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Emerging technology trends in Pharmaceutical industry

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Abstract

This review's objective is to provide an early look at upcoming technological advancements in the healthcare and pharmaceutical sectors. In order to accomplish this, we assess cutting-edge medical innovations from the pharmaceutical and healthcare sectors as well as contemporary technologies. Artificial intelligence, for instance, is able to understand the connection between different formulations and process factors. Blockchain is an intricate database that secures data to keep the system safe from hacking or alteration. The use of cloud computing technology enhances drug discovery. In the future, hospitals will need space for scanning and 3D printing because these technologies can create almost anything, including medical devices and human body parts, as well as custom medications. Both surgical procedures and the handling of chemicals in laboratories frequently use robotics. A database used in operating rooms, hospitals, labs, and clinics to help with information gathering is called IT (Information Technology). The quality of life of our elderly population can be maintained with the aid of cutting-edge medical advances and technologies. In order to address these issues, pharmaceutical companies and medical technology companies should collaborate to advance superior practices by integrating them into other related fields.

Keywords: Artificial Intelligence (AI); Digital Therapeutics; Cloud Technology; Robotics in pharma industries;3D Printing; Blockchain Technology.

1. Introduction

In the last few decades, technology has drastically changed human existence, affecting all facets of it such as business, manufacturing, communication, transportation, and the pharmaceutical and medical sectors. Consequently, it is evident that pharmacists in the modern world are using IT systems to design and construct their everyday responsibilities in a way that is more productive and effective. The technological system is easy to use, manages more work in less time, and has a low degree of complexity and inaccuracy in its working process. Furthermore, because the pharmaceutical business depends so significantly on technology-based systems for both manufacturing and research and development, IT requirements for state-of-the-art operational procedures are viewed as essential components of the sector [1]. The digitization of the manufacturing industry is a critical step in any improvement of the production process. The process of digitalization, which allows for cost savings, higher output, and change adaptability, includes growing use of robotics, automated solutions, and computerization. The pharmaceutical industry (PI), on the other hand, has resisted digitization, mostly due to the complexity and skill required of the development and production processes involved. Despite this, the growing demand for both traditional and new pharmaceuticals makes digitizing patient information imperative [2]. The prescription process can be automated, patient planned proceedings and records can be preserved, the electronic statute of limitations can be expedited, and clinicians and pharmacists can benefit from new technologies (e.g., barcode medicine identification, the internet, electronic medical records, mobile technology, telecare technology, electronic prescription and discharge system, etc.) [3, 4]. But considering the serious concerns and persistent threat posed by the Covid-19 outbreak, digitization seems to be the best way to ensure that everyone has access to safe pharmaceuticals [5]. Pharmacies are starting to transition from ordinary to advanced jobs in order to produce next-

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generation pharmaceuticals. As career opportunities grow, so does the range of employment in pharmaceutical research. Modern work options are emerging as a result of technological advancement, and they have the potential to greatly increase the output of the pharmaceutical sector and enable the creation of new drugs that will be brought to market. current inclination for cutting-edge automation technology. Cutting-edge information technologies and contemporary industrial processes must be blended to maintain economic competitiveness in the current world. People visit hospitals these days to get diagnosed and treated for a variety of ailments. Physicians use advanced diagnostic and therapeutic instruments while consulting with patients. But the revolution in diagnosis and treatment delivery is about to change due to developments in robotics, information technology, artificial intelligence (AI), and 3D printing. Future technological advancements in the healthcare and pharmaceutical industries are taken into consideration in this study [6].

2. Technologies in industries and healthcare

Thera are top eight pharma health tech trends that will shake up the industry.

2.1. Artificial Intelligence (AI)

The pharmaceutical and consumer healthcare sectors are increasingly utilizing artificial intelligence and machine learning. A branch of computer science called artificial intelligence is capable of analyzing intricate medical data. Their capacity to take advantage of significant associations within a data collection can be used in the manufacture of medications, predictive forecasting, clinical trial patient identification, therapy, and disease detection and diagnosis. The biggest benefit of artificial intelligence is that it lowers the costs related to drug development, which lowers the costs related to medication development, increases returns on investment, and might even save prices for the end user.Artificial Intelligence (AI) is the application of methods that make computers behave like humans. Machine learning (ML), a branch of artificial intelligence (AI), uses statistical techniques to learn both with and without explicit programming. Three categories exist within machine learning (ML): reinforcement learning, unsupervised learning, and supervised learning. A kind of machine learning called deep learning (DL) uses artificial neural networks to adapt to and learn from vast volumes of experimental data. Big data and related data mining and algorithmic techniques may help us find new compounds that may one day be drugs, find or repurpose medications that may be more effective when taken alone or in combination, and advance the field of genetic marker-based personalized medicine. With the increasing amount of data and the continuous increase in computer power, the emergence of DL was observed[7]. AI is both complex in its nature and in its application. It is a complex blend of mathematics, computer science, and other sciences. The complexity of programming enables machines to mimic human cognitive abilities. The primary benefits are as error reduction, used in daily application, repetitive jobs etc.

2.1.1. Applications[8-14]

- Manufacturing Process Improvement
- Drug Discovery and Design
- Personalized Medicine and Rare Diseases
- Identifying Clinical Trial Candidates
- Drug Repurposing
- Moving Toward AI in Pharma Development
- Research and Development

2.2. Digital Therapeutics

"Digital therapeutics is defined as "a health discipline and treatment option that uses digital and often online health technologies to treat a medical or psychological condition." For instance, a smartphone app can motivate users to make healthy eating and activity changes in their lives. It can also encourage patients to take their medications as prescribed, which can help prevent symptoms from getting worse and predict when a condition will flare up. One of the most important aspects of a digital therapeutic is that it uses "optimized" individual treatment approaches (e.g., by using machine-learning algorithms to the individual's observed data), the application of tailored medicine. [15] "Digital health" or "eHealth" refers to the use of various digital technologies to assist and provide health services for the development of people's health and well-being, often involving individuals who are not actually sick. Digital health technology includes things like telemedicine, social media, applications (apps), wearable technologies, smartphones, and digital therapeutics (DTx). These technologies offer fresh approaches to addressing global issues, with the aim of enhancing the standard of healthcare through the adoption of a patient-centered care model. Although this sector has not yet created its own common language, health-care technology can be divided into three main categories: digital health, digital medicine, and DTx.[16] Patients use digital versions of Patient Support Programmes (PSP) as the majority of their

technological instruments. With the intention of giving patients support to help them better understand their general health, manage their condition, and/or get counseling regarding the progress of their illness, they are usually connected to organizational or other needs. The bulk of digital PSPs are personalized apps, which are used to promote patient compliance, enhance communication between patients and providers, provide disease monitoring tools, and generally motivate people to participate actively in their own daily healthcare. PSP can be useful for research as well, clearly according to data protection requirements, since it can gather data via questionnaires and/or clinical diaries. Clinical trials involving experimental approaches are hardly conducted on applications that lack therapeutic efficacy. One example of digital medicine is Propeller, which was developed for those with asthma or chronic obstructive pulmonary disease (COPD). Here, the sensor is positioned directly above the inhaler, automatically documenting the dose location, timing, and frequency. After that, an app on a smartphone gets this data. Approved on July 7, 2020, Propeller is the first sensor of its kind to get marketing authorization in Europe. [17]

Digital therapeutics and other aspects of digital health have been highlighted by the FDA as a tool that can enable patients to make more informed decisions about their own health and offer new choices for promoting prevention, early detection of life-threatening illnesses, and chronic condition management outside of conventional care settings. A revolutionary method to therapy and disease management known as "digital therapies" involves the use of digital technologies to help individuals manage their own health and medical issues. Utilizing mobile phones, the Internet, and new technological advancements in big data analytics, machine learning, and artificial intelligence, digital therapies adopt the concept of personalized medicine by customizing a patient's care. Digital medications could save hundreds of billions of dollars in medical expenses by substituting safer and more economical options for traditional treatment. Like medications, digital treatments also need to be thoroughly tested in randomized controlled clinical trials to generate reliable evidence of their safety and efficacy. In contrast to traditional medication development, however, the timescales for producing a digital therapy can be greatly shorter because some processes, such as toxicity assessments, are not applicable. Conducting clinical trials to assess digital medicines offers unique opportunities to employ innovative study designs and big data analytic methodologies, but it also poses new logistical, statistical, and ethical challenges. Collaboration between bio/pharma and IT firms can speed the development of innovative digital medicinal products.

2.3. Cloud Technology

The phrase "cloud computing" refers to Internet-based IT services that offer shared, always-on computer resources for PCs and other devices. The literature contains studies on cloud computing-based services and applications in the health services industry. Studies on the security and privacy of patient data as well as data management issues resulting from the internet transmission of all data are still underway. Healthcare decision-support systems can be powered by cloud computing, which also facilitates the processing of big data analytics in the industry. The pharmaceutical industry is known for adopting cutting-edge technologies later than other industries or businesses. It's true that there has been a noticeable improvement, and there are several examples of how cutting-edge technology is being used. Businesses do, however, take into account the possibility of possible risks and disadvantages. However, a variety of state-of-the-art methods are progressively being adopted in medical centers and research labs, enabling scientists and business leaders to maximize their methods and related procedures. We have web-based portals that facilitate secure and dependable data exchange about treatments, drugs, and research. Wearable technology and smartphone apps allow us to keep an eye on therapy progress and other data. Next, the relevance of 3D printing emerges, allowing medical practitioners to digitize patient organ data into digital files suitable for three-dimensional printing, for example. Personalized implants, 3D printed prosthetics, working organs, pharmaceuticals, and other medical supplies are also available. The good news is that research companies and academic institutions are still exploring even more tech-driven options and models, seeing the benefits of software improvements when it comes to critical research procedures and best practices in medicine. The most recent example of technology entering the industry is cloud computing. In essence, cloud software solutions are being used in many research and healthcare initiatives. It is well knowledge that workers in this field regularly handle massive amounts of sensitive data and documentation. Consequently, practitioners can handle lab data, patient personal and treatment information, statistical analysis, or picture data more quickly thanks to cloud technologies and cloud-based infrastructures. And since safety in all its forms is crucial, protecting such data is extremely important. As a result, a variety of cloud deployment options—public, private, and hybrid—are available that are intended to manage data and documentation while satisfying specific requirements related to security, availability, and privacy. Additional advantages include the ease with which data can be tracked, monitored, and preserved; the capacity to reduce data storage space; the promotion of simpler and more effective collaboration; the capacity to maintain, manage, and distribute electronic health records among authorized physicians and organizations; the capacity to communicate updates and information; and the quicker access to real-time analytics. By utilizing cloud computing and Big Data, researchers can build extensive Big Data pools that provide public access to information from more complex and large-scale systems. A new paradigm in healthcare and the scientific field as a whole arises after taking all of this into account. Without a question, life science technology is developing more quickly than it has in the past. Along

the way, they offer a variety of advantages and modern opportunities to researchers, physicians, and even patients. Emergence of new patterns modifies the current therapeutic environment. The digital future of Pharma will involve wearables, mobile devices, social media, and cloud computing. [18]

2.4. Robotics in pharma industries

The pharmaceutical industry's sophisticated R&D, manufacturing, and packaging operations relies heavily on robotics. There are numerous motivations for using robots in this business, ranging from higher worker safety to improved product quality. Another benefit of robotic pharma product production is that it speeds up the medication development process. The usage of robotics systems in the pharmaceutical sector has enormous potential, and pharmaceutical companies are gradually adopting more robotic systems into their operations. Pharmaceutical firms, like other industries, require improved speed and precision equipment created with robotics, such as syringes, inhalers, and diabetic testing kits. Robotics is commonly employed in both surgery and chemical handling in laboratories. [19]

- Robots Used In Pharmaceutical Industry
- Pharmaceutical Container Replacement Robot
- Cylindrical Robot for High Throughput Screening
- Six-Axis Robots suit Class 1 Clean Room Applications
- Space Saving Ceiling Mounted Robot
- Robots for filling, inspection, and packaging
- Robots for producing medicines
- Robots in the laboratory
- 3D Printing

Another technology that has completely changed every part of our life is 3D printing. It appears to have the potential to make a significant impact on medicine and healthcare. This change could be realized by providing more inexpensive, customized, and accessible healthcare. A new era may dawn if 3D printers become more sophisticated, printing biomaterials becomes safer, and the general public embraces this new technology. In the future, hospitals will need space for scanning and 3D printing because these technologies can create almost anything, including medical devices and human body parts, as well as custom medications.

The primary uses of 3D printing in the healthcare

- Preparing 3D models of tumor
- Generating medical equipment
- Replicating human parts
- Preparing artificial heart valves

3D printing has been extensively employed in the industrial sector for rapid prototyping and producing delicate contact components. The technology is gradually infiltrating the pharmaceutical business. 3D-printed pills and pharmaceutical prescription products and gadgets have been extensively researched in business and academia. [20]

2.5. Information Technology

A database used in operating rooms, hospitals, labs, and clinics to help with information gathering is called IT (Information Technology). "The healthcare industry relies heavily on information." One crucial responsibility is handling the enormous volumes of data that are gathered in labs, clinics, hospitals, and surgery departments. Sharing this information is essential because it gives the patient a sense of increased involvement and control. Technology has developed into a vital tool for enhancing an organization's capacity for change. Any device that stores, retrieves, modifies, transmits, or receives digital or electronic information falls under the umbrella term of information and communication technology (ICT). Health information technology (HIT) encompasses a range of technologies used for electronically gathering, transferring, displaying, or storing patient data. It is often referred to as the application of ICT in healthcare. 1 The term "health information technology" (HIT) also describes how patients, healthcare providers, insurance companies, and other governmental organizations use computerized systems to obtain healthcare information.

Telemedicine: Telemedicine is the provision of rapid access to information sharing over a long distance in order to provide medical knowledge and healthcare services. Numerous studies have shown that telemedicine may provide patients and families with a rapid and dependable solution.

Telecare: Telecare provides the care and security that elderly and physically disabled individuals require to remain in their homes while getting care. Sensors can be beneficial and supportive for people who are at danger of falling or who have diseases such as dementia.

M-Healthcare: Refers to mobile communications and network technology for healthcare systems. With this in mind, it appears that the growth of e-health systems—the outcome of advances in biology, wireless and information technology, and computing—has led to the evolution of healthcare. In order to construct next-generation m-health systems, nanotechnologies, tiny biosensors, and wearable, pervasive, and ubiquitous computing systems must be used [21].

IT plays an important role in the pharmaceutical sector by enhancing compliance, data integrity and reliability, and overall product quality. The implementation of software has provided regulators monitoring the production site enormous confidence, especially after they discovered many data integrity issues during their inspections to these firms. As computerized systems replace paper-based systems, information technology has a beneficial effect on operational efficiency, cost, and production.

Convenient Data Handling: Patient data storage is essential, and secure patient data storage is even more vital. There doesn't seem to be a slowdown in the popularity of online pharmacies anytime soon. Given the state of the market and the purchasing patterns of consumers, this tendency is probably just going to become worse. Because information technology makes data and record administration easier, doctors and pharmacists can now concentrate on more important tasks. Access to crucial patient data and medical information has greatly improved. Eliminating time-consuming record-keeping has resulted in a significant improvement in their efficiency. The term "health information technology" (HIT) describes information technology utilized in the medical field. Not just physicians and pharmacists, but all parties involved have profited from this. Patients no longer need to keep track of their medication orders every time they want to buy medications. They can get to it at any time and from any location.

Ease Data Analytics: The ability to use advanced analytics to analyze data in real-time opens up a multitude of new business prospects. Using historical supply chain and consumer health data analysis, we may be able to better understand and plan for future situations. Tools for artificial intelligence (AI) and machine learning (ML) have given pharmacy owners vital insights into factory management, supply chains, and other areas. It is anticipated that 75% of businesses would have used AI by the end of 2024. In addition to enabling e-documentation, simple medicine order storage, and safe data preservation, it has decreased manual labor. Each application performs a unique set of tasks, such as gathering, maintaining, and evaluating data pertinent to a certain functional area.

Internet-based services: A software distribution and licensing model known as Software as a Service (SaaS) involves centrally hosted software that is licensed on a subscription basis. It is also occasionally referred to as "on-demand software". One kind of cloud computing service called platform as a service (PaaS) gives consumers access to a platform where they may create, execute, and maintain apps without having to deal with the hassles of app development and deployment. The popularity of PaaS and SaaS has grown simultaneously. A lot of pharmacies have adopted the so-called "digital twin" approach, whereby they duplicate an actual organization or system digitally in addition to replicating their daily operations online.

Telecare: Healthcare consultants use digital communication technologies to give distant services to patients. This has enabled people to communicate with doctors from the comfort of their own homes. While lowering travel expenses, this has made it easier for persons with limited mobility to obtain healthcare. Remote consultation with doctors is becoming increasingly popular when you do not require special care.[22]

2.6. Blockchain Technology

Blockchain is an intricate database that secures data to keep the system safe from hacking or alteration. The blockchain technology has the potential to improve many aspects of health and wellbeing. Examples include tracking prescription drugs, monitoring clinical trials, monitoring devices, and monitoring health insurance. Because the blockchain uses several network connections, it lowers the danger of network assaults and single points of failure. By timestamping entries, the decentralized platform minimizes fraud, and smart contacts enable user data to be kept in an unchangeable ledger throughout the network. By eliminating manual operations like ledger reconciliation across several discrete ledgers and administrative tasks, blockchain helps to reduce system expenses. The usage of several cryptographic linked chains significantly improves both transaction speed and security.

Blockchain technology can assist the pharmaceutical business in mitigating the hazards associated with counterfeit and unlicensed pharmaceuticals, which are on the rise. An integrated global positioning system and chain-of-custody

monitoring, which is akin to device tracking and forms the basis of prescription smart contracts, enable the identification of pill containers. Blockchain offers continuous verification and transparency for joint transactions involving several supply chain partners.

Blockchain technology has been discovered as a feasible tool to protect against counterfeit drug distribution in the pharmaceutical business. Blockchains can be used to track the origin of medications, drug transit, and raw material acquisition. Additionally, blockchain technology minimizes the number of intermediaries engaged in the pharmaceutical process, lowering costs and boosting safety.

Table 1 Advantages and disadvantages of technology

Sr. No.	Advantages of technology in Pharmacy	Disadvantages of technology in Pharmacy
1.	E-pharmacy Services for Rural Areas	Risk of data breaches and hacking
2.	E-prescription	Lack of technical expertise leading to errors
3.	Improved E-Verification Systems	Limited access to technology in rural and underserved areas
4.	Battling Substance Abuse	Decreased job opportunities for pharmacy technicians and other staff
5.	Recording immunization provided by pharmacists	Dependence on technology leads to system failures
6.	Increased Efficiency in Prescription Processing	Dependence on technology leads to system failures
7.	Better Medication Management	Limited funding for technology in some healthcare settings
8.	Increased Access to Pharmaceutical Information	Compliance with regulations and laws
9.	Predictive Analytics in drug utilization review	Lack of reimbursement for technology-assisted services

3. Conclusion

The results of this study indicate that the pharmaceutical and healthcare sectors greatly benefit from innovative technologies. The advancement of sophisticated sensor technology and artificial intelligence can be used to sum up how technology has affected various sectors and healthcare facilities. Blockchain is a sophisticated database that stores data in a way that makes it impossible to alter or hack the system. Future factories will be digital factories. Hospitals will be entirely robotic. 3D printers will be installed in hospitals to produce nearly anything, including human body parts and medical equipment. Big data analyses in the health sector will be processed more quickly thanks to cloud computing technology.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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