MACHINE AND HUMAN TOGETHER

INNOVATING HEALTHCARE WITH TECHNOLOGY

Editors:
Shaweta Sharma
Akhil Sharma
Shivkanya Fuloria
Anurag Singh

Bentham Books

Machine and Human Together: Innovating Healthcare with Technology

Edited by

Shaweta Sharma
Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University
Greater Noida, Uttar Pradesh-201310
India

Akhil Sharma
R. J. College of Pharmacy
Raipur, Uttar Pradesh-202165
India

Shivkanya Fuloria
Department of Pharmaceutical Chemistry
Faculty of Pharmacy, AIMST University
Bedong-08100, Kedah
Malaysia

&

Anurag Singh
School of Computing Science and Engineering
Galgotias University
Greater Noida, Uttar Pradesh-201310
India

Machine and Human Together: Innovating Healthcare with Technology

Editors: Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh

ISBN (Online): 979-8-89881-162-4

ISBN (Print): 979-8-89881-163-1

ISBN (Paperback): 979-8-89881-164-8

Published by Bentham Science Publishers Pte. Ltd. Singapore, in collaboration with Eureka Conferences, USA. All Rights Reserved.

First published in 2025.

Bentham Science Publishers Pte. Ltd.
No. 9 Raffles Place
Office No. 26-01
Singapore 048619
Singapore
Email: subscriptions@benthamscience.net

CONTENTS

FOREWORD

Welcome to the future of healthcare, a future where human ingenuity intertwines seamlessly with technological innovation to redefine the very essence of patient care. "Machine and Human Together: Redefining Healthcare with Innovations" embarks on a journey through this dynamic landscape, where the convergence of human expertise and cutting-edge technologies reshapes the boundaries of what is possible in healthcare delivery. In the pages that follow, you will discover a world where artificial intelligence, machine learning, robotics, and data analytics converge to revolutionize every aspect of healthcare. Through captivating examples and insightful analyses, this book showcases how these advancements empower healthcare professionals, enhance diagnostic accuracy, and personalize treatment regimens like never before.

However, innovation does not come without its challenges. As we navigate this brave new world, we must confront ethical dilemmas, privacy concerns, and the ever-present need to ensure that technology remains a tool for good. As you embark on this journey, envision a future where human compassion and technological prowess harmonize to provide healthcare that is not only efficient and effective but also deeply empathetic and patient-centered. Together, let us embrace the possibilities of tomorrow and redefine healthcare for the betterment of humanity.

Neeraj Kumar Fuloria
Department of Pharmaceutical Chemistry
Faculty of Pharmacy, AIMST University
Semeling Campus, Jalan Bedong–Semeling 08100 Bedong
Kedah Darul Aman
Malaysia

PREFACE

In "Machine and Human Together: Redefining Healthcare with Innovations" we embark on a journey into the future of healthcare, where human ingenuity and technological advancement converge to reshape the landscape of patient care. This book is composed from a profound acknowledgment of the transformative potential inherent in the collaboration between human expertise and cutting-edge technologies. Within these chapters, readers will encounter a myriad of examples illustrating how artificial intelligence, machine learning, robotics, and data analytics are revolutionizing healthcare delivery. From streamlining diagnostic processes to personalizing treatment plans, the possibilities are both awe-inspiring and boundless.

Nevertheless, amidst the excitement of innovation, we must remain mindful of the ethical considerations and disparities that may arise. This preface invites readers to engage in critical reflection on these challenges and to explore pathways toward responsible and equitable integration of technology in healthcare. As we delve into the world of "Human + Machine," let us embrace the vision of a future where technology amplifies human compassion and enhances patient-centered care. Together, let us navigate the complexities of healthcare innovation with a shared commitment to improving health outcomes for all.

Shaweta Sharma
Department of Pharmacy, School of Medical
and Allied Sciences, Galgotias University
Greater Noida, Uttar Pradesh-201310
India

Akhil Sharma
R. J. College of Pharmacy
Raipur, Uttar Pradesh-202165
India

Shivkanya Fuloria
Department of Pharmaceutical Chemistry
Faculty of Pharmacy, AIMST University
Bedong-08100, Kedah
Malaysia

&

Anurag Singh
School of Computing Science and Engineering
Galgotias University
Greater Noida, Uttar Pradesh-201310
India

List of Contributors

Akhil Sharma	R. J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India
Afroz Khan	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Akanksha Sharma	R. J. College of Pharmacy, Raipur, Uttar Pradesh 202165, India
Amit Raj Singh	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Aryan Kumar	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Ashish Verma	Department of Pharmacy, Mangalmay Pharmacy College, Greater Noida, Uttar Pradesh-201306, India
Anurag Singh	School of Computing Science and Engineering, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Arfa Shams	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Chanchla Devi Haldkar	Shri Rawatpura Sarkar Institute of Pharmacy, Jabalpur, Madhya Pradesh-482001, India
Ganna Rajan	Department of Pharmacy, SGRR University, Dehradun, Uttarkhand-248001, India
Gunjan	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Jyoti Pandey	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
MD Kaif	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Naga Rani Kagithala	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Niranjan Kaushik	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Priyanka Dubey	Department of Pharmacy, Banasthali Vidyapith, Vanasthali, Rajasthan-304022, India
Pushpak Singh	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
SK Abdul Rahaman	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Sagar Pamu	Pharmacy Practice Department, Institute of Pharmacy, Nirma University, Ahmedabad, Gujarat-380001, India
Sarvesh Paliwal	Department of Pharmacy, Banasthali Vidyapith, Vanasthali, Rajasthan-304022, India
Shivangi Bhardwaj	Department of Pharmacy, Banasthali Vidyapith, Vanasthali, Rajasthan-304022, India

Shivkanya Fuloria	Department of Pharmaceutical Chemistry, Faculty of Pharmacy, AIMST University, Jalan Bedong—Semeling 08100 Bedong, Kedah, Malaysia
Shilpa Thukral	Dnyan Ganga College of Pharmacy, Thane, Maharashtra-400615, India
Shekhar Singh	Faculty of Pharmacy, Babu Banarasi Das Northern India Institute of Technology, Lucknow, Uttar Pradesh-226028, India
Shekhar Singh	Faculty of Pharmacy, Babu Banarasi Das Northern India Institute of Technology, Lucknow, Uttar Pradesh-226028, India
Shaweta Sharma	Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India
Sunita	R. J. College of Pharmacy, Raipur, Uttar Pradesh 202165, India
Swapnil Sharma	Department of Pharmacy, Banasthali Vidyapith, Vanasthali, Rajasthan-304022, India
Swati Verma	Department of Pharmacy, Banasthali Vidyapith, Vanasthali, Rajasthan-304022, India
Shaikh Yahya	Department of Pharmaceutical Chemistry, School of Pharmaceutical Education and Research, Jamia Hamdard, New Delhi-110062, India
Yatindra Kumar	Department of Pharmacy, GSVM Medical College, Kanpur, Uttar Pradesh-208002, India

CHAPTER 1

Synergy of Humans and Machines in Healthcare

Amit Raj Singh[1] and **Shaweta Sharma**[1,*]

[1] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: This chapter explores the synergy of humans and machines in health care, focusing on how they work together to enhance outcomes in medical practice. By combining human creativity and judgment with the precision and data-processing capabilities of machines, this partnership addresses key shortcomings in contemporary medical practices. It discusses various applications of AI and ML in health care: drug discovery, diagnosis, predictive analysis, telemedicine, and remote patient monitoring. Innovations in technology are revolutionizing the spheres where quicker drug development, enhanced diagnostic accuracy, and cost-cutting are evident. The integration of AI in treatment facilitates personalized medicine through the assessment of vast volumes of data, predicting outcomes, and developing the most optimal treatment plans for each patient. Technologies enhance telemedicine access to healthcare by providing real-time monitoring of chronic disease management and wearable devices equipped with IoT sensors. It will conclude the chapter by stating how this human-machine synergy will revolutionize healthcare delivery and enhance patient care, while also providing innovative solutions in medical research.

Keywords: Artificial intelligence, Drug discovery, Machine learning, Predictive analysis, Remote patient monitoring, Telemedicine.

INTRODUCTION

The term "synergy" is derived from the Attic Greek word synergia, which is derived from synergos, meaning "working together." The effect of this synergy of humans and machines is that both produce something that can easily turn out to be more than the potential of the single result if one of them works alone; it occurs largely in that people add, creativity and judgment with appropriate context, while computers can better process information and execute actions with high accuracy for innovative and improved productivity in health care and many aspects of manufacturing, scientific investigation, *etc*.

* **Corresponding author Shaweta Sharma:** Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

Technological breakthroughs are revolutionizing nearly every sector, with the health care business poised to gain significantly from these innovations. Significant developments in technology and financing have led to the widespread adoption of machines in healthcare facilities for various activities, including next-generation sequencing, electronic data collection and storage, as well as diagnosis and treatment recommendations. The gathering and analysis of big data have reached extraordinary levels, surpassing human analytical and interpretative capacities, thanks to sensors and innovative algorithms that enable the continuous measurement and storage of patients' health metrics. The conversion of AI technologies and big data into actionable biological and clinical information has expanded, facilitating precision medicine. These algorithms now possess the potential to learn and thus enhance over time. The benefits of employing AI algorithms or neural networks in healthcare are increasingly evident in numerous healthcare systems, resulting in reduced diagnostic errors, resource conservation, and enabling doctors to address the needs of additional patients [1, 2].

The collaboration between humans and AI is becoming a potent tool to rectify the existing deficiencies in medicine.

These deficiencies encompass inadequate prediction accuracy, vulnerability to critical diagnostic and therapeutic mistakes, unexpected repercussions of empirical decision-making, and inefficient hospital procedures, frequently culminating in inferior patient care. AI is poised to transform how urologists provide care for their patients. AI encompasses the scientific, engineering, and developmental processes of systems that replicate human intellect and behaviour. Effective AI encompasses unique insights in perception, pattern recognition for text, audio, and images, as well as decision-making and problem-solving capabilities. Significant progress has been achieved in creating synergistic human-machine systems that leverage the advantages of both human and AI-generated reasoning [3].

The key areas in healthcare include human and machine drug discovery & drug development, diagnosis & predictive analysis, telemedicine and remote patient monitoring, robot-assisted surgery, and hospital management. This book chapter will discuss these topics in detail and how human and machine synergy have impacted them, as well as their future perspectives.

DRUG DISCOVERY & DEVELOPMENT

Finding and developing drugs is a lengthy process that involves searching, designing, and testing new drugs to fulfill fundamental health needs. Once a candidate molecule is identified, it is also tested in preclinical and clinical studies, where its safety, efficacy, and potential side effects are determined. Such procedures may take years and have to be done with cooperative efforts from scientists, doctors, regulatory agencies, and drug manufacturers. Despite all these problems, successful drug discovery will lead to novel therapies, thereby enhancing the condition of patients and improving medical science [4, 5].

In recent years, technological advancements have significantly transformed the majority of factors involved in the drug discovery process, facilitating and accelerating individual phases. High-throughput screening techniques enable scientists to rapidly evaluate thousands of chemicals for potential therapeutic benefits, thereby significantly accelerating the primary discovery phase [6].

Furthermore, computational strategies, including AI, are increasingly finding applications in predicting the properties and behaviors of drug candidates, thereby reducing the reliance on the traditional trial-and-error approach [7, 8]. ML is a significant area within AI, allowing machines to learn from data without being programmed [9]. ML algorithms have been very effectively applied in various niches of drug discovery, such as genomics, proteomics, and transcriptomics, having revealed important molecular pathways and molecular biomarkers related to the pathologies of many diseases. This has enabled the validation and prioritization of tractable drug targets. ML may one day eradicate, if not minimize, testing on live animals [10]. Fig. (**1**) shows the various applications of AI in drug discovery and development.

A study by Margulis [11] and his group is one such example of the use of ML in drug discovery. The aim was to explore how ML can be useful in identifying highly bitter compounds in the early stages of drug development. The aim was to understand if a specific ML algorithm can be used as an alternative to *in vivo* testing to predict the bitterness of different drug molecules. Eighty percent of the bitter compounds present were matched to those associated with a brief access taste aversion (BATA) test, indicating that the above research was successful. This experiment, following the BATA test, revealed that toxicity should not be directly linked to being bitter, as scientists had hypothesized over time. This denotes how ML can produce required outputs with new knowledge simultaneously. Fig. (**2**) represents machine learning in drug design.

The study by Raschka *et al*. [12, 13] shows the functionality and applicability of ML technology in GPCR ligand recognition, which is an important concern regarding drug design. The task is to determine if older-fashioned technology used for blocking Sea Lamprey Receptor 1 (SLOR1) receptor signal inhibiting tests can be replaced with newly attained results from the ML algorithm, as validated by the described use of these tests. The results generated by the

CHAPTER 2

Artificial Intelligence in Clinical Decision Support

Gunjan[1] and **Shaweta Sharma**[1,*]

[1] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: Artificial Intelligence (AI) is revolutionizing the healthcare industry by improving medical research, diagnosis, therapy, and patient care. AI systems use machine learning, natural language processing, and computer vision to analyze vast volumes of medical data, assist physicians in making informed decisions, and develop individualized treatment regimens. AI is also crucial for early illness detection, health outcome prediction, and process improvement in the medical field. However, to fully leverage AI in healthcare, several problems must be resolved, including patient data protection, ethical considerations, and legal constraints. AI has the potential to revolutionize healthcare by assisting physicians in making more informed decisions, enhancing patient safety, and mitigating the impact of staffing shortages. Regulators and politicians are concerned about the reliability of Clinical Decision Support Systems (CDSSs) and Artificial Intelligence (AI), as well as whether users trust them. This study examines these disparities with a particular focus on physicians' perceptions of AI and trust in CDSS. Clinical Decision Support Systems (CDSS) are currently successfully using AI, which can be classified into two categories: data-driven and knowledge-based. AI is particularly helpful for tasks like determining the reasons for cardiac enlargement, evaluating ECG data, and detecting electrolyte imbalances. However, AI has drawbacks, such as a lack of accountability for incorrect medical judgments or treatment outcomes. An ageing population is predicted to make the skilled labor shortage in the healthcare industry worse, and AI-based Clinical Decision Support Systems (AICDSS) have shown benefits in reducing workload and enhancing healthcare. AICDSS has gained recognition for its ability to use both organized and unorganized clinical data to help patients and healthcare professionals in various circumstances. However, AI-based AICDSS must be more effectively incorporated into existing healthcare practices to use vast amounts of data while adhering to stringent privacy regulations and ensuring user satisfaction. To promote the application of AI-CDSS in clinical settings and achieve wider acceptance, a comprehensive understanding of the variables influencing physicians' inclination to use AI-CDSS and their relationships with each other is needed.

Keywords: Artificial intelligence, Clinical decision support systems, Diagnosis, Machine learning, Medical data analysis, Patient care.

[*] **Corresponding author Shaweta Sharma:** Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

INTRODUCTION

First launched in the 1980s [1], AI-CDSS are technologies that use clinical expertise, patient data, and wellness data to improve medical decision-making [2]. These systems provide vital information and intelligent tools to identify, treat, and enhance health concerns, which benefits patients, carers, and medical professionals [3]. Advanced AI technology is used by modern AI-CDSS to evaluate patient information from digital medical records, provide rational evaluations or suggestions, and assist medical professionals in making informed decisions [4], as well as assessing data that humans cannot comprehend or understand [5]. In the healthcare industry, AI-CDSS is frequently utilized for activities including patient management, diagnosis, treatment, prevention, and decision-making. They are thought to be crucial for raising the standard of healthcare since several systems have been demonstrated to improve physician performance [6]. Researchers have investigated the application of AI-CDSS in several healthcare domains. According to Hansen *et al* [7], AI-CDSS enhanced the precision and comprehensiveness of nursing interventions. According to Alsharqi *et al*. [8], these systems use machine learning to analyze and interpret echocardiogram images efficiently. By examining their data, Islam *et al*. [9] showed how AI-CDSS assists diabetic patients in tracking and controlling their insulin levels. In anaesthesiology, AI-CDSS are commonly used to help minimize inhaled anesthetics, increase preoperative use of beta-blockers and antibiotics, and aid with anesthesia billing and recordkeeping [10 - 12]. Doctors are the primary clients of AI-CDSS, and their adoption of these systems depends on their desire to utilize them. Concerns about undeveloped technology, data privacy, a lack of human interaction, and mistrust of new systems are among the reasons why some physicians have a favorable opinion of AI-CDSS, while others are apprehensive. According to Wagner *et al*. [13], only 54.9% of family physicians were amenable to diagnosing patients with AI. According to a study by O'Leary *et al*. [14], 82% of healthcare experts polled found AI useful for detecting uncommon disorders. According to a 2020 survey of 156 American radiology students conducted by Park *et al*. [15], more than 75% of the respondents believed AI would have a big influence on medicine in the future, with 66% anticipating it would have a significant impact on diagnostic radiography. AI reduced the students' interest in radiology, according to nearly half of them (44.2%). 71% of 632 academics and students from the areas of ophthalmology, radiology, and dermatology in a study by Scheetz *et al*. [16] thought AI would advance medicine, and 85.7% thought it would affect the demand for healthcare workers in the next ten years. According to a South Korean poll by Oh *et al*. [17], only 5.9% of doctors were quite knowledgeable about AI, despite the fact that the majority of them believed it to be useful. Similarly, UK medical students feel unprepared to deal with AI, according to 2020 research by Sit *et al*. [18]. Concerns about technology replacing human labor are the key reason why many experts have conflicting opinions regarding AI in healthcare. According to Poon and Sung's [19] research, doctors' scepticism regarding AI in clinical settings hindered advancement due to a lack of confidence. Since there are still high expectations for AI-CDSS, it is essential to research physicians' inclination to use these systems and understand the factors that affect their utilization in order to successfully integrate them into clinical practice. Prior studies have demonstrated that the application of AI in diagnosis and treatment is constrained by factors such as worries about professional autonomy. Doctors in underdeveloped nations were less inclined to adopt AI-CDSS because they believed their independence would be threatened. Still, their desire to do so rose when they were involved in the system's planning and design, according to Sambasivan *et al*. [20]. Compared to physicians in large hospitals, Laka *et al*. [21] found that primary care physicians identified patient preferences, autonomy issues, and time restrictions as the main obstacles to using AI-CDSS. The majority of current research focuses on the individual elements that influence physicians' usage of AI-based clinical decision support systems (AI-CDSS). Still, it doesn't examine how these aspects combine or function as a whole. Studies that examine every element influencing physicians' choices to use AI-CDSS and how they relate to one another are also lacking. Our study employs fsQCA to investigate the combined impacts of many factors on Chinese doctors' desire to adopt AI-CDSS in order to assist in promoting its usage in healthcare.

FRAMEWORK FOR AI-CDSS ADOPTION INTENTION

The Unified Theory of Acceptance and Use of Technology (UTAUT) was proposed by Venkatesh *et al*. [22] in 2003 to explain the variables that influence an individual's desire to embrace new technology. The four primary components of the UTAUT—performance expectation, effort expectancy, social influence, and enabling conditions—all have an intentional impact on behaviour [23]. The UTAUT also considers the impact of age, experience, gender, and voluntary usage on the adoption of technology. The hypothesis was first created to examine the practical advantages of implementing new technology in businesses. With the rise of AI technologies, an increasing number of academics are using the UTAUT to study how people use AI. According to Tornatzky *et al*.'s [24] Technology-Organization-Environment (TOE) model, organisations' adoption and implementation of new technologies are also influenced by organisational, technological, and external environmental variables. Fig. (**1**) shows the framework for AI-CDSS adoption intention.

CHAPTER 3

Robotics in Surgical and Medical Procedures

Swati Verma[1,*], Sarvesh Paliwal[1], Swapnil Sharma[1], Shivangi Bhardwaj[1] and **Priyanka Dubey[1]**

[1] *Department of Pharmacy, Banasthali Vidyapith, Vanasthali, Rajasthan-304022, India*

Abstract: Recent advancements in artificial intelligence and robotics have transformed mechanized surgical techniques. Robotic technology improves surgical precision, consistency, and agility. Robots use computed tomography and magnetic resonance imaging in image-guided procedures to guide instruments to the treatment area. This necessitates the development of novel algorithms, user interfaces, and sensors to register the patient's anatomy with preoperative image data and to develop the procedure. The use of remotely controlled robotics in minimally invasive surgery enables surgeons to access internal organs and tissues without the need for extensive incisions. Sensing technology and specialized mechanical designs are necessary to optimize dexterity in the face of these constraints. Currently, a variety of surgical procedures employ robots. In the field of neurosurgery, image-guided machines are capable of performing biopsies on brain lesions with minimal collateral damage. Orthopaedic surgeons frequently employ robotics to shape the femur, ensuring it is in ideal alignment with a prosthesis during a hip joint replacement procedure. Although the initial clinical outcomes are promising, numerous unresolved questions remain, including physician acceptability, excessive capital expenditures, performance validation, and safety concerns. This chapter discusses how robotics can be utilized to enhance the accuracy and speed of surgery by enabling AI systems to make informed decisions and implement real-time adjustments across multiple procedures. Medical research has undergone significant enhancements as a result of robotics, and this chapter examines the evaluation of the relevance of robotics.

Keywords: AI, Healthcare, Robotics, Surgeons, Surgical assistants, Tele-surgery, Transition in surgery.

INTRODUCTION

Surgical procedures and other medical therapies have evolved in conjunction with the expansion of global scientific knowledge. In recent years, technological advancements and the introduction of new surgical techniques have dramatically altered numerous aspects of surgical procedures [1]. The intricate integration of

* **Corresponding author Swati Verma:** Department of Pharmacy, Banasthali Vidyapith, Vanasthali, Rajasthan-304022, India; E-mail: verma22swati@gmail.com

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

data with physical activity provided by robotic systems has resulted in a significant cultural shift. Some of the numerous applications include industrial production, quality control and inspection, laboratory automation, exploration, field service, rescue operations, surveillance, healthcare, and medicine. In recent decades, people have utilized robots to automate or enhance specific tasks, such as installing test devices or electrical circuits. Nevertheless, their most substantial economic impact often results from their role as essential intermediaries for integrating computers into comprehensive manufacturing or service operations [2].

Soon, robot hardware and computer-integrated surgical systems might make it possible to create medical treatments that are less invasive, more precise, and more focused. Robotic technology can perform surgical procedures with a reduced risk of complications, less blood loss, and quicker recovery periods for patients [3]. By connecting data sources, such as medical images, to operations performed in the operating room, robotic technology has the potential to improve the efficiency of clinical processes. Thanks to advancements in imaging and other sensor data that transcend human motion control, robots may soon be capable of performing surgical procedures that are physically impossible for humans to complete. Medical robots could significantly enhance the field of interventional medicine by simplifying the use of various components within larger computer-based systems. These systems can aid in diagnosis, pre-surgical planning, precautionary measures during and after surgery, hospital logistics and scheduling, as well as long-term monitoring and quality control. Modern surgical procedures have undergone significant transformations as a result of the integration of robotics. The surgical process has become more straightforward as technology has advanced and new instruments have been developed, leading to numerous enhancements in surgical techniques. Neurosurgery and other medical disciplines have made significant strides in recent years, largely due to the advancement of image-guided surgery [4].

The utilization of surgical robotics in hospitals and universities has experienced substantial expansion. Surgical robotics has evolved into a multibillion-dollar industry over the past two decades. Today, thousands of surgical operations worldwide utilize robots deployed in over 1,000 locations. The initial recorded robotic surgical treatment was the catalyst for the development, expansion, and widespread adoption of surgical robotics [5].

Some individuals may perceive robotic systems and surgical robots as “smart” surgical instruments that assist human surgeons in providing more effective, safer, and minimally invasive treatments to individual patients. Additionally, the information infrastructure and consistency of medical robots and computer-integrated surgery in health care are as critical as CIMS is to industrial production (Fig. **1**) [6]. The orthopedic surgery subspecialty has advanced significantly due to the introduction of new technologies and research. The orthopedic industry has experienced significant benefits as a result of the development of CRIGOS, or miniature robotics for image-guided orthopedic surgery. This technology has inspired a significant number of individuals to undergo foot surgery. Robotics was initially implemented in the field of orthopedics; however, they have since infiltrated other medical disciplines. Robots have revolutionized neurosurgery, in addition to benefiting ocular surgery. Scientific advancements have enabled the attainment of new levels of precision and proficiency in medical research, thereby significantly enhancing patient satisfaction [7].

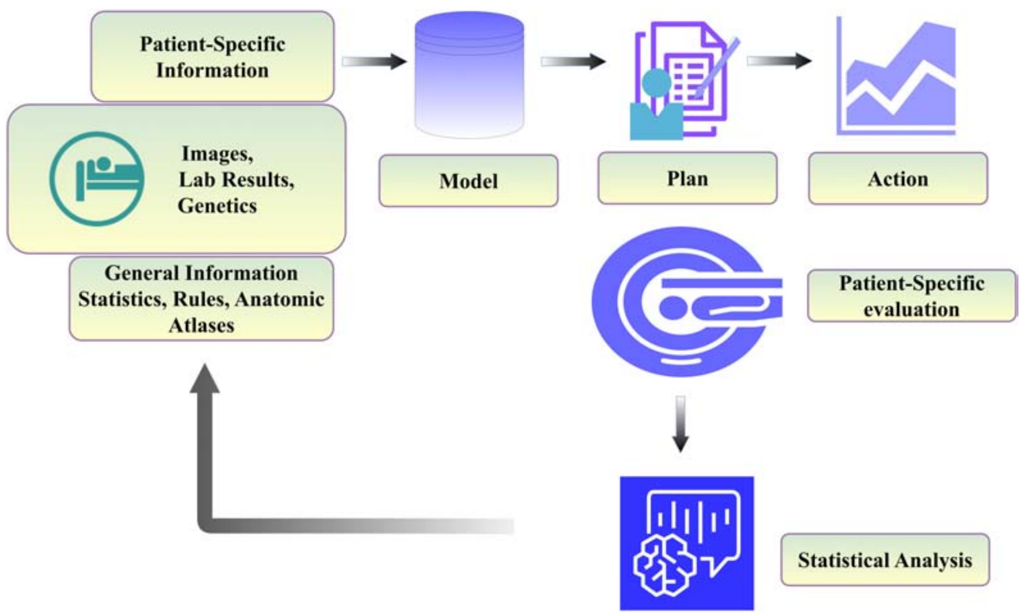

Fig. (1). Work-flow of computer-integrated surgery.

Before robots can realize their full potential in interventional medicine and surgery, significant advancements in hardware design, software, and clinical integration are required. The hardware side is perpetually engaged in the process of reducing the size, enhancing safety, and ensuring that robotic devices comply with imaging standards. The development of control and planning algorithms that consider tissue deformations, uncertainty in sensing and motion, and other factors is a focus of extensive software research in Artificial Intelligence (AI) for robotic surgical instruments. The translation of these innovations into clinical practice is contingent upon the development of user-friendly visual and tactile interfaces for

CHAPTER 4

Genomic Medicine and Personalized Healthcare

Sunita[1], **Akhil Sharma**[1], **Akanksha Sharma**[1], **Shekhar Singh**[2] and **Shaweta Sharma**[3,*]

[1] *R. J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

[2] *Faculty of Pharmacy, Babu Banarasi Das Northern India Institute of Technology, Lucknow, Uttar Pradesh-226028, India*

[3] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: Genomic medicine and personalized healthcare are important innovations in modern medicine that aim to customize healthcare based on individual differences in genetic profile. This chapter provides a brief overview of the developing field of genomic medicine, starting with the basics of human genome sequencing and the importance of genetics in disease prevention. Also, the chapter focuses on important technologies, including NGS, CRISPR gene editing, WGS, and genomic data types such as SNPs. The chapter discusses the importance of targeted medicine, illustrating how it outperforms classical methods through targeted therapy, decreased side effects, and individualized prevention. It also encompasses particular applications in oncology, pharmacogenomics, rare genetic conditions, and infectious diseases. The rapid growth of some technological advances, such as AI, ML, and big data implementation, plays a crucial role in genomics data analysis and interpretation. The challenges in genomic medicine, such as data privacy, ethical dilemmas, and lack of accessibility, are discussed. The chapter concludes by discussing the future of genomic medicine, referring to it as "the patient-centered solutions of the future".

Keywords: Data privacy, DNA sequencing, Genomic medicine, Personalized healthcare, Pharmacogenomics, Precision medicine.

INTRODUCTION

Genomic medicine is a novel approach to patient care that uses information about a person's genome to guide diagnosis, prevention, and treatment. Genomic medicine aims to identify the genomic foundations of diseases by analysing patterns in DNA, RNA, and proteins to provide personalized treatment options.

* **Corresponding author Shaweta Sharma**: Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

Personalized healthcare uses this approach but adds information about the individual (including genetic, environmental, corporate, and lifestyle factors) to create a custom healthcare solution. Collectively, these paradigms are moving from a one-size-fits-all model to a precision model and improving patient clinical outcomes. Genomic medicine is a fourth revolution in the field of healthcare, possibly in the future as a main modality impacting other specialties such as oncology, pharmacogenomics, rare genetic disorders, infectious diseases, *etc.* It also assists in the detection of the predisposition to disease and increases the therapeutic effect while preventing the side effects [1, 2].

Importance in Modern Healthcare

Integrating genomic medicine into current healthcare offers the promise of significant paradigm shifts in critical areas of disease prevention, diagnosis, and treatment. This allows for preventive measures and personalized lifestyle modifications based on genetic susceptibilities. In the field of oncology, genomic profiling permits the selection of targeted therapies that boost efficiency and decrease adverse effects. It also helps healthcare providers to give medications based on a patient's genetic composition with the best possible dose and minimum adverse drug reaction–some of the significant benefits of pharmacogenomics. It contributes to a paradigm shift in the sense of preventive care that alleviates the economic burden imposed on the healthcare system by slowing down the progression of chronic diseases. In addition, genomic medicine provides patients with useful information about their health, which enables shared decision-making. The reason for its significance in present healthcare is its accuracy, and it could be a stepping stone for equal and efficient healthcare [3 - 5].

Role of Technology in Advancing Genomics

Technological developments have played a key role in bringing genomic medicine to the forefront of healthcare. Typical next-generation sequencing (NGS) technologies have revolutionized genetic analysis because they have successfully launched whole-genome sequencing into fast, more accurate, and cheaper approaches. The integration of big data analytics and machine learning tools has been instrumental in indicating patterns, analyzing large genomic datasets, and predicting disease risk. AI simplifies analysis of complex genetic interactions and can aid drug discovery by revealing novel therapeutic targets. In addition, partly due to the ease of keeping and exchanging genomic data, cloud computing provides the potential for collaborative research and speeding up innovations. Digital healthcare tools, alongside genomic data, such as wearables, can capture health metrics in real time, thus getting a comprehensive view of patients' health. In order to alleviate privacy challenges, secure and transparent genomic data sharing will be facilitated *via* the use of blockchain technology. Together, these technologies have moved genomics from the periphery to the center of precision medicine, enabling innovations in personalized medicine [6, 7].

UNDERSTANDING GENOMIC MEDICINE

Basics of Human Genome and DNA Sequencing

The entirety of human genetic information, over 3 billion base pairs of DNA, is known as the human genome, which describes the complete set of instructions for our development, function, and reproduction. This information is stored as sequences of four nucleotides: adenine (A), thymine (T), cytosine (C), and guanine (G). The genome consists of 23 pairs of chromosomes and harbors approximately 20,000-25,000 protein-coding genes and large non-coding regions responsible for regulating gene expression and function. The sequencing of our genome has been one of the most important achievements in biology and medicine, facilitated primarily by the advent of DNA sequencing technologies [8].

The same goes for DNA sequencing, which is basically just a form of determining the detailed order of nucleotides in a DNA molecule, which has changed a lot from its early beginnings. Foundation-level traditional methods, such as Sanger sequencing, were expensive and time-consuming. Next-generation sequencing (NGS) has changed the landscape, allowing the rapid, high-throughput analysis of whole genomes at a fraction of the cost. NGS platforms break DNA into little pieces, sequence them in parallel, and subsequently reassemble the data computationally. Novel technologies, such as third-generation sequencing, which already analyze larger fragments of DNA in real time, further enhance precision and reduce the time from sequencing to results [9].

The sequencing of the human genome, initially performed in 2003 as a result of the Human Genome Project, has provided unprecedented opportunities for understanding genetic variation, evolution, and susceptibility to diseases. It showed that even though humans share 99.9% of their DNA, the remaining 0.1% explains individuality and differences between us all, including the likelihood of the disease. These variations, such as single-nucleotide polymorphisms (SNPs) and structural changes, are often studied to understand genetic influences on health and disease.

The knowledge gleaned from DNA sequencing has broad applications. This allows us to find the mutations related to genetic diseases, come up with targeted therapies, and participate in pharmacogenomics, such as customizing the

CHAPTER 5

Telehealth and Virtual Consultations

Jyoti Pandey[1,*], **Ganna Rajan**[2], **Gunjan**[1] and **Shaweta Sharma**[1]

[1] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

[2] *Department of Pharmacy, SGRR University, Dehradun, Uttarkhand-248001, India*

Abstract: In the present scenario, with the advancement in technology, a new feature called Telemedicine has been introduced. Telemedicine is a blend of information and communication technologies (ICTs) with medical science. The virtual consultation is a part of telemedicine. The primary difference between a virtual consultation and a typical one is that it enables you to obtain a medical opinion without physically meeting the physician. Online consultations also allow doctors to communicate with other physicians and access various electronic medical records to support patient care. In the past two years, during the COVID-19 pandemic, we have seen that people prefer telemedicine over face-to-face interaction because it is considered safer. Fortunately, telemedicine and virtual consultations *via* video conferencing or other digital platforms can reduce the number of doctor visits and relieve patients of the time and expenses associated with traveling. Hence, telemedicine is fruitful in reducing treatment costs and saving time for patients and healthcare practitioners. Additionally, due to its quick and useful features, it helps improve hospital and clinic workflow. It would be simpler to monitor discharged patients and oversee their recovery with the help of this revolutionary technology. The primary goal of telemedicine and virtual consultation is to deliver high-quality healthcare services throughout India. This involves making healthcare more accessible to both affluent and impoverished communities, offering quicker, less expensive, and better communication for treatment, expert follow-up, and record storage. Geographical barriers to healthcare are lessened, particularly when it comes to reaching remote locations with inadequate transportation connections. Therefore, it can be concluded that telemedicine offers mutual benefits for both patients and healthcare providers. However, achieving its full potential is fraught with difficulties. This chapter explores several key legal and ethical issues relevant to the practice of telemedicine and virtual consultations, including the doctor-patient relationship, informed consent, patient rights, treatment workflow, malpractice, and confidentiality standards.

Keywords: Healthcare, Medical care, Telemedicine, Virtual consultation, Virtual technologies.

[*] **Corresponding author Jyoti Pandey:** Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: jpandey1112@gmail.com

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

INTRODUCTION

Improved healthcare and greater accessibility for more people are made possible by cutting-edge technology and high-quality network services. One especially helpful tool that helps people maintain their long-term health and access preventive treatment is telemedicine. This is particularly beneficial for individuals who struggle to access high-quality healthcare due to budgetary or geographical limitations. The efficiency, organization, and accessibility of healthcare could all be enhanced by telehealth. This is a relatively new field of study, but it is growing rapidly. For instance, treating people with heart problems over the phone and remotely monitoring their vital signs has improved their overall quality of life while reducing their risk of hospitalization and mortality. People seek a diagnosis or rehabilitation plan for a variety of compelling reasons. As a result, patients may feel more assured that they are receiving the best possible care. Since telemedicine eliminates some of the obstacles that prevent patients from accessing this crucial kind of therapy, it is an excellent choice for treating mental health issues [1 - 3].

Patients can receive safe medical care *via* telemedicine at a mutually convenient time. This eliminates the need to take time off work or arrange childcare. When visiting a doctor's office, sitting close to other people increases the risk of infection, particularly for individuals with weakened immune systems or those with long-term medical conditions. Telemedicine lowers the risk of hospital-acquired infections. Additionally, doctors can earn more money by treating more patients online, and telemedicine companies can incur lower operational expenses. Patients are likely to be happier since they do not have to drive to the office, wait for treatment, or risk contracting an illness in the hospital, while caregivers are shielded from any infections from patients [4, 5].

The ability of medical professionals to treat multiple patients virtually has improved due to telemedicine. Telemedicine is likely to remain a viable option for a while, now that its worth has been established. Many physicians were first exposed to telehealth through video conferencing, but emerging telemedicine technology will deliver much more. For example, specialists can contribute remotely during crises, and clinicians can utilize natural language processing to automatically take notes during patient sessions. An Internet of Things (IoT) cloud platform may receive data gathered from medical equipment and organize it for use in patient care [6 - 8].

Patients in remote locations can greatly benefit from telemedicine, particularly in countries with limited or no healthcare services. Secure technology and software are necessary for both patients and physicians to maintain accurate medical information. When an in-person visit is not required, some clinics allow patients to continue receiving treatment from their normal physician by offering virtual meetings with doctors *via* online video conversations. Online consultations with a physician or nurse practitioner are an additional choice. These days, many large businesses incorporate automated health kiosks into their healthcare offerings. There are also nursing call centers where nurses provide home care guidance through question-and-answer sessions [9 - 11]. Prescription refills, taking blood pressure medication, and remembering appointments are all made possible by this technology, which supports health management. Additionally, patients may self-test, participate in specialized training programs for their condition, and consult physicians regarding their symptoms. In general, electronic health technology facilitates the management of chronic conditions by providing patients with access to treatment *via* smartphones and monitoring applications [12, 13].

Many believe that technology-assisted consultations help address many of the challenges in delivering healthcare to an aging and increasingly diverse population. Long-term results for major disorders like cancer are improving, and more individuals feel comfortable taking charge of their health, despite the health system's struggles with growing rates of long-term illness and reliance. According to the UK's National Information Board, to successfully address these health and demographic changes, a new type of healthcare system is required — one that reduces the prevalence of typical outpatient visits, for instance [14].

In addition to providing patients with advantages such as reduced travel expenses and discomfort, remote consultations can also be more economical for the healthcare system. Nonetheless, there are concerns that they could pose clinical hazards or be less palatable to staff and patients, as they can present logistical, technological, and legal difficulties. Research on remote consultations *via* video technology, such as Skype, is still in its infancy but is beginning to expand [15 - 17]. Specifically, a recent analysis identified 27 published studies on Skype's usage in clinical care, all but one of which not advantages [17].

Some of these studies involved as few as five patients, while the majority were brief descriptions of modest, early-stage programs. This evaluation includes a few more current studies as well as the higher-quality primary publications from Arnfield and colleagues that are relevant to our research. A study on family-based behavioral support for adolescents with poorly managed type 1 diabetes mellitus focused on the “working alliance,” or the strength of the relationship between patients, caregivers, and medical professionals [18]. The authors found that ten Skype meetings were equally effective as ten in-person meetings in maintaining the working relationship [19].

CHAPTER 6

Wearable Technology for Health Monitoring

Aryan Kumar[1], **Shaweta Sharma**[1,*] and **Pushpak Singh**[1]

[1] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: Wearable technology in modern healthcare is an incredible tool for the provision of continuous monitoring, personalization, and better management of disease. With smartwatches, a fitness tracker, and sophisticated sensors, these gadgets collect and interpret data concerning heart rate, blood pressure, oxygen saturation, levels of glucose, and an electrocardiogram ECG. Progress in sensor technology, artificial intelligence, and networking has facilitated enhancements in patient outcomes and, in turn, contributed to the reduction of healthcare costs. Such advancements in wearables incorporate the use of AI in predictive analytics and anomaly detection to predict and intervene earlier in cases of arrhythmias, diabetes, and sleep apnea, among others. The advent of non-invasive biosensors has broadened their applications, facilitating continuous glucose monitoring and hydration status evaluation without the need for needles. These wearables, in conjunction with cloud-based platforms, enable seamless data interchange with healthcare professionals, hence improving remote patient monitoring and telemedicine applications. The COVID-19 pandemic expedited the utilisation of wearables for symptom tracking, recovery monitoring, and long-term effect identification. Furthermore, wearables are essential in clinical studies, as they provide real-world data on patient compliance and treatment effectiveness. Notwithstanding its potential, obstacles remain, encompassing concerns regarding data privacy, device precision, and the digital divide impacting accessibility. Emerging trends indicate the convergence of wearables with augmented reality (AR), 5G connectivity, and machine learning to enhance immersive and intelligent health solutions. As wearable technology advances, it is poised to transform patient-centered care, improving the accessibility, proactivity, and efficiency of health monitoring.

Keywords: Artificial intelligence in healthcare, Biosensors, Health monitoring, Remote patient monitoring, Wearable technology.

INTRODUCTION

In a rapidly evolving environment, almost all innovations must be interconnected, accessible from afar, and subject to analysis. To achieve this, we employ the Internet of Information.

* **Corresponding author Shaweta Sharma**: Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

The Internet of Everything (IoE) enables objects to connect to the online world, thereby making them 'smart,' including devices like smartwatches and smart lights. The Internet of Things enhances human autonomy in interacting, contributing, and collaborating with objects [1]. The Internet of Things (IoT) has been implemented across various sectors, including agriculture, home automation, roadway management, transportation oversight, water supply management, vehicle management, electric power systems, and energy efficiency [2].

Wearable technology is rapidly becoming addictive due to its capacity to facilitate a level of self-awareness previously unattainable. The worldwide initiative for wearable technology in conjunction with medical devices has intensified in recent years, and numerous problems exist in integrating it with monitoring sensors. These wearable healthcare gadgets differ from the majority of medical devices in that they produce very extensive and intricate datasets, which is in contrast to conventional sensors. Intelligent wearable technology embodies the subsequent form factor of computational models, amalgamating features of a telephone, wristwatch, and fitness tracker, along with other biophysical sensors. We are in an era of mobile computing and networking for wireless and wearable technologies, as well as instruments for processing extensive health data resources [3, 4].

The technology of IoT-enabled portable gadgets with sensors is a swiftly growing field in medical treatment. As the healthcare sector advances, there is a demand for accessible diagnostics and effective data monitoring and administration. The ultimate objective is to integrate IoT into emergency services, connected residences, intelligent healthcare facilities, electronic health records, and similar domains [5]. The information gathered by intelligent devices and an advanced medical facility can track the signs of illness instantaneously. This can promote advancements regarding health care, medical procedures, drugs, and immunizations. The ultimate objective is to provide data security and accessibility for authorised individuals through cloud computing, fog computing, and similar technologies [6].

Coronavirus disease (COVID-19), which first arose in late 2019, resulted in over three million fatalities globally, significantly affecting patients' physical and mental health [7, 8]. It is crucial to monitor the physiological as well as hemodynamic characteristics of individuals, such as their body temperature, pulse, arterial pressure, as well as airflow, in order to evaluate their health status during treatment, especially for those with mild symptoms who are secluded at residence [9]. Furthermore, chronic conditions like cardiovascular disorders as well as hyperglycemia lead to a substantial number of annual deaths, including arteriosclerosis, diabetes, coronary heart disease, and hypertension, which can be successfully reduced with prompt identification and sustained constant surveillance [10 - 13]. However, the continuous monitoring of the above-described physiological indicators at home using traditional clinical procedures and instruments is challenging due to their limited practicality and high costs. Advancements in adaptable electronics, as well as nanotechnology, have led to the development of portable gadgets that demonstrate remarkable elasticity as well as skin-like conformity, making them significant contenders for healthcare applications [14 - 23]. Currently, various advanced medical devices have been developed for measuring blood pressure, body temperature, heartbeat, and glucose levels, utilizing piezoelectric effects, capacitance effects, and electrochemical principles [24 - 30]. These tracking devices can be easily integrated into smart clothing or watches for ongoing healthcare, enabling home-based telemedicine surveillance. This chapter aims to promote the evolution of ubiquitous health tracking devices, along with their healthcare implications, by focusing on recent breakthroughs in skin-like sensing technologies. It provides an extensive overview of health monitoring principles, device fabrication, potential clinical applications, and upcoming advancements [31, 32].

IOT AND HEALTHCARE

Health care constitutes one of the most respected sectors for IoT use. Through the Web of Things, clinicians can provide online assistance to individuals. Portable IoT-enabled wellness tracking gadgets can significantly reduce the gap between the person receiving treatment and the medical professional. The Internet of Things (IoT) enables personalised patient care by facilitating the assessment of health conditions and the formulation of tailored treatment strategies. Portable sensors would enable physicians to remotely monitor patients' health and respond instantly. Nonetheless, real-time metrics necessitate a continuous Internet connection. Despite the rapid advancement of IoT in healthcare, its implementation remains incomplete in many medical sectors [33]. The creation of suitable Internet applications for traditional medicine continues to encounter challenges. The substantial rise in medical research is likely to result in the Internet of Things garnering an increasing number of studies in the forthcoming years. Contemporary medical practitioners must gather extensive big data and analyse and interpret it to make informed and personalised recommendations. All of it requires substantial effort and time. Emerging IoT technology can expedite and streamline this process. The widespread implementation of electronic health registration has resulted in an increasing volume of digitised medical data. A comprehensive review and evaluation of all this information requires significant time. Moreover, it is essential to train medical personnel in AI-based technologies closely linked to IoT [34]. By leveraging the synergistic capabilities of digital innovations, such as the IoT and AI, physicians can more effectively customise treatments to meet patients' specific requirements. These technologies enable the

CHAPTER 7

IoT and Connected Devices in Healthcare

Pushpak Singh[1], **Shaweta Sharma**[1,*] and **Aryan Kumar**[1]

[1] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: The integration of IoT (Internet of Things) in healthcare is enhancing and revolutionising the methods by which healthcare providers provide patient care and measure health through continuous monitoring. IoT-enabled wearable devices and remote patient monitoring systems promote the constant and immediate collection of health data, enabling individuals to effectively manage chronic illnesses, such as cardiovascular diseases, diabetes, and respiratory disorders. Contemporary gadgets, such as smartwatches equipped with sensors for heart rate and ECG monitoring, alongside continuous glucose monitors for blood sugar level assessment, deliver personalised, real-time data that improves patient outcomes. Asthma and COPD sufferers can benefit from smart inhalers equipped with monitoring technology that checks drug adherence and warns of possible problems. Networked devices enhance cost efficiency by decreasing hospital readmissions and outpatient visits, facilitating effective patient self-management, and optimizing healthcare delivery. However, the widespread adoption of IoT faces challenges, like cybersecurity issues, data privacy violations, and a lack of interoperability between devices, which hinder integration with the existing healthcare systems. Regulatory barriers, primarily related to device approval and data protection laws, also hinder the full integration of IoT technologies into healthcare. This holds promising prospects for IoT in healthcare, especially with the anticipated introduction of 6G technology, which will enable faster data transfer and reduced latency, while allowing for better connectivity to increase the efficiency of real-time monitoring and telemedicine applications. The power of artificial intelligence would support predictive analytics and decision-making processes. Healthcare monitoring will benefit from high data capacity with minimal latency. This can be achieved through the practical application of IoT in smart beds, telemedicine platforms, and fall detection systems, thereby improving patient outcomes and operational efficiency. Achieving this will require addressing the aforementioned challenges as IoT technology continues to advance.

Keywords: AI, Cloud computing, Connected devices, Data analytics, Healthcare automation, Interoperability, IoT, Plockchain, Smart sensors, Telemedicine, Wearable technology.

* **Corresponding author Shaweta Sharma**: Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

INTRODUCTION

The Internet of Things (IoT) refers to the concept of interconnecting everyday products with the Internet, enabling them to collect and exchange data. IoT encompasses devices, such as smart home appliances, wearables like fitness bands, and industrial sensors, *e.g*., factory monitoring systems. They are widely used in various industries, including home automation, manufacturing, healthcare, and transportation. The primary objective is to enhance efficiency, offer real-time monitoring, and automate processes to conserve time and resources [1, 2].

The Internet of Medical Things (IoMT) is a specialized subset of IoT that incorporates IoT technology into the healthcare field, which is currently transforming the medical sector by introducing innovative services through the use of connected devices and sensors. Medical devices and applications connected to healthcare systems are used to enhance patient care and improve health management. Examples include wearable health devices (*e.g*. heart rate monitors, glucose meters), smart hospital equipment (*e.g*., connected infusion pumps, ECG machines), hand hygiene monitoring systems, ingestible sensors, remote patient monitoring tools (*e.g*., telehealth platforms, IoT-enabled sensors), depression or mood tracking, connected contact lenses, Parkinson's disease monitoring systems, connected inhalers. These technologies are all designed to continuously monitor vital health parameters, such as sleep quality, heart rate, and blood pressure. The Internet of Things in healthcare (H-IoT) comprises a network of medical devices integrated with sensors, software, and connectivity to gather, transmit, and analyse data, thereby enhancing patient care, optimising healthcare systems, and significantly improving a person's quality of life. These systems enable automated decision-making and facilitate seamless communication among patients, healthcare providers, and medical systems. By utilizing these devices, healthcare providers can remotely monitor patients, access vital patient information instantly, collect real-time data for analysis, and facilitate streamlined communication between medical professionals. This enables medical professionals to make quicker decisions and potentially implement life-saving interventions [3].

The healthcare industry's Internet of Things (IoT) market was worth $139.74 billion in 2023 and is expected to reach $822.54 billion by 2032, growing from $175.61 billion in 2024, with a compound annual growth rate (CAGR) of 21.3%. The Internet of Things in the healthcare market was dominated by the Asia Pacific region in 2023, accounting for 40.32% of the total market share [4]. In 2023, the size of the IoT market in India reached US$1.2 billion. The market is expected to reach US$3.3 billion by 2032, with a CAGR of 12.17% from 2024 to 2032, according to IMARC Group [5]. Furthermore, these devices can mitigate the likelihood of prescription errors by offering alerts and reminders for both healthcare practitioners and patients. The objective is to provide a more interconnected and personalised healthcare approach that advantages both patients and providers. The incorporation of IoT devices in healthcare can transform this sector and significantly enhance the quality of patient care [6].

Function of IoT in Healthcare

IoT technology in healthcare assists patients, physicians, hospitals, carers, and insurance companies. Patients may utilise wearables, such as fitness bands and wireless devices, to track their physical activity and inform health-related decisions [6]. IoT devices, encompassing wearables and implanted sensors, gather essential physiological data, such as blood pressure, glucose levels, body temperature, respiration rate, heart rate, and rhythm. This data is transmitted using communication protocols, including Bluetooth, Wi-Fi, and specific IoT protocols, to healthcare servers or cloud-based systems [7]. In the healthcare sector, IoT technologies are currently being applied to offer new possibilities for remote monitoring, enhancing patient care, customised treatment strategies, improving patient outcomes, and streamlining healthcare delivery [8]. The IoT in healthcare notably enhances patient care while also significantly lowering healthcare costs by optimizing processes, automating routine tasks, facilitating simultaneous data acquisition and monitoring, and reducing the need for costly interventions [9].

IoT platforms enhance healthcare operations by automating administrative tasks, improving efficiency, and reducing the need for a large administrative workforce, resulting in cost savings. Furthermore, common duties, such as monitoring vital signs and recording medication administration, can be automated, thereby reducing the likelihood of errors and decreasing labor expenses. Primarily, the prompt detection and concurrent monitoring capabilities of IoT assist in preventing costly medical complications, minimizing hospitalizations, and alleviating the need for costly therapies, thereby substantially reducing healthcare costs. Wearable sensors are employed in healthcare applications to gather physiological data from patients, including body temperature, blood pressure, heart rate, rhythm, electrocardiogram (ECG), and electroencephalogram (EEG). It also helps in augmenting the engagement of a patient [10].

Empowering patients with more autonomy in healthcare involves motivating them to track their health information and interact more effectively with healthcare professionals. Additionally, environmental data may be collected, including temperature, humidity, time, and date, which are stored in a log [11].

Although IoT technology offers significant benefits for healthcare providers in terms of vital information, it also presents challenges, including privacy and security risks associated with the dissemination of sensitive health information

CHAPTER 8

Blockchain Solutions for Secure and Efficient Health Data Management

Ashish Verma[1], **Akhil Sharma**[2], **Shivkanya Fuloria**[3], **Shaikh Yahya**[4], **Anurag Singh**[5] and **Shaweta Sharma**[6,*]

[1] *Department of Pharmacy, Mangalmay Pharmacy College, Greater Noida, Uttar Pradesh-201306, India*

[2] *R. J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

[3] *Department of Pharmaceutical Chemistry, Faculty of Pharmacy, AIMST University, Jalan Bedong—Semeling 08100 Bedong, Kedah, Malaysia*

[4] *Department of Pharmaceutical Chemistry, School of Pharmaceutical Education and Research, Jamia Hamdard, New Delhi-110062, India*

[5] *Scbool of Computing Science and Engineering, Galgotias University, Greater Noida, Uttar Pradesh-201310, Uttar Pradesh-201310, India*

[6] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: Challenges in health data management include difficulties with data security, privacy, and interoperability. When healthcare organizations store patient information in electronic formats, the need for systems to address these issues becomes even more vital. Innovative methods such as blockchain technology and big data analytics are emerging as promising solutions for these challenges. Blockchain is used to create a secure and decentralized structure that helps ensure the immutability, transparency, and privacy of health records. In contrast, big data is used to analyze large amounts of data to improve patient care, predict disease outbreaks, and even optimize healthcare operations. This chapter explains the integration of blockchain and big data in healthcare, providing insights into how blockchain security measures and big data inputs will assist in filling the existing gaps. Blockchain improves big data analytics by providing data integrity and traceability, allowing secure exchange between medical systems. Examples of this integrated approach can be seen in applications in EHRs, clinical trials, public health monitoring, and supply chain management. However, challenges such as scalability, privacy concerns, and regulatory limitations persist. This chapter concludes by evaluating the benefits of this integration over traditional systems, highlighting its potential to improve healthcare outcomes and enhance trust in health data management.

* **Corresponding author Shaweta Sharma**: Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

Keywords: Big data analytics, Blockchain, Data privacy, Health data management, Healthcare operations, Healthcare security, Interoperability.

INTRODUCTION

The healthcare sector is dealing with major issues in managing data because of the huge volume and complexity of healthcare data, such as electronic health records (EHRs), medical imaging, lab results, and patient monitoring data. This data is typically siloed across multiple systems and platforms, leading to further difficulty for healthcare providers in sharing or accessing it in a timely manner. Moreover, healthcare institutions also face unique regulatory requirements regarding patient confidentiality and data security. They are pervasive issues, and data inconsistency caused by diverse formats and incomplete records can challenge data analysis and the ability of systems to interact effectively. In addition, more diverse data, such as clinical, administrative, and real-time patient data, need to be integrated into one system to make more informed decisions. Healthcare providers constantly deal with delayed information exchange, manual data entry errors, and security risks caused by growing cyber threats. As the healthcare landscape transitions to a more patient-centric, value-based care model, the need for effective healthcare data management has never been more crucial. These challenges are critical and call for novel solutions to make data more accessible, secure, and reliable, all while ensuring privacy and regulatory compliance [1, 2].

Health care is sensitive, and therefore, data security and privacy are paramount. Patient confidentiality and the integrity of medical records are at risk due to cyberattacks, data breaches, and unauthorized access. Protecting data privacy also involves the use of effective security protocols like cryptography, access restriction, and authentication measures to prevent data theft or misappropriation. In addition, healthcare data should be able to interoperate across multiple platforms and systems so that different healthcare providers, organizations, and other stakeholders can share information easily and securely. In the absence of interoperability, disparate data systems block the delivery of high-quality care and produce poor patient outcomes. The absence of standardized healthcare data formats adds an extra layer of complexity to interoperability initiatives. Technologies that standardize data-sharing protocol and technology to enable increased communication across various platforms will also be critical for data exchange and, ultimately, comprehensive patient care. Utilizing blockchain and big data analytics, problems such as poor data quality, high susceptibility to breaches, and time-consuming assessment/reporting procedures can be resolved. These technologies can work together to enable healthcare systems to be more transparent, trustworthy, and interconnected [3, 4].

Blockchain and Big Data Analytics have a significant impact on the healthcare field, as these technologies are transforming healthcare data management. Blockchain is a form of distributed ledger technology that allows secure, transparent, and tamper-resistant record-keeping in a decentralized manner. In healthcare, blockchain can be utilized for the storage of medical records, protecting them from data breaches and making sure there are no unauthorized changes to the data in any way. This enables a safe framework for exchanging patient data between various organizations, including healthcare providers, while controlling access and privacy. In addition to the characteristics above, Blockchain includes smart contracts that are capable of automating administrative procedures, minimizing human error, and boosting operational efficiency.

Big Data Analytics is transforming the healthcare industry by allowing for large-scale, structured, and unstructured data processing and analysis. With the help of advanced algorithms and machine learning techniques, it extracts actionable insights from patient data, including predictive analytics for early disease detection, personalized treatment plans, and operational enhancements. Healthcare providers can utilize Big Data Analytics to make data-driven decisions, optimize resource utilization, and enhance patient outcomes. When integrated with blockchain, Big Data Analytics can provide a more secure and efficient environment for data sharing, analysis, and decision-making. These two technologies, when combined, have the potential to significantly enhance the effectiveness, efficacy, security, and efficiency of healthcare systems, while also reducing costs and improving patient care quality [5, 6].

BLOCKCHAIN TECHNOLOGY IN HEALTHCARE

Blockchain is a revolutionary technology that facilitates secure, transparent, and decentralized transactions without requiring any central authority. Blockchain technology is a game-changer that allows safe, transparent, and decentralized transactions without needing a central authority. At its core, it is a distributed ledger system that records data over multiple computers in a manner that makes it virtually impossible to change or tamper with the data once it has been added to the system. The structure of blockchain provides data integrity and transparency, which makes it a perfect solution for industries like healthcare, where the exchange of accurate and secure data is imperative [7, 8]. Fig. (**1**) describes the use of blockchain technology in the healthcare industry.

Key Components of Blockchain

The foundational elements of blockchain include the decentralized ledger, consensus mechanisms, and cryptography. Blockchain technology is built on top of the decentralized ledger. Blockchain is data shared between a network of nodes

CHAPTER 9

Human-Centered Design in Health Tech Innovations

Akanksha Sharma[1], **Shaweta Sharma**[2], **Ashish Verma**[3], **Sunita**[1], **Shilpa Thukral**[4] and **Akhil Sharma**[1,*]

[1] *R.J College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

[2] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

[3] *Department of Pharmacy, Mangalmay Pharmacy College, Greater Noida, Uttar Pradesh-201306, India*

[4] *Dnyan Ganga College of Pharmacy, Thane, Maharashtra-400615, India*

Abstract: Human-Centered Design (HCD) plays a pivotal role in transforming health technology by focusing on the needs, preferences, and experiences of end-users, such as patients and healthcare providers. This chapter describes HCDs while emphasizing their role in addressing challenges in traditional health tech design and meeting the growing demand for user-friendly healthcare solutions. Core HCD principles, such as user-centric approaches, empathy-driven research, and iterative feedback loops, are detailed, along with techniques, such as user personas, journey mapping, and prototyping. HCD is being applied in health tech innovations, not only in medical devices but also in mobile health (mHealth) applications. Practical examples of this include the variety of wearable health monitors, telemedicine platforms, and simplified clinician interfaces. The value of HCD is multifaceted, leading to better patient outcomes from designs that make patients feel at home in familiar environments. Clinicians also see increased efficiency due to less cognitive load and less resistance to technology adoption, as a result of tools that seamlessly integrate into their workflows. Additionally, when new technologies, such as AI, IoT, and data analytics, are integrated into HCD frameworks, personalized and continually evolving healthcare experiences are created. These include difficulties in finding the right balance between usability and technological sophistication, navigating regulatory and ethical hurdles, and encouraging interdisciplinary collaboration that continues to hinder effective deployment. This discussion serves as positive reinforcement for a collaborative, hands-on approach to health tech design, where innovation meets user needs and results in technologies for healthcare that empower patients, support clinicians, and streamline the delivery of care.

* **Corresponding author Akhil Sharma**: R.J College of Pharmacy, Raipur, Uttar Pradesh-202165, India; E-mail: xs2akhil@gmail.com

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

Keywords: Electronic health records, Healthcare, Human-centered design, Medical devices, Mobile health (mHealth) applications, Prototyping, User-centric approaches.

INTRODUCTION

Human-Centered Design (HCD) is a design method that focuses on the user's needs, behaviors, and interests during the design process. Grounded in empathy and collaboration, HCD entails engaging with end-users firsthand to guarantee that the product or solution meets the users' expectations and addresses their pain points. This is in contrast to traditional design, which, in some cases, had more focus on being technically feasible or delivering a business goal, even if the usability of the product was compromised, where the process was involved [1, 2].

In health technology, the HCD is a multidisciplinary process taking into consideration diverse areas, such as engineering, design, psychology, and healthcare. It requires multiple loops of creating prototypes, testing them, and making adjustments based on user input to guarantee effective solutions that also support the user journey. The fundamental aspects of HCD are to observe the user environment, iteratively engage with users in the design process, and design solutions that can meet varying demands [3].

Importance of HCD in Health Tech

The healthcare field itself is complex, with multiple actors like patients, service providers, administrators, and regulators. Each has different needs, wants, and pain points, so a user-centered approach is critical for creating viable health tech products. The importance of HCD in health technology lies in its ability to address these complexities while delivering meaningful and practical innovations.

One of the major benefits of HCD in health tech is its ability to improve patient engagement. HCD focuses on making technologies that are easier to understand and utilize, thus empowering patients to take an active role in managing their health. Wearable devices that monitor vital signs or mobile applications aiding chronic disease management are more effective if they are intuitive and easy to use, as they promote regular use and adherence to treatment plans [4].

Healthcare providers often face significant cognitive and operational burdens, particularly when interacting with cumbersome or poorly designed technologies. By focusing on user-centered design principles, HCD can create tailored solutions that meet the needs of clinicians while maintaining the integrity of their workflow, ultimately helping to ease their cognitive burden in their day-to-day practices. Emerging technologies in healthcare, especially telemedicine, artificial intelligence (AI), and IoT-enabled devices, have greatly enhanced the potential.

However, their usage can rely heavily on user experience. One of the key barriers to adopting new technology is overcoming resistance from users. HCD seeks to manage these concerns through the reduction of learning curves and ensuring new solutions fit seamlessly into the workstream. HCD can accelerate the widespread adoption of innovative health technologies. The design of health technologies without a focus on the needs of a diverse user team may result in excluding certain populations, such as older adults, people with disabilities, or people with limited digital literacy. HCD involves designing for diverse audiences to ensure accessibility and availability for all people. It helps cover the digital divide gap and empowers equal access for all to avail the healthcare solution [5, 6].

Overview of Challenges in Traditional Health Tech Design

Although health technology has transformed healthcare delivery, conventional design practices often fail to consider user needs, resulting in poor adoption, inefficiency, and user dissatisfaction. Throughout history, health technologies have often been developed with a focus on capabilities and organizational objectives instead of user needs. This has resulted in products that may be functional but are often difficult to use, leading to frustration among patients and healthcare providers alike [7].

Technological innovation is essential to health tech, but there can be an overemphasis on new features, and this may come at the expense of usability. Technological overkill can lead to unwieldy user interfaces with too many features to learn when the focus is more on showcasing technical chops than solving users' problems. Such an approach often leads to technologies that are left unused or fall by the wayside altogether. Traditional health tech designs typically neglect the need for accessibility to meet the diverse needs of users, including those with disabilities, older adults, or people with low health or digital literacy. For example, a mobile health application with a complicated interface or small text size may be difficult for older adults to use, thereby limiting its effectiveness and dissemination [8].

Another significant challenge in traditional health tech design is the lack of interoperability and integration across healthcare systems. The isolated development of technologies leads to silos of information, making seamless communication and coordination among healthcare providers a challenge. These silos not only affect care quality but also create a burden for users who have to deal with multiple fragmented systems [9].

CHAPTER 10

Utilization of Machine Learning in Disease Anticipation and Prevention

Ashish Verma[1], **Akhil Sharma**[2], **Shaikh Yahya**[3], **Shivkanya Fuloria**[4] and **Shaweta Sharma**[5,*]

[1] *Department of Pharmacy, Mangalmay Pharmacy College, Greater Noida, Uttar Pradesh-201306, India*

[2] *R.J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

[3] *Department of Pharmaceutical Chemistry, School of Pharmaceutical Education and Research, Jamia Hamdard, New Delhi-110062, India*

[4] *Department of Pharmaceutical Chemistry, Faculty of Pharmacy, AIMST University, Jalan Bedong—Semeling 08100 Bedong, Kedah, Malaysia*

[5] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: Predictive and preventative strategies for the disease have been transformed through ML (machine learning), which has created opportunities for earlier diagnosis and personalized care that were not previously available in healthcare. This chapter summarizes the role of ML in healthcare, emphasizing its importance in predicting diseases and preventing their onset. The key algorithms, including decision trees, neural networks, and support vector machines, and the fundamentals of ML (supervised, unsupervised, and reinforcement learning) are covered. It covers different data sources for ML applications, including genomic data, wearables, and public health data. Data preprocessing and feature engineering steps, such as cleaning, selection, and transformation, are also covered. The chapter delves into model training, evaluation metrics, and challenges such as handling imbalanced data, overfitting, and underfitting. It highlights personalized disease prediction models and risk factor assessments, which can show how individual health data can lead to more tailored predictions. The role of ML in preventive healthcare is also explored, with a focus on early intervention approaches and lifestyle change recommendations. It further explains the significant implementation of ML for disease prediction, including early detection of kidney diseases, infectious outbreaks, and mental health disorders. Finally, this chapter also discusses the challenges and limitations of the implementation of ML in healthcare.

Keywords: Data preprocessing, Disease prediction, Disease prevention, Early diagnosis, Health data, Healthcare, Machine learning, Personalized models.

* **Corresponding author Shaweta Sharma:** Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

INTRODUCTION

Machine Learning (ML) has become a transformative technology in the realm of healthcare, leveraging its ability to analyze large and complex sets of data with remarkable speed and accuracy. This entails training algorithms to recognize patterns, forecast trends, and offer insights that were previously impossible to obtain through conventional methodologies. ML has dramatically improved healthcare delivery, ranging from automating diagnostic processes to tailoring treatment plans based on patient data. Applications of AI in healthcare include medical imaging, drug discovery, patient monitoring, and electronic health record management. Further, ML's synergy with wearables and mobile health applications has facilitated continuous monitoring of health, leading to proactive interventions. With the constantly rising global burden of diseases, ML is a promising, scalable, and cost-effective strategy to address healthcare challenges. ML represents the future of precision medicine and patient outcome improvement by enabling real-time clinical decision-making, and predictive analytics, and enhancing the ability of clinicians to tailor care responses [1].

Disease prediction and prevention are imperative for minimizing the global healthcare burden and improving the population's health. Predictive measures facilitate the early identification of individuals at risk, which can lead to timely intervention before the onset of severe symptoms. Preventive approaches can help prevent complications, decrease mortality rates, and reduce healthcare costs by avoiding the need for costly treatments for advanced diseases. This includes estimating the risk of cardiovascular disease or diabetes due to genetic, lifestyle, or environmental factors, which can help patients and clinicians implement lifestyle changes or initiate preventive medications. Moreover, prevention reduces the emotional and financial burden on patients and their families, ultimately leading to a healthier population. While chronic diseases, pandemics, and new diseases disrupt healthcare systems across the globe, prediction and prevention have become the greatest imperative to ensure care is sustainable and equitable. Shifting from reactive treatments to upstream healthcare interventions will help society move toward a holistic perspective of health [2].

ML helps clinicians with early diagnosis and prevention by revealing trends in patient information that would remain unnoticed using traditional tests. ML algorithms can examine parameters like genetics, lifestyle, and environmental factors to predict disease propensity for personalized risk estimation. These empower diagnostic precision and enable the early identification of chronic diseases, cancers, and infectious pathogens that allow timely interventions. From recommending lifestyle changes to monitoring adherence to treatment plans, MLdriven solutions enable preventive care approaches that can prevent long-term health complications and improve patient outcomes [3, 4].

FUNDAMENTALS OF MACHINE LEARNING

ML is a branch of artificial intelligence that enables computer systems to learn and improve from experience without being explicitly programmed, and its fundamentals are summarized in Fig. (**1**). This refers to the process of creating algorithms that break down massive amounts of data, recognize patterns, and make data-based predictions or choices. This is extensively used in recommendation systems and image recognition, as well as in healthcare for predicting and preventing diseases. ML models improve their performance over time as they learn from data, making it possible to detect anomalies, classify data, and perform regression. Its transformative potential lies in the ability to automate complex processes within various disciplines [5, 6].

Types of Machine Learning

Machine learning encompasses three primary types: supervised learning, unsupervised learning, and reinforcement learning. These approaches cater to diverse data patterns and applications, especially in disease prediction and prevention.

Supervised Learning

Supervised learning is the most widely used category of ML. In this category, models are trained on labeled datasets. Each input is paired with a corresponding output, enabling the model to learn the relationship between them. This is the most commonly opted method of training in healthcare for many tasks, such as disease diagnosis, prediction of patient outcomes, and personalized treatment planning. For example, in medical diagnosis, algorithms scrutinize past patient data to detect patterns signifying specific ailments, like diabetes or cancer. The labeled data offers a ground truth and allows the model to learn to make accurate predictions on new and unseen data. Popular techniques of this type include regression, decision trees, and support vector machines. The model's success relies heavily on the quality of the labeling. Challenges include obtaining high-quality labeled datasets and addressing potential biases. Nevertheless, supervised learning has played a crucial role in improving the accuracy and efficiency of diagnostic systems, which helps in early diagnosis and intervention [7 - 9].

CHAPTER 11

Virtual Reality and Augmented Reality in Medical Training and Therapy

Sunita[1], **Akhil Sharma**[1], **Akanksha Sharma**[1], **Ashish Verma**[2] and **Shaweta Sharma**[3,*]

[1] *R.J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

[2] *Department of Pharmacy, Mangalmay Pharmacy College, Greater Noida, Uttar Pradesh-201306, India*

[3] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: The virtual reality (VR) and augmented reality (AR) revolutionize medical training and therapy. VR immerses users in a completely simulated environment, whereas AR enhances real-world experiences by layering digital information. VR and AR provide groundbreaking advancements over traditional methods in medical training, such as virtual dissections, streaming of datasets visualizing anatomy, and even surgical simulations. These training methods boost skills development, crisis management skills, and tailor-made learning, which can further improve both student and professional proficiency. VR is changing the field of pain management in therapeutic settings, supporting rehabilitation for physical recovery and providing treatment strategies for mental health conditions such as anxiety, PTSD, and phobias. VR-based cognitive rehabilitation programs are enhancing the outcome of brain injury and disorder. Despite these advancements, challenges remain, such as expensive equipment, integration with healthcare systems, and acceptance among medical professionals and patients. In the future, continuing developments of immersive technology, increased accessibility, and remote applications will expand the role of VR and AR in the treatment of healthcare. This chapter focuses on the technological background, current applications, and future directions of VR and AR in medicine, as well as their possibilities of transforming the landscape of medicine as the foundation of future medical education, patient care, and therapy.

Keywords: Augmented reality, Healthcare innovation, Immersive technology, Medical simulation, Medical therapy, Medical training, Virtual reality.

* **Corresponding author Shaweta Sharma:** Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

INTRODUCTION

Virtual Reality (VR) is a computer-generated virtual environment that can either replicate or be similar to the real world. It allows the user to interact with three-dimensional (3D) settings by utilizing devices such as controllers, headsets, and gloves. VR replaces the real world with a simulated one, offering an isolated yet interactive experience. Unlike VR, AR enhances the existing surroundings rather than replacing them, providing a blended view of virtual and physical elements. From hardware to software, the combination of VR and AR is a great way to give experiences beyond other interface systems, thus becoming a great tool in many industries. In healthcare, these technologies are reshaping how training, treatment, and patient engagement are conducted, providing innovative solutions to complex challenges [1, 2].

The applications of VR and AR are becoming popular and are being used as disruptive technologies in the healthcare field because they can help improve training, diagnosis, and therapy. VR provides realistic simulations of clinical scenarios for medical training, enabling students and practicing medical professionals to practice surgical operations without the risk. AR complements this by providing real-time guidance during live surgeries, overlaying critical information like anatomy information or imaging scans onto the surgical field. They enhance the patient education experience as patients find it easier to visualize the condition as well as the treatment. In therapy, VR is used for exposure therapy in mental health treatments, which gives patients the opportunity to face their fears or PTSD (Post-traumatic stress disorder) in a controlled environment. AR enhances physical rehab by visualizing exercises and providing better feedback for more efficient workouts. Moreover, the use of these in pain management and telemedicine highlights their usefulness for a variety of healthcare needs. AR and VR must also be integral to modern healthcare innovation because their ability to merge virtual and physical realities streamlines processes that promote accessibility and personalized care [3 - 5].

TECHNOLOGICAL COMPONENTS OF VR AND AR

Medical training and therapy use VR and AR based on their capability to simulate and augment scenarios in the real world. VR provides completely digital environments, and AR interactively blends our digital information with the physical world. To provide their function in healthcare, both technologies depend on efficient hardware and software. Whether it be realistic simulations for training purposes or real-time guidance during procedures, the dynamic interaction between VR and AR promises precision, accessibility, and efficiency. Using cutting-edge computing, sensing, and visualization technologies, these innovations are poised to revolutionize medicine [6].

Virtual Reality (VR)

Virtual reality generates non-exploratory digital environments, replicating real-world scenarios or cultivating new ones for training, education, and therapy. The immersive nature of VR allows medical professionals to practice complex procedures or simulated patient interactions without any real-world repercussions. This increases the amount of time on task, results in fewer mistakes, and builds self-efficacy. VR has become a key feature of new healthcare technology as it can tailor a person-specific environment to individuals, providing realistic experiences to users to adjust to different situations [7].

Hardware

VR is dependent on its hardware, such as VR headsets, motion sensors, and haptic feedback devices, which make it effective. Headsets like the Oculus Quest, HTC Vive, and PlayStation VR provide you with immersive visuals and sound to interact with 3D environments. Motion sensors monitor real-life physical movements and transfer them to the virtual space in real-time. Haptic devices like gloves and suits, which provide tactile sensations to users, enable them to feel the virtual world. In the health sector, these technologies act as virtual human beings to perform effective simulations of surgeries, helping in training for upcoming trainees. A critical feature of such devices is haptic feedback, which simulates the texture and stiffness of human tissue and is essential to practicing the fundamentals of performance. The progress in hardware is making it lighter, cheaper, and more accessible, and it has led to the general adoption of VR in the medical field [8, 9].

Software

VR software is important for developing these dynamic simulations specific to the medical field and is important for practicing and practical learning. Platforms like Osso VR and ImmersiveTouch provide a realistic 3D visualisation of surgical procedures featuring 3D anatomical models and procedural training modules. These applications replicate real-world situations like conducting surgeries, diagnosing diseases, and managing emergencies. AI and machine learning in VR software can measure a user's performance and offer personalized feedback for improvement. For example, pain VR is an application that provides parallel environments for pain relief and cognitive therapy in a therapeutic environment. VR software is also more useful in health care because it has certain EHR interactivity and training analytics built into it for seamless interoperability [10].

CHAPTER 12

Digital Therapeutics: Prescribing Software for Health

Yatindra Kumar[1], **Akhil Sharma**[2], **Sunita**[2], **Shilpa Thukral**[3] and **Sagar Pamu**[4,*]

[1] *Department of Pharmacy, GSVM Medical College, Kanpur, Uttar Pradesh-208002, India*

[2] *R.J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

[3] *Dnyan Ganga College of Pharmacy, Thane, Maharashtra-400615, India*

[4] *Pharmacy Practice Department, Institute of Pharmacy, Nirma University, Ahmedabad, Gujarat-380001, India*

Abstract: Digital Therapeutics (DTx) is a new way of providing health care, and delivering evidence-based therapeutic interventions to patients using high-quality software programs to prevent, manage, or treat a medical disorder or disease. Distinct from traditional therapies and the rise of mobile health apps, DTx addresses the need for targeted treatment of diseases and behavioral health conditions, filling therapy gaps that are not addressed by current treatment options. This chapter explores the core principles of DTx, including human-centered design to promote accessibility and usability, integration with electronic health records (EHR), and the incorporation of AI and machine learning for personalized, data-driven interventions. Different kinds of DTx are mentioned, such as disease-specific therapeutics for chronic conditions like diabetes and cardiovascular diseases, behavioral health interventions including cognitive behavioral therapy (CBT) apps, and tools for chronic disease management. Next-gen technologies, such as virtual reality (VR), augmented reality (AR), wearables, and blockchain, play a crucial role in enhancing DTx by providing real-time patient feedback, immersive therapies, and security. This chapter also discusses how DTx could integrate into healthcare, its clinical adoption, the need to train healthcare providers, and plans to engage with patients. Challenges to DTx integration, including resistance to technology and interoperability issues, are examined alongside strategies to overcome these obstacles.

Keywords: AI and machine learning, Behavioral health, Chronic disease management, Digital therapeutics, Health systems integration, Healthcare technology.

* **Corresponding author Sagar Pamu:** Pharmacy Practice Department, Institute of Pharmacy, Nirma University, Ahmedabad, Gujarat-380001, India; E-mail: dr.sagar@live.com

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

INTRODUCTION

Digital Therapeutics (DTx) is a part of the fast-growing field of digital health, where software-based interventions are implemented to help with evidence-based therapeutic interventions. These are technology-based tools that are used to prevent, manage, or treat medical problems in patients. In contrast to traditional methods, DTx provides a scalable and accessible way to facilitate healthcare, filling current treatment deficiencies. As a consequence of these advances in digital health, DTx has come into prominence for its advantage of enhanced clinical outcomes, better patient engagement, and reduced healthcare costs [1].

By employing a targeted, evidence-based approach with clinical validation, digital therapeutics differentiate themselves from traditional therapy and mHealth (mobile health) apps. Conventional therapies, whether in the form of medications or in-person therapies, depend on physical intervention, whereas DTx utilizes software as a means of treatment. In contrast to general wellness or fitness apps, the design of DTx solutions typically emphasizes scientific rigor, regulatory compliance, and clinical testing to demonstrate therapeutic value. DTx provides therapeutic interventions with measurable clinical outcomes, whereas mHealth apps have been primarily used to monitor and improve health habits. Furthermore, DTx is often integrated within healthcare systems, with physician involvement, and supports chronic disease management based on data-informed decisions [2].

Addressing Gaps in Current Treatments

DTx overcomes many of the accessibility, affordability, and scalability limitations of current treatment options. In more traditional healthcare settings, patients living in more remote areas are frequently unable to obtain treatment, and the costs of care for the long term may be prohibitive. However, DTx circumvents these barriers through scalable, remote interventions delivered *via* smartphones, tablets, or computers. Moreover, DTx bridges the gap in chronic disease management through continuous monitoring, personalized feedback, and enhanced adherence to treatment regimens. DTx brings new solutions that improve patient engagement and outcomes for diseases that classical therapies can not treat, like mental health disorders, substance use, or rehabilitation. DTx combines the ability to draw data-driven inferences to enable clinicians to make better decisions and hence significantly improves the quality of care [3].

Role in Healthcare Technology

Digital therapeutics are designed to work with the existing healthcare ecosystems, such as Electronic Health Records (EHRs), telehealth platforms, and even wearable devices to promote eHealth. DTx provides the healthcare provider with remote, data-driven tools to monitor a patient's progress, optimize treatment decisions, and deliver the highest quality of personalized care possible. From a treatment perspective, DTx provides an accessible and interactive platform to give patients the tools to take charge of their health, which, in turn, improves adherence and long-term outcomes. DTx also plays a role in preventative care, with such solutions able to reduce risks and manage early symptoms through non-invasive means, before they develop into a known disease [4].

TECHNOLOGY AND DESIGN PRINCIPLES FOR DIGITAL THERAPEUTICS

Human-centered design (HCD) is not the same as software utility; DTx optimizes usability, retention, and efficacy by focusing on patient needs and behaviors contrary to many existing models of treatment; the goal of DTx is to improve treatment adherence. When integrated with health systems, it allows the seamless flow of data, interoperability, and clinician involvement and helps deliver personalized care to improve outcomes [5].

AI (Artificial Intelligence) and ML (Machine Learning) are also essential to DTx because they analyze huge datasets, predict responses from patients, and adjust interventions dynamically. They improve accuracy, automate decisions, and streamline therapeutic delivery. By harnessing user-centric design, system integration, and AI-driven insights, DTx can provide scalable, evidence-based interventions that help improve patient health whilst minimizing healthcare system burden [6]. The technology and design principles for digital therapeutics are shown in Fig. (**1**).

Human-Centered Design in DTx

In HCD, the end-user is kept at the center of the design and development process, including research, prototyping, testing, and refinement. In DTx, this method includes working closely with patients, providers, and other stakeholders to recognize pain points and co-design solutions that boost user engagement and treatment adherence. HCD not only drives empathically-informed insights but also employs iterative feedback loops to ensure DTx applications reflect actual use cases and clinical needs. The importance of user trust, satisfaction, and commitment to long-term adoption is pivotal to the desired therapeutic outcomes in DTx, and effective HCD gives rise to the same. It also focuses on design simplicity and intuitiveness, allowing users to easily integrate the DTx solutions into their everyday lives. Ultimately, HCD ensures that digital interventions are not just likely to work technically but also are practical, user-friendly, and deeply attuned to the human experience of healthcare [7].

CHAPTER 13

Cybersecurity in the Age of Connected Healthcare

Chanchla Devi Haldkar[1], Shaweta Sharma[2], Sunita[3], Akanksha Sharma[3] and **Akhil Sharma[3,*]**

[1] *Shri Rawatpura Sarkar Institute of Pharmacy, Jabalpur, Madhya Pradesh-482001, India*

[2] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

[3] *R.J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

Abstract: In the digital age, interconnected technologies are essential for healthcare systems, ranging from the Internet of Medical Things (IoMT) to telemedicine. This chapter discusses the importance of cybersecurity in protecting patient data and ensuring the continuity of services in the healthcare sector. The gradual transition of the healthcare sector to more advanced technologies such as cloud computing, artificial intelligence (AI), and mHealth (mobile health) apps creates several new security challenges, such as data breaches, ransomware, and vulnerabilities in medical devices. The chapter discusses the challenges of securing these systems, taking into account risks from interconnected devices, remote monitoring, and data sharing between different constituents in a healthcare ecosystem. Best practices for mitigating cybersecurity threats, including encryption, authentication, and risk management strategies, are discussed. Additionally, new technologies such as AI and blockchain provide new ways to increase security. The chapter also highlights the importance of training healthcare providers, developing robust cybersecurity policies, and complying with regulatory frameworks to protect against evolving cyber threats. As healthcare technology continues to advance, it is essential to adopt comprehensive cybersecurity measures to ensure patient safety and data privacy.

Keywords: Cybersecurity, Data breaches, Encryption, Healthcare policies, Healthcare technology, IoMT, Medical devices, Ransomware, Risk management.

INTRODUCTION

Cybersecurity in healthcare refers to the strategies, technologies, and practices designed to protect sensitive health data and systems from unauthorized access, cyberattacks, and breaches. With the increasing reliance on digital technologies in the healthcare sector, safeguarding patient information and ensuring the availabi-

* **Corresponding author Akhil Sharma:** R. J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India; E-mail: xs2akhil@gmail.com

lity of critical systems have become paramount. Cyberattacks in healthcare can result in dire consequences, including compromised patient safety, financial losses, and erosion of trust in healthcare providers. Unlike other industries, healthcare faces unique challenges due to the high value of medical data on the black market, the complexity of interconnected systems, and the need for uninterrupted operations. Effective cybersecurity measures in healthcare not only protect sensitive information but also enable compliance with regulations such as HIPAA and GDPR, ensuring ethical and legal data handling [1, 2].

Overview of Healthcare Systems in the Digital Era

The introduction of digital technologies is reshaping the landscape of modern healthcare systems to become an ecosystem of interconnected devices, platforms, and stakeholders. Wearable health monitors and smart diagnostic tools, for example, closed-loop systems that adapt to lifestyle or behavioral inputs in real-time, could provide personalized care through the Internet of Things (IoT). Cloud computing has completely transformed how data is stored and shared, while telemedicine platforms have increased the accessibility of healthcare services. This improves efficiency, provides high-level patient outcomes, and allows data-driven decisions. At the same time, they can expose them to cybersecurity risks through more entry points, and securing heterogeneous systems can be difficult. Such a transition to digital healthcare highlights the urgent requirement of cybersecurity to secure the availability, confidentiality, and durability of these systems [3, 4].

Evolution of Healthcare Technology

Healthcare technology has evolved with massive innovations that redefine care delivery. Smart devices introduced by IoT, which range from implantable defibrillators to home monitoring systems, allow for more proactive health management. Telemedicine has changed the way patients and providers engage with one another, especially in the context of a crisis such as the COVID-19 pandemic. AI has also transformed diagnostics, where machine learning algorithms have diagnosed diseases based on patterns in medical imaging and genomic data for some time now. Blockchain is growing in popularity to secure medical records and ensure data integrity. Together, these developments enable a super-connected healthcare ecosystem to revolutionize efficiencies, accessibility, and personalization. However, dependence on technology only increases the threat of cyberattacks, which makes it necessary to keep innovating in the cybersecurity field to protect it [5, 6].

HEALTHCARE TECHNOLOGY LANDSCAPE

The connected healthcare space is witnessing robust growth, led by innovations in the space such as the Internet of Medical Things (IoMT), cloud computing, mHealth apps, and telemedicine, as shown in Fig. (**1**) . By integrating machine learning, artificial intelligence, and big data, predictive analytics and personalized care are on the verge of becoming a reality. However, the interoperability issue limits data sharing across the healthcare ecosystem, which requires a rigorous framework of interconnected features to guarantee that there is seamless data exchange while still keeping the data secure and compliant in this interconnected environment [7, 8].

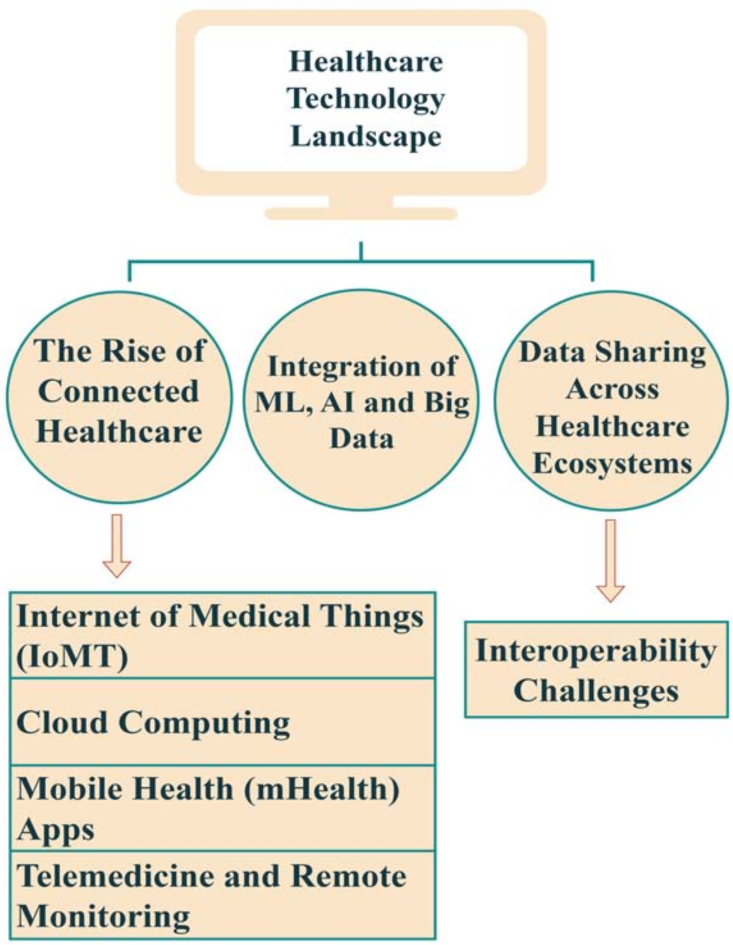

Fig. (1). Various technologies used in healthcare systems.

CHAPTER 14

Remote Patient Monitoring and Home Healthcare Solutions

SK Abdul Rahaman[1,*], **Afroz Khan**[1], **MD Kaif**[1], **Naga Rani Kagithala**[1], **Arfa Shams**[1] and **Niranjan Kaushik**[1]

[1] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: Remote Patient Monitoring (RPM) enables patient observation outside traditional medical settings, such as at home or remote locations, enhancing care access and reducing healthcare costs. By using digital technologies, RPM collects health data like vital signs, blood pressure, and sleep quality from patients in one particular location and securely transmits it to healthcare providers elsewhere for analysis and recommendations. This method promotes real-time monitoring using mobile medical devices, helping prevent unnecessary hospitalizations, improve recovery, and ensure patient safety. RPM gathers biometric data such as heart rate and blood oxygen level, analyzes it, and shares insights with caregivers remotely. These programs can perform bedside-like observations, reducing optional readmissions and in-person visits. The approach revolutionizes healthcare by shifting from reactive to proactive care, improving patient outcomes, engagement, and satisfaction while lowering costs. Future advancements in RPM, powered by wearable technology and artificial intelligence, aim to personalize care, enhance early disease detection, and support secure data exchange. As these innovations grow, ensuring patient data privacy and security will remain critical, alongside developing integrated home healthcare ecosystems. RPM and home healthcare solutions are transforming healthcare delivery, prioritizing accessible, effective, and patient-centered care.

Keywords: AI, Biosensor, Case studies, Challenge, Chronic disease management, Cloud computing, Healthcare, Integration of RPM, IoT, Mhealth, Real-time remote monitoring, Remote patient monitoring, Wearable.

INTRODUCTION

Remote Patient Monitoring stands as a novel approach to enhance well-being and optimize patient management and care [1]. Patient disease-related and physiological data are communicated digitally over the telephone, Internet, or

* **Corresponding author SK Abdul Rahaman:** Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: rahamandr123@gmail.com

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

videoconferencing from the patient's residence to a healthcare facility, facilitating clinical input. It facilitates the early identification of illness decompensation, hence permitting timely treatments and decreasing mortality and hospitalization rates, while also enhancing patient education and self-management. Technology has experienced several alterations, facilitating the extensive adoption of telemedicine [2]. Currently, equipment includes intelligent sensors, wearable or handheld gadgets, Internet-connected smartphones, and implanted monitoring devices that are readily accessible. The substantial volume of articles on telemonitoring in the last decade indicates the growing significance of technology in healthcare, notwithstanding the increasing interest in telemonitoring treatments and evidence.

Remote Patient Monitoring

Remote Patient Monitoring (RPM) is a technology-based system that captures a variety of health-related data directly from the point of care, such as vital signs, blood pressure, oxygen levels, body temperature, and brain activity, among other metrics [3]. Following collection, the data is distributed to healthcare professionals working in medical institutions such as hospitals, clinics, critical care units, and nursing homes. Remote Patient Monitoring (RPM) uses a variety of monitoring technologies, such as wearables, sensors, and mobile applications, to gather and transmit patients' health data to healthcare practitioners.

The purpose of remote patient monitoring systems is to collect various physiological data from patients. Electrocardiograms (ECGs), electroencephalograms (EEGs), heartbeats and respiration rate, blood oxygen levels (also known as pulse oximetry), nervous system signals, blood pressure, body/skin temperature, and blood glucose levels are the most commonly collected data. In addition to these, patient weight, activity level, and sleep information are occasionally gathered. Numerous studies have been conducted for applications in sleep monitoring and wound care [4].

The COVID-19 pandemic disrupted normal healthcare practices, necessitating the employment of inventive ways to ensure treatment continuity. RPM has become an essential tool, allowing healthcare practitioners to oversee patients' health state and deliver personalised treatment without requiring patients to leave their residences [5].

Data processing and acquisition systems, hospital end terminals, and communication networks are the fundamental components of a remote monitoring system. The various sensors or devices with embedded sensors that have wireless data transmission capabilities make up the data acquisition system. As technology advances, sensors may be more than just medical ones; they may also be cameras or smartphones. This is due to current studies that examine contactless techniques, in which the surgical instruments do not come into contact with the patient's body [6].

Telemonitoring collects real-time data from patients so that medical professionals can assess their health state remotely, regardless of the technology used. The observed advantages and disadvantages of telemonitoring must be assessed in order to keep improving this technique, which is becoming more and more pertinent to patient care. Thus, the purpose of this systematic review was to determine how medical professionals felt about and dealt with RPM.

The Role of Home Healthcare in Modern Medicine

Given that it protects people's health, health care might be regarded as vital to our existence. Hospitals and private clinics have had fewer beds for the past 20 years. At the same time, as the population ages, more people are experiencing chronic degenerative diseases, which result in both handicaps and functional limitations. In actuality, the financial circumstances surrounding the care of elderly have led them to focus on Home Health Care (HHC) outside of hospital facilities. In order to feel more comfortable, patients receiving palliative care or therapies for various chronic diseases prefer care that removes them from their family context as little as possible.

Importance and Benefits of Remote Patient Monitoring

A healthcare provider initially evaluates and determines a patient's condition suitable for remote patient monitoring and initiates a program to deliver the service [7]. Upon concluding that a patient will gain from remote monitoring, the physician secures the patient’s permission and prescribes a suitable gadget such as a blood pressure monitor or glucose meter, which is electronically linked *via* a selected network. The gathered data is subsequently communicated electronically to the clinician, who analyses it and offers guidance to the patient based on the findings. Providers are required to undertake additional measures, including ascertaining coverage, establishing patient intake procedures, and training personnel to administer the RPM services. Patients may necessitate support in using the technology, and their user-friendliness is contingent upon the design and intricacy of the equipment supplied. Collaborating with an RPM vendor like Patient One can assist healthcare providers in establishing effective patient programs. The use of RPM has shown several advantages in healthcare provision and home care, which are elaborated and shown in Fig. (**1**) .

CHAPTER 15

Healthcare Chatbots and Virtual Assistants

Akanksha Sharma[1], **Ashish Verma**[2], **Akhil Sharma**[1], **Shekhar Singh**[3] and **Shaweta Sharma**[4,*]

[1] *R. J. College of Pharmacy, Raipur, Uttar Pradesh-202165, India*

[2] *Department of Pharmacy, Mangalmay Pharmacy College, Greater Noida, Uttar Pradesh-201306, India*

[3] *Faculty of Pharmacy, Babu Banarasi Das Northern India Institute of Technology, Lucknow, Uttar Pradesh-226028, India*

[4] *Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India*

Abstract: Healthcare chatbots and virtual assistants are transforming patient care by integrating artificial intelligence (AI) and automation into healthcare systems. Chatbots act as interactive text conversational agents, whereas virtual assistants are more sophisticated, enabling voice interaction and personalized healthcare assistance. These technologies help to improve patient engagement, access to information, and administrative efficiency. AI, machine learning, natural language processing (NLP), and voice recognition play a critical role in helping chatbots and virtual assistants understand and respond to patient needs. Due to their integration with Electronic Health Records (EHRs), these tools are also used in a variety of specializations that allow for seamless communication, personalized symptom checkers, medication management, mental health support, chronic disease management, and even diagnostic assistance. They also enable telemedicine visits and clinical decision support, streamlining the healthcare experience. Despite their potential, challenges remain, including the accuracy of medical information and the need for continuous learning. This chapter discusses the different types of healthcare chatbots and virtual assistants and their applications and technologies; it also highlights the limitations involved in their use.

Keywords: Artificial intelligence, Clinical decision support, Healthcare automation, Healthcare chatbots, Machine learning, Natural language processing, Patient engagement, Virtual assistants.

* **Corresponding author Shaweta Sharma:** Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, Greater Noida, Uttar Pradesh-201310, India; E-mail: shawetasharma@galgotiasuniversity.edu.in

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

INTRODUCTION

Healthcare chatbots and virtual assistants are AI-driven solutions used by healthcare professionals and patients to communicate, making healthcare services more accessible and efficient. Chatbots are essentially text-based systems that answer questions and provide medical advice using natural language processing (NLP), in addition to scheduling appointments and processing user input. Virtual assistants are more advanced types of systems that engage with patients *via* voice and text for personalized support and can integrate with EHRs or medical devices. Such technologies enhance accessibility, create new efficiencies in workflows, and help patients take control of their health. Using artificial intelligence, they function as intermediaries in providing precise, timely, and contextual information, revolutionizing conventional healthcare systems into more economical and patient-centric models [1, 2].

Although chatbots and virtual assistants use AI, they are different in functionality and complexity. Most chatbots will be designed for use cases (symptom checking, appointment setting) and will provide rule-based or AI-based responses. In contrast, virtual assistants offer broader, more dynamic support. They interact with healthcare systems, employ voice recognition, and adjust to user preferences for personalized care. For example, a chatbot can respond to a patient asking about medication dosing. Still, a virtual assistant can remind a patient to take their medication proactively, keep a log of whether they took it, and use the health data to give them insights. Chatbots facilitate simple interactions, whereas virtual assistants have deeper contextual conversations and are often regarded as care companions [3].

Growing Role of AI and Automation in Healthcare

Artificial intelligence (AI) and automation are transforming healthcare by improving efficiency, accuracy, and accessibility. Advancements in AI algorithms can process extensive medical records, aiding in diagnostics, treatment planning, and predictive analytics. Automation helps simplify administrative tasks like appointment scheduling, billing, *etc*., thus alleviating the burden on the healthcare provider. Machine learning and other technologies make personalized medicine possible, customizing therapy based on individual patient genetic and lifestyle data. In laboratories, robotic process automation (RPA) is used to perform faster and more error-free testing. AI-powered tools within telemedicine enable remote consultations for continuous care. These advances help to respond to issues like dwindling workforce numbers, growing patient loads, and soaring healthcare costs. The integration of AI and automation will lead to quicker, more accurate care and better outcomes, in turn enhancing patient satisfaction in the process [4].

Chatbots and virtual assistants play an important role in the healthcare domain by delivering timely assistance and accurate information to patients. They enable 24/7 access to information, allowing patients to inquire about symptoms, medications, or healthcare services without waiting for a healthcare professional. Virtual assistants take it a step further and provide personal guidance, track chronic conditions, and send reminders for medications or appointments. Such tools promote adherence to treatment plans and enable patients to become active participants in their health management. For healthcare providers, the solution streamlines workflows by automating repetitive tasks, allowing clinicians to devote more time to care needs that require more complex solutions. The use of AI-driven applications enhances healthcare delivery as it becomes increasingly more efficient, accessible, and oriented towards the patient [5].

Significance of Machine-Human Interaction in Healthcare

In healthcare, machine-human interaction is critical for connecting technology with patient care. Integrating machines with human emotions ensures the accuracy of diagnosis, helps in treatment, and satisfies patients. AI-powered chatbots like ChatGPT and virtual assistants make seamless communication possible, assisting people in navigating the healthcare system with ease. Machines can evaluate symptoms and deduce treatments, but humans still enable the contextualization necessary to make ethical decisions. Such collaboration engenders trust, resulting in better health outcomes. The digital transformation of healthcare is inevitable, but striking a balance between the efficiency of machines and the empathy of humans is critical to ensure that high-quality, patient-centered care is provided in the future [6].

TECHNOLOGIES BEHIND HEALTHCARE CHATBOTS AND VIRTUAL ASSISTANTS

Healthcare chatbots and virtual assistants employ Natural Language Processing (NLP) to understand user intent, as shown in Fig. (**1**). Machine Learning (ML) and AI enable chatbots to learn and adapt to healthcare-specific contexts. Voice recognition technology supports seamless speech-to-text and voice synthesis. Integration with EHR/EMR systems ensures personalized patient treatment, and cloud computing gives scalability, interoperability, and secure handling of data [7].

Natural Language Processing (NLP)

NLP empowers chatbots to understand, interpret, and generate human language by analyzing words, phrases, and context. It forms the basis for conversation, allowing virtual assistants to extract meaning from queries, respond in

SUBJECT INDEX

Shaweta Sharma, Akhil Sharma, Shivkanya Fuloria & Anurag Singh (Eds.)

E

F

G

H

I

K

L

M

N

O

P

R

S

T

U

V

W

X

Z

Shaweta Sharma

Dr. Shaweta Sharma, M. Pharm., Ph.D., is currently employed as Professor at Galgotias University, Greater Noida. She has completed her Ph.D. in 2017 from Teerthanker Mahaveer University, Moradabad, U.P., India. She has been contributing to academics from more than 15 years. She has published numerous research papers in Scopus-indexed journals, presented at national and international conferences, and filed multiple patents. As an editor and author of several books and book chapters with leading publishers, she actively contributes to advancing pharmaceutical education, innovation, and healthcare technology.

Akhil Sharma

Dr. Akhil Sharma, M. Pharm., Ph.D., is presently working as Professor and Principal at R.J College of Pharmacy, Raipur, Aligarh, U.P., India. He has completed his Ph.D. in 2016 from Teerthanker Mahaveer University, Moradabad, U.P., India. He has been serving the profession of Pharmacy from more than 15 years. He has published numerous research papers in Scopus-indexed journals, presented at national and international conferences, and filed multiple patents. As an editor and author of several books and book chapters with leading publishers, he actively contributes to advancing pharmaceutical education, innovation, and healthcare technology.

Shivkanya Fuloria

Dr. Shivkanya Fuloria, Ph.D., is presently working as Senior Associate Professor, Department of Pharmaceutical Chemistry, Faculty of Pharmacy, AIMST University, Semeling Campus, Jalan Bedong-Semeling, Bedong, Kedah Darul Aman, Malaysia 08100. She has over 20 years of experience spanning academics, research, and industry, she holds qualifications in B. Pharm, M. Pharma, PhD in Pharmacy, and a PDCTM. Her publication record includes 3 MOOCs, 5 books, 11 book chapters, 14 patents, and 166 papers. She has supervised 1 PhD, 5 M.Pharm, 2 M.Sc., 27 B.Pharm. students. She has participated in 87 conferences, trainings, webinars, and seminars. Additionally, she has been honored with 6 awards for his contributions to the field.

Anurag Singh

Dr. Anurag Singh is an accomplished academician and IT professional with over 11 years of experience in education technology, process automation, and outcome-based education. He holds a Ph.D. in Computer Science and Engineering from Galgotias University, specializing in cognitive science and machine learning. Currently serving as Director-ERP and Associate Professor at Galgotias University, he oversees large-scale academic technology deployments, including ERP and LMS for 40,000+ students. His expertise spans active learning pedagogies, accreditation support (NAAC, NIRF, NBA), enterprise solutions, and generative AI applications in education. Dr. Singh has published extensively in reputed journals and conferences, developed custom IT solutions, and provided consultancy to global universities. His work bridges technology and education, fostering innovation and student success.