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Review

Artificial Intelligence in e-Health: A Review of Current Status in Healthcare and Future Possible Scope of Research

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Abstract: Artificial Intelligence (AI) has been emerging promptly currently due to software algorithms, hardware employment, and applications in many sectors. The Healthcare sector is drawing the attention of healthcare professionals and researchers from a multidisciplinary viewpoint like administration, business, finance, record keeping, decision making, and services. Extensive usage of electronic health records gives rise to an immense quantity of clinical data. For patient welfare, disease diagnosis is vital for appropriate treatment but human inaccuracy may obstruct precise diagnosis because of complex medical information. The usage of information and communication technologies together evolved e-health. Integration of artificial intelligence in e-health smoothens the various challenges faced by healthcare systems. In this review, the authors have attempted to summarize the applications of artificial intelligence in various fields of e-health: Improving electronic health records, disease diagnosis and decision making, remote patient monitoring, and telehealth. Healthcare experts can understand how well AI works and supports in refining task execution with increased efficiency, minimizing the pressure of workload, and optimizing resources, best example has been observed in the pandemic COVID-19 scenario. More work and innovations will be endured by researchers with encouragement to thrust the boundary and it will broaden the latitude of healthcare sectors as well as AI algorithms.

Keywords: Artificial Intelligence, Healthcare Applications, Electronic Health Record, Remote Patient Monitoring, Telehealth, COVID-19

Introduction

Artificial Intelligence (AI) is the intelligence demonstrated by any machine, computer, or robot. It is the simulation of human intelligence, programmed by machines to think like humans and simulate their actions like perception and emotion. As AI technology is growing, it has a huge impact on our quality of life. In today's world AI become a part of everyone's daily life in a countless number of applications therefore mankind has become dependent on it (Birdwell *et al*., 1986). Many AI-based Optimization Algorithms have been introduced by researchers and successfully applied in various applications

Soni *et al*. (2020). Modern, emerging, and innovative areas of optimization like Artificial Intelligence, Machine Learning, Deep Learning, quantum computing, etc., are encouraged. AI has transformed Industrial operations a lot and currently, the health care sector has been growing tremendously (Rong *et al*., 2020; Kaur *et al*., 2019).

The major objective of any healthcare organization is to provide four P's services to their clients: Personalized, prognostic, precautionary, and participation. Artificial Intelligence can contribute a lot to this dimension; therefore, the integration of AI and health care can be viewed as e-health (Ramesh *et al*., 2004; Chen and See, 2020; Jiang *et al*., 2017). e-health has changed the traditional culture of the health care industry from various viewpoints: Health record keeping, medical diagnosis, recommended treatment, patient monitoring, and follow-up (Bohr and Memarzadeh, 2020; Jeddi and Bohr, 2020). Healthcare professionals have lots of responsibility and investigations must be performed precisely. Huge data is available and extraction of accurate data is quite tedious but technology contributes a lot to all obstacles. AI-enabled e-health system performs superior to conventional system in terms of patient data management,

advanced and quick diagnosis, disease investigation, suggested treatment, and enhanced outcomes. Therefore, the effectiveness of the overall healthcare system increases with reduced medical error (Mukherjee and McGinnis, 2007; van der Kleij *et al*., 2019).

This paper is about the review of revolutions in the healthcare sector with Artificial Intelligence as a tool. The remaining portion of the paper is inclined towards different applications of AI in various areas of health. Finally, the conclusion and future scope are summarized.

Background Review

Rong *et al.* (2020) describe the current innovations of AI in biomedicine and healthcare. AI applications for disease prediction, diagnosis, living support, information record keeping, and processing. The latest development in AI contributes to novel solutions to complex problems. Developments meet with trending demand supply which finally assists the individual quality of life.

Kaur *et al.* (2019 demonstrated e-health through awareness, availability, possibility, and clinical support. Remote patient consultation, diagnosis, monitoring, and reminders through messages have a constructive influence on patient outcomes. Information technology has strengthened the healthcare domain.

Ramesh *et al.* (2004) describe the various AI techniques for some important scientific applications. AI has proven very effective and efficient in almost every domain of healthcare. Artificial Neural Network (ANN) is a generally used tool for analytics. Fuzzy systems, evolutionary computational algorithms, swarm intelligence, and hybrid algorithms are commonly used for numerous clinical events.

Chen and See (2020) reviewed almost eleven papers related to healthcare. AI efficiently functions in four domains of COVID-19. These domains are disease diagnosis, community health, decision-making, and therapeutics. Numerous limitations or barriers have been identified, which can be improved by AI-driven systems. AI holds potential over human-handled operations and it can be further empowered with big data.

Jiang *et al.* (2017) describe the current and future status of AI applications. Healthcare data may be structured or unstructured, whereas AI can be functional. Machine learning algorithms are useful for structured data while deep learning and natural language processing are efficient for unstructured data. The key disease for investigation is neurology, cardiology, oncology, and stroke have been investigated.

Bohr and Memarzadeh (2020) emphases about the increasing demand for healthcare services along with pitfalls. Healthcare professionals are updating themselves with the latest technological developments while healthcare organizations are struggling to include innovative technologies to maintain patient trust and expectations. AI-enabled tools are helpful for the healthcare ecosystem to convert them into next-generation healthcare expertise. AI empowers operations, delivery, safety, and remote interaction with cost savings.

Jeddi and Bohr (2020) deliberated various terminologies used for patient monitoring remotely from the hospital, such as telemedicine, Telehealth, mobile health, and remote patient monitoring. Advancements in wireless technology and electronics make remote patient monitoring interesting and appealing. Many advantages have been discussed like quick detection, continuous monitoring, reduced cost, rapid consultation, and emergency medical care. Technologies have contributed to sensors and monitoring devices in terms of cost and size. These days many devices are available in the market and used our smartphones or tablets and wearables etc.

Coorevits *et al.* (2013) discussed the outline of diverse methods for gathering data given the clinical research process. Some attractive potential delivered by fresh varieties of federated EHRs has been described. Various hurdles and challenges faced have also been listed here.

Persell *et al.* (2009) proposed the long-distance communication model for treating high cholesterol patients. To make it flourish, it must collaborate with some interventions which will encourage physicians to adopt treatment strategies. The test has been done on patients who were at high risk for budding CVD via EHR data. Through customized outreach, CVD risk has been reduced and patient care against such can be taken.

Singh *et al.* (2021) projected a hepatitis diagnostic arrangement that is helpful for physicians to evaluate complex cases difficult to distinguish. Integrating intelligent algorithms have transformed the medical domain which can be viewed as a renovation. Results verified the proposed approach efficient in comparison to other diagnostic traditional approach. Computed errors are also very less which makes it appealing for treating hepatitis patients.

Handelman *et al.* (2018) described the background overview of Machine Learning. ML has been significantly contributing to various domains. It is the future of computer-aided diagnostic and biomedical research. Various ML algorithms applied in medicines have been investigated. Their limitations and future possibilities in medicine have been also deliberated.

e-Health

The term e-health is nowadays a buzzword, used by almost everyone. It not only describes internet medicine but also marks the use of the latest digital technologies.

Initially, the term was used by industry professionals given other e-related works like commerce, business, etc. Because of the availability of the Internet, users can converse with healthcare professionals virtually and share data such as text, audio, and video. The World Health Organization precisely defined e-heath as the use of information and communication technologies in a cost-effective manner to upkeep health-related fields. Some of the significant areas of e-health are depicted in Fig. 1.

Academicians and researchers also find this a very challenging field because it is reinforced by electronics, informatics, and telecommunication. Technological promises toward global health care are its vision. e-health is used by the community on a large scale, and people residing in rural and remote areas can make use of it effectively (Kaur *et al*., 2019; Mukherjee and McGinnis, 2007). Timely information related to prevention, diagnosis, quality care, empowering patients, and most important making them aware is the major task. The "e" in e-health not only characterizes electronic but is a collection of ten e's. each one of independent e has its meaning and significance, as shown in Fig. 2:

- Efficiency: It is the most important factor in health care and the challenge is to increase efficiency. Therefore, the cost must be reduced and it could be achieved by decreasing waiting time, escaping duplicative screening/diagnostic through value-added communication capabilities
- Enhancing: An increase in efficiency not only reduces cost but impacts the level of quality care improvement. Empowering patients for their treatment and quality assurance improves the quality of service. Comparison among various service providers can be done and premium quality providers can be designated
- Evidence-based: Effectiveness and competence of e-health medications must be evidence-based i.e., benchmark quality control must be available. Noting can be assumed randomly, even now ample work needs to be done in this direction
- Empowerment: Awareness about the diagnostic, knowledge base of medicines and their electronic health records of patients and consumers, must be accessible over the internet. Therefore, e-health uncaps the new prospects for patient-centric care and assists evidence-based treatment selection
- Encouragement: Bonding between health professionals and the patient will be stronger when treatment will be transparent and when all decisions must be taken jointly. Transparency means for a diabetic patient; a person can monitor glucose levels along with diet and other required parameters daily which encourages patient participation in protective care
- Education: Health professionals must keep them updated through various online sources. Similarly, patient education is also important such as health awareness and preventive measures, which can be done through the internet, videos, etc.
- Enabling: Empowering data exchange in a reliable way and conversation in a consistent way among healthcare workers and patients
- Extending: Outspreading the scope of healthcare beyond traditional boundaries both geographically and conceptually. Patients may get services from worldwide providers and the nature of service may be simple or complex or a requirement of any product
- Ethics: e-health also addresses the new issues by including a new form comprises of patient-doctor interaction, challenges, privacy, and learned consent
- Equity: One of the challenges of e-health is to make it fair which will further justify it among the population. At the same time, there is a substantial risk that may enlarge the gap between haves and have-not. E-health is not equally reachable for people residing in rural areas, financially weak persons, those less educated, deficiency of resources hence some measures are required for equitable access to all. Currently, the digital gap is between male vs. female, poor vs. rich, old vs. young, urban vs. rural, common vs. rare illness

The attractive features of e-heath are cost-effectiveness, quick access to patient's medical records, reduced redundancy of data, better decision making, reduced medical error along with efficient use of ICT (van der Kleij *et al*., 2019). It comprises many more technological interventions together such as electronic health records, mobile health, telemedicine, big data, and artificial intelligence. Awareness about superior health can be increased and people can be encouraged toward a healthy lifestyle, physical activities, prevention, better nutrition, and of course education. Health professionals and researchers have identified a few challenges like deficiencies of clinical and II-related resources, personal cost, monitory fence in procurement, streamlining and standardization of health-related information structure, sometimes time-consuming.

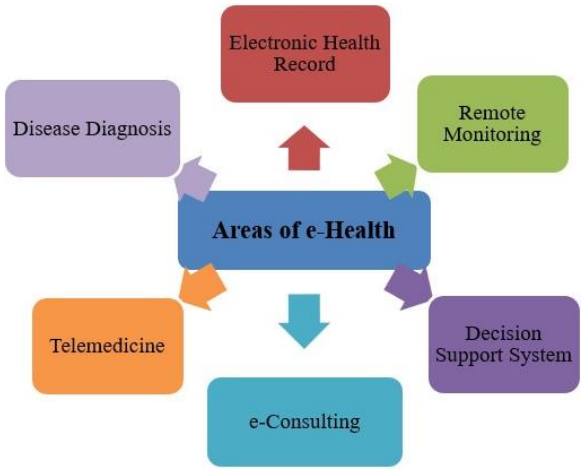

Fig. 1: Components of e-health

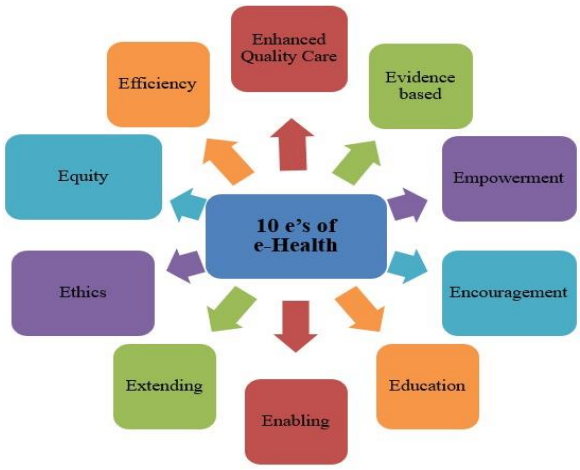

Fig. 2: Ten e's of e-health

Significance of AI in e-Health

The key objective of healthcare is to provide services that are personalized, projecting, participatory, and preventive. In the past few years, the demand for e-Healthcare has extended significantly. Artificial Intelligence in healthcare needs to be honest and transparent. Integration of technology with algorithms-enabled systems is widely accessible and used. They are broadly categorized into three categories like as, Supervised Learning, Unsupervised Learning, and Reinforcement Learning, as shown in Fig. 3 (Solan *et al*., 2005; Kotsiantis *et al*., 2007):

- Supervised learning is the commonly used AI method where learning depends upon existing samples. Labels of data set are known in advance which helps train algorithm and hence create predictions. It is very sensitive for data quality i.e., depends upon input provided therefore wrongly labeled data may lead to wrong predictions. Regression and classification are the types of supervised learning
- Unsupervised learning may not depend on user input and contain self-organizing algorithms. They are neither classified nor labeled. They are suitable for recognizing correlations inside a dataset. Statistical significance could not be recognized. It can be assembled into clustering and association problems. It is a very powerful tool for data analysis and pattern identification
- Reinforcement learning consists of the feedback given by learning data. It has the capability of being adaptive in nature and hence achieving certain objectives. Performance evaluation is being done based on feedback response; the self-driven car is the best example of this
- Semi-supervised Learning uses both supervised and unsupervised techniques. A small fraction of data is labeled here but the majority of data is unlabeled. It is used in special cases where it is very costly to procure a fully labeled dataset

AI has shown a revolution in the medical industry because of promising results in changing environments with reduced burdens on healthcare workers. AI for wellbeing contributed a significant role in almost every domain of the COVID-19 pandemic, as shown in Fig. 4. The marketplace share has enlarged enormously in the year 2019 due to COVID-19., which was USD 14 billion in the year 2014. The global market was evaluated at about USD 45 billion, which was expected to reach USD 175 by the year 2026 (Kichloo *et al*., 2020; Fortune Business, 2021; Calton *et al*., 2020). Many telemedicine firms are observing a spike in the consequences of the COVID19 pandemic. India individually shares 41% of response in teleservices by the year 2018, which has enlarged appreciably in the year 2020 (Cabestany *et al*., 2018; Secinaro *et al*., 2021). Numerous factors contribute to the enlargement of the market them as rising chronic respiratory diseases (Chebrolu *et al*., 2020). This is the major reason for getting popularity of AI in healthcare which has drawn the attention of policymakers also.

The incorporation of AI technology in healthcare has undoubtedly moved the healthcare industries. It has changed the revolution in treatment procedures due to enhanced patient outcomes.

Complex processes can be efficiently automated by reducing downtime in decision-making and enhancing accuracy. In the past few years, this field has drawn the attention of researchers which can be observed in the growth of published research papers in various domains of healthcare. In the year 2000, the number of publications in this field was nearly 1450, which increases to 5700 in the year 2017 and is expected to cross by 10,000 in the year 2022. Many industries are devoting more and more funds to inventions and modernizations (Rong *et al*., 2020; Allam *et al*., 2020). In the year 2020, Microsoft itself announced a budget of USD 40 million to address the challenges faced by the healthcare sector. Artificial Intelligence has massive scope in various domains of healthcare, Table 1 summarizes the various usage and applications in respective domains.

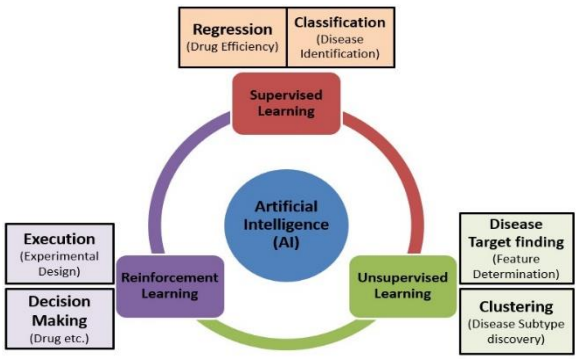

Fig. 3: Classification of AI

Table 1: Various applications of artificial intelligence in healthcare

S. No	Reference No.	Application area	Descriptions
1	Ramesh (*et al*., 2004; Bohr and Memarzadeh, 2020; Liu and Deng, 2010; Mishra *et al*., 2018)	Health monitoring	Nowadays many wearable gadgets are available on the market which gives satisfactory details about an individual. Substantial parameters like SpO2 level, heart rate, ECG, Pulse Rate, Body Temperature etc., can be observed parameters can be shared with the doctor for consultation and advice
2	Liu and Deng (2010; Han *et al*., 2013; Sun *et al*., 2017; Singh *et al*., 2021; Gaskin *et al*., 2016)	Disease diagnosis	Using AI algorithms for disease diagnosis improves efficiency and diagnosis exactness. AI is very powerful; many researchers and hospitals are using it for fast data processing and response. It reflects better outcomes for radiology diagnosis and treatment like brain strokes, heart disease, tumors, etc.
3	Kaur *et al*. (2019; Singh *et al*., 2020; Keshvardoost *et al*., 2020; Gong *et al*., 2020; Handelman *et al*., 2018)	Personalized treatments	Direct interaction between doctors and patients can happen in online mode even from a remote location. Many IoT devices are available which offers accurate monitored data. It reduces time and cost involved, but increases patient satisfaction
4	Chen and See (2020; Singh *et al*., 2020; Mishra *et al*., 2018; Calton *et al*., 2020; Ghosh *et al*., 2020)	Virtual assistants	Voice-enabled AI-based Chatbots have drawn the attention of everyone in healthcare. It provides 24 × 7 interaction with patients to make them comfortable and hence resources and time can be saved. Remote patients can be monitored and reminder about medicines can be given. Any emergency the situation can be observed and alerts can be given to families/hospitals. This technology has helped a lot during the coronavirus crisis
5	Jeddi and Bohr (2020; Calton *et al*., 2020; Mishra *et al*., 2018; Gong *et al*., 2020; Mamoshina *et al*., 2016	Remote patient-restricted monitoring	AI-aided processes support substantially tracking, analyzing, and monitoring people, elderly persons, and those having a chronic disease. During COVID-19, helped a lot in terms of in-house services, personalized care and emergency assistance
6	Liu and Deng (2010. Polat *et al*., 2017; Han *et al*., 2013; Singh *et al*., 2021; Panch *et al*., 2018)	Medical imagine	Using AI in investigating medical imaging is still under research and extensive assessment. Though AI has shown improved accuracy for investigate imaging irregularities. Sometimes AI-enabled systems can detect disease and irregularities well in advance than the doctors. Medical imaging has given higher productivity with the integration of automation
7	Bohr and Memarzadeh (2020; Keshvardoost *et al*., 2020; Mishra *et al*., 2018; Mamoshina *et al*., 2016)	Nutrition	Large number of nutrition-associated apps and gadgets are available with varied accuracy and functions. Integration of AI with such apps can suggest personalized recommendations and ideas depending upon individual's habits and likings
8	Coorevits *et al*. (2013; Persell *et al*., 2009; Hersh, 2007; Botsis *et al*., 2010; Peissig *et al*., 2012)	Electronic health record	Now almost every hospital has a Patient Information System which contains every patient's Electronic Health Record. These systems effectively handle the appointment process, admission process, follow-up, reminders to patients. Healthcare experts also get benefit from such systems to swipe fast the health record, making a good clinical decision evaluating patient progress. Machine Learning algorithms and Natural Language Processing is frequently used for this
9	Kaur *et al*. (2019; Jeddi and Bohr. 2020; Meystre *et al*., 2017; Singh *et al*., 2020; Mamoshina *et al*., 2016	Mobile health	Many software applications along with variants of AI, facilitates budding healthcare technology via mobile applications, like a smartwatch, cell phones, laptops, etc. It supports better communication and convenience to both health provider and patient
10	Jiang *et al*. (2017; Bohr and Memarzadeh, 2020 Peissig *et al*., 2012; Polat *et al*., 2017; Han *et al*., 2013)	Mental health	As per the survey now out of four persons one suffers from some kind of mental illness. AI-based systems provide extreme benefits in early detected and identify the need for support from family, friends or psychiatric. Patterns analysis is done based on tone, choice of words, time to respond, rate of speech, etc.
11	Gaskin *et al*. (2016; Hamedan *et al*., 2020; Walczak and Velanovich, 2018; Portnoy *et al*., 2020)	Precision medicine	Augmented AI has proven its strength to examine and predict hereditary and cancerous disease, etc. Clinical decisions for patients having exceptional problems, few symptoms, and slow response to treatments can be taken
12	Bohr and Memarzadeh (2020; Chebrolu *et al*., 2020; Solan *et al*., 2005; Kotsiantis *et al*., 2007)	Drug development	AI-enabled systems reduce the experimental cost and speedup the process. They can alter the most of discovery's task therefore to validate the result only physical experimentation needs to be done. The impact of the drug on patients' tissues can be investigated

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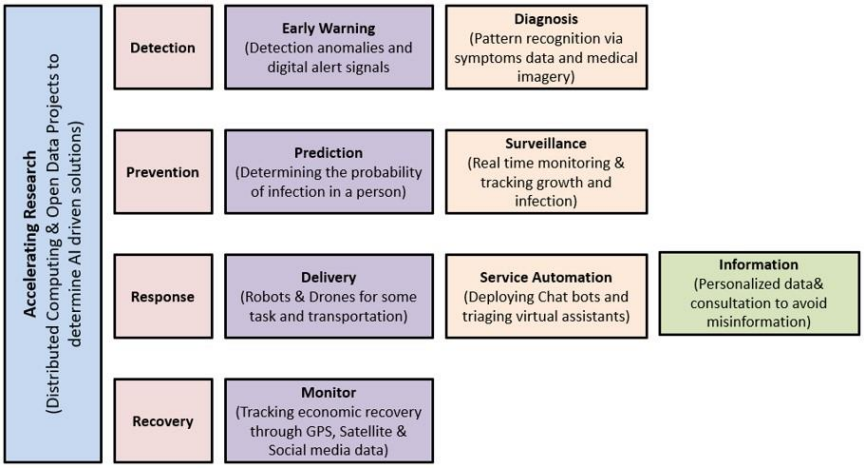

Fig. 4: Features of AI in e-health

Artificial Intelligence for Improving Electronic Health Records (EHR)

Electronic Health Records (EHR) is the electronic kind of patient history record, includes which is maintained and updated over time (Coorevits *et al*., 2013). The importance of EHRs has gained popularity because accessing digital data is easy and many more patients can be served. EHRs mainly deal with contact details, family history, allergies, vaccination status, existing health diseases, hospitalization records, details about surgeries accomplished, progress notes, radiology reports, insurance information, etc. (Meystre *et al*., 2017; Persell *et al*., 2009). EHR helps to automate the entire clinical workflow and can provide various interface, therefore bonding between patients and hospitals build up (Hersh, 2007; Botsis *et al*., 2010). Some advantages of EHRs are:

- Efficient storage and retrieval of medical records
- Information is updated from time to time and shared among various required sources
- Capability to share multimedia reports as well
- Efficient for decision making
- Improves patient care
- Reducing redundant efforts, tests, and delay in treatment
- Sometimes provides corrections in services and patient's upkeep
- Possible long-term reduction in cost to medical organizations

EHR system seems to be complex because of the huge data handling and discrete nature of task associated, sometimes which may lead to misalignment. Some traditional ways of handling are Making the system united and efficient from the initiation, use of some open source EHR, etc. An encouraging solution is to apply Artificial Intelligence (AI) in an EHR system to make them quick, efficient, easy to use, and flexible. AI helps in quick data extraction, optimization of time required in the process gives a quick solution, avoids redundancy, and most importantly it can handle huge data with improved performance. Nowadays some vendors are working in this direction and providing services to their clients and keep updating or customized on a requirements basis. During the pandemic COVID-19, it was only feasible because EHR systems are more efficient (Panch *et al*., 2018; Singh *et al*., 2020). This area is rapidly improving and providing market to vendors and researchers to minimize challenges with technological advancements (Peissig *et al*., 2012). Figure 5 enlarges some of the significant tasks handled by AI in the domain of electronic health records.

A. Reducing Administrative Workload for Medical Documentation

It has been observed that approximately 50% of the time involved in each hospital visit is for admin work (a study given by American Medical Association). Admin work comprises initial documentation, entry into the computer, billing, security, etc. Patient time is very valuable and spending so much time at the initial stage may create dissatisfaction, irritation, arguments, and breakdown. Such type of situation can be dealt with efficiently by Natural Language Processing (NLP) where medical transcripts can be captured automatically by NLP, which reduces the time involved in admin work. Speech-to-text algorithms, based on Artificial Intelligence are very much effective in reducing burdens due to administrative work. AI is helpful for EHR solutions via voice-based commands and performs documentation of patient complications, analysis, and measures in specific formats. Such type of system makes the overall process very convenient for extracting explicit patient information. It is also capable of translating narration into an actionable task for creating a real-time conclusion.

B. Automatically Extracting Patient Information

Patient information must be easily and accurately extracted from the EHRs for quicker diagnosis though sorting information among huge data is the biggest challenge. In some case studies, it has been found that almost 40% of hospitals are struggling with this problem. One recent scenario where doctors faced the situation during the pandemic COVID-19. Artificial Intelligence is capable to cross this barrier, therefore AI supported EHR systems which are adaptive in nature, and provides quick access to records, extraction of the required information, and reduction in error. Recently Amazon Web Services launched Amazon Comprehend Medical, which is a cloud-based service capable to retrieve catalog data from medical documents. Some other companies like Innodata, Intellidact, etc., are working in the same direction to provide clinical support.

C. Improved Decision Making

EHR systems create enormous data which itself needs advanced algorithms/procedures, therefore advanced Artificial Intelligence, Machine Learning, and Deep Learning are required. These tools/techniques can unfold patient perception, provides personalized attention, critical care monitoring, and even forecast high-risk situations. Epic Systems is predominantly used by US hospitals, which can handle accessibility, organization, storing, and sharing of medical health records. It can perform some advanced tasks like prediction of mortality, risk levels, readmission in hospital, and patient health deterioration. Google and some other companies are working with EHRs data and developing prediction models, creating solutions for even adaptive environments like personalized care. Recently one healthcare application has been developed, capable to predict high-risk conditions patients and the probability of patients who can respond to treatments.

D. Interoperable EHR

There must be some standards of digital medical document handling, record keeping, and process of document sharing otherwise information analysis will be a tedious task among diverse EHR systems. In the absence of standards SOPs, the probability of getting correct information will be reduced, and hence risk increases. Use of Artificial Intelligence and Machine Learning in some organizations, evidence of resolving interoperable disputes in medical documents. Amazon Web Services plays a vital role here.

Artificial Intelligence in Disease Diagnosis

Health is the utmost vital aspect of life and a well-known fact is that "early diagnosis saves lives". Disease diagnosis can be perceived as a procedure of determining something based on pre-existing classification and hence doctor can label a precise illness. Mostly the overall process is refined and structured, which is patient-centric. Figure 6 shows the disease diagnosis model. In the diagnosis process, Artificial Intelligence is applied at step number 4 during the interaction, medical history, and diagnostic testing. When a person feels some health problem via some indicators, that person visits a clinic/hospital. Initially, medical history is collected by the doctor during the interaction, and if required physical examination, laboratory testing, or screening is done. Based on whole information congregation, amalgamation and interpretation, disease diagnostic accomplished and suitable treatment is suggested. During treatments, patients need to visit the hospital for observation and corrective measures and final results have been achieved. All such detailed information will be utilized for another patient if required.

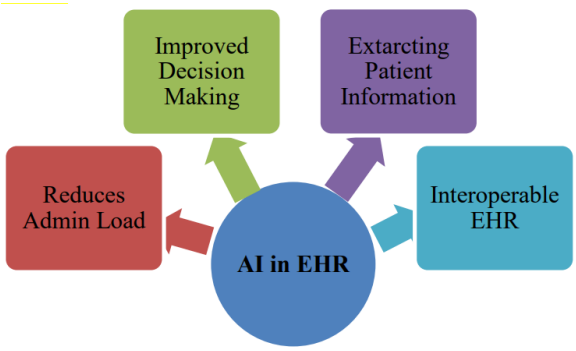

Fig. 5: Task performed by AI-enabled EHR system

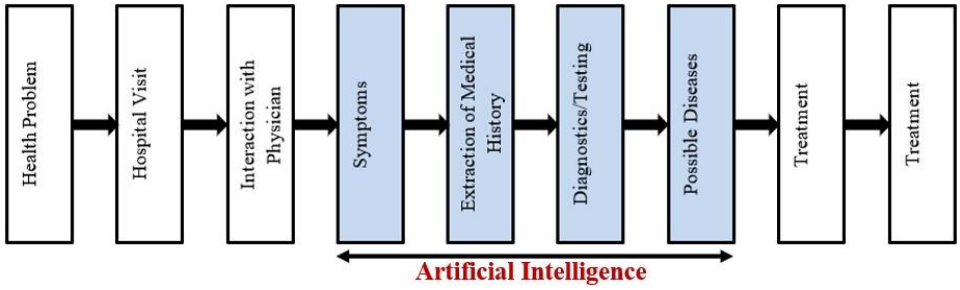

Fig. 6: Disease diagnostic model

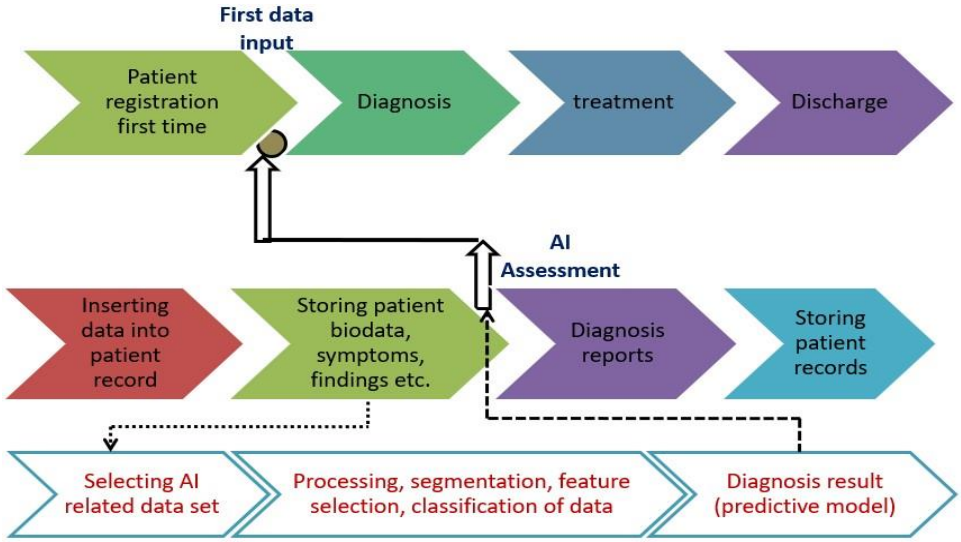

Fig. 7: Detailed process of AI-enabled disease diagnostic

Nowadays Artificial Intelligence has transformed our daily life in almost all aspects. Since health is very much important and medical-related data is endlessly increasing so researchers have made an attempt to apply AI for early disease diagnostic and became successful too. AI-enabled programs have been designed and trained for data sets, which are a collection of earlier patient diagnosis and treatment, current patient history, symptoms, laboratory results, and scanning results. When these algorithms/programs run, they help in decision making and even unobserved information helps in the prediction of precise information about the disease. Some of the diseases to be diagnostic are Breast cancer, liver cancer, cervical cancer, kidney-related issues, hepatitis, dermatological, cataract, heart-related, pancreatic, etc., disease (Liu and Deng, 2010; Polat *et al*., 2017; Han *et al*., 2013; Sun *et al*., 2017; Singh *et al*., 2021; Mishra *et al*., 2018; Gaskin *et al*., 2016; Hamedan *et al*., 2020; Walczak and Velanovich, 2018). The detailed process is depicted in Fig. 7. Researchers and healthcare centers gather data/information from various inputs, data centers, or expertise. AI algorithms are applied to quick data extraction, processing, and quick response for improved treatment conclusions.

Artificial Intelligence in Remote Patient Monitoring

Currently, the world is growing rapidly as modern technologies are transforming the industrial sectors. Artificial Intelligence is one among various scientific tools, which impacts completely the health industry and the results are significant. Remote Patient Monitoring (RPM) is one of the sub-divisions of e-health, which has grown significantly during COVID-19 (Calton *et al*., 2020). AI-enabled remote patient monitoring is a very efficient tool for ordinary to chronic disease management. RPM works by collecting data and transmitting that data to the health care officials through some connected device (Jeddi and Bohr, 2020). During Pandemic COVID-19, there was a shortage of healthcare resources, and most of the time non-essential appointments/procedures have been postponed. Therefore, it has shifted the conventional way of treatment towards distance monitoring and care, therefore the majority of health care organizations have adopted RPM. Patients have shown trust; even for high-risk patients their issues, diagnosis, improvement in health, and other patient data can be tracked efficiently. Some of the examples of RPM, which can be successfully implemented have been enumerated in Fig. 8.

It seems RPM will keep growing post-pandemic also. Some organizations can use it for their employees to maintain their health records and to make sure that their employees are healthy. Figure 9 shows the working of Remote Patient Monitoring, it is bidirectional. Data is being received from the patient, analyzed by the doctor, corrective measures can be taken and feedback from the patient is involved.

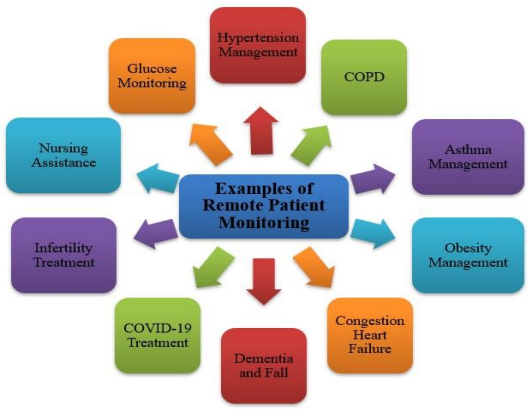

Fig. 8: Examples of the remote patient monitoring systems

The process of RPM may differ depending upon the type of device used to collect the required patient data. Most wireless sensors are used to collect data and then it is sent to the cloud and other remote patient monitoring servers. The analysis is done with the help of artificial intelligence algorithms to get clinical decision making which is then shared with health care professionals. Personal interaction can be done between patient and physician or notification can be sent or expert interaction/opinion is provided in complex diagnoses. Recently some applications are available which provide a good user interface to see available prescriptions, track patient health data, display treatment/doctor/hospital recommendations, and send notifications also. Some of the benefits of RPM are:

- Reduced time delay
- Cost-effective
- Easily accessibility of patient health data
- Increased efficiency
- Better management of critical patient conditions
- Best use of available health resources and
- More patient involvement during treatment by providing quality education and support
- Improved patient outcome
- Personalized care
- Patient satisfaction and assurance
- Increased revenue for healthcare systems
- Improvement in overall quality of service

Telehealth

Telehealth is a cluster of all telemedicine and Telemedicine is a cluster of all remote patient monitoring. Both Telehealth and telemedicine are necessary for the expansion and up-gradation of patient quality care across the globe. It is a broader term that includes a wide range of technologies to facilitate the health care system and provides services in distance mode. It can be subcategorized as:

- Tele Education
- Patient Portal
- Telemedicine
- Interactive Patient Care
- Remote Patient Monitoring
- Store and Forward

Telehealth characterizes the conversation between patients and healthcare professionals for the admittance of quality services. It can remove the topographical and financial barriers, therefore, improving the accessibility of numerous medical services with reduced cost (Keshvardoost *et al*., 2020). The use of telemedicine reduces virus transmission among patients by providing medical care at a distant mode, it is a promising technology recently (Mishra *et al*., 2018; Gaskin *et al*., 2016; Hamedan *et al*., 2020; Walczak and Velanovich, 2018; Solan *et al*., 2005; Kotsiantis *et al*., 2007; Calton *et al*., 2020; Keshvardoost *et al*., 2020; Portnoy *et al*., 2020; Ghosh *et al*., 2020; Gong *et al*., 2020). With the continuous development of technologies like AI, ML, IoT, remote patient monitoring, etc., patients residing in isolated or remote areas with inadequate medical facilities, can be examined/treated by a doctor (Mamoshina *et al*., 2016; Handelman *et al*., 2018). The process of telemedicine is illustrated in Fig. 6. Oxford has defined telemedicine as "remotely diagnosis and treatment of a patient through communication technologies". For example, a Physician may consult online consultation, or in the absence of a radiologist in a city, another radiologist from another city can see and interpret the imaging results of a patient. Figure 10 is drawn to demonstrate the workflow of telemedicine. Interaction between data sources and physicians can make through telephone, WhatsApp, emails, etc. Every required notification, reminder, and feedback is included here.

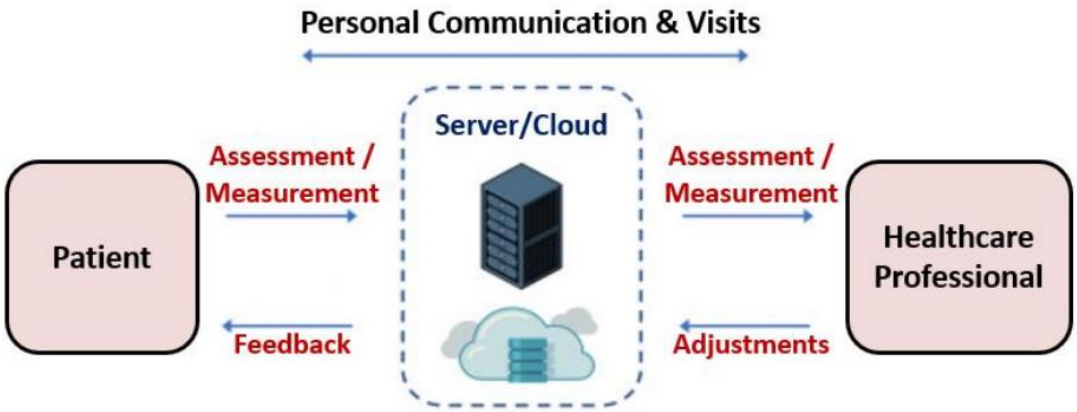

Fig. 9: Architecture of remote patient monitoring system

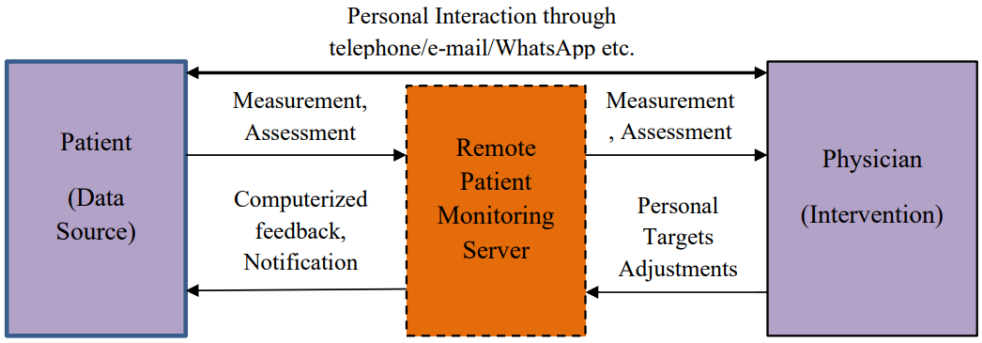

Fig. 10: Workflow of telemedicine

Three major implications of telemedicine in healthcare are:

- Tele psychiatry: A special field of psychiatry, used to treat patients in a distant mode
- Tele colposcopy: Used to assess women having lower genital tract neoplasia in collaboration with an expert colposcopist in a distant mode
- Tele Mammography: High-quality, real-time, remote patient management system used to screen mammography

Conclusion and Future Scope

Artificial Intelligence has proved its effectiveness in almost all sectors and healthcare is one among them, its growth is immense and remarkable. In this paper, researchers have summarized recent enlargements of AI in e-health in many important applications, which is effectively materialized in COVID-19 also. Nonstop evolution and appropriateness in the arena of AI, show the significant progressive role in distinct compound-type complications of e-health. Practically healthcare professionals understand the magnitude to which AI advances electronic health record sorting, disease diagnosis, enhanced decision making, remote patient monitoring, and nursing assistance. Therefore, the healthcare sector gets the benefit and appropriate recommendations can be given for further emerging AI-based methods. Concurrently state-of-the-art digital health is capable guarantee the value-added patient outcome.

This literature review also discloses that several health-associated facilities using AI, are still uncovered like quality data analysis and skilled assistance. Given the future scope of work, the researcher suggests the unexplored problems of healthcare along with the detailed process of managing and sorting electronic health records, disease diagnosis, remote patient monitoring, etc., and which particular AI-based algorithms work well. Results, process efficiency, and probability of error can be compared among different conventional and hybrid algorithms also. Innovative AI competence, machine learning, and deep learning could also be applied in the e-health sectors to develop novel solutions. The overall objective is to develop a cost-effective and efficient healthcare system on a larger scale, which will eventually benefit the quality of the lifecycle of persons in need.

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Author's Contributions

All authors equally contributed in this study.

Ethics

This study reflects the authors' own study and examination in a truthful and complete means. The paper is not currently being considered for publication elsewhere.

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