

Review Article

ROLE OF PHARMA DIGITALIZATION IN HEALTHCARE DEVELOPMENTS

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ABSTRACT

Healthcare development is a revolutionary sector where digital technologies drive success, with exponential growth seen in a computing system involving advancements in medical devices. Due to social distancing norms, widespread lockdowns, and an emphasis on individualized healthcare, the Covid-19 pandemic has inevitably increased the usage of digital technologies. "Digital" has become the most essential part of day-to-day existence, and all sectors are adapting more swiftly to the digital world. The healthcare system is more complicated, as its culture and structure are not ready to accept innovation, since development in healthcare involves decision on a person's life or death. The use of digital health tools has the potential to significantly improve individual patient care by enhancing the accuracy diagnosis and treatment of diseases. For the clinical adoption of any digital healthcare technology, evidence is required first, and their effects must be assessed before integrating them into healthcare systems such as Electronic Health Records (EHRs). The broad definition of digital health encompasses fields like wearable technology, telehealth and telemedicine, personalized medicine, the Internet of Things (Internet of things (IoT)), virtual reality (VR), Artificial Intelligence (AI), and mobile health (mHealth). Pharmaceutical digitalization is still in a testing phase regarding offering advanced administrations beyond conventional products. In this paper, digitalization from the perspective of diverse case studies was carried out to collect data from several companies, and a literature study was conducted to complement the data on healthcare development. The digitalization of health care is a game changer for developing health care.

Keywords: Digitalization, Healthcare development, Artificial Intelligence (AI), Virtual reality (VR), Alexa, Telemedicine and m-health

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INTRODUCTION

Development in the Healthcare system isn't a show business. The healthcare system is very complex and its structures and culture are not fully ready to accept innovation because this system is a center of care for the person. The Healthcare systems are benefactors to all time-saving operations; they acknowledge patient's requirements, state-up loyalty and care, and offer a superior experience in patient healthcare. Digitalization in healthcare development is sometimes truly Life expectancy or life bereavement since the innovative developments have to show evidence for technological clearance prior to accept for clinical adoption, afterward their integrated effects into the healthcare system [1]. But somehow, the level of digitalization, broadly integrating this innovation into care and building with high technologies and automation now these have become a part of our everyday life and we depend on them absolutely. Digitalization's concept is clear with a broad sense that digital technologies fused into all public spheres. The way for developing quality data always affects the opportunity for digitalization [2]. Pandemic changed the perception towards digitalization with widespread potential to put in pharma manufacturing, networking and online marketing strategies, and pharma-academics with the healthcare system to trigger an upsurge in interest in digitizing the technologies for delivering quality products. Globally, half of the pharma manufacturers and pharma vendors accepted the truth for universal digitalization on that pandemic, triggered the platform of interest in digitalization in healthcare developments [3]. The chains of health care system are demanding to overpower the transformation of business on a digital level, in digitizing the pharma supply with the use of digital technologies, digitizing the business processes to optimize, enhancing the company's productivity, and finally building the new experiences of satisfaction in customer's needs which changes along with further development in technologies. With the passing of time, technological developments in the healthcare system create more luxurious interactions between the customer-company interfaces [4]. The main objective for writing this report is to provide a brief overview of how the role of pharma digitalization helps built-in a superior healthcare system or the impact of the digitalization

processes on the product's quality services. The healthcare system accepts the need for digitalization and should understand how digitalization can be build-in. With the aim of digitalization, it changes the company's aspects of digitalization, gaining of digital resources, and design of growth, internal organizational structure, and goals of product quality attributes.

Goals of digitalization

The goals behind the development in the Healthcare digitalization system mainly involve:

- 1) Improvement of product.
- 2) Automation of the processes.
- 3) Simplification of communication.

With these three goals, digitalization in the pharma-healthcare system will become a vital compulsion for business, and they will need to think consider moving towards digitalization. The healthcare system involves all the helping hands that healthcare professionals need to deliver for safe physical and mental well-being for people. The digital revolution in healthcare creates new business opportunities and models, targeting issues in medical practice, serviceability, and other problems related to our growing society. Digitalization in healthcare covers seven technology-based areas of research [24].

All five clusters are joined together into a model representing how these different forms of implementation technology lead to operational efficiencies in the healthcare service delivery system. Healthcare data includes clinical research results as the big source of data and also electronic health records (EHR), data from customer's self-tracking devices, patient treatment records such as visual and medically written records, letters from doctors, e-prescriptions, and also documentation in relation with claims [26]. All these medical treatment models are digitalized to improve the healthcare quality and operational process efficiency by helping in clinical and administrative systems linked to determination, impartation, estimation and faithfulness in patient's overall treatment. To

improve personalized care, digitalization speeds up the progress of Big data from clinical research results and data from health analytics through the use of health apps and wearables devices. Telemedicine involves teleconsultation, telecare, telemonitoring, or telehealth and

telediagnosis has made an impact on the internal processes of the healthcare system and also maintains the position of healthcare system superiority [27-29].

Table 1: Definitions of digitalization

Author(s)	Definition(s)
Maxwell and McCain (1997)	Information is dissected by digital technology into its tiniest parts. Digitalization enables the manipulation of information, text, pictures, software code, music, and video in previously unimaginable ways by breaking an analog signal into separate components. This explains its informing and transforming capabilities [5].
Hagberg <i>et al.</i> (2016)	One of the most major ongoing changes in modern society is digitalization, which affects many aspects of daily life and business. Both the process of going from "analog" to "digital" (such as switching from cash to electronic payments) and the facilitation of new types of wealth creation are referred to as "digitalization" [6].
Clerck J. (2017)	Digitalization is defined as the use of data and digital technology to generate money, enhance operations, replace or alter existing business procedures, and establish a framework for digital business with digital information at its center [7].
Lenka <i>et al.</i> (2017)	The definition of digitalization in the literature on industrial management is, the phenomena of intelligent, interconnected machines that are driven by information and digital technologies [8].
Machekhina (2017)	All information kinds (text, voice, images, video, and other data from diverse sources) must be transformed into a digital language, which is known as digitalization [9].
Parviainen <i>et al.</i> (2017)	The act or process of digitization; is the transformation of analog data into digital form, particularly for eventual usage with images, video, and text [10].
Thorseng and GrInternet of things (IoT) (2017)	A change in the current socio-technical structures from being mediated by non-digital artifacts or relationships to being mediated by digitized artifacts and relationships with newly embedded digital capabilities [11].
Valenducand Vendramin (2017)	The term "digitalization" refers to the ubiquitous synergy of digital technologies throughout the entire economy and society, not the advent of a new revolution [12].
Crittenden <i>et al.</i> (2019)	Through channels, digitalization enables new ways for businesses and customers to interact [13].
Devereux and Vella (2018)	Digitalization is the way-process of a generic technology being adopted. Electrification was the most recent such phenomenon. Distances between people and things are reduced through the digitalization of goods and services. It makes you more mobile. It renders network effects significant [14].
Eling and Lehmann (2018)	The fusion of new technologies that improve consumer interactions, data accessibility, and corporate processes with the analog and digital worlds [15].
Gobble (2018)	Digitalization is the process of creating and harvesting value in new ways using digital technologies, likely including digitized information [16].
Morley <i>et al.</i> (2018)	The Fourth Industrial Revolution, artificial intelligence, and other digital technologies, concepts, and trends are all included in the term "digitalization," which refers to the expanding use of information and communications technologies (ICT) throughout the economy [17].
Ringenson <i>et al.</i> (2018)	The reorganization of social life around digital media and communication infrastructures is known as digitalization [18].
Gebre-Mariam and Bygstad (2019)	The term "digitalization" refers to the creation and adoption of information and communications technologies (ICT) systems, as well as the ensuing organizational change. It describes the replacement of socio-technical structures that were previously mediated by non-digital artifacts with those that are mediated by digital artifacts [19].
Srai and Lorentz (2019)	Digitalization is the reorganization of numerous social life spheres around digital media and communication infrastructures. The usage of digital technologies can be summed up as digitalization [20].

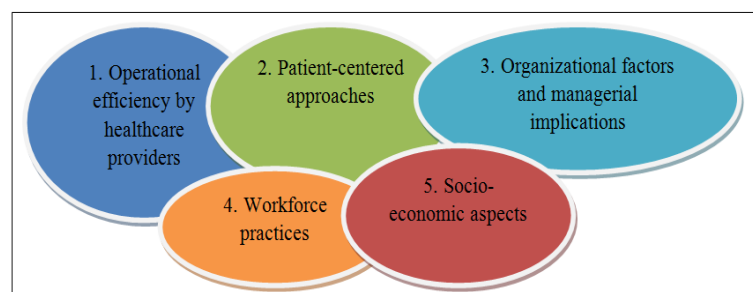


Fig. 1: Five clusters of healthcare system developments [25]

Digital health

Digital health includes a variety of categories, including mobile health (m Health), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine. From mobile medical apps and software that support the daily clinical decisions doctors make to artificial intelligence and machine learning, digital technologies have led to a revolution in health care. Digital medical tools hold enormous potential to improve our ability to accurately diagnose and treat diseases and improve the provision

of health care to the population. Digital health technologies use computing platforms, connectivity, software, and sensors to help people stay healthy [30].

Digital health technology can help patients and customers better manage and keep track of their actions related to their health and wellness. Smartphones, social networks, and internet Applications are changing the way we communicate, but they are also enabling us to monitor our health and well-being in novel ways and expanding our access to information. In order to improve health care and

health outcomes, these developments are bringing together people, information, technology, and connection [33].

Table 2: Digital health services as support/complement or substitute [31, 32]

"Digital health services support, complement or substitute established health services or offer even entirely new services."

Ex. of digital H-services as supporting:

1. Tools for managing and monitoring chronic conditions/track patient status

- Mental health
- Diabetes
- Respiratory diseases
- Cardio-vascular diseases

2. Diagnostic decision support (algorithms)

Ex. of digital H-services as complementing:

1. Identification of Radio frequency (RFID)-tracking such as devices hospital beds.

2. Caregivers Mobile networking

3. Tele-consultation

4. Tools of Digital diagnostic

Ex. of digital H-services as substituting:

1. Electronic health record (EHR)

2. E-prescription

3. Hospital employee's Internal communication

4. E-referral

5. Automatization of simple process steps

a. Vital parameters Monitoring (eICU)

b. Barcode-based medication administration

c. Remote appointment, care over distances

Example for new health services

1. E-triage (communication and database tool)

2. Hospital logistics Robot

3. Chronically ill patient's Tele-monitoring

4. Dashboard's Performance

5. Patient's flow Routing

6. Treatment recommendations based on Bigdata-algorithms

7. Extended purchaser analysis

8. Medical chatbots

9. Tools Prevention such as apps, fitness trackers)

10. Patient-supporting networks

11. Questionnaires

12. Appointment's e-booking

13. tediagnosis

These days, a lot of medical equipment can link to and communicate with other equipment or systems. Digital features are being added to devices that have already received FDA approval, authorization, or clearance. These features are being investigated in new kinds of gadgets.

Patients, healthcare professionals, researchers, traditional medical device sector companies, and companies that are new to the FDA regulatory standards, including mobile application developers, are just a few of the stakeholders involved in digital health activities.

The FDA has been striving to provide clarification on the following issues in the digital health sector using realistic methods that balance advantages and risks: [34].

Software as a Medical Device (SaMD) (<https://medical-devices.com/excellence/digital-health-center/software-medical-device-samd>); Software as a Medical Device (<https://medical-devices.com/medical-devices/software-medical-device->

[and/artificial-intelligence-and-machine-learning-software-medical-device](#)): Artificial Intelligence and Machine Learning (AI/ml)

Digital health center Excellence/cybersecurity (medical equipment); Device Software Functions, Including Mobile Medical Applications (<https://medical-devices.com/excellence-of-the-digital-health-center/device-software-functions-including-mobile-medical-applications>); Digital health reports (<https://medical-devices.com/digital-health-center-excellence>); Medical Device Data Systems (<http://medical-devices.general-hospital-supplies.com/medical-device-data-systems>)

Digital Health Center Excellence's "Medical Device Interoperability" (<https://medical-devices.com/excellence/medical-device-interoperability>); Telehealth and telemedicine (<https://healthit-initiatives/telehealth-and-telemedicine>); Digital Health Center Excellence's Wireless Medical Devices (<https://medical-devices.com/medical-devices/wireless-medical-devices>)

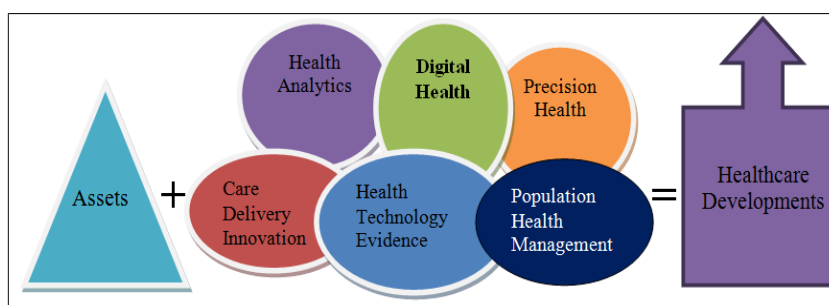


Fig. 2: Digital technologies developments for healthcare sectors [35]

Digital technology is becoming an essential component of healthcare and is poised to transform how doctors practice their craft. In terms of medical care standards, operational efficiency has been substantially enhanced by digital technology. Both patients and healthcare workers now have much better overall experiences because of the transition. Digital technology has had a significant impact on the healthcare industry in several sectors, including:

Improved access to medical data and information

The ability to store and access data has been one of the main advantages of the digital revolution. Patients' data are now accessible to healthcare providers from anywhere. Additionally, the intranet and internet have made it possible for medical personnel to

quickly exchange medical information with one another, improving patient care.

Massive data (Big data)

Collecting big data quickly is another great advantage of digital technology for healthcare. Digital technology makes it possible for researchers, clinicians, and those conducting epidemiological studies to instantly obtain data from a more diverse and large population than ever before. Medical personnel can stay up to date on cutting-edge practices and trends because of such data collection, which enables meta-analysis. Additionally, having access to big data enables clinicians to more accurately identify risk factors and suggest suitable preventive or intervention measures [36].

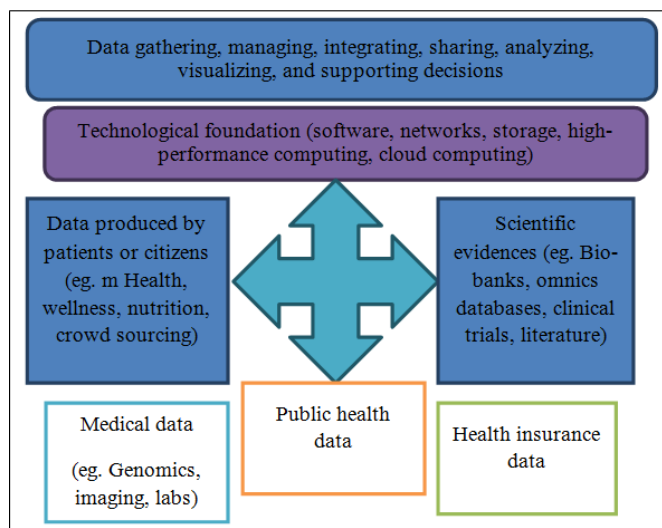


Fig. 3: The data ecosystem in healthcare developments [37]

Communication lines improvement

Healthcare professionals once used beepers to communicate, but today's digital technology has made communication incredibly simple. Healthcare professionals can communicate through email, smartphones, text messaging, and other means. Patients no longer need to receive letters from doctors in the mail informing them of their appointments and testing. All of this is now made simpler and more affordable thanks to the Internet of Things (IoT) and technology. Additionally, medical practitioners can use social media, online platforms, and their own webinars and films to communicate with other professionals. It is now simple to converse across geographical boundaries thanks to teleconferencing [38].

E-health records

The development of digital technology has been a blessing when it comes to patient medical records. Large paper files were once transferred from one department to another, but during the transfer; patient medical charts frequently disappeared or were damaged. In emergency rooms, it could take a while to locate their medical records if they arrived late at night or on the weekend. Patients had to be referred through a laborious process, and doctors had to deliver a large package containing medical information. There were many different locations where medical records were kept; some records were still with the internist, some with the psychiatrist, and others with the rehabilitation expert. It was complete anarchy. All of this has changed as a result of electronic health records (EHR), which have made life simpler for both patients and healthcare professionals [39].

Telemedicine/Telehealth

There are still many remote areas in the world where there is a shortage of medical professionals. Video conferencing is one

significant advantage of digital technology. Telehealth is not only affordable, but it can also assist in identifying those who require urgent care. Today, telemedicine is frequently used by psychiatrists to provide counseling to patients who are unable to physically visit their offices. Healthcare professionals who work in remote locations are also receiving education and training through telecommunication [40].

Education online

Another significant advantage of digital technology is the availability of online learning, particularly for degrees in the healthcare sector. Today, individuals who want to work in healthcare can finish their healthcare degrees entirely online. This gives people the freedom to learn whenever, wherever, and from whichever school they choose. There is no longer a need for healthcare workers to travel great distances or take time out of work thanks to the availability of online education.

Health apps

The digital revolution has resulted in the creation of hundreds of health apps. With the help of these apps, patients can keep tabs on their health and illnesses, receive medical information, access test results, and receive reminders when it's time for checkups. Additionally, medical professionals can quickly check test results, drug dosing recommendations, and other urgent information thanks to healthcare apps.

Social media digitization in healthcare: benefits and drawbacks

According to several kinds of research, there are certain advantages and hazards to using social media for health promotion. Social media is helpful in fostering changes in health behavior as well as in the areas of patient education, community outreach, and customer service. Social networking sites enabled "the development of a social

support system and the broadcast of knowledge, both crucial in maintaining daily physical activity," according to the study. Additionally, there were concerns that patients would rely too heavily on social media, which might make them less likely to seek counsel from a healthcare expert. The healthcare sector may become more digital as a result of various technological advances, including:

- Telemedicine
- Big Data
- Internet of Things (Internet of things (IoT))
- Virtual reality (VR)
- Artificial Intelligence (AI)
- Alexa

Telemedicine

The interactions between patients and healthcare providers are changing as a result of numerous creative solutions. Telemedicine solutions give customers on-demand access to medical specialists and allow them to search for doctors, schedule virtual appointments, and communicate with doctors through voice or video calls [41]. The development of telemedicine is one of the biggest changes in the US healthcare system. Telemedicine is rapidly developing in large countries like the USA, where access to healthcare practitioners is constrained. Ninety percent of the healthcare executives polled said that their organizations have begun developing or integrating telemedicine systems. The use of videoconferences for patient and physician consultations is among the best instances of telehealth technology. Virtual appointments make it easier for patients to communicate with doctors in isolated or rural locations where access to healthcare is scarce. Telemedicine allows patients with mobility issues to communicate with medical specialists [41-43].

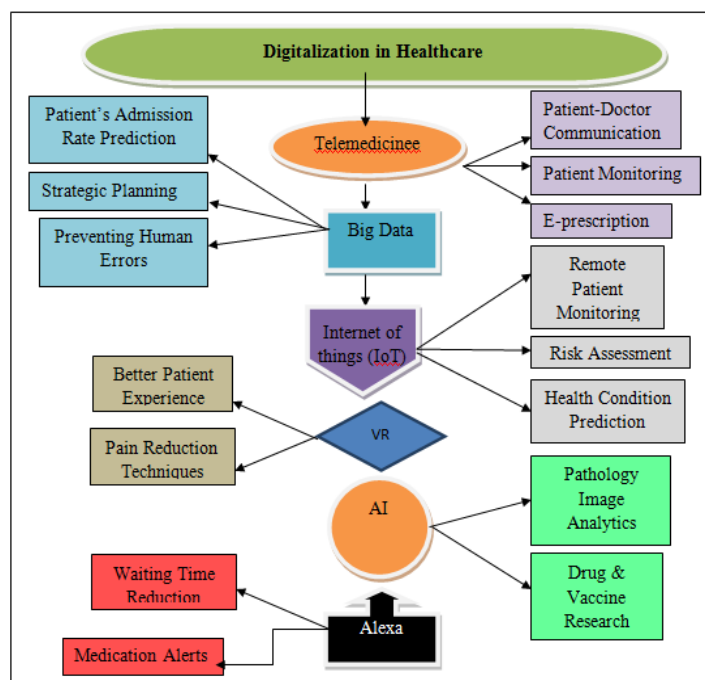


Fig. 4: Flowchart of digitalization in healthcare system [44]

Big data in healthcare

Big Data is revolutionizing how we utilize, analyze, and manage data across all industries. Healthcare is one of the industries with the most promise, as it can be used to prevent diseases, improve quality of life, save costs associated with treatment, and predict epidemic outbreaks. The use of Big Data in healthcare can lead to beneficial and life-saving results.

Emerging technologies have made it simpler to gather crucial healthcare data and transform it into insightful information that can be used to deliver better treatment. Healthcare workers may anticipate problems and find solutions before it's too late by using data-driven insights. Let's understand how Big data can be used in healthcare and what benefits it provides [45].

Patient's-predictions for improved staffing

The question of how many employees to have on duty at any given moment is one that shifts managers in the healthcare industry frequently encounter. You run the risk of unused labor expenditures and resources if a manager keeps too many employees. On the other hand, having too few employees may lead to subpar customer service, which may be more harmful to the patient's health. Big Data can help with this problem.

Real-time-alerting

One of the most important applications of big data analytics in the healthcare sector is real-time alerting [47]. Hospitals utilize clinical decision support software to instantly evaluate medical data and give guidance to healthcare professionals so they may make educated decisions. Health information about the patient is continuously collected and sent to the cloud via wearable technology.

Informed strategic planning-using health data

Strategic planning in healthcare is made easier by big data. Healthcare administrators can examine the outcomes of patient examinations in several demographic categories. They can also identify issues that deter patients from seeking therapy. The University of Florida produced heat maps that focused on certain problems like chronic diseases and population increase using free global health data and Google Maps. As a result, using healthcare data to design smart tactics is also possible [48].

Preventing human errors

It has been observed that professionals frequently mistakenly prescribe the incorrect medication or dispatch a different medication. By examining user and prescribed medication data, big

data can be used to decrease such errors. The big data healthcare tool can be used to monitor prescription data gathered from various medical professionals. The software can highlight prescription errors made by any doctor, potentially saving countless lives.

Internet of things (IoT)

Before the Internet of Things (IoT), the only means of contact between patients and doctors were in-person visits and texts. The patient's health could not be regularly monitored by doctors or hospitals, and appropriate action could not be taken. Internet of things (IoT)-enabled gadgets to make remote monitoring possible in the healthcare sector, unleashing the potential to maintain patient safety and health and enable doctors to deliver better care. The Internet of things (IoT) has increased patient happiness and engagement since it has streamlined and simplified interactions with clinicians [49].

The potential benefits of the Internet of Things (IoT) for the pharmaceutical sector are enormous. By identifying problems and making corrections before they become a problem, a network of connected devices with monitoring sensors can lower the chance of equipment failure and ensure precision production [50].

The FDA has already authorized the first medication product including a digestible sensor at this point, in 2015. An ingestible sensor and a particular sort of medicine to treat mental illness were coupled by the Japanese pharmaceutical companies Otsuka and Proteus Digital Health. The ultimate goal is to assess drug adherence in the acute management of manic and mixed episodes related to bipolar I disorder in adults, in the treatment of schizophrenia in adults, and in the use of adjunctive therapy in the management of the major depressive disorder in adults [51].

IoT-for-physicians

Physicians can track their patient's health in real-time using wearables and home monitoring equipment with Internet of things (IoT) sensors integrated. The Internet of things (IoT) enables medical personnel to be more vigilant and actively engage with patients. Doctors can choose the best course of therapy for patients and get the desired results with the help of data collected by Internet of things (IoT) devices [52, 53].

IoT-for-patients

Patients can personalized care through IoT devices like fitness bands and wireless heart rate monitoring cuffs. Internet of things (IoT) devices can inform patients about health visits, monitor daily steps, blood pressure, and much more. The elderly can benefit from real-time remote monitoring through Internet of things (IoT) devices with an alarm system, which notifies medical professionals and family members [54].

Role of the internet of things (IoT) in the healthcare industry [55]

Monitoring-and-reporting

IoT devices can be used for real-time monitoring in the event of a medical emergency like diabetes, asthma attacks, or heart failure. Internet of things (IoT) devices collect and send health information, such as weight, blood pressure, oxygen, and blood sugar levels, and electrocardiograms (ECGs). The information is saved in the cloud and can be sent to the authorized party, who may be a physician, an insurance company, a health organization, or an outside consultant. Authorized users can examine the collected data, no matter their location, time, or device. Remote monitoring of heart failure patients using IoT devices has resulted in a 50% reduction in the 30-day readmission rate, according to the Center for Connected Health Policy.

Tracking-and-alerts

IoT devices provide alerts in real-time, making it easier to monitor, track, and alert in critical conditions. Using mobile applications and other related devices, healthcare Internet of things (IoT) devices give notifications to people about critical conditions while collecting crucial data and transferring it to doctors for real-time surveillance.

Improving-research-system

Internet of things (IoT) devices produces a significant amount of healthcare data quickly. Managing this data without cloud access can be challenging. The Internet of things (IoT) makes it possible to acquire a tonne of data on the patient's sickness that would have taken years to gather manually. The gathered information can potentially be used in statistical analysis to help fund medical research.

Data-assortment-and-analysis

Internet of things (IoT) healthcare devices produces a significant volume of data quickly. If you don't have access to the cloud, it becomes difficult to save and manage the data. Additionally, it might be challenging for healthcare professionals to manually examine data that has been gathered from numerous sources and devices. But with edge computing, Internet of things (IoT) devices can collect, report, and analyze data in real time, reducing the requirement for data archiving.

Enhanced-disease-management

The Internet of things (IoT) makes it possible to remotely monitor patients in real-time using medical equipment, guaranteeing that no information about a patient's state is overlooked. It makes early and speedy disease diagnosis possible. A healthcare Internet of things (IoT) device and medical application can be used to monitor a patient's condition even when a nurse or doctor is not there with the patient. Internet of things (IoT) healthcare devices are connected, so they can offer rapid assistance when required. A lower or higher restriction can be defined for these devices [55].

Monitoring of staff, patients, and inventory

Security is a problem that must be handled in hospitals all around the world. The management of patients, employees, equipment, and physicians is a major responsibility for hospital administrators. Internet of things (IoT) and real-time GPS services are being used by hospitals to improve the monitoring procedure.

Connected inhalers with sensors

The addition of sensors to medical equipment can help doctors follow a patient's condition with more accuracy. One of the businesses has created a sensor that can be fastened to an inhaler to obtain accurate information, such as when you last took medication and when you should resume taking it.

Ingestible-sensors

The medical staff can track blood levels, body irregularities, and whether a patient has taken prescribed medications by having patients ingest tiny capsule-sized Internet of things (IoT) sensors. It is helpful for elderly individuals whose medication can be efficiently monitored.

Blood-coagulation-testing

A Bluetooth-enabled coagulation system makes it easier for the user to instantly monitor blood clot tests. Knowing the blood clot level is helpful in the treatment of chronic illnesses like diabetes or heart attacks. The Internet of things (IoT) in healthcare enables diabetic individuals to regularly monitor their blood coagulation system. It assists patients in staying within the therapeutic range to lower their risk of bleeding or stroke [55].

Virtual reality (VR)

With the help of specialized gear, such as headsets, a person may hear, see, and interact in a 3-D image or environment thanks to the technology known as virtual reality. Users can immerse themselves in a simulated environment thanks to technology. VR immerses users in a virtual experience rather than just showing a screen, as is the case with conventional user interfaces. Virtual reality is being used in the healthcare sector to provide patients with better care. One of the patients, for instance, received chemo every week for about 6 y to treat colon cancer. During the 4.5 h of the chemotherapy treatment, she used to read books, talk to people, or watch TV [56, 57].

Here's how virtual reality (VR) can help the healthcare industry: [58]

Pain-reduction

The Children's National Hospital in Washington, DC, launched a program in 2019 that included a virtual reality headset for kids who needed operations like stitches, sutures, and foreign body removal in emergency rooms. About 40 kids, ranging in age from 7 to 23 y, participated in the event. Each child was provided a virtual reality (VR) headset covered in protective gear to cut down germs. Then, children selected between different scenarios, including walking through a jungle, talking with a friendly snake, and taking a roller coaster ride. Parents could see what their children were watching thanks to virtual reality (VR) headsets that were connected to screens. Kids felt no pain at throughout the exercise, which delighted parents who saw how well-behaved and content their child was. As a result, many medical facilities are using virtual reality technology for pain management treatments.

Pacing up recovery in physical therapy

Patients' physical treatment sessions can be made more enjoyable with virtual reality (VR) by immersing them in a simulated setting. One study found that after receiving virtual reality (VR) therapy, children with cerebral palsy saw a noticeable improvement in their mobility. A gamified method of physical therapy has been launched by Neuro Rehab virtual reality (VR), one of the top suppliers of virtual reality physical therapy.

Virtual reality (VR) simulation to understand problems from someone else's perspective

Embodied Labs simulates what it feels like to live with existing health issues via virtual reality. It enables users to engage with 360-degree videos while wearing a virtual reality (VR) headset to experience life from someone else's perspective. The first lab created by the business, we are Alfred, transforms users into Alfred, an African-American man in his 74s with macular degeneration and high-frequency hearing loss [59].

Artificial Intelligence (AI)

By performing jobs that are often performed by people at a fraction of the cost and in a fraction of the time, artificial intelligence makes the lives of doctors, patients, and hospital administrators easier. Artificial Intelligence (AI) is reimagining and reviving modern healthcare through machines that can grasp, predict, learn, and act, from discovering connections between genetic codes to operating robots that assist in surgery, evaluating chronic conditions, and doing risk assessment [60].

Compared to clinical decision-making and conventional analytics, Artificial Intelligence (AI) has a lot of benefits. When learning algorithms interact with training data, they can become more exact and accurate. It enables people to learn previously unattainable information on treatment variations, patient outcomes, and diagnostics. The future of the pharmaceutical industry is artificial intelligence and machine learning [61, 62].

Diagnosing and reducing errors

Ten percent of all deaths in the US were the consequence of medical mistakes and incorrect sickness diagnoses. One of the most intriguing technologies that can potentially enhance diagnostic procedures is Artificial Intelligence (AI). Deadly human errors might occur as a result of heavy caseloads and insufficient medical histories. However, Artificial Intelligence (AI) is faster than any medical practitioner at predicting and diagnosing illnesses. For instance, an Artificial Intelligence (AI) model employed algorithms and deep learning in one study to diagnose breast cancer more frequently than 11 pathologists [63].

Analytics for pathology Images

One of the most important sources of diagnostic information for healthcare professionals across the board comes from pathologists. According to Jeffrey Golden, MD, Chair of the Department of

Pathology and Professor of Pathology at HMS, 70% of healthcare choices are based on pathology results. A pathology result makes up between 70 and 75 percent of all the data in an EHR. Proscia, one of the digital pathology systems, uses Artificial Intelligence (AI) to find patterns in cancer cells [64].

Management of Electronic Health Records

Every day, the healthcare sector generates huge amounts of data, commonly known as "Electronic Health Records (EHR)" (containing patient information, fresh research discoveries, and diagnosis specifics). Artificial intelligence integration into EHRs gives businesses knowledge they may use to consult with patients and make wise decisions. Artificial Intelligence (AI) and electronic health record (EHR) systems can enable healthcare practitioners to manage their observations rather than manually entering the data [65].

Notifying doctors when patients are in trouble

Google's DeepMind Health Artificial Intelligence (AI) is being used by numerous hospitals across the world to swiftly move patients from diagnosis to treatment. The DeepMind Health Program notifies medical professionals when a patient's condition deteriorates and can potentially help with disease diagnosis by looking for similar symptoms in the vast dataset. The clinician can identify the ailment more effectively and rapidly by gathering the patient's symptoms and entering them into the DeepMind platform [65].

Alexa

The Amazon voice assistant is already popular in people's daily lives and smart workspaces. Nurses, doctors, patients, and pharmacists will all use Alexa in their daily work over the next several years. Healthcare professionals and patients can communicate via voice technology like Alexa [66].

▪ Enabling diabetes patients to manage their solution effectively

With a \$250,000 prize pool, AWS and Merck and Co., Inc. together launched the Alexa Diabetes Challenge in 2018. With its Sugarpod digital platform for managing diabetes that has undergone clinical testing and is based on Alexa, Wellpepper was declared the winner. Alexa can efficiently manage treatment for diabetic patients using Sugarpod and track their progress. It demonstrates how Alexa can be used to treat chronic conditions like type 2 diabetes.

▪ Enhancing interaction in the hospital

Aiva, a Los Angeles-based business, employs an Alexa-enabled platform to assist patients in interacting with caregivers including nurses, and controlling in-room entertainment. With the help of this platform, patients can ask Alexa to turn on or off the television, change the channel, and make a phone call to the caregivers.

▪ Managing blood pressure with Alexa Skills

A well-known manufacturer of medical equipment, Omron, has introduced a watch dubbed "HeartGuide" that can detect blood pressure and relay readings using an Alexa skill at a time when life appears hectic.

▪ Reducing wait times

Hospitals can set up Alexa Skills so that patients can access the contact details for specific departments. By providing patients with information on the wait times at each clinic or hospital Alexa's skills can help them save time and reduce stress. It ensures that the patient arrives on time and averts emergencies [67].

Here is a chronology of how India's healthcare system has undergone a digital change. The introduction of digital health IDs, which the government believes will be embraced by the majority of the people, is the culmination of India's healthcare system's digital revolution.

Table 3: Digital campaigning programs in India [68]

2015-Digital India campaign	To alter the nation's economy, the Indian government starts the Digital India program. This includes making sure that all public services, like healthcare, are accessible to citizens online. The strategies to make this possible include expanding the availability of WiFi and implementing 5G.
2017-Digital health IDs	A digital healthcare system that integrates data for citizens and stakeholders across private and public healthcare providers is proposed, and it includes the concept of a digital health ID. Hospitals, internet pharmacies, telemedicine providers, labs, and insurance corporations are anticipated to participate in the new system.
2020-Covid-19 and the acceleration of digital healthcare	Between March 2020 and May 2020 alone, Covid-19 causes a 500% increase in the utilization of virtual consultations. The pandemic also brings to light a digital divide, as people must access the Co-Win website and upload their identification documents using a smartphone or computer with a reliable internet connection to schedule vaccines. This requirement is more common in urban areas than in India's vast rural areas.
August 2020-Digital Health IDs launch	The National Digital Health Mission of India launches a pilot program in six regions, introducing the introduction of digital health IDs. The IDs are created using a person's address and mobile number. The ID contains medical information that may be accessed using a mobile app. The records are accessible to consumers and healthcare providers.
2021-National Digital Health Mission officially launches	In September, India's National Digital Health Mission will formally commence. Along with the wider implementation of IDs, other initiatives include the Digi-doctor digital doctor registration and electronic health records. Additionally, a planned Unified Health Interface seeks to connect various digital health solutions through an open, interoperable platform.

Digitalization technologies to reshape the future of the pharmaceutical industry

Adopting cutting-edge technologies can be crucial to the pharmaceutical industry's digital revolution. However, choosing the appropriate technologies is necessary to seize this chance. Artificial intelligence, machine learning, augmented reality and virtual reality, digital apps, the internet of things, blockchain, 3D printers, and organs on chips are just a few of the innovations that are beginning to change the pharmaceutical industry in the same way they have other sectors like media, retail, banking, telco, education, and others. Pharma executives, academics, innovators, and lawmakers are all fully aware of the disruptive potential of digital projects and are testing out a variety of them [69].

Blockchain

For the majority of industries, blockchain technology is still currently difficult to implement. However, the advantages that this technology can bring to the pharmaceutical sector are difficult to comprehend. Blockchain can help in a wide range of areas in this sector, including identity management for consumers and patients, production and distribution, and research and development.

A new drug's research and marketing is a protracted, costly, and risky procedure. The estimated time and cost:

- 8 to 12 y (sometimes more), approximately \$800 million to \$2.5 billion per drug.
- Only one in five medications is successful in reaching the market.
- Additionally, only one in three medications that reach the market is "profitable," with a return of only 3.2%.

By safeguarding intellectual property data, blockchain offers a chance to reduce these costs while enhancing transparency and trust for all parties involved in this process. Cross-collaboration is prohibited by current intellectual property laws, which adds to the complexity of the procedure. Blockchain might be able to offer a platform for the facilitation and protection of intellectual property, as well as the facilitation of royalties, payments, and incentive models that might motivate participants to contribute ideas to their research and development processes.

3D-printing drugs

Previously, 3D printing was only an idea seen in science fiction. But in 2015, Aprexia Pharmaceuticals created Zipdose, a patented process for 3D printing drugs that enables high-dose medications in a fast disintegrating form. This idea has now gained recognition and has been put into practice. They later created Spritam, which cures epilepsy, using this technology. This was the first 3D-printed medication to receive FDA approval. The pharmaceutical industry's supply chain operations will probably undergo a full transformation when this manufacturing technique obtains widespread. Hospitals and pharmacies might be able to print the pharmaceuticals they need on-site in ten years [71].

The University College of London is also experimenting with ways to print medications in amusing shapes for children to make it simpler for them to take, which could turn it into a lucrative business opportunity. These new developments could open several doors for B2B businesses engaged in the sales, sales operations, and marketing of pharmaceuticals, in terms of new sources of income and profits [72].

Organs-on-chips

Drug testing on humans or animals as part of expensive, time-consuming clinical trials is now a thing of the past with the newest craze, the "Organs on Chips" notion. Consider a clinical study where the properties of live things are so accurately replicated that they can be completed in less time and with less expense while still producing great results. The "silico trial" is the name of this technique [73]. A medicine product, gadget, or intervention may be developed using it as a kind of individualized computer simulation for regulatory evaluation. With current technology and biological knowledge, fully simulated clinical trials are not possible, but their development would be predicted to provide significant advantages over the *in vivo* clinical trials that are now used [74]. One of the most cutting-edge simulations in this regard is "HumMod." The most complex mathematical model of human physiology ever made, "HumMod," tries to recreate how human physiology functions.

The covid-19 pandemic has sparked a digital change in pharmacy and remote care

The COVID-19 coronavirus pandemic has been a significant catalyst for the usage of technology. With the advent of digital health technology, the emphasis on novel models has switched to online platforms, chatbots, remote patient monitoring, and virtual visits (for risk assessment, screening, and triage). The pandemic has demonstrated the value of digital health solutions and provides a chance to integrate them into our healthcare infrastructure. Digital technology and remote care are now more integrated than ever into our daily lives and, critically, into healthcare responsibilities. As a result, healthcare procedures are becoming exponentially more computerized. The Australian government has accelerated the supply of electronic prescriptions as part of its National Health Plan for Covid-19 [75-77].

According to the study's findings, digital health will have a significant impact on the pharmaceutical industry's business model by 2020 [81].

- 84% of poll participants think it will be important to have a digital health strategy by 2020, compared to 13% who think it is important now.
- Even though digital health initiatives are now just in the evaluation and piloting stages, 73 percent of participants are confident that these initiatives will be put into place by 2020.
- 77 percent of respondents think digital health will bring in new business by 2020, and 94 percent think it will either improve on the present value proposition (37 percent) or create a brand-new one.

- 57 percent Therefore, according to all participants, digital health will have a significant (27%) or even vital (73%) impact on their pharmaceutical businesses' ability to compete.
 - The India Brand Equity Foundation (IBF) projects that by 2020, the industry will grow at a CAGR of 23% due to digital interventions in Indian healthcare.
 - The Indian telemedicine market is anticipated to grow at a CAGR of 23% between 2016 and 2020, reaching US\$ 32 billion by that year.
 - The use of telemedicine technologies might help India save \$4–\$5 billion annually.
 - By 2021, AI-related healthcare applications in India will be worth US\$ 6 billion (INR 431.97 billion).
 - Digital health records (DHRs) are already used by 76 percent of Indian healthcare providers.
- The health technology sector in India is home to 4,892 start-ups.

Table 4: An overview of all case studies from pharmacy schools on digital health initiatives [78-80]

Region of WHO	Country	Digital health initiatives
African region	Nigeria	Pharmacy and digital health education in a Nigerian university.
America region	Bolivia	Moving toward the ecosystem of knowledge, complex and integrative solutions for promotion and prevention in digital health.
	Canada	To incorporate digital health education into pharmacy curriculum, a nationwide electronic resource is being built.
	Canada	Design, pedagogy, and a five-year analysis of student data for a pharmacy informatics course.
	United States	An instructional framework for teaching healthcare applications in pharmacy school.
Eastern Mediterranean region	United Arab Emirates	Inter-professional education and collaborative care are being developed through early clinical experience in an academic health system.
European region	Greece	Improving the clinical abilities of current pharmacy students in the treatment of patients using digital health.
	Ireland	Through simulated surgical ward rounds, inter-professional learning in digital health and virtual patient contacts are possible.
	Netherlands	Co-development of a course in digital pharmaceutical care.
	Spain	Creating in Madrid a postgraduate program in digital health.
	Switzerland	A collaborative patient-pharmacist teaching approach is increasing pharmacists' ability to work with patients as partners in their use of digital health.
South East Asian region	Ukraine	The improvement of pharmacy students' information literacy during their study of the biological chemistry subject.
	India	Creating a program for digital literacy.
Western Pacific region	India	A fundamental change in pharmacy education is preparing graduates for the new world of digital counseling.
	Australia	La Trobe University's pharmacy program offers digital health.
	Malaysia	In a public pharmacy school in Malaysia, teachers and students are developing their digital literacy skills.

Table 5: Various mobile health apps, their description and images

Mobile app	Description
1. Kardia Mobile	AliveCor Inc.'s Kardia App enables users to take a professional-grade EKG at anytime, anywhere, using their smartphone and the AliveCor® Kardia Mobile EKG Monitor. Leading cardiologists endorse it, and many people all over the world have used it extensively. It is simple to use and detects AFib or regular cardiac rhythm in just 30 seconds after the user places their fingertips on the electrodes (no wires, patches or gels required) [86].
2. Mobile MIM™	In the areas of radiation oncology, radiology, nuclear medicine, neuroimaging, and cardiac imaging, MIM Software Inc. offers useful imaging solutions. With good reason, the Mobile MIM™ app was the very first medical app to appear in the Apple App Store. The SPECT, PET, CT, MRI, X-ray, and ultrasound medical pictures are viewed, registered, fused, and displayed for diagnosis using the Mobile MIM™ app [86].
3. BlueStar Diabetes	The WellDoc Inc.-created BlueStar Diabetes App functions by gathering blood-glucose data and offering coaching in real-time. With more than 20,000 automated coaching messages, WellDoc's system analyses the data and provides a personalized coach to help patients manage their medication and treatment [86].
4. iExaminer	The PanOptic Ophthalmoscope can now be used as a portable digital imaging device that allows users to view and photograph the eye thanks to the new Welch Allyn iExaminer app. It is intended to make conditions like glaucoma and retinal detachment easier to detect. To take high resolution photos of the fundus and retinal nerve, the adapter places the PanOptic Ophthalmoscope's optical access in line with the iPhone camera's visual axis. The user can then print and save the images to an email or patient file using the associated iExaminer App. Imaging can take place everywhere and at any time [87].
5. Triton Sponge	Gauss Surgical created the Triton Sponge app for use in operating rooms. The first and only app in the world for real-time estimation of surgical blood loss, Triton Sponge uses an image processing algorithm to determine how much blood is spilled on sponges [87].
6. AirStrip ONE	Through a platform that allows mobile interoperability, the diagnostic tool AirStrip ONE transmits patient data from medical devices, electronic medical records, and patient monitors to clinicians. Clinical data encompasses information generated by medical equipment and includes vital signs, allergies, prescriptions, medical imaging, and test findings [87].
7. Strava	The primary activity that Strava is intended to track are cycling, running, and swimming, however there are MANY other options. Along with other information, Strava collects GPS, heart rate, and elevation data and shows the information in interactive graphs. To automatically import GPS data, Strava connects to services like the Connect app from Garmin. Strava Summit gives users access to extra features like training packs, safety packs, and analysis packs [87].
8. B. O. L. T One	Blood pressure, oxygen saturation, pulse, body temperature, blood sugar, blood cholesterol, and total hemoglobin count are all measured by the wireless B. O. L. T One health monitor. An ECG monitor with a single channel is used to do this. Using a spirometer, BOLT can monitor your lung health. Using a useful mobile app, B. O. L. T assists you in keeping track of your vital signs [87].
9. Stroke Riskometer™	A unique and user-friendly tool for determining one's risk of having a stroke in the next five to ten years and what they can do to lower that risk is the Stroke Riskometer™ app. The app can also indicate your risk of diabetes, dementia, and heart attacks. It simply uses 20 questions that have undergone scientific testing to evaluate a person's risk of stroke and to provide important information on how to lower that risk [87].
10. First Aid–American Red Cross	Accidents do occur! With a straightforward mobile health app, the official American Red Cross First Aid app puts professional advice for common emergencies in one's hand. The software makes doing first aid simple with movies, interactive quizzes, and straightforward step-by-step instructions. It is fully connected with 9-1-1, enabling anytime EMS calls via the app. (US-only users) [87].

Digitalization of medicine using mobile health apps

Pharma businesses all across the world are now realizing that simply generating and researching pharmaceuticals is no longer sufficient. A recent trend demonstrates that they must provide a full bundle in addition to the physical appearance of the medications themselves. Digital health mobile apps, gadgets, or services that could be prescribed by a doctor or included with a prescription are already referred to as "around the pill" offers. A wearable monitoring gadget and an app are sometimes included in packages, allowing patients to get constructive feedback from their doctors and from the app's own automatic, individualized comments. The following apps are already well-liked in the app stores: social network linking patient's apps, fitness apps for chronic conditions, finding free health care clinics and hospitals, ordering drugs via e-commerce apps, cross-checking clashes by different medications [82-85]. Here are the top 10 digital health apps or services that are used for digitalization. Healthcare apps are unquestionably the next big thing for the pharmaceutical companies.

India's top 5 digital health-tech apps [88, 89]

Cure fit

Bengaluru-based Cure. Fit was established in 2016 and provides solutions for physical fitness, healthy eating, and mental wellbeing

through both offline and online channels. Cure. fit has launched a primary care (Care. fit) vertical, which includes doctor consultation, health checkups, and managed care plans on a single platform, as part of its mission to make health and fitness simple. Cure. fit intelligently integrates physical fitness (Cult. fit), mental fitness (Mind. fit), and healthy food (Eat. fit). The company raised a US\$ 120 million round in July 2018 to strengthen its technology platform by offering AI-driven health planning, create its own fitness devices, and also to explore opportunities to expand its services to newer markets [88].

DocsApp

DocsApp is a platform for online medical consultations that was established in Bengaluru in 2015. Investors believe that the platform, which only accepts specialized physicians and connects them with patients in less than 30 min, has fundamentally changed the relationship between patients and physicians in numerous ways. The platform goes above and beyond in comprehending the patient's condition and, as a result, connecting them with the appropriate physician. In 2018, it amassed 5 million Google Play Store installs and saw a 150 percent increase in income year over year. Additionally, it asserts that 65 percent of its user base is from rural areas of the nation. More than 100,000 consultations are presently provided each month.

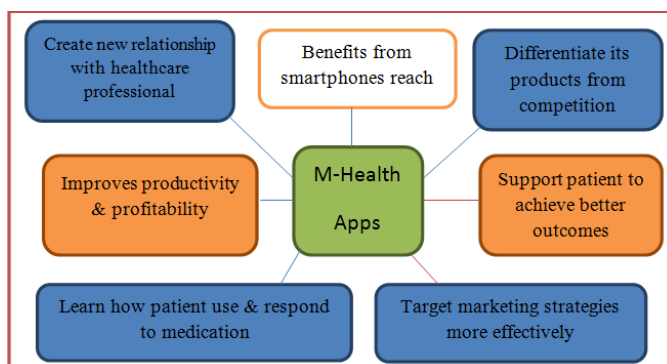


Fig. 5: Benefits of using mobile health apps [89]

Forus health

The mission of Forus Health, which has its headquarters in Bengaluru, is to leverage technology to improve access, lower the cost of diagnosis (affordability), and raise awareness about the need to end preventable blindness, a major worldwide health issue. Forus Health's first product, 3nethra Classic, has been installed in 2,200 locations so far, according to the startup, which says that their solution is accessible in 26 countries.

Health Plix

In order to help doctors treat a variety of diseases, HealthPlix, a company founded in 2014, has integrated AI-driven Clinical Decision Support (CDS) system into its Electronic Medical Records (EMR) software for hospitals and clinics. As of July 2018, the business asserted that more than 1.2 million distinct patients were treated in 150 cities across 20 states using the HealthPlix EMR technology. Around 60% of their users are based in Tier 2 and Tier 3 towns in India.

Innovaccer

Innovaccer, headquartered in New Delhi, helps healthcare organizations implement value-based care models and improve care delivery with artificial intelligence applications for care management, reducing physician burnout, and improving patient engagement. According to the company, as of January 2019, customers have so far improved outcomes and saved more than US\$ 400 million in costs.

CONCLUSION

The objectives of this report were to present a comprehensive overview of the state of digitalization in the healthcare system,

highlight technological advancements in mobile health apps, and recommend areas for potential future research in the area. The pandemic-related healthcare system crisis exposed flaws in the system as well as the rapid pace of technological change and the constrained financial resources. The advancement of telemedicine, artificial intelligence, virtual reality, and mobile health apps are tools that enable access to and the secure use of screening technologies in healthcare for needs in neurology, oncology, cardiology, diabetes, and psychology. To advance systematic study and impart their understanding of these technologies to society for digital management, trained academicians and research scholars are needed.

A more comprehensive view of the healthcare system has been created as a result of the requirement for doing research on business model transformation and the implications of digital health technology. The goal of using digital healthcare models on a data-driven basis is to provide a predictive care towards digital healthcare system by redefining experience, improving patient empowerment, or improving digital system enhancements. The usage of digital platforms can enhance processes for collecting data, communicating clinical trial results, monitoring production-related operations, etc. Digitalization has caused a significant fundamental shift in pharma operations, including production, marketing, communication, and clinical trials, which creates the opportunity for pharma companies to perform significantly better. Pharma processes were digitalized to create a road plan for how to organize, carry out, and deliver inventions to customers while greatly reducing costs and maintaining data operations. As emerging trends for providing patients with improved solutions and attentive care materialize, digitalization has a discernible impact. The two main,

inescapable drivers of innovation change are the technology itself and the security and privacy of patient data. The pandemic increased the need for digital transformation to improve the standard of the healthcare sector.

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