage, collaboration, and sharing of healthcare data techniques. It is where cloud computing leaves no stone unturned!

Healthcare is one such sector that has been at the forefront of adopting cloud technology. Healthcare providers are coming to realize the true potential of cloud solutions across the globe.

According to the BBC research report, estimated global spending by stakeholders in the industry on cloud computing is expected to be around 35 billion dollars by 2022. It is anticipated that the CAGR of cloud services and solutions will maintain a trajectory of 15% rise and the size of the Cloud-powered healthcare market is to be around 55 billion dollars by the year 2025.

KEYWORDS: *healthcare, cloud, computing, systems, role, technology, information, operational*

INTRODUCTION

The growing demands of technology have compelled the options for reliable infrastructure in IT and data storage. The one that has acquired center stage over the few years is the concept of cloud technology.

In its simplest form, “cloud computing” refers to the on-demand availability of computer system resources like data storage or computing power. The term “cloud” is used to describe data centers available to many users over the internet, distributed over multiple locations from central servers.[1,2]

Cloud computing provides easy storage of documents in a place where you can access them from any device at any time. Initially, all of the applications and software had to be on a computer or server that you could only access at a specific location. Due to the introduction of the cloud, people could access their programs and information using the internet. This principle is also applicable to data storage. Despite keeping folders full of critical work on your computers and servers, it is possible to store the data remotely and can be backed up to the cloud.

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For example, Netflix works on cloud computing to run its video streaming service and other business systems.



Cloud-based healthcare refers to integrating cloud computing technology for the creation and management of cloud-based health care services. More healthcare providers are looking to work with vendors that provide cloud computing solutions to save and retrieve their digital records. As the information can be stored securely off-site, it is regarded as a significant benefit for large and small provider organizations. A Cloud-based healthcare system addresses the following essential requirements in the healthcare industry:

- On-demand access to computing with enormous storage resources, which are not feasible in traditional healthcare systems.
- Support large datasets for EHR, radiology images and genomic data offloading.
- Ability to share EHR among authorized physicians, hospitals and care-providing institutions in different geographic locations,

offering timely access to life-saving information and minimizing the needs of duplicate testing.

- Improvement in analysis and monitoring the data on diagnosis, treatment, cost and performance.[3,4]

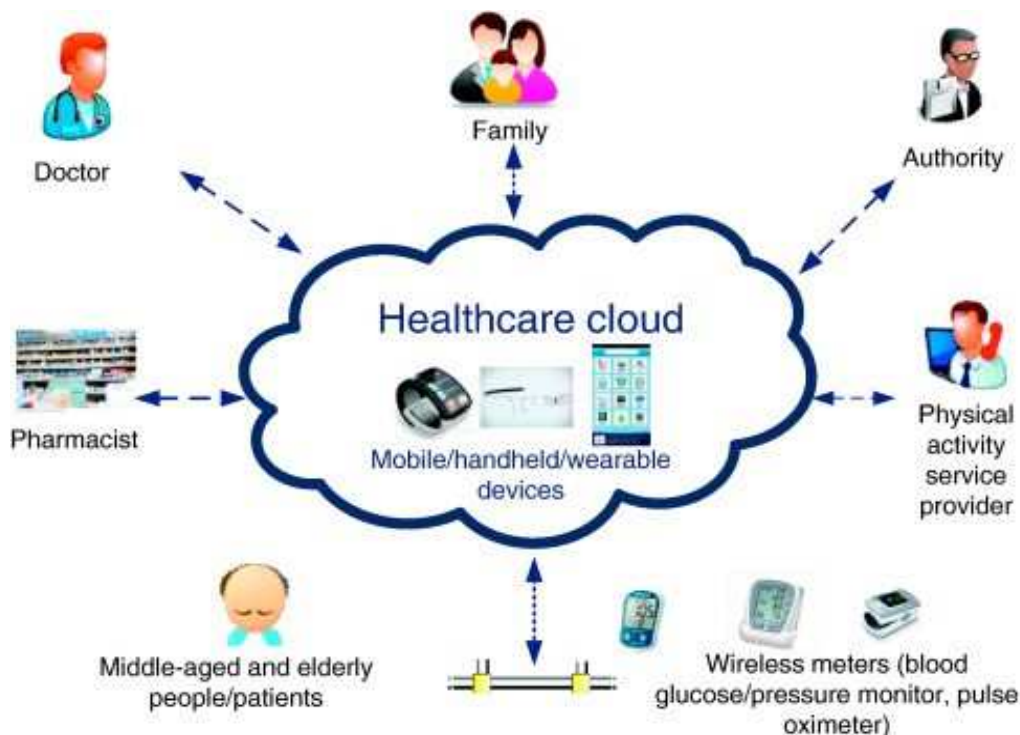
Discussion

A cloud-based healthcare system reduces operational spending while giving better-personalized care, efficient workflows, resulting in better health services. At the same time, patients receive quicker responses from healthcare providers and can access their healthcare data with improved tracking.

When a healthcare ecosystem is managed on an on-premise server, it includes EMR and medical billing systems. Therefore, the expenses will be high due to overhead factors such as

- Maintenance of upgrading records
- Backup amenities
- Load balancing issues
- Space Utilization

With these shortcomings, opting for a cloud health strategy is a need of time. Adopting a cloud-based health system would manage all overheads and infrastructure. The cloud-based healthcare system develops a confined plan in remote patient monitoring with telehealth and telemedicine solutions. Regulating easy interoperability with an organized hierarchy are the objectives of any cloud-based healthcare system. A well-organized cloud-based healthcare system develops new insights for healthcare management solutions. As cloud computing is a giant shared pool in the healthcare industry, cloud solutions can scale up or shrink all the storage resources and adapt to ever-changing needs.



Healthcare organizations have been adopting new technologies to streamline processes, deliver new patient care applications and provide improved healthcare services. Despite these IT solutions, they face challenges like high infrastructure cost, the need for computational resources, scalability, all-over access, multi-tenancy and rising demand for collaboration. The following characteristics of the cloud address these challenges:

- **On-demand service:** The resources are provided immediately without any human intervention.
- **Resource Pooling:** Multiple users can have access to cloud services at the same time.
- **Elasticity:** It is possible to add, remove or upgrade as per the organizational requirements.
- **Broad Network Access:** A wide range of network accessibility is provided from any location at any time.
- **Measured Service:** Clients need to pay only for what they utilize.[5,6]

Results

Cloud computing offers various benefits by allowing users to use infrastructure, platforms and Software provided by the cloud providers. Cloud Computing in healthcare can be of two types. The distribution model (Hardware/Software) can be deployed as Software as a Service, Infrastructure as a Service, and Platform as a Service. The deployment model (who owns it) can be private, community, public, and hybrid. Following are the benefits of cloud-based innovative solutions to overcome the pain points of the healthcare industry.

1. Centralized Access to Digital Health Records

Earlier, all the patients carried separate files or medical records for their every physician's visit. It has become challenging for doctors and staff to maintain and managing the paperwork. This process is now replaced and made more manageable through cloud migration. With cloud services, all the medical records are located at a single centralized location. These records remain accessible through web portals at healthcare centers and can be retrieved whenever required. A secure cloud platform ensures data storage facilities with hosting solutions and virtual machines for swift access to medical records and patients' quick diagnosis.

2. Improved Patient care standards

A cloud-based healthcare solution enhances patient care by bringing innovative treatment to the desk. With few clicks, a patient can initiate virtual sessions or schedule an appointment with a doctor, execute auto-reminders for the upcoming appointments, follow-ups using cloud services. After surgery, regular interaction with doctors, a reminder for medicine usage, and upcoming facility information are provided by the cloud platform. Patient vitals can also be supervised remotely by doctors with the help of cloud-connected medical infusion pumps. Users can share, view, and store their medical records in the cloud, while doctors can archive and access them remotely as well.

So, whenever a patient comes to the hospital, the doctors can update the health condition in the cloud system and can have the necessary treatment process in no-time. Cost-cutting, better management and timely attention to each detail are effective means of improved patient care standards.

3. Cybersecurity in HIE and PHI

Protecting healthcare information is a significant concern in the healthcare industry. Transitioning this information to the cloud can provide the right amount of security to protected health information (PHI) and healthcare information exchange (HIE) systems. Companies providing cloud computing for healthcare analyze and implement measures that secure cloud hosting. Thus, cloud computing in healthcare results in data security and protection from unauthorized access.[7,8]

HIE Cyber Security – Top Concerns

- Mobile Devices - BYOD
- Medical Devices/Robotic Surgery
- HIPAA & BAAs
- Internal & External Breaches
- Data Leakage
- Limits of Technology & Inadequate Security Systems
- Funding
- Patient's Lack of Confidence
- Third Parties-Vendors
- Remote Connections



➤ Healthcare Information Exchange (HIE)

Health information exchanges help healthcare organizations to share data present in mostly proprietary EHR systems. HIEs can be deployed via a linkage to a strategic cloud implementation. Cloud-computing systems can be designed for HIEs to be safer than traditional client-server systems against the prevalent causes of healthcare data breaches. When transitioning to cloud computing, HIE systems become

- Adaptable to various departmental needs and organizational sizes.
- Burdenless the high-cost expenses.
- Portable to access the information and systems remotely.

➤ Protected Health Information (PHI)

The high potential application of cloud computing is to manage access to personal health records (PHR) and Electronic Health Records (EHR). It allows users to access the PHR database through software and share the PHR data. For example, Microsoft health vault is a cloud-based platform used for PHR management. This platform allows patients to store, manage, and share their PHR by providing them with convenient means of importing their health data from medical devices into the Health Vault without intermediary tools and software. The medical data can be easily monitored, managed, and shared through a user interface. This program also provides advanced sharing features enabling a different level of control over shared data, multi-profile sharing, and communicating with designated health organizations, devices, or software applications, all under the data owner's vigilance. This platform uses standard sharing protocols like SOAP, CCR/CCD equipped with programmer interfaces so that the health vault becomes useful for desktop and mobile applications.



4. Cost-effective resources

Cloud computing in healthcare offers better support in HR, administrative and operational functions. It also ensures the services when it comes to scheduling, sourcing files, referrals and inventory management to make

the process efficient, lucrative and cost-effective. Therefore, better resource allocation is possible at a low cost using cloud services.

5. Scalability to emergencies

Cloud services are highly beneficial during the emergencies like pandemic outbursts, natural calamities or long traffic jams. During such times, the availability of doctors and medical assistance is insufficient. Therefore, the information is transmitted through cloud systems to the attendant with instructions about treating the injured or ailing individuals.

6. Paving the way for medical research and development

Care providers, doctors, and medical professionals invest a lot of time in research to improve their practice. They collect crucial information about surgeries and treatment. It stored and segregated information can help them analyze and research well and set them as case studies and a thesis for future reference to other doctors.[9,10]

7. Supply Chain Maintenance

The high volume of data related to medical equipment, medications and pills need to be managed well. During the storage, the date must include all the columns, like – expiry date, buy date, supplier details, etc. This entire data can be stored and retrieved from the cloud. The cloud services updates about the equipment and medications approaching their expiry require an immediate refill.

8. Access to high powered analytics

Since a significant part of analytics is data storage and manipulation, cloud-based tools become useful when tasks are more analytical. Healthcare data, either structured or unstructured, is a huge asset. It is possible to collect relevant patient data from multiple sources in the cloud. Applying big data analytics and artificial intelligence algorithms on the cloud-stored patient data can boost medical research. With advanced cloud computing, large datasets are quickly processed.

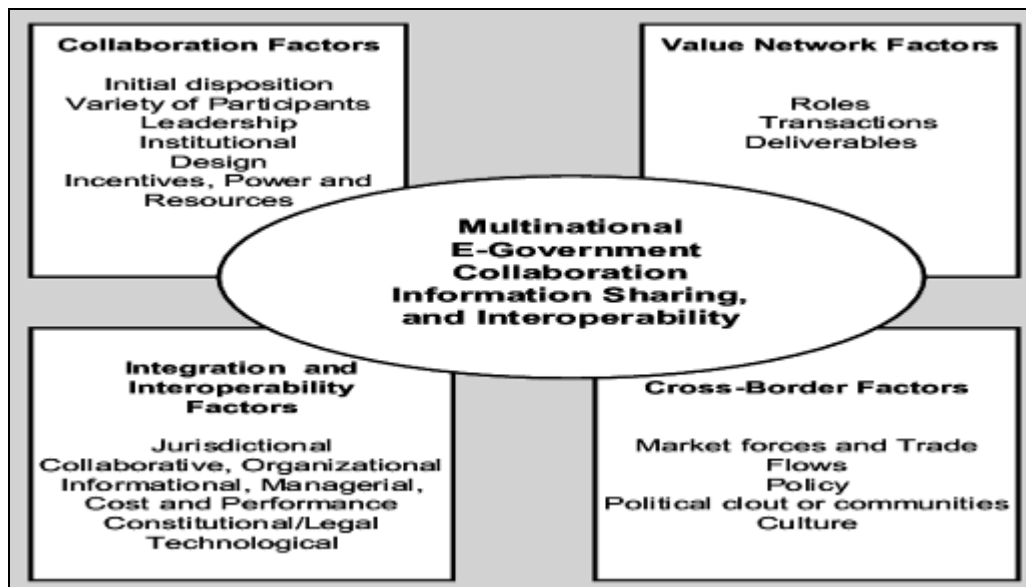
Analyzing patient data also can pave the way for formulating more personalized care plans for patients. It also ensures that all the patient details are on record and nothing gets missed out when prescribing treatments.

9. Patient ownership of data

Cloud computing centralizes the data and gives patients control over their health. It boosts patient participation in making decisions about their health. As the backups are automated and there is no single touchpoint where the data is stored, recovery of data becomes effective.

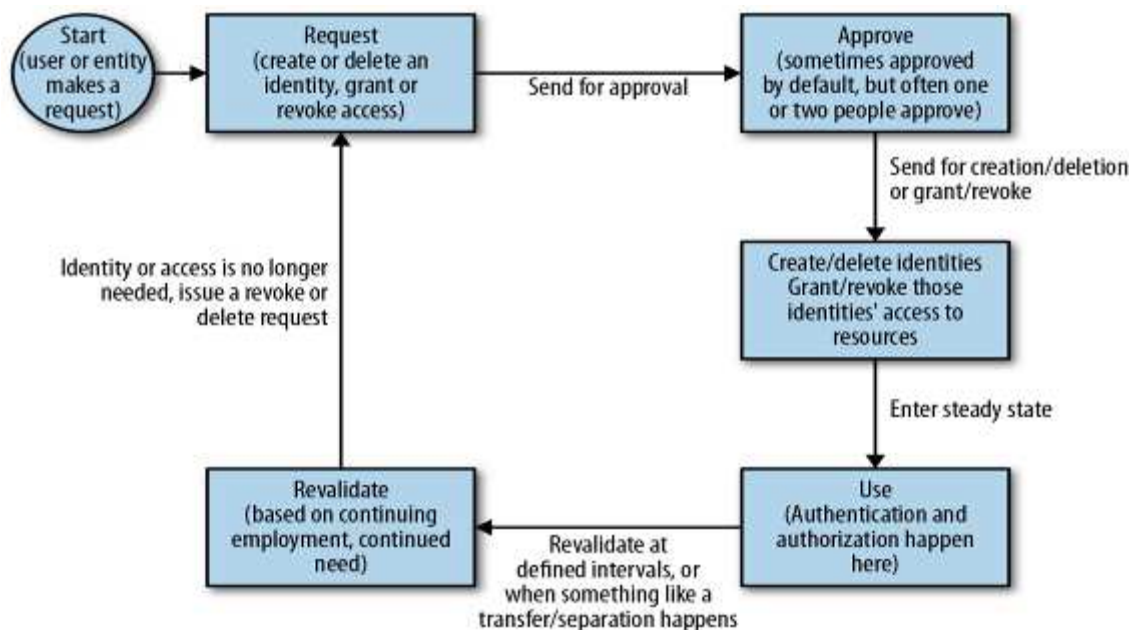
10. Collaborative Interoperability

Moving healthcare data to the cloud improves collaboration and promotes accessibility, thereby increasing patient engagement. Cloud computing allows clinicians and healthcare providers to collaborate and improve health outcomes for the patients. When all the data is available at a single location, a collaborative unit is formed among the stakeholders to make plans, track progress and offer consistent care to improve health outcomes. The patient histories, diagnostics and other medical records are instantly shared over the cloud to different expert physicians. Also, the collaboration with health insurance companies can result in seamless payout-making healthcare facilities.[11,12]



Implications

Cloud computing provides a secure infrastructure to hospitals, medical practices, insurance companies, and research facilities.



The main objective behind it is to improve computing resources at lower initial capital outlays. Also, cloud computing can reduce the barriers to innovation and modernization of healthcare systems and applications. It ultimately results in making the overall health data management system more flexible and scalable.

Depending upon the functionalities, some of the initial stages of workflow include collecting patient's healthcare data. The sensor node at the patient side is responsible for managing the overall data of a patient. This data contains the heartbeat, blood pressure and physiological details of the patient. The information is collected through biometric equipment, which transmits it further to the wireless sensor node. Therefore, the data gets uploaded to the cloud from a wireless sensor node using a sensor data dissemination mechanism.

The workflow of the cloud services is presented from the perspective of private and public cloud communication scenarios. Private cloud platform includes hardware and software components that address all identified healthcare requirements. The essential functionalities involved in this workflow are authentication, authorization, data persistence, data integrity and data confidentiality.[13,14]

➤ Authentication

It is carried out through cryptographic protocols for allowing users to access private cloud resources after successful identity verification.

➤ Authorization

This process ensures the users access private cloud resources.

➤ Data persistence

This function helps to store the healthcare data for a long-term basis.

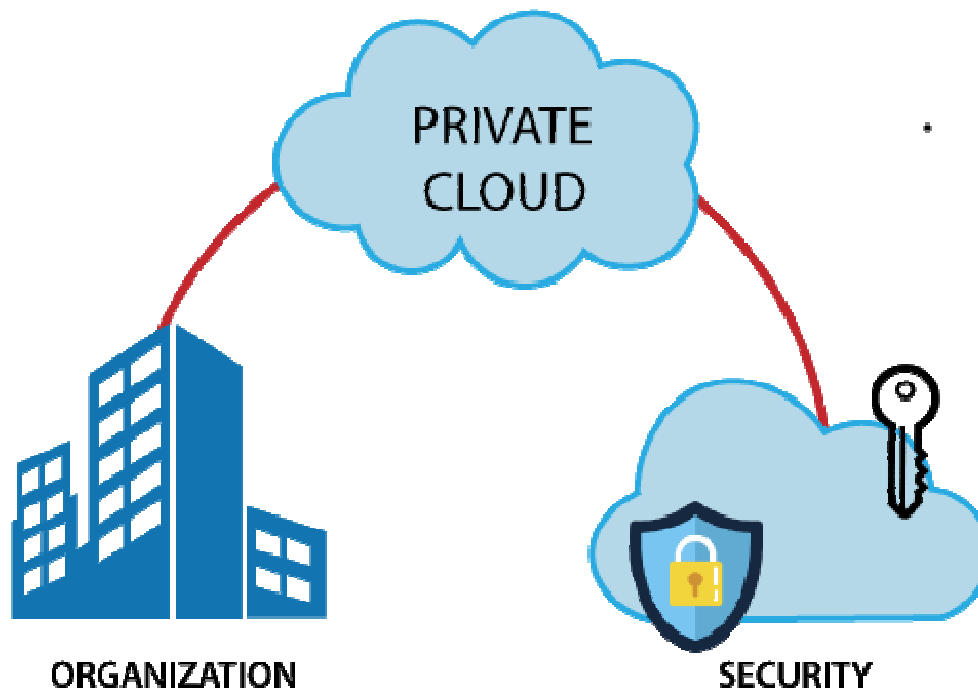
➤ Data integrity

It ensures that the data is complete and consistent during any exchange operation.

➤ Data confidentiality

It results in transmitting the data, which remains accessible only by the user.

The following steps of cloud-based architecture give a complete idea of the overall workflow process.



Step 1: Patient requests authorization.

Public cloud services are addressed only by external users like patients and third parties like insurance companies, pharmacies, research healthcare companies, drug manufacturers. A patient is also supposed to be an external user. So, he logs on using (username and password) addressing public identity and access control cloud services to place a request for authorization.

Step 2: Request is processed at Public cloud and forwarded to Private cloud network.

Based on request type for storage, access or processing health data, it is processed at the public cloud level and is forwarded to identity and access control service from the private cloud.

Step 3: Request is either accepted or rejected.

If a private cloud server accepts the request, it is forwarded to a healthcare private cloud application server. On the contrary, if the request is rejected, a notifying message is sent specifying the request’s rejection.

Step 4: Physician requests for authorization.

The physician is considered an internal user. Therefore, he logs on to the private cloud services and sends an authorization request containing user and password to identity and access control.

Step 5: The physician’s request is processed to access the data from the cloud application server.

Once the authentication is successful, private cloud services process the request, and physicians can access the data from the public cloud application server.

Step 6: A medical advice is directly sent to the patient.

A physician can directly send the feedback in terms of medical advice or prescription to the patient.[15,16]

Developing such types of cloud-based healthcare solutions for rural health and in the event of disasters is meaningful. Besides, care-providing institutions and medical practitioners should initiate using cloud-based medical records and medical image archiving services. This kind of solution’s main objective is to reduce the burdensome task of the doctors and medical staff with improved medical systems and effective patient care.

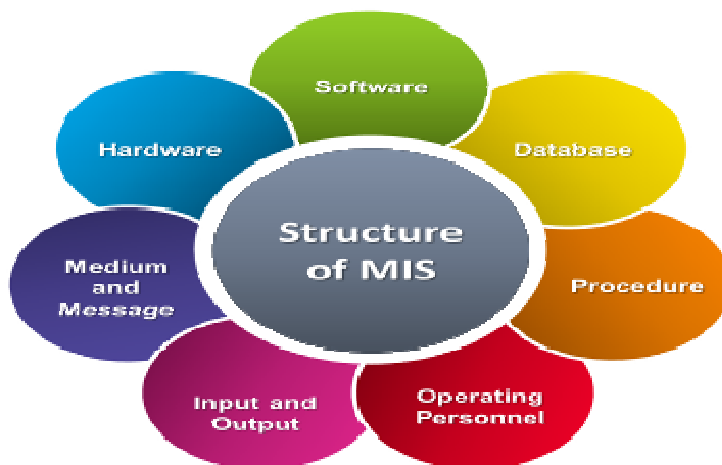
Conclusions

Cloud computing exhibits an essential need to develop applications for high-performance data processing and management. There are numerous cloud service offerings for healthcare, covering a wide range of capabilities. This trend is highlighted through different applications and architecture based on cloud in healthcare. Following applications of cloud computing in healthcare are aimed to drive a tech-led healthcare system.

1. Management Information Systems

The Healthcare industry has started using management information systems for streamlining the information flow within and outside the organizations. Physicians use the system to provide better patient care; customers use it for querying service; administrators use it to manage the human resource, billing and finance; top

management use this system for decision making and forecasting purposes. Due to the confidentiality of the information, developers use cloud-based platform services to develop, test, and deploy this system. It ensures the rapid collaborative development, cross-platform compatibility, and integration of the system with other legacy systems.[17]



2. Telemedicine and Drug Discovery

Nowadays, information and communication technologies are blended to support and provide patient care services. Cloud computing can be used as an ICT infrastructure for telemedicine projects. Telemedicine technologies like telesurgery, audio/video conferencing, and teleradiology have made it necessary to collaborate and communicate between healthcare stakeholders. Telehealthcare services help the patients to get clinical treatment at any place. Besides, medical professionals can share their expert opinion to deal with complex medical cases. Cloud-based software enables doctor-patient and doctor-doctor interaction along with transmission and archiving of medical images. Cloud-based solutions in telemedicine are applicable:

- For sharing patient medical data in real-time across geographical boundaries.
- For retrieving the archived at their place and time.
- For reducing unnecessary visits to doctors with savings of time and money.

The process of drug discovery needs ample computing resources to discover the potential compounds from trillion chemical structures. Various cloud-based IaaS services add significant value in simplifying this process. For example, a joint venture of Molplex, Newcastle University and Microsoft Research has adopted IaaS cloud in drug discovery, thereby reducing time and cost.

3. Digital Libraries

Libraries serve as the source of knowledge for medical students, researchers and practitioners. The paper-based medical libraries in developing countries cannot meet the financial barriers. Hence, cloud-based digital libraries offer a large volume of file storage, indexing service, query languages, hosting service library management systems. Cloud-based solutions are applicable to digitize libraries for:

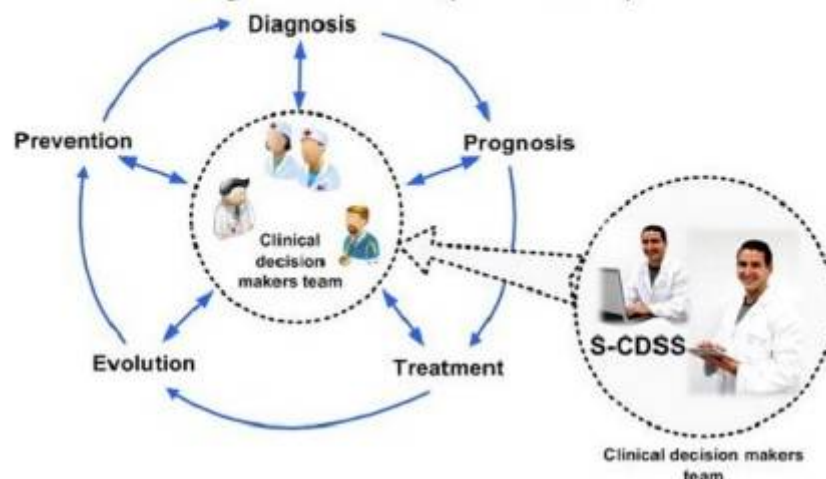
- Institutions and individuals to avail the facility on demand.
- Information seekers make the searching process easy through a semantic-based query approach.
- Physicians to get aware of current progress in the medical domain and hence improve their work practice.

4. Virtual Medical Universities

Cloud computing has acquired its hold in the academic sector owing to its flexibility and pay-as-you-go model. Various applications are developed to support on-campus as well as off-campus for academic learning. Medical universities can use cloud-based models to deliver online lectures, conduct seminars and increase collaboration among academia worldwide. Cloud computing can assist medical institutions in reaching many learners at a low cost and with less effort.

5. Clinical decision support system (CDSS)

Clinical Decision Support Systems (CDSS)



It is an expert system that follows a medical specialist's knowledge and behavior to create the advice upon the patient record analysis. Physicians use this system for diagnosis and medication purposes. Cloud computing technology can develop these systems to support patient care as per the requirement. The advent of smartphone technology with built-in sensors to track the heart rate, blood pressure, diabetes makes these cloud systems efficient for real-time diagnosis. So, the patients can share their data with the system and get appropriate advice. When adopted with cloud services, these systems can ensure the precise treatment process, especially in case of emergency, when doctors are not available. [18] For example, Brayen developed a cloud-based CDSS on the information management and sharing framework. It was designed for a repository specified by Clinical Decision Support Consortium (CDSC). This repository included the data related to hypertension, diabetes, and coronary artery diseases and is based on a community cloud hosted by Partners HealthCare. This architecture involved the cloud hosting-based engine, which stored a limited data set of primary care patients. The main purpose of this platform was to deliver preventive care notifications to clinicians and end-users.

6. Population Health management

Cloud services help to track diseases, map them geospatially and inform the population where risk exists. Healthcare organizations can implement these services using cloud computing. The tool that exists in the marketplace today is Disease Control and Prevention (CDC). The CDC centers are developed as a part of a surveillance strategy to promote public health surveillance challenges.



7. Better Practice Management

Healthcare providers can track, manage & optimize financial and admin processes with cloud computing. It boosts productivity by automating day-to-day tasks to simplify the practice. Cloud services allow medical practitioners and care providers to find vast amounts of data to produce effective treatment plans. Patients can avail of these services to explore their medical issues and collaborate with their treatment provider. For example, the Flatiron oncology cloud is an end-to-end technology solution developed for cancer patients' value-based care.

8. Health Education

The web is a source of information to create awareness among the masses about fitness, health, dietary and sanitation issues. Most people acquire health-related information from the internet using trusted resources like web pages, helper groups, and blogs on particular disease types. Patients who already have suffered from a specific disease can share their knowledge, experience, dietary plan and medication process with new patients as a part of self-care. Cloud services like PaaS and SaaS can teach and train our masses about self-care. The hosting services are provided to these resource owners. Also, the helpers can rent cloud applications like chat tools, forums to start their group.

9. Biological Softwares

Cloud computing models solve the issues of big data in biological software. This process is known as the bioinformatics cloud. The cloud model developed for biological software delivers services like data storage,

data acquisition, and data analysis and the optimization of life science algorithms and data-intensive scientific tools in bioinformatics.

Eventually, the healthcare industry is no exception to the fact that the data is omnipresent. As Cloud technology progresses exponentially, there is a vast amount of potential for Cloud computing in the healthcare industry. Quality healthcare has acquired the status of a human's fundamental right. Also, this is a costly and highly complicated subject. Even the world's developed economies find it difficult to cope with the sheer scale of healthcare needs. However, channelizing cloud computing power into the healthcare system can surely make tangible progress useful in quality and affordable healthcare for all, rather than a few privileged ones.[19,20]

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