

Chapter 1: Introduction to Smart Healthcare: Healthcare Digitization

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1.1 Introduction

Smart healthcare is ability of cyber-physical systems integrated with AI, ML, IoT and blockchain to cater the needs of telemedicine for the users. The rapid increase in the world's population renders a critical challenge to the existing medical and healthcare services [1, 2]. Although the healthcare infrastructure and cutting-edge technologies are improving, the medical system still faces three critical issues Artificial intelligence in smart healthcare, artificial intelligence in general is its ability to recreate intelligence and intellectual actions of human according to the specific situation. AI is aiding many sectors such as smart environment particularly in smart grid, robotics etc. AI is a combination of algorithm from mathematics and computer science which process the algorithms. Topic used are linear algebra, statistics, probability, calculus etc. there are three types of artificial intelligence such as Artificial narrow intelligence, artificial general intelligence and artificial super intelligence. Artificial narrow

intelligence works in which the machines are already given a pre-defined decision given by humans and process it, in this stage the AI will not think on its own and it is the simplest level of artificial intelligence.

Artificial general intelligence is in when the AI used in the machines as the freedom to think but only at human level. Artificial super intelligence is when the intelligence of the built AI is exceeds the intelligence of humans. Internet of things is the artificial intelligence put in action the IoT devices after the ai has taken a decision it's work is over it is now the task of the IoT devices to fulfill the decision and produce the desired output. Internet of things connects all the devices working in the internet to the cloud and access them from one place. Blockchain is a public ledger for peer-to-peer transaction and finding it course in integration with modern day technologies. Blockchain are of two types private and public blockchain. Blockchain offers a data storage system which is more secure, high efficiency, privacy and stability. Current uses of block chain are in cryptocurrency public ledger, financial services, supply chain management etc. As the name suggests, 'big data' represents large amounts of data that is unmanageable using traditional software or internet-based platforms [18]. Big data can be classified as data's having aspects such as:

- **Volume:** refers to the size of the data occupying in the user's environment created from different sources.
- **Velocity:** refers to big data being transmitted and available in real-time, e.g., vital signs, and often arriving in bursts rather than at a constant rate [13].
- **Variety:** it refers to the different types of data which are generated or processed like whether the data is grouped or ungrouped and raw or clean etc.
- **Value:** the value of the data means the impact of the particular data will have on the

organization in business analytical part.

Veracity: veracity of the data refers to the accuracy, truthfulness and meaningfulness of the data generate for the particular program to be run by the organization. It also refers to the meaningfulness of the analyzed data from the generated data, is it being helpful for the study or not. Big data will help to maintain all the transactional records, financials and will keep the track of Electronic Healthcare Records (EHRs) data of patients, feedback and schedule of doctors and nurses and help administration to make decisions [15]. This concept is being used in many facets of healthcare, ranging from predicting patterns in the health of the people like disease prediction, symptom prediction and predicting physical exercise to improve health [16]. Edge-of-Things (EoT) is a new computing paradigm that represents a middle computing layer between IoT devices and cloud computing, bringing computing power (e.g., IoT gateways) closer to IoT devices. The EoT layer is not only useful for basic transmitted functionality, but can also perform real-time analytic services and smart decision-making within a local smart community domain [7]. In this chapter, we will be studying the integration of these technology in action.

Types of healthcare systems are:

- **Remote patient monitoring:** Remote patient monitoring is common application of IoT device. It's most commonly available as wearable IoT device in which tracks the heart rate calories blood pressure body temperature and more. Once the data has been collected it forwards the data to another software application. Designing sensors for medical equipment to collect data is a well-known research area of electronic healthcare. Notwithstanding, that equipment is very specific and are mostly located in hospitals and

similar healthcare facilities [5]. The heartbeat sensor is developed based on the plethysmography theory. It measures the change in blood volume through anybody's organ that causes the light intensity to move through that organ [3]. after it tracks if the if there is any emergency situation or something is wrong with the vitals of the human it sends back to the relatives of the closest person the human belong to and also the doctor. New researchers developed a smart healthcare system that monitored patients' health using five sensors: two sensors (heart rate sensor and body temperature sensor (LM35)) for patient condition monitoring and three sensors (room temperature sensor (DHT11), CO sensor (MQ-9), and CO2 sensor (MQ-135)) for detection of the living [4].

- **Glucose monitoring:** There is a problem in glucose monitoring device which is not able to get the correct record results since the glucose of the patient fluctuates widely therefore periodic testing is not only enough to detect a problem. IoT devices can solve this problem by automatic monitoring of glucose level in patient and keeping it in a record and whenever there are continuous peaks in the glucose consistently it will allow the patients glucose level are problematic. Challenges in setting up this device include it should be small enough to be set in a watch and it does not consume too much charge in a small period of time. Future research in glucose monitoring devices must address these challenges and find alternatives
- **Hand hygiene monitoring:** In a place like hospital or food preparing stations hygiene should be ensured at its peak. the spreading of any bacteria fungus or dirt to the objects should be minimised therefore in order to ensure the employees in the hospital are sanitized enough there is an hygiene monitoring device setup. The device can give instructions for how to sanitize for a particular surgery for a particular patient. Research

shows that these devices reduce infection rates in in the patient post-surgery by more than 60%

- **Depression and mood monitoring:** It is difficult for the patient to visit their psychologist or the health care provider to describe about their feeling every week. there is mood monitoring IoT devices which address the challenge by monitoring the patient's heart rate and blood pressure which can intern tell about the patient's mental well-being. This is the best device which tells the patient depressed before the patient is admitting it. Future research in these monitoring devices include accurate prediction of the depression symptoms from a dataset of the blood pressure and heart rate collected and check in accordance with the user using it now and get complete accuracy.
- **Parkinson's disease monitoring:** People with age above 50 or 60 or more prone to Parkinson disease resources that the early onset of Parkinson's can be cured using drugs but later stages of Parkinson cannot be cured. IoT solve these challenges by continuously collecting data about the Parkinson symptoms from the patient therefore it can be cured in the early onset
- **Connected inhalers:** Asthma and copd attacks come suddenly with only a little warning. persons experiencing attacks needs help from other person therefore usage of connected inhalers can a patients closed ones living in that locality that they are under asthma attack. The connected inhalers can also monitor the frequency of attack and it can find the reason behind the attack by collecting the data from the environment on what trigger the attack. The connected inhalers can also alert patients when they leave without taking inhalers from home
- **Ingestible sensors:** Popularity of the ingestible devices in the body which are called as

bio sensors sense, they go inside the body collect the data from the digestive and other systems and provide data about stomach pH level etc. it must be small enough therefore it can be swallowed easily and must be able to pass through the food pipe and esophagus. Nanoparticle biosensors have been designed with some that are fully implantable. These sensors act as a 'fuel gauge' transmitting internal measurements of physiological function in a step towards digitizing the human body [8].

- **Connected contact lenses:** Contact lens another healthcare device which provides data in a passive way it includes a micro camera with which the user to take picture at snap of his eyes and Google is the first to have patented connected contact lenses. The use case of this connected contact lenses is to be explored in the future
- **Robotic surgery:** As Discussed earlier usage of robots in the smart surgery can help the doctors to make micro size incisions in in human blood vessels so that it can lead to accurate cut and the surgery would be infection less and it promotes faster healing for patients. Challenge of this device is that it must be micro sized and be reliable enough to perform micro inclusions without any disruption in the process robotic sensors are already used in the surgery but the research of micro robot hands is in development stage.

1.2 Motivation

In a vast country like India or the united states of america the doctors per 100000 people is very low and it is that not everyone can get access to the best healthcare, therefore there is no option of choosing the best doctor in the world, the patients seem to be fine if there is atleast a doctor available for the treatment. Therefore telemedicine is very much ignored by the patients due to

the less knowledge to the access of telemedicine. In this chapter it is discussed about how the healthcare digitization can take place and the the end users can benefit from it and become knowledgeable to telemedicine, the smart healthcare devices are also discussed in this chapter. In 2020 corona virus has changed the world's existing healthcare system the transformation of the healthcare digitization was at very slow pace, but after the corona virus hit us in 2019. There was a rapid digitization which has not happened in the previous decade. The governments which could not adapt to the digitization or ignored digitization faced in increase of covid-19 cases during the pandemic.

One such example is south korea which did not adapt to digitization due to its stringent impositions imposed in the smart healthcare sector which increased covid-19 cases. In this chapter, we have analyzed the healthcare sector before, during and after covid-19. The idea in this chapter is to connect different technologies such as Artificial intelligence, Internet of Things, big data and blockchain analyzing about its interoperability and also the technical challenges faced while connecting these technology. There is an under-utilization of blockchain in smart healthcare sector, therefore in the paper it is discussed the usecases of all the technologies in the smart healthcare. In this chapter, it is discussed the barriers in the way of smart healthcare which the patients feel difficult and also discussed the telemedicine benefits which removes the below said barriers.

In another side, we can see (in figure 1) the multimedia application role and importance in healthcare and smart healthcare.

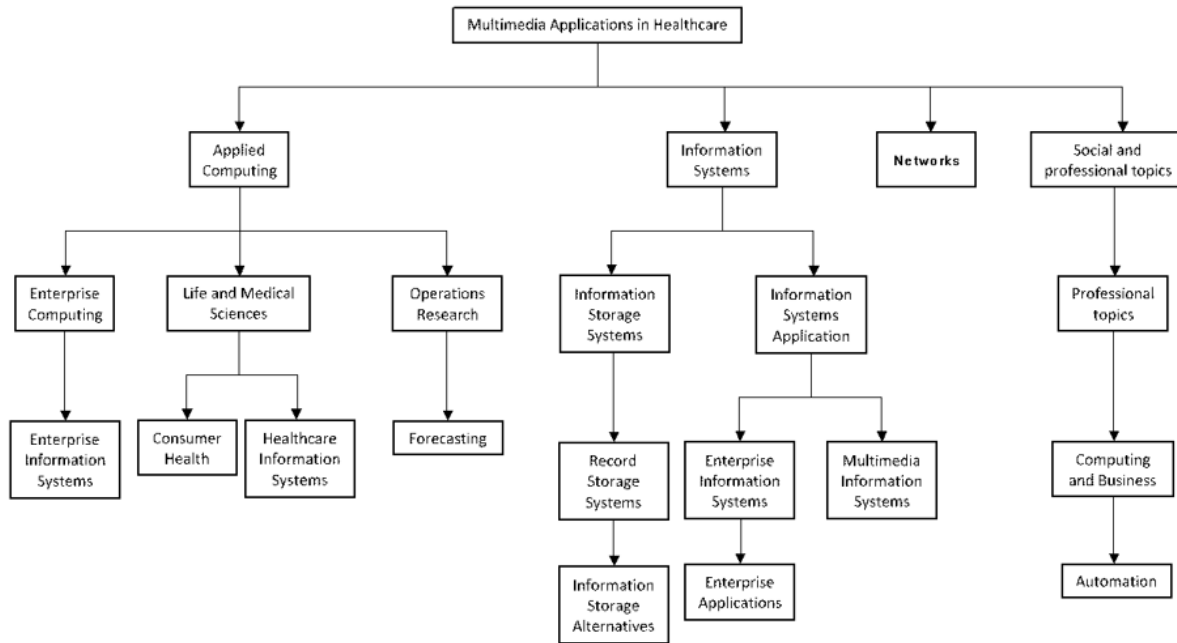


Figure 1: Multimedia Applications in Healthcare

Aspects of smart healthcare:

Digitization of healthcare is not only technological advancement but it's an all-round development of smart health care facilities information based. The health care hospital and the primary health centre is in the process of developing to an information-based system but it also the time for the healthcare ecosystem in homes and community to information-based system as well. It makes the information-based system more efficient can be easily personalizes and convenient for the larger scale healthcare systems to access it. Hence, there are few requirements for smart healthcare which can be listed here as:

- Patient-centered care:** The traditional healthcare model followed was a disease centric approach where the focus was shifted through diagnosing the symptoms patients have and it wasn't treated according to the doctors prescribed treatment protocols. The challenge in the disease centre where if

the patient had previous history of other diseases or allergies if it is not treated in accordance to it in a disease centre approach therefore in this chapter usage of electronic health records is talked in detail regarding to this. If the patients past health history is ignore and his given a wrong treatment can result in danger. The four in patient centric approach main focus lies on the health history of the patient needs and the beliefs of the patient. The patient's preference is given a high value in a patient centred care.

- **Personalized management:** Health care in the today's generation provided health care system hospital. The service is never customizable or changed according to the patient's opinion. In building a patient centric smart health care environment the needs and preference of patient must be respected and their system takes their opinions into consideration.
- **Prevention is better than cure:** Model focus on preventive rather than treating a disease after it occurs. This is made by continuously monitoring the user behaviour their body conditions, symptoms, environment, lifestyle choices they live in which are the most important factor causing illness. Analysing these factors before the disease can help in making the people more health conscious and fill in the diseases in the future.

1.3 Progress towards Smart Healthcare

1.3.1 Healthcare - Pre-Covid 2019

In the 1970's AI was introduced to healthcare to solve existed problems in bio medical engineering. Advances in AI in emerging technologies such as Big data, machine learning and cloud computing etc., has also been an integral part of evolving smart healthcare before 2019. The watson for oncology AI smart healthcare application created by IBM, it is a product trained by the oncologists for the users to get an opinion on diagnosis for cancer and gives a good accuracy of 90 percentage e solutions by the oncologist doctors. The artificial intelligence has developed an algorithm for accurate diagnosis of diseases, predication of response from the user, improving efficiency in the workflow operations in the hospital, increasing the overall procedure accuracy. In the 1950-70 era an industrial robotic arm was built by the General Motors in 1961 and was used in the assembly line for predefined die casting. There was built the Shakey, flakey robot by the Stanford Research International (SRI), but for the smart healthcare field ai was very slow to be adopted.

The 1970's era was period referred to as AI winter as it had low fundings for any technology to be developed, but yet there was an official adaptation of ai in healthcare was done in 1971 by the (SUMEX- AIM) for the biomedical researchers across the world to connect to each other. Later in 1975 there was a conference in the Rutgers university about the topic AI in medicine. In 1987 there was a product Dxplain developed by the university of Massachusetts that proposes to generate differential diagnosis to provide information about 500 diseases. Then there was enhanced deep a developed using natural language processing to provide evidence-based medicine responses. In the recent era there was pharma Bot developed in 2015 to assist in medicine education. Using AI, the healthcare system was transformed more into patient centric approach and helped in also increasing the efficiency of staffing in the hospital. As of now there are many hospitals and health centers equipped with the smart healthcare system. Additionally,

wearable scanners or medical devices are used for patient health management after treatment, and apps that are developed exclusively for certain hospitals can check patients' conditions 24/7.

In the pre-COVID period, in addition to telemedicine, there were a number of contactless healthcare systems in use. In the pre covid era, there were man tracking systems checking vital signs using the technology radio frequency identification known as RFID. In the recent era there was employability if AI based robots in the healthcare industry to assist in inpatient rounds, writing and modification of medical records, administrative work in the reception and assisting in providing information about the treatment. Before the covid era there was no emphasis on the mental health of person there was no much importance on the mental health monitoring.

1.3.2 Healthcare during covid 2029 era

Even after our world seeing many epidemics like swine flu, Sars covid-2019, etc., the whole world was shocked and was not prepared for the corona virus, people in India already having less medical knowledge became more scared and insecure due to the fake news spreading around the world due to the virus. But with the doctor's side there was no fear as the virus seemed similar to the Sars cov-2 pandemic in the 2000's, but the doctors feared the patients having other complications in body like diabetes mellitus, chronic kidney disease, lung disease etc. since the death in corona was very minimal but the persons with other complications in the body were more likely to be dead.

The immediate effects of corona virus on the person in the world are listed below:

- Decreased financial security: For the people without valid medical insurance in India

or USA feared of the high-cost medical treatment for the corona virus.

- Increased stress on informal caregivers: Since the virus is communicable even the informal caregivers such as parents or relatives to virus affected person fear to give the unconditional help to the affected person.
- Challenges with protections of individuals with disabilities: Not all the person with disabilities have a caretaking member with them, it was difficult for the people with disabilities not having a caretaker.
- Absenteeism of home care workers: The pandemic has largely affected the home care workers profession since the person hiring employees for the home workers profession feared that the home care workers working in different houses have the chance to spread the virus to the ones who is hiring. There was also fear among the primary workers to work in the public places due to the fear of catching the virus.
- delay in the procedure for the chronic conditions apart from corona virus: There was non-availability and poor doctor management of doctors in the city by the hospital management due to the pressure created by the virus spreading, for the other treatment for the chronic conditions were delayed.
- Ignorance to visit health care centres in person: During the time of virus spreading the patients having other problems than corona virus started looking for inaccurate home remedies specified in different healthcare websites. If there is fever or common cold causes the reason for it caused can be many, but the remedies given in the website will not work for all the causes, therefore doctor's live diagnosis is the best.
- Impacts on mobility due to confinement: Due to some areas being marked as red zone which means it is affected highly by the virus, those sorts of places or the road leading

to those places are blocked, therefore the primary health care facility or the hospital or pharmacy in that area cannot be reached.

- Concerns about medicine shortages: During the starting stage of the pandemic due to the less awareness of the virus or the not following the protocols which are needed to be followed in the work environment some of the pharma industry was closed due to the fear of spread of virus among it's employees resulting in drug shortage in the country. Also, during the initial stages of the pandemic there was a block of import/export of drug in the industry leading to the shortage of drugs.
- problems about using masks, and face coverings for those having breathing difficulty: The people who had past history of breathing difficulties such as asthma, wheezing etc., felt difficulty in using the mask in public places during the pandemic.
- Distress and burnout of health care workforce: As discussed earlier there was poor management of the workforce during the pandemic including the healthcare staffs, nurses and doctor. There was also poor management of different wards in the society. the lessons learnt during the pandemic was to involve a patient centric treatment approach and innovative smart healthcare methods needed to be adopted.

During the virus many of the hospitals in the countries at least by a 50 percent has shutdown it's health care facility for treatments such as diabetes, hypertension etc., and also more than 60 percent of the country's rehabilitation facilities have been closed during the pandemic in order for the doctors to avoid face to face counselling. Also, during the pandemic many people preferred online diagnosis instead of the traditional way of meeting the doctor. There was rapid development of the tele medicine sector of the smart medicine sector during the pandemic which reduced the interaction of the patient with the third person and now they can directly be diagnosed by the

doctor. The amount of usage of the smart healthcare systems by the patients before the pandemic was 10 percent but after the impact of the virus it grew to 50 percentage facilitating more people to use innovative and contactless healthcare systems. In the interview with the team of Stanford institute of health and medicine it was mention that 76 percent of the outpatient causalities were dealt online.

Such telemedicine services can reduce the risk of infection during the spread of an epidemic disease by delivering care through ICT while the patient practices social distancing. The ai in healthcare was proved and doing greater achievements in reducing the problems in healthcare industry such as shortage of healthcare personnel, abolished the token system being followed in the hospitals and healthcare centres. During the pandemic there was many research showing the accurate test of the corona virus such as the one like x –ray of lungs and using the concepts of convolutional neural networks in testing for the corona virus in the individual. The ai foundation in basis of healthcare setup now will also be helpful in the future to predict the growth of virus, prevent the virus.public places in the smart environment. It uses IoT and AI to get the things needed to done by the user.

1.3.3 Healthcare post covid-19 era

The World Health Organization in 2019, defines telemedicine as “the delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their

communities”.

COVID-19 prove to be a great macroeconomic shock the stock prices on the April of the 2020 fell down to great margins like Nifty in 2020 April fell to its low 8000 rupees and now which is October 2022 regain momentum and clinched 16000. Not only in India but also in the United States of America and also the European union there was a massive it in the stock market and which is reflecting the country's economy down fall. But due to the adoption of modern-day technologies during the covid-19 and the post covid 19 the companies' industries were able to manage itself to run with the profit margin instead of a loss. those companies which could not update themselves to modern day technology suffered a loss. Functioning of the government, the government ensured to change their policy and priorities. Due to this change of priority and policy this this added to the growth of IoT in smart environment and also particularly in the smart health care. Most of the leading expert and researchers believe that there will be more of influence of technology in the life of humans in the post covid era too.

Telemedicine market 45.5 billion in 2019 and suspected to reach 175 billion by 2026 this tells the used demand of IoT in smart health care sector. the modern-day researchers and engineers need to come up with new research products for the model for the smart healthcare. The healthcare company should find smart healthcare division research division due to the rise in market demand for smart health care products. The growth of the smart healthcare products owes to the government's regulation with respect to tele medicine to minimize the spread of covid-19 by contactless treatment. The telemedicine products directly impacted the other industries because using of tele medicine products made sure of contactless treatments which reduce covid cases which in turn made the government to remove new regulations which made the other industries to recover. Country such as South Korea underutilized smart health care products by posing rigid

regulations on smart health care sector which fuel the spread of covid-19 and industry loss in their country therefore without the help of government health care the development of telemedicine cannot take place. It is that ICT information and communication technology will play a greater role in the healthcare domain such as in the treatment of disease, prevention and analysis etc. in the future the role of the smart health care products develop an effective disease treatment and prevention and spontaneous action to healthcare personal shortage or equipment shortage and innovative methods to create smart health care environment.

1.4 Internet of Things-based Healthcare

The definition of IoT based on IoT European Research Cluster (IECR) project Internet of Things is dynamic network infrastructure which has the capability of self-configuration on the bases of interoperable and standard communication protocols []. IoT is about integration of the “things” that form the life of people into software applications, leveraging benefits from the information continuity. IoT technology is a recent component of Information and Communication Technologies (ICT), looking into the potential of combining wireless sensor networks, beacons, radio-frequency identification (RFID), data processing, security, etc. in healthcare services [14, 21, 25, 26, 27, 28, 29, and 30].

- **IoT for patients:** The modern day IoT smart healthcare devices enable use of devices for person of any age can wear the device example of few devices are fitness bands it's monitors blood pressure heart rate monitor oxygen level SP O2 it also monitors the calorie count exercise monitoring and also the blood pressure wearing during the exercise in this way the patients and the patients relative can monitor their family members. On any

disturbance in the regular activity or the body vitals of the patient the IoT device will send an alert alarm to the family members mentioning the emergency of the patient this in turn effectively enables better tracking system for the elderly patients even a small disturbance noticed and treated can prevent the major incident.

- **IoT for physicians:** As mention wearing the IoT devices and monitoring equipment's this helps in a way where the physicians can track the patient's data and keep a track of their record in a digital format and also be ready for the procedure for the immediate medical attention. this help healthcare professionals to be more watchful and connect to the patients immediately, this in turn achieve for goal of patient centric healthcare systems.
- **IoT for hospitals:** Apart from the advantage of monitoring patients' healthcare using smart IoT devices the hospital also gets another use in IoT devices tag with location sensors to track their medical equipment's like surgery instruments wheelchairs oxygen cylinders etc. In India due to the covid-19 there was a shortage oxygen cylinders by implementing the IoT sensors for the location tracking the hospitals could track the medical equipment's instead of leaving it to the third-party members who in turn the oxygen cylinder for money in the private market. blockchain supply chain management technology could also be used in the above process this we will discuss later in the chapter. Deployment of the medical staff at different locations in the hospital can also be virtualized and analyzed using IoT devices using technology such as artificial intelligence and machine learning algorithms. In the hospitals IoT devices can also be used in monitoring devices from preventing patients getting infected. Another use of IoT devices hospitals include inventory, temperature monitoring, humidity monitoring and environmental monitoring.

- **IoT for insurance company:** Insurance companies using IoT enabled devices reduces the fraudulent claim of insurance. The recent development of IoT devices enabled insurance company to track the patients' health is for her exercise routine so that they could reduce or increase the insurance amount by looking at into their exercise routine.

5 Blockchain and its benefit in healthcare

There are few benefits of using decentralized and distributed concept using for healthcare, which can be listed here as:

- **Securing Patient Data:** Secrecy of the patients' data is the most important part that are many cases in which the patients record is scampered and the same data is replaced by another data submitted to the doctors and hospital between this decade 2010 to 2022 there are more than 200 million patient records which are breached. Not only change the date of from the patients record but also use their credit card, debit card bank information and steal money using the patients record. the better alternative to securing patient record is blockchain as blockchain is already used for application such as supply chain management in tracking of the goods and transactions peer to peer, blocks in can ensured temper proof distributed and in correctable patient record and can be used to store patients record in a secure way.
- **Supply chain management of healthcare drugs and equipment's:** Medicines drugs or surgery equipment's are not directly made in the hospital they are imported from labs and pharmaceutical industries worldwide they are further supplied from the industries to the other countries according to their needs therefore due to the long tedious process of drug import. blockchain can be used in the supply chain

management of the medical drugs to ensure tamper free and transparency.

- **Single Longitudinal Patient Records:** Blockchain is a chain of blocks and all the attributes of the patients record during with the hospital is noted and will be entered into the blockchain ledger the attributes can be lab test results, treatment, fees, past disease etc. This can be used by the hospital physicians and hospital workers to analyse the patient's disease based on the lab test from a single patient record and also offering discounts to the customers by analysing regularly to the hospital.
- **Supply chain optimization:** As discussed previously the authenticity of the medical goods such as medical drugs surgery equipment's needed to be ensured of their authenticity. the previous use of blockchain in supply chain management can be used in the supply chain management of the medical drugs and products this enables the hospital or the buyer to view the visibility and transparency of the goods that was brought. This also increases the confidence of the customers to buy from the same company again.
- **Decentralized storage of medical records:** The interplanetary file storage in system in the blockchain enables the industry to store data in the decentralized storage environment.
- **Improves electronic health record systems:** Not only the patients record system can be stored under the blockchain, the medical drugs available in the healthcare facilities the medical equipment's can also be stored in the blockchain storage decentralized which can be later viewed to see the availability and can be edited.

Table 1: Key Elements of Blockchain Technology

Decentralized	
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Transparent	
Immutable	
Autonomy	
Open Source	
Anonymity	
Trusted	

Hence few other benefits are:

- Patients Predictions for Improved Staffing:** To reduce the labor cost during a shift in the hospital to avoid unnecessary labour cost and also, we need to have the correct number of workers to be present at the hospital unit for a good customer service. Use case of healthcare data analytics can be used in this problem to predict the number of patients for a good customer service outcome. Use cases of healthcare analytics are in many domains such as medical expenses clinical data patient behaviour and the pharmaceutical industries etc. Be used in both the macron micro level work. Analytics facilitates both administrative and financial data analysis. Data analytics healthcare is used to eat the doctors in making the decisions faster using the data available and enhance the treatment of patients this is used for the patients having medical histories and suffering from multiple conditions. Help in examining the data of the patient and medicines prescribed by the doctor and dosage level check if it is correct treatment and then revert back to the patient and correct if there are any errors.\
- Electronic Health Records (EHRs):** Electronic health records is one of the important applications of big data in the smart health care. Health record for each person which includes

the demographics, medical history, allergies, laboratory test results etc. Records are shared to the health care person to the information system in a secure way. Every record has one modifiable file where doctors can change data in the record. Electronic health records can also alert and remind the patient when they should get a new lab test or visit a doctor for a follow up. Many countries apart from the USA are struggling to implement electronic health record in their system European union are left behind and United States of America digitized healthcare using electronic health record with 94% of the hospitals adopting it. McKinsey report states that the electronic health record as improved outcomes in treating cardio vascular and saved 1 billion dollars due to reduced office receipts and lab tests. EHRs may empower patients to play more active roles in caring for their health by directly delivering information to these individuals. Patients not only can know specific details about their health parameters and illnesses but also can present medical records to other healthcare professionals when needed [10].

- **Enhancing Patient Engagement:** Many patients are becoming interested in smart health care device that record the heart rate, blood pressure, calorie count, oxygen level etc., in the body and that information can be couple with other data sets available to identify similarities between the two data sets if identified it would display, they are in the risk of that particular disease. Person suffering with chronic insomnia and higher heart rate can signal risk for cardiovascular diseases in the future. patients become health conscious and get incentive from insurance companies and lower their insurance amount. Use case of the above said product is suitable for person suffering from asthma or high blood pressure and can reduce unnecessary visits to the hospital.

- **Track Mass Diseases:** In the beginning of covid-19 it has impacted humans around the world physically, mentally and socially. it's ability to spread and mutate to strong form gave a challenge to the health care industry which tried to learn from it and control the spread of the

disease. With the help of the big data technologies the healthcare professional were able to track in real time the spread of corona virus, how fast it is able mutate to other virus, it' effect on the country's economy. This is only done by analyzing massive amounts of datasets coming from different medical sources. Technologies such as ai, medical imaging and analytics allowed to detect corona virus in the patient from chest x-ray, tomography, ultrasounds etc. it was in 2022 EU patented the research “analyses images of the lungs taken by a CT scanner, identify the signs of coronavirus, and assesses the lesions “to identify the signs of corona virus, this level of technology helped the European Union (EU) to flatten the corona virus curve.

1.6 Artificial intelligence and its benefit in healthcare

An example comes from the world of chess, which was the first real test of human intellect versus machine. In 1997 IBM's Deep Blue beat the reigning chess grandmaster Garry Kasparov, a tremendous feat of computational capability for the time [17].

- **Increased efficiency of the diagnostic process:** A lack of the existing medical data history can increase the chance of errors of the physicians in the diagnostic process. The use of AI in smart health care will be to predict and diagnose the disease origin faster than the lab testing by the clinic with a very minimal percentage of error lower than the human error. For example, in 2017 there was research published for detecting the for detecting and diagonalsing breast cancer which prove to be percentage higher accuracy than pathologist testing technology is used deep learning, AML models. Not only AI and ml is needed to provide accurate solutions the vast amount of data which is the big data is needed to write efficient algorithm to get accurate solutions.

- **Reduced overall costs of running the business:** As discussed earlier using AI the process of manual testing makes the diagnosis and the treatment more efficient but it also cuts a cost required to do it manually the technology is developed using image processing and analytics coming under AI can analyses images of CT scan x-ray etc., can reduce the manual work involved and also reduce the percentage error. Give the introduction of a in smart health care patients are treated faster not tedious waiting Times, no admission fees etc. Cross cutting of AI is rank below Robot assisted surgery 40 billion, Nursing assistant 20-billion-dollar, Fraud deduction 18 billion dollars and Dosage preferring 17 billion dollars.
- **Safer surgeries:** AI IoT devices in the smart healthcare can provide assistance in surgery and reduce the error manual error in the surgery robots or the devices can be more cautious when working around sensitive organs tissues reduce risk of infection and unnecessary blood loss. Treatment of very minute blood vessels or nerves in the body that is a study with shows robot hands are much more efficient than manual hands to treat the sensitive places. The advantage of robot hands over manual hands it can reduce tremor during the surgery and reduce the error due to manual human tremor.
- **Enhanced patient care:** Health care facilities before pandemic covid19 was not well managed and was chaotic with use number of patient visiting the hospital and hospital not making any efforts to manage it before the pandemic the patient care was not patient centric, no importance given towards the patient pre pandemic. In a study it shows that 80% of the patient feel poor communication is the worst part in the treatment process. AI can rapidly scan data reports using image analytics and processing it could be used here so that there is a faster processing of the data and no tedious process for the patients to be followed [17-21].
- **Easy information sharing:** As said before the use of blockchain in the smart health care

integrated with ai and IoT device can increase the efficiency of the transfer and storage of data. it tracks the data of the patient it can do it in seconds where traditional tracking of data can take more time which in turn allows doctor to focus on treatments rather than the data tracking. The device called freestyle liber glucose monitoring system helps the patient to track their glucose levels and transfer the glucose level reports to the doctor or the professional in the hospital for efficient treatment.

- **Better prevention care:** Aarogya Setu app developed by the Indian government the National informatics centre is one such of an AI ml integrated device application which tracks the user with covid-19. It proved to help in great amount to reduce the infection in the country. intelligent platform called Blue Dart analyzed the spread of covid-19 using airline ticket and flight path and accurately predicted that the spread was from Wuhan to Bangkok and Taipei. furthermore, analysis of compounds for drug testing and finish research which can take years into only a few weeks. Which helps the researchers develop vaccines for the disease quickly.

1.7 Problems with access to present healthcare system

Few Problems with access to present healthcare system are:

- **Limited Appointment Availability Office Hours:** Mini healthcare hospitals and primary health centres are opened in the time when the working-class people work which is between 8:00 a.m. to 6:00 p.m. Therefore, the timing is not always useful. The timing should be made in such a way that it also benefits working class people as well as the non-working-class people in order to avoid a rush or a queue. Extending office in the hospitals for the doctors and the workers is one of the most important tasks in building a patient

centric medical treatment. The alternative of this is sector which allows the patient to receive medical treatment without their physical presence in the hospital but to their virtual presence in the video call or conference call with which is directly connected to the doctor. Due to a smaller number of doctors per the area of 10000 of people in an important factor for the limited appointment availability in many countries such as United States of America and India. There must be an efficient relocation of the doctors from different centres in the time of work to fulfill the appointments of the patient.

- **Geographic, Clinician Shortage Issues:** Due to higher pay in the urban areas the doctors are most likely to shift their centres to the urban areas and the persons living in the rural area cannot get the same quality of the healthcare as one of them living in the urban area. The rural residents can also encounter social and various communication barriers in their process of access to the healthcare that limit their ability to get the best healthcare. In order for them to receive the best healthcare there must be access to necessary health care services available in a timely manner. Study shows that rural residence has to travel 40 miles for a radiation treatment and the urban residence should travel only 15 miles for the same treatment. Due to the boom of access to the telemedicine or the smart health care after the pandemic and also during the pandemic it reduces the gap between the patients and the doctor living in both urban and rural area so that they get the same quality of the treatment from the urban area doctor it was only for the lab test they have to go to the nearest lab centre. The telemedicine services also connect smaller hospitals or health care centres with the larger government academic medical centres. A study shows that in United States that is 40 physicians per 100000 people in rural area and 53 physicians per 100000 people in the urban areas.

- **High healthcare costs:** Main barrier in the way of accessing the best healthcare system by the user is the high healthcare cost. In the study by the best health and gallop poll it found that three out of 10 Americans tell high cost of healthcare as the health care access barrier for them, those patients who said high cost as the barrier for the health care access skipped medical care at least one in 3 months. One more study tells that person making more than 120,000 dollars annually out of which 20% of them said they could not access the health care due to its high healthcare cost. The cost of the healthcare treatment was increased around 10% higher than it was before the covid-19. 40% of the US skip treatment or regular follow up to the doctor due to the high cost of healthcare, in which 30% of them were earning high income and 50% of the low-income patient skip care because of high healthcare cost.
- **Social determinants:** In addition to the barriers of the healthcare industry itself there are also social determinants of patients which play a major role in their access to the healthcare which makes it harder for them to get into the doctor's office. Some social determinants already discussed in the chapter include geographical location, their staying, income and transportation access. In addition to it race or racial discrimination has also resulted in problems related to access of healthcare by the patient. Red lining policy introduced back in 1938 to separate desirable and undesirable created racial discrimination. Therefore, there needs to be healthcare digitized. Traditional healthcare organizations have realized that they need to change the way they work, for example, over the two years most of the large pharmaceutical companies have started to employ a chief digital officer [9].

1.8 Challenges in healthcare digitalization

Popular challenges faced in implementing/ building a smart healthcare system are:

- **Old habits of employees and customers:** The process of digital transformation is itself a long process that to0 in the healthcare domain the employees or the customers might feel anxious to use or adapt to new solutions instead they often stick to the old solution because of their old habits which stop in improving the patient centric treatment approach. The new enterprises software domain is widely being accepted by many health care organizations thinking that without change the competition is very tough. Healthcare digitization is not only implementing new software and developing mobile applications and web applications it is also to change the way perspective of the employees think and work and the users think and work. Process will need a huge amount of funding but once a technology developed it always works for the lifetime sparing only few developments son upgrade which is at less cost.
- **Lack of software interoperability:** **Interoperability** is defined as connection of different cyber physical systems device and application to access exchange integrated and cooperatively used data in a coordinator matter within and across regional and national boundaries to provide timely and seamless portability of information and optimize the health of individuals and populations globally. Exchanging information between two or many systems involving their respective technologies can be a desirable feature in healthcare digitization for example the data of the patient stored in blockchain must be transferred to the IoT device to check for if the patient is eligible for a discount in the treatment based on their previous entries. The absence of interoperability between the software makes the communication between the company and the patients less efficient

and more time consuming.

- **Data protection:** Note that some of Goals of information security systems are:
 - Confidentiality: Means securing the information from the unauthorized user to see.
 - Integrity: Means that patient's data will not be changed by third party user.
 - Authentication: It means that identification of the person who trying to access the data in the system.
 - Availability: It means that authorized users can anytime access their data when in need.

Hence, respecting the user's data in the process of the smart health care digitization transformation is very important if the data of the patient is breached it can be misused by the third party occurs as discussed earlier it can also be used to steal the credit card debit card or banking number information so that they can steal money from the users.

- **Costs of digitization:** Cost of digitization in healthcare digitization is not cheap. it needs IT infrastructure companies to work to build a new smart healthcare product for the healthcare company and its not over after building the product. Product must be maintained developed upgraded and updated by the IT company, therefore it's not going to be a cheap process it will need more funds for building it. But looking at the advantage the health care company in the future it would increase income and save a lot of money by offering new medical services to their customers
- **Data Processing:** A major challenge in the healthcare industry is discussed which is there is a demand for huge amount of data needed to provide robust and accurate solution to the users for the machine learning algorithm to work efficiently and give accurate solution to the uses but in the real sons it's only a small amount of data that

hospitals, clinic and professional collect without huge amount of data is difficult to provide accurate solution. The major problem lies in the collection and mining of the data. Rise in telemedicine, the doctors giving diagnosis in different channels through different companies makes it harder for the doctor to update the patients record which in turn results in no data at the end and AI ml cannot provide a solution. The solution for this could be they can industry was come up with the new way to record and update the patient and doctors record for both in person virtual visit. For example, in the European union stringent data protection regulation act has been enforced so that the organization must not use and store data for their personal purpose if done the has to pay fine of 4% of companies' annual turnover.

- **Improving Cybersecurity:** Security and privacy protection are certainly very important issues of IoT applications, particular healthcare IoT. This is because healthcare IoT tends to use location, personal, and context information of users in order to provide its services [6]. As discussed, earlier protection of data is most important and for the users to get confidence in the smart healthcare digitization process. the study conducted by IBM says that HealthCare organization associated with high possibilities of data breach which is three times than in any other domain. Accurate authentication deficiency and excessive user permission are other main reasons which lead to the data breach in the smart health care sector. the more software technology is coming together in the smart health care such as adaptation of internet of medical things that will be more likely cause software attacks. There must be a cyber security team behind the product working continuously for the removal of bugs threats from the third-party hackers. There is not only data breach there are also bugs

in the updated software for removing the bugs There must also be a technical team working behind for the removal of bugs and update the product before and after the launch.

- **Digital User Experience:** The design of the product like a connected IoT monitor device, mobile or web application must be developed in way so that it's user interface and experience are user friendly because the age range of which the people use the product can be anywhere between 3 to 100. The UI and UX team must take to consideration and developer product user friendly.
- **Operator Interface:** This interface allows network operators to register to the SHS in order to manage current and historical information from environmental sensors, set rules and alarm notifications [1]. An uncomfortable designed healthcare device might make the patient to remove the device and limits the data which it is able to collect. The user interface should be as convenient and intuitive as possible. Even people who are not familiar with the software should be able to use the complete functionality, e.g., new user data, constraints of different sorts, history access, etc., [12]. If the software of the healthcare device is difficult to use it will also result in the medical professional not to prescribe the device to the other patient. Does not matter how strong the technology or the development of the product it comes down to the user interface and the user experience therefore this is most important thing to take into consideration in developing a smart health care device.
- **Quality Assurance Testing in Healthcare:** It is important to ensure that the software is capable to deliver the required task and service to the user. The software testing it's to view the business work flow and increase performance of the device to get accurate

results. This is done by software and execution for a given variable. The central accurate output within short time. As the discussed earlier healthcare applications, we've sensitive data about patient the breach of this data can result to problem. Usage of security testing with penetration testing can make the application breach proof and sustainable.

1.9 Future research in smart healthcare

The major challenges include interoperability of interconnected devices in the cloud, cyber security preventing attacks, collection of more medical patient related data and efficient management of all the devices connected to the cloud [17-30]. The other challenges include usage of ideas to reduce the cost for developing and management of the device. The approach of the future health care must be patient centric healthcare approach which means that the healthcare is there to support the patient not only in the diagnosis and treatment aspect but also the other aspects as discussed in the problems with access to healthcare. The new development in healthcare should be of immediate diagnosis of diseases based on the everyday difficulties faced by the humans so as to stop the spread at initial stage. The future research also includes the risk prediction and the prevention of any new virus. The main paths for future research revolve around

- challenges about engaging patients or citizens in designing e-health services,
- the necessity to develop purely disciplinary research and reach a common taxonomy,
- patient empowerment,
- the impact of digitization on healthcare practices and the relationship between

patients and healthcare professionals, and

- insufficient strategic and policy reflection about the impact of digitization [11].

In near future, researchers can work towards improvement of healthcare as its revolution 4.0, which will be useful and convenient to the society 5.0 (refer figure 2).

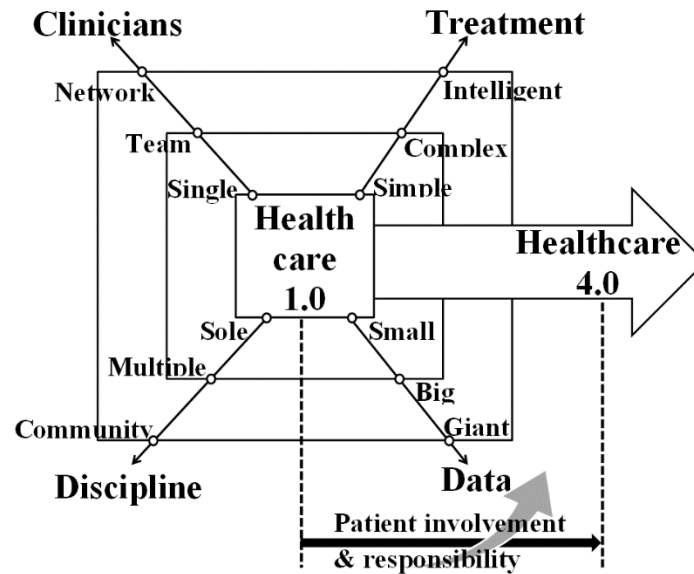


Figure 2: Healthcare 1.0 to Healthcare 4.0

Hence, in this work the author discusses about the cyber physical systems and it's uses cases in cyber physical systems. The author explains about the importance of cyber physical systems and medical cyber physical systems. The author describes in detail about the types of attackers and types of attacks in the medical cyber physical systems. The author also speaks about the issues and challenges of medical cyber physical systems (CPSs) in the future. The author first introduces the technologies emerged due to covid such as processes in ai, cloud computing, Big data, blockchain, IoT. Author speaks about application of artificial intelligence, internet of things and internet of medical things development primarily in the covid – 19 eras.

1.10 Conclusion

Smart healthcare after developed it has to be well maintained by both the users in the smart environment and the developers working in the back end in the smart environment who develop, upgrade, update the products. Without the further research in the challenges discussed above the smart healthcare will not be welcomed by the users using smart healthcare in telemedicine. In this chapter, we have discussed the challenges faced by the users in the smart healthcare and also discussed solutions to few challenges or the approach or the way the problem can be solved. By focusing on the challenges above and have built the smart healthcare, the chapter vision can become into a reality.

References

- [1].L. Catarinucci *et al.*, "An IoT-Aware Architecture for Smart Healthcare Systems," in *IEEE Internet of Things Journal*, vol. 2, no. 6, pp. 515-526, Dec. 2015, doi: 10.1109/JIOT.2015.2417684.
- [2].H. Zhu *et al.*, "Smart Healthcare in the Era of Internet-of-Things," in *IEEE Consumer Electronics Magazine*, vol. 8, no. 5, pp. 26-30, 1 Sept. 2019, doi: 10.1109/MCE.2019.2923929.
- [3].Islam, M.M., Rahaman, A. & Islam, M.R. Development of Smart Healthcare Monitoring System in IoT Environment. *SN COMPUT. SCI.* **1**, 185 (2020). <https://doi.org/10.1007/s42979-020-00195-y>
- [4].M. Nasr, M. M. Islam, S. Shehata, F. Karray and Y. Quintana, "Smart Healthcare in the Age of AI: Recent Advances, Challenges, and Future Prospects," in *IEEE Access*, vol. 9, pp.

145248-145270, 2021, doi: 10.1109/ACCESS.2021.3118960.

- [5]. A. Solanas, F. Casino, E. Batista and R. Rallo, "Trends and challenges in smart healthcare research: A journey from data to wisdom," 2017 IEEE 3rd International Forum on Research and Technologies for Society and Industry (RTSI), 2017, pp. 1-6, doi: 10.1109/RTSI.2017.8065986.
- [6]. D. He, R. Ye, S. Chan, M. Guizani and Y. Xu, "Privacy in the Internet of Things for Smart Healthcare," in IEEE Communications Magazine, vol. 56, no. 4, pp. 38-44, April 2018, doi: 10.1109/MCOM.2018.1700809.
- [7]. A. Alabdulatif, I. Khalil, X. Yi and M. Guizani, "Secure Edge of Things for Smart Healthcare Surveillance Framework," in IEEE Access, vol. 7, pp. 31010-31021, 2019, doi: 10.1109/ACCESS.2019.2899323.
- [8]. Sanjeev P. Bhavnani, Jagat Narula, Partho P. Sengupta, Mobile technology and the digitization of healthcare, *European Heart Journal*, Volume 37, Issue 18, 7 May 2016, Pages 1428–1438,
- [9]. Michelle Helena van Velthoven, Carlos Cordon, Goutam Challagalla, Digitization of healthcare organizations: The digital health landscape and information theory, *International Journal of Medical Informatics*, Volume 124, 2019, Pages 49-57, ISSN 1386 5056.
- [10]. Cáceres SB. Electronic health records: beyond the digitization of medical files. *Clinics (Sao Paulo)*. 2013;68(8):1077-8. doi: 10.6061/clinics/2013(08)02. PMID: 24037000; PMCID: PMC3752637. Dash, S.P. The Impact of IoT in Healthcare: Global Technological Change & The Roadmap to a Networked Architecture in India. *J Indian Inst Sci* **100**, 773–785 (2020). <https://doi.org/10.1007/s41745-020-00208-y>.
- [11]. Vincent Mabillard & Jan Mattijs, 2022. "**Digitization And Co-Production Of**

Healthcare: Toward A Research Agenda, "Working Papers CEB 21-021, ULB --
Universite Libre de Bruxelles.

- [12]. André Kochanke. 2020. Digitization in the healthcare industry: the cloud scheduler. *XRDS* 26, 3 (Spring 2020), 34–37. <https://doi.org/10.1145/3383382>
- [13]. Kankanhalli, A., Hahn, J., Tan, S. *et al.* Big data and analytics in healthcare: Introduction to the special section. *Inf Syst Front* **18**, 233–235 (2016). <https://doi.org/10.1007/s10796-016-9641-2>.
- [14]. M. Ojha and K. Mathur, "Proposed application of big data analytics in healthcare at Maharaja Yeshwantrao Hospital," 2016 3rd MEC International Conference on Big Data and Smart City (ICBDSC), 2016, pp. 1-7, doi: 10.1109/ICBDSC.2016.7460340.
- [15]. C. Kaul, A. Kaul and S. Verma, "Comparitive study on healthcare prediction systems using big data," 2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), 2015, pp. 1-7, doi: 10.1109/ICIIECS.2015.7193095.
- [16]. Dash, S., Shakyawar, S.K., Sharma, M. *et al.* Big data in healthcare: management, analysis and future prospects. *J Big Data* **6**, 54 (2019). <https://doi.org/10.1186/s40537-019-0217-0>
- [17]. Siyal, Asad Ali, Aisha Zahid Junejo, Muhammad Zawish, Kainat Ahmed, Aiman Khalil, and Georgia Soursou. 2019. "Applications of Blockchain Technology in Medicine and Healthcare: Challenges and Future Perspectives" *Cryptography* 3, no. 1: 3.
- [18]. Meghna Manoj Nair, Amit Kumar Tyagi, Richa Goyal, Medical Cyber Physical Systems and Its Issues, International Conference On Recent Trends In Advanced Computing 2019, ICRTAC 2019

- [19]. A. Mohan Krishna, Amit Kumar Tyagi, Internet of Things based e-Healthcare System: An Useful Review on Critical Issues and Challenges, International Journal of Advanced Science and Technology Vol. 29, No. 3, (2020), pp. 3223- 3237 3223 ISSN: 2005-4238 IJAST, 2019 SERSC.
- [20]. Tyagi, Amit Kumar and G, Rekha and SU, Aswathy, Role of Emerging Technologies in COVID 19: Analyses, Predictions, and Future Countermeasures (December 16, 2020). Available at SSRN: <https://ssrn.com/abstract=3749782> or <http://dx.doi.org/10.2139/ssrn.3749782>
- [21]. Sai, G.H., Tripathi, K., Tyagi, A.K. (2023). Internet of Things-Based e-Health Care: Key Challenges and Recommended Solutions for Future. In: Singh, P.K., Wierzchoń, S.T., Tanwar, S., Rodrigues, J.J.P.C., Ganzha, M. (eds) Proceedings of Third International Conference on Computing, Communications, and Cyber-Security. Lecture Notes in Networks and Systems, vol 421. Springer, Singapore. https://doi.org/10.1007/978-981-19-1142-2_37
- [22]. Amit Kumar Tyagi, Aswathy S U, G Aghila, N Sreenath "AARIN: Affordable, Accurate, Reliable and INnovative Mechanism to Protect a Medical Cyber-Physical System using Blockchain Technology" IJIN, Volume 2, Pages 175-183, October 2021.
- [23]. M. M. Nair, A. K. Tyagi and N. Sreenath, "The Future with Industry 4.0 at the Core of Society 5.0: Open Issues, Future Opportunities and Challenges," 2021 International Conference on Computer Communication and Informatics (ICCCI), 2021, pp. 1-7, doi: 10.1109/ICCCI50826.2021.9402498.
- [24]. Tyagi A.K., Fernandez T.F., Mishra S., Kumari S. (2021) Intelligent Automation Systems at the Core of Industry 4.0. In: Abraham A., Piuri V., Gandhi N., Siarry P., Kaklauskas A.,

Madureira A. (eds) Intelligent Systems Design and Applications. ISDA 2020. Advances in Intelligent Systems and Computing, vol 1351. Springer, Cham. https://doi.org/10.1007/978-3-030-71187-0_1

[25]. Sai, G.H., Tripathi, K., Tyagi, A.K. (2023). Internet of Things-Based e-Health Care: Key Challenges and Recommended Solutions for Future . In: Singh, P.K., Wierzchoń, S.T., Tanwar, S., Rodrigues, J.J.P.C., Ganzha, M. (eds) Proceedings of Third International Conference on Computing, Communications, and Cyber-Security. Lecture Notes in Networks and Systems, vol 421. Springer, Singapore. https://doi.org/10.1007/978-981-19-1142-2_37

[26]. Jayaprakash, V., Tyagi, A.K. (2022). Security Optimization of Resource-Constrained Internet of Healthcare Things (IoHT) Devices Using Asymmetric Cryptography for Blockchain Network. In: Giri, D., Mandal, J.K., Sakurai, K., De, D. (eds) Proceedings of International Conference on Network Security and Blockchain Technology. ICNSBT 2021. Lecture Notes in Networks and Systems, vol 481. Springer, Singapore. https://doi.org/10.1007/978-981-19-3182-6_18

[27]. Kute, S., Shreyas Madhav, A.V., Tyagi, A.K., Deshmukh, A. (2022). Authentication Framework for Healthcare Devices Through Internet of Things and Machine Learning. In: Suma, V., Fernando, X., Du, KL., Wang, H. (eds) Evolutionary Computing and Mobile Sustainable Networks. Lecture Notes on Data Engineering and Communications Technologies, vol 116. Springer, Singapore. https://doi.org/10.1007/978-981-16-9605-3_27

[28]. Shruti Kute; Amit Kumar Tyagi; Rohit Sahoo; Shaveta Malik, "Building a Smart Healthcare System Using Internet of Things and Machine Learning," in Big Data Management in Sensing: Applications in AI and IoT , River Publishers, 2021, pp.159-178.

- [29]. Shruti Kute; Amit Kumar Tyagi; Meghna Manoj Nair, "Research Issues and Future Research Directions Toward Smart Healthcare Using Internet of Things and Machine Learning," in Big Data Management in Sensing: Applications in AI and IoT , River Publishers, 2021, pp.179-200.
- [30]. Kumari, S., Muthulakshmi, P., Agarwal, D. (2022). Deployment of Machine Learning Based Internet of Things Networks for Tele-Medical and Remote Healthcare. In: Suma, V., Fernando, X., Du, KL., Wang, H. (eds) Evolutionary Computing and Mobile Sustainable Networks. Lecture Notes on Data Engineering and Communications Technologies, vol 116. Springer, Singapore. https://doi.org/10.1007/978-981-16-9605-3_21