PRECISION HEALTHCARE

PATIENT CARE, DECISION TOOLS, WEARABLES, LEGAL AND ETHICAL ISSUES

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Precision Healthcare: Patient Care, Decision Tools, Wearables, Legal and Ethical Issues

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FOREWORD

As a senior pharmacologist with teaching experience of more than 38 years in the field of Healthcare, Management of Diseases, Quality of Life, Precision Medicines and Applications in clinical services, I believe that the book titled "Navigating Precision Healthcare: Patient Care, Decision Tools, Wearables, and the Legal-Ethical Landscape" will play an important role in teaching and learning of the students of health sciences, computer science with specialisation in Machine Learning and Artificial Intelligence.

The editor's acumen and knowledge in the fields of machine learning, computer science, and legal studies will provide a cutting-edge perspective in the book, offering insights from experts in medicine, technology, ethics, and law. Precision healthcare represents a paradigm shift in the way patient care is delivered, incorporating personalized treatment plans, advanced decision-making tools, especially in anti-cancer therapy.

In this book, the editors' aim is to provide healthcare professionals, researchers, policymakers, and patients with a deep understanding of the opportunities and challenges presented by precision healthcare. The enlisted chapters cover a wide range of topics, from the latest advancements in precision medicine to ethical considerations of using patient data in decision-making. The proposed book also delves into the legal implications of implementing precision healthcare practices, offering guidance on how to navigate this rapidly evolving landscape.

I hope that this book will serve as a valuable resource for anyone interested in the future of healthcare delivery. We believe that by exploring the combination of patient care, decision tools, wearables, and the legal and ethical landscape, we can collectively work towards a more personalized, efficient, and ethical healthcare system.

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PREFACE

Precision healthcare, or personalized healthcare, is a medical approach tailored to a person's healthcare depending upon their genetics, environment, and lifestyle factors. Based on the parameters collected through sensors such as wearables, timely intervention can be tailored to safeguard patients even if they are not under the direct supervision of a medical practitioner. Precision healthcare encompasses a broader scope, covering genomics, precision medicine, machine learning algorithms, large language models, big data analytics to support clinical decisions and documentation, various aspects of patient care, and precise decision-making based on radiology through the use of computer vision. Maintaining and respecting patient’s data privacy and security is essential. The regulatory framework and law must be in tandem with ever-changing technology. Precision healthcare represents a significant shift towards individualized healthcare, aiming to improve outcomes and reduce costs in the long run. This book is an effort to bring relevant literature on healthcare in one place for use by academics, researchers, medical practitioners, and legal practitioners.

This book explores the concepts and techniques of precision healthcare, a promising and flourishing frontier in healthcare. Precision healthcare is a multidisciplinary field that draws work from machine learning, the Internet of Things, databases, statistics, information retrieval, pattern recognition, oncology, and knowledge-based systems. This book offers comprehensive information on various aspects of healthcare. The contents of this book will facilitate the reader's understanding of what is necessary in their respective fields. We aim to present an overall understanding of topics concerning precision healthcare from the students' perspectives, introduce the techniques and tools developed to facilitate healthcare operations, AI tools concerning oncology to enable researchers, complex legal frameworks and their implications, and discuss research directions. This book will encourage people from diverse backgrounds and experiences to share their thoughts, facilitating the promotion and development of this exciting and dynamic field.

The first chapter begins with outlining the foundations, challenges and AI-driven advancements shaping modern precision medicine. Chapter 2 examines how precision healthcare leverages data, AI, and collaborative innovation to deliver personalized treatments, while addressing the ethical and operational challenges that shaped its real-world adoption. Chapter 3 examines the transformative influence of the Internet of Medical Things (IoMT) on healthcare. Chapter 4 presents the IoMT-based lung disease classification to facilitate practitioners' decision-making. Chapter 5 gives insight into wearable technologies aiding the monitoring of patients' vital statistics and helping implement preventive strategies in emergencies. Chapters 6 to 8 illustrate the application of machine learning and data science in detecting and categorizing various diseases, including cardiovascular and diabetes. Chapter 9 explores the distinctive features, applications, and potential challenges associated with adopting large language models in the healthcare industry. Chapters 10 and 11 present various thoughts on ethical and legal frameworks concerning the adoption of precision healthcare technologies in the medical sector. Chapter 12 introduces the evolving field of precision healthcare and its promise for personalized, technology-driven patient care.

The editors are thankful to all the authors from various fields who have generously shared their knowledge and insights. Their contributions offer diverse perspectives, ensuring a well-rounded understanding of precision healthcare. The editors would like to express their gratitude to Prof. (Dr.) Arun Garg, Vice Chancellor, MVN University, for his valuable support. We extend our heartfelt thanks to the reviewers and our publishers for their unwavering support and dedication. This book would not have been possible without their collective efforts.

As the demand for personalized medical solutions grows, understanding the principles and applications of precision healthcare becomes increasingly essential. This book will inspire and inform, sparking new ideas and fostering advancements in precision healthcare. We invite you to explore the wealth of knowledge within these pages and join us in the journey towards a more personalized approach to medicine.

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CHAPTER 1

Precision Healthcare: Objectives, Challenges, and Solutions

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Abstract: Precision Medicine (PM) is an expanding discipline that necessitates the use of novel technologies to provide uniformity in data gathering from more than 1 million individuals and manage vast quantities of patient data. Nevertheless, ethical, social, and legal considerations, such as privacy, informed consent, and cost, present substantial obstacles. The idea requires significant government funding, amounting to millions of dollars, and must get approval from Congress over many years. Physicians and healthcare professionals must thoroughly comprehend molecular genetics and biochemistry to incorporate this technology into conventional healthcare procedures effectively. A precision health system necessitates a strategy that encompasses healthcare providers, payers, pharmaceutical firms, Information Technology (IT) businesses, employers, governments, and social groups in an interconnected manner. The system employs sensing technologies, computations, and communication to guarantee health data's security, privacy, and reliability. This chapter examines the goals, difficulties, implementations, and remedies of precision healthcare using Artificial Intelligence (AI) and Machine Learning (ML) methodologies.

Keywords: Technology, AI, Challenges, Drug, Governance, Healthcare, ML, NLP (Natural Language Processing), Objectives, Privacy, Precision health, Physicians, Security.

INTRODUCTION

PM is a branch of medicine that applies algorithmic analyses and quantitative, patient-specific data to administer the suitable medication to the correct patient at

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the optimal moment [1, 2]. This method, endorsed by the United States, the GF (Gates Foundation), and the CZI (Chan Zuckerberg Initiative), has expanded its focus beyond genetics. It currently includes systems medicine, customized medicine, computational systems biomedicine, and P4 (Predictive, Preventative, customized, Participatory) medicine, and precision medicine. It encompasses a wide range of medical and physiological datasets.

The discipline of precision health focuses on identifying preclinical problems early, launching preventative measures, and evaluating disease risks at the individual level [3]. It encompasses individualized medical treatment that considers a person's distinct genetic, genomic, or omics makeup while incorporating lifestyle, social, economic, cultural, and environmental variables [4]. Precision health is more comprehensive than PM since it includes approaches to promote health and prevent diseases outside healthcare facilities. The goal is to align promotion, preventive, diagnosis, and treatment interventions with the genetic, biological, environmental, social, and behavioral factors influencing health while prioritizing the individual's needs [5]. Precision health fundamentally redirects attention from treatment to the promotion of health and the prevention of illness initiation.

Personalized Medicine (PM) is a data-driven method of treating health disorders by targeting individual genetic variations, replacing the expensive trial-and-error technique. Over the next two decades, PM will empower medical professionals to identify the most effective medication for a patient's therapy and reduce adverse side effects. Electronic health records will enable clinicians to access essential medical information instantly, while DNA sequencing will provide risk profiles for common ailments and individual susceptibility to certain disorders [6]. Integrating health-related data with gene mutations yields more accurate information for clinical implementation. Next Generation Sequencing (NGS) has decreased the expenses of sequencing a whole genome. At the same time, smart wearable devices will gather data to be stored in a unified database that combines genetic, metabolic, and lifestyle information. Nevertheless, PM's primary obstacle to materializing is the presence of economic, behavioral, or systemic elements.

Providing a more precise approach to the avoidance, analysis, and treatment of illness is the objective of the Precision Healthcare initiative. Conventional medical therapies have been developed to provide a “one-size-fits-all” technique. However, even though these therapies could be successful for some people, the goal of precision healthcare is to make the process of diagnosing a disease or sickness, as well as the treatment, remedies, and prevention of disease or illness, more individualized, proactive, predictive, and accuracy-oriented [7]. The fundamental objective of precision healthcare is to enhance clinical outcomes for individual patients by employing exact therapy targeting. This is accomplished by using genetic, biomarker, phenotypic, or psychological features that differentiate a specific patient from others with similar clinical presentations. Precision healthcare aims to ensure that appropriate therapies are administered to the relevant patients at the proper time (shown in Fig. **1**).

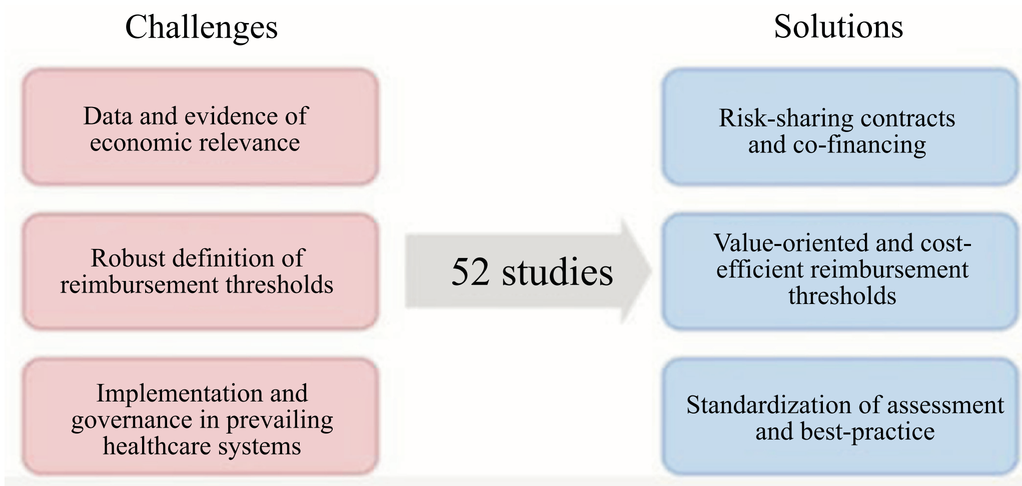

Fig. (1). Integration of personalized medicine in healthcare systems [8].

A health technology's economic case is established by contrasting its price and potential health risks with alternatives. By capitalizing on the variability among individual patients, PM has the potential to enhance cost-effectiveness. Nevertheless, the lack of clinical and economic data, as well as the reliance on assumptions, might make demonstration difficult. Prioritizing decision-makers' needs early may enhance the generation of evidence for resource allocation decisions. The economic rationale for PM may be progressively refined to minimize ambiguity [9].

The World Economic Forum's PM Programme aims to establish policy frameworks, advance societal advantages, and mitigate dangers using inventive collaborations, standards, and support models [10].

Numerous impediments hinder precision medicine, including the extensive data requirements, the necessity for secrecy and concealment, and the potential for data corruption due to noise. The data processing method currently takes 26 hours, which is too long for critical care decision-making. Assessing the accuracy of data is also tricky. Capacity development is crucial, especially in educating healthcare professionals and utilizing modern AI, machine learning, and laboratory

CHAPTER 2

Achieving Precision in Healthcare: A Path Forward

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Abstract: Precision healthcare is an approach aimed at delivering personalized medical treatments tailored to the unique needs of individuals. Personalized medicine, also known as precision medicine, is a healthcare approach that considers genetics, lifestyle, and environmental factors, classifying individuals based on their medical histories. Its goal is to prevent disease and develop target-based solutions for various medical conditions. Serving as a predictive model, this model aids in developing medical solutions customized explicitly to the ailment at concern. The practical implementation of this model requires collecting and analyzing large datasets. This presents a global challenge for the effective implementation of precision medicine. It also raises ethical, social, and legal concerns, including the importance of safeguarding patients' private health information. Millions of dollars in funding are required for precision medicine to be implemented successfully over the long term. Another significant issue that must be addressed when addressing the concept of precision medicine is the necessity for trained professionals. Large datasets can be handled due to contemporary technologies like machine learning and artificial intelligence. Additionally, researchers working together to improve the results are advantageous. Shortly, patients and healthcare professionals can look forward to the greatest tailored therapies and treatments with the advancements in modern medicine. This chapter addresses the challenges faced in effectively implementing precision medicine healthcare and discusses solutions for efficient healthcare delivery to improve patient outcomes for disease prevention.

Keywords: Advancements, Challenges, Disease prevention, Modern technology, Precision medicine, Personalized healthcare.

INTRODUCTION

Precision healthcare is an emerging approach that focuses on treating and preventing diseases. This approach considers the unique characteristics of each

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patient, tailoring treatment to enhance accuracy and effectiveness. The term "precision medicine" was coined by the "National Research Council report", which emphasized individual characteristics-based healthcare. All medicines are developed with precision in mind [1]. However, the precision healthcare approach is focused on personal traits like specific biological modifications, gene structure or regulation, transcription, and molecular signaling pathways. Fig. (**1**) illustrates the relationship between genetic and environmental factors that influence human health, which is essential for developing personalized healthcare solutions. Precision medicine allows doctors and researchers to classify each line of treatment for a particular class of people based on their response to the treatment. It is a "different for all" approach, where the cure for a disease is based on individual signs rather than a "one fits all" approach. A widely recognized example is blood donation, where compatibility between donor and recipient blood types is rigorously verified to prevent complications [2 - 5].

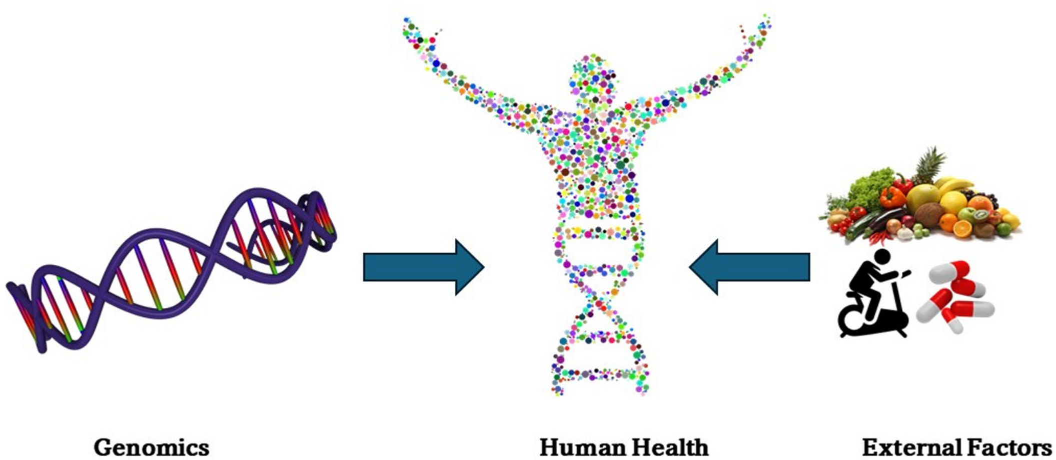

Fig. (1). Personalized healthcare: Relational factors.

The goal of precision medicine thus requires a large set of accurate data that can be analyzed to treat an individual precisely. Target-based medicinal treatment would benefit from this kind of data, which can help eradicate diseases like cancer and diabetes. Fig. (**2**) illustrates the flow of implementing complete personalized healthcare. Collecting large data sets with legal, ethical, and social guidelines is challenging. Advanced computational tools and techniques are required to ensure precise health information is collected. Artificial intelligence and machine learning can bridge data analysis for precise outcomes based on available data sets. For the same, funding agencies should come forward to boost the process of precision healthcare. All these insights aid in opting for a global collaboration that could result in health innovations for precision medicine healthcare. The full potential of digital data can only be utilized if we think globally without any regional or financial boundaries. The medical field is shifting from conventional treatments to target-based treatment based on patients' information, which can bring out more precise healthcare decisions [1 - 15].

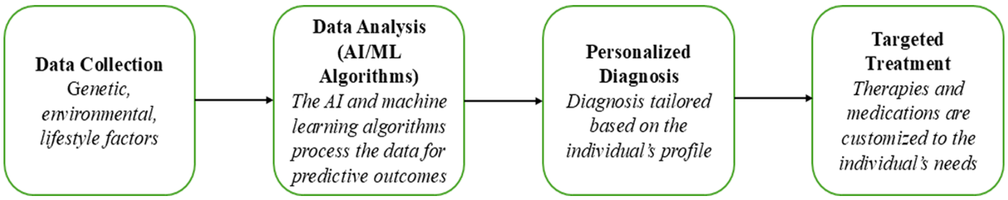

Fig. (2). Personalized healthcare flowchart.

We begin by discussing the objectives of implementing precision healthcare. We next address significant challenges to precision medicine in classifying individuals based on their history for a future personalized approach for specific treatments. We discussed the challenge of handling large datasets and using advanced computational tools to analyze the data precisely and promptly. Also, the funding challenges are elaborated on, and the availability and possibilities are discussed. Finally, we discuss a road map to achieve objectives while considering the challenges of transforming medical care from one for all to individual personalized healthcare.

OBJECTIVES

Advances in medical technology have improved the understanding of the link between DNA sequences and the underlying causes of diseases. The success rate of gene therapies is improving, but it is not cost-effective. Precision healthcare is the latest trending approach for dealing with patients' health *via* individually tailored therapies and thus extends the lifespan [2 - 6]. Based on the lifestyle and other factors like cultural, economic, and environmental, precision healthcare helps patients achieve optimal health. Integrating genomic, clinical, and outcome data would enhance the individual's health. The following are the objectives of precision healthcare [8, 16 - 19].

- Extensive data collection of individuals' health based on various factors.
- Identify the most suitable care for each patient.
- Determine the changes in the genetic factors that lead to the disease when the conditions are undiagnosed.
- Prescribe medications that can avoid serious side effects.
- Identify the lifestyle, cultural, and environmental factors that can lessen the side effects of medications and dosages.

CHAPTER 3

Unlocking the Power of the Internet of Medical Things: Revolutionizing Healthcare

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Abstract: The Internet of Medical Things (IoMT) revolutionizes healthcare by establishing connections between medical equipment and systems to provide more intelligent and streamlined care. This study examines the transformative influence of the Internet of Medical Things (IoMT) on healthcare, with a specific emphasis on its capacity to improve patient outcomes using remote monitoring, tailored treatment, and the management of chronic diseases. Additionally, it analyses how the Internet of Medical Things (IoMT) improves the effectiveness of healthcare operations, resulting in cost reduction and streamlined workflows. With the increasing adoption of the Internet of Medical Things (IoMT), it is crucial to prioritize strong security and data privacy. This involves implementing effective cybersecurity measures and adhering to regulatory compliance to safeguard patient data. Despite the presence of hurdles such as interoperability and infrastructure needs, the future of the Internet of Medical Things (IoMT) holds the potential for a healthcare system that is more interconnected and efficient. Healthcare providers can achieve better patient care, optimize resource allocation, and contribute to a healthier future by adopting the Internet of Medical Things (IoMT).

Keywords: AI, Automation, Blockchain, Connected devices, Cloud computing, Data analytics, Digital health, IoMT, Interoperability, Predictive analytics, Patient-centric care, Remote monitoring, Smart healthcare, Telemedicine, Wearables.

INTRODUCTION

The Internet of Medical Things (IoMT) represents a revolutionary change in healthcare technology by combining interconnected medical equipment, software

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applications, and healthcare systems into a unified network. This network enables the uninterrupted and smooth data transfer, substantially revolutionizing the provision of medical treatment and clinical procedures. The Internet of Medical Things (IoMT) enables intelligent medical equipment and sensors to monitor and control health issues in real-time, providing a proactive approach to healthcare.

The Internet of Medical Things (IoMT) revolves around interconnected medical equipment, including wearable sensors, remote monitoring tools, and smart implants. These devices collect a vast amount of health data, including vital signs and patient activity levels, and send this information to healthcare providers. The continuous stream of data improves the capacity to monitor health patterns, identify potential problems early, and make more knowledgeable choices regarding medical treatment and care.

In addition, the Internet of Medical Things (IoMT) facilitates a transition towards healthcare guided by data, where immediate observations result in more individualized and effective patient treatment. The incorporation of these devices into Electronic Health Records (EHRs) and other healthcare systems enables enhanced collaboration among healthcare practitioners and enhances overall patient outcomes. The ongoing development of the Internet of Medical Things (IoMT) holds the potential to bring about substantial progress in the delivery and experience of healthcare. This signifies the emergence of a new era characterized by interconnected and intelligent medical technology [1].

THE TRANSFORMATIVE IMPACT OF IOMT ON PATIENT CARE AND OUTCOMES

The Internet of Medical Things (IoMT) has greatly transformed patient care by improving healthcare delivery and management. An outstanding advantage of IoMT is its capacity to enhance patient outcomes by implementing more efficient and prompt therapies. Integrating cutting-edge technology, such as wearable devices and remote monitoring tools, enables IoMT to deliver healthcare practitioners immediate and up-to-date information regarding patients' health status. The continuous stream of information allows for more precise and quicker diagnosis, decreasing the probability of problems and enhancing overall health management.

Remote patient monitoring is essential to the Internet of Medical Things (IoMT), enabling healthcare practitioners to monitor patients' vital signs and health indicators remotely. This feature is especially advantageous for managing chronic illnesses, as it enables ongoing monitoring without regular face-to-face appointments. Regular monitoring and rapid adjustments to treatment programs based on real-time data can benefit patients with diabetes, heart disease, or respiratory disorders. Adopting this proactive strategy aids in properly treating symptoms and mitigating potential health emergencies.

In addition, the Internet of Medical Things (IoMT) allows for the customization of healthcare by adapting treatment strategies to each patient's specific requirements. The comprehensive data gathered from intelligent devices enables a more nuanced comprehension of each patient's well-being, resulting in tailored interventions and more accurate treatment approaches. Personalization increases the efficacy of care and enhances patient pleasure and involvement.

To summarize, the IoMT has a significant and far-reaching effect on patient treatment and results. The Internet of Medical Things (IoMT) is revolutionizing healthcare by utilizing advanced remote monitoring, optimizing the treatment of chronic illnesses, and providing tailored healthcare solutions. This trend is leading to a new era of care that is more impactful, efficient, and focused on the patient's needs [2].

STREAMLINING HEALTHCARE OPERATIONS WITH IOMT: INCREASED EFFICIENCY AND COST SAVINGS

The Internet of Medical Things (IoMT) transforms hospital operations by significantly improving efficiency and decreasing expenses. Healthcare facilities may enhance operational efficiency by integrating interconnected medical equipment and intelligent technology. This integration enables them to streamline processes, make informed decisions based on data analysis, and allocate resources in a more efficient manner.

IoMT significantly enhances healthcare efficiency by optimizing workflows. Integrating devices and systems facilitates effortless communication between many components of the healthcare ecosystem, thereby decreasing reliance on manual data input and mitigating errors. This automation expedites patient registration, data acquisition, and information dissemination, resulting in more streamlined operations and decreased administrative encumbrances.

The Internet of Medical Things (IoMT) also helps to save costs by improving resource allocation. By utilizing real-time data obtained from remote monitoring devices and smart sensors, healthcare providers can better understand patient requirements and effectively allocate resources based on priority. Monitoring equipment can facilitate identifying patients needing rapid attention, hence optimizing the utilization of medical personnel and resources. This focused strategy not only decreases unneeded treatments and hospital admissions but also decreases overall operational expenses.

CHAPTER 4

Comparative Analysis of IoMT-based Lung Disease Classification using Deep Learning in Healthcare

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Abstract: Lung diseases cover a wide range of conditions that affect how we breathe and create serious public health issues. This chapter gives an organized overview of pulmonary disorders, sorting them by anatomical areas and disease features. A thorough review of recent literature shows new progress in finding and classifying lung diseases, mainly focusing on computer-based methods. The chapter also examines the role of deep learning, a component of artificial intelligence, in addressing complex diagnostic tasks that have traditionally relied on human expertise. By utilizing neural networks and data-driven methods, deep learning enables the accurate identification of lung infections and enhances predictions in clinical settings. The chapter discusses new technologies like machine learning, the Internet of Things (IoT), and intelligent sensing systems for their potential to change respiratory healthcare. The aim is to update researchers and practitioners on the convergence of biomedical science and innovative computing.

Keywords: CNN Model, Challenges, Deep learning, IoMT (Internet of Medical Things), Lung diseases.

INTRODUCTION

The Internet of Medical Things (IoMT) is nowadays connecting many devices and wearables all over the world for the quick processing of data. Notably, occupational exposures have demonstrated relevance in contexts such as tuberculosis and the recent COVID-19 pandemic [1]. Lung cancer is a disease caused by the abnormal development of cells. Other environmental factors connected to lung infection include asbestos, radon gas, air contamination, and synthetic compounds like uranium, beryllium, vinyl chloride, and arsenic [2]. These conditions may vary, ranging from a bit of discomfort to critical situations.

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The findings revealed that higher cumulative cigarette usage correlated with diminished lung function, increased likelihood of respiratory symptoms, and a potential connection to instances of COPD within the HIV-positive group [3]. Air pollution is the mixture of all toxic gases and particles. These gaseous particles disseminate deep into our lungs and cause serious respiratory problems [4].

Infections, environmental factors, genetic predispositions, or a combination of these factors mainly cause lung diseases. The outcomes, particularly for non-smoker individuals, accentuate a direct and meaningful connection between antecedent lung diseases and the probability of developing lung cancer [5]. They can affect anyone, regardless of age or gender [6]. It consists of a series of tubes and passages that allow air to enter and exit the lungs. Neural networks enable them to learn and represent complex patterns in data. Pneumonia is an infection affecting the lungs, leading to the accumulation of infected fluid in the alveoli of one or both lungs, causing breathing-related difficulties [7]. Different symptoms of lung infections are chest pain, breathing problems, cough, fever, and fatigue. There is community-acquired pneumonia, which continues to be a significant contributor to both illness and mortality [8]. Fig. (**1**) illustrates a clear chest X-ray image of a patient with asthma.

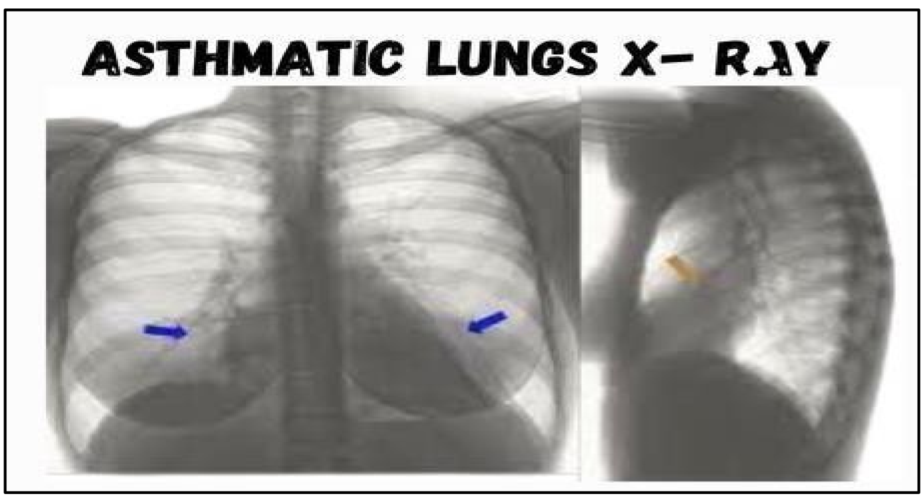

Fig. (1). Lung X-ray [8].

In the realm of pneumonia detection, many studies have incorporated TL approaches and data augmentation techniques. For instance, Tobias et al. have directly employed Convolutional Neural Networks (CNNs) [9]. In contrast, Stephen et al. have trained the CNN model from scratch, and also applied different augmentation techniques like scaling, rotation, zooming, height shift, shear, and flipping [10]. Several other authors [11 - 13] have opted for pre-trained CNNs to detect pneumonia. Notably, some studies also introduced data augmentation techniques to enhance the training mechanisms in training datasets, for instance, Rajpurkar et al. have used horizontal flipping [14] for pneumonia detection. At the same time, Ayan and Ünver [15] have utilized convolutional networks to detect pneumonia. Recent studies have demonstrated the effectiveness of transfer learning and convolutional neural networks in diagnosing pneumonia from chest X-ray images [16, 17], highlighting both the promise and challenges of deploying such models in clinical settings. Respiratory diseases such as asthma and COPD are characterized by airway obstruction or narrowing, which reduces airflow and impairs breathing. Relative Risk (RR) is the most common metric used in epidemiology to compare the likelihood of developing a respiratory condition. When amalgamated, the cumulative risk stemming from these conditions yielded an overarching relative risk of 1.80.

Furthermore, individuals with prior bouts of pneumonia exhibited a lung cancer risk of 1.43, while those with a tuberculosis history carried a risk of 1.76. Despite a reduction in the observed effect among non-smokers, the risk remained appreciable for both pneumonia (RR = 1.36) and tuberculosis (RR = 1.90). Table **1** summarizes the CNN frameworks specifying the datasets that various authors have used in recent years.

Table 1. Comparative analysis of different deep learning frameworks.

Deep learning techniques	Dataset	references
Deep Siamese-based neural network	Unspecified Kaggle dataset	[18]
Use of augmentation and TL	LDOCTCXR	[19]
CNN with a majority voting technique	LDOCTCXR	[12]
CNN with transfer learning	LDOCTCXR	[20]
CNN, along with an LSTM model	Mooney Dataset	[21]
Use of CNN for lung disease detection	2018 RSNA dataset	[22]
CNN, along with a hybrid technique	NIH Dataset	[23]
CNN with TL	Private dataset	[24]

According to the latest statement of the World Health Organization (WHO), tuberculosis is one of the most critical causes of death in the world [25, 26]. One approach, demonstrated by Heo et al. [27], involves utilizing social factors, including height, weight, and age, to enhance the overall performance of the CNN model. Table **2** shows the comparative study of different deep learning techniques.

CHAPTER 5

Wearable Healthcare

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Abstract: The increasing global population, climate change, aging and chronic diseases, availability of healthcare facilities in selected cities and towns, and increasing cost of medical expenses are just a few reasons that are driving transitions from traditional hospital-based systems to individual-centric healthcare systems. With advancements in the semiconductor industry, material science, and data science, wearable technology has seen noticeable advancement and growth. The chapter aims to cover the technical aspects involved in wearable technology. The work delved deep into the architecture aspects, energy harvesting and management, and data processing cycle, forming the technological backbone for monitoring and transferring vital body signals to remote locations. The aggregate information helps detect, prevent, and monitor diseases in healthcare. The chapter thoroughly discusses the wearable type in healthcare and the latest devices commercially available for consumption in the healthcare industry. The chapter highlights the limitations and challenges hindering their availability at the grassroots population level. This chapter aims to ensure that technological advancements can be comfortable and healthy for ordinary people.

Keywords: Computing, Human, Healthcare, Sensors, Wearable.

INTRODUCTION

The human race has made sustained efforts toward the longevity of human life. Present medical facilities do not come at an affordable cost to ordinary people, especially in third-world countries. Technology intervention is required to ensure affordable healthcare. ICT-based healthcare in post-COVID times has caught the attention of the government, scientific communities, and academia. A possible solution is using numerous IoT sensors that can communicate with each other and are backed by cloud services for the collection and analysis of data.

Wearable technologies are the next megatrend that aims to provide reasonably priced healthcare to patients [1]. Different authors have defined wearables based on their application area, and there is no standard way of defining wearable

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technology. The two most appropriate definitions, considering the vast applications of wearable are:

- “An application-enabled computing device that accepts and processes inputs. This device is a fashion accessory usually worn or attached to the body. The device could work independently or be tethered to a smartphone, allowing some meaningful interaction with the user. The wearable product could be on the body (like a smart patch), around the body (like a wristwatch or a headband), or in the body (like an identification sensor embedded under the skin or a sensor attached to the heart monitoring cardiac aberrations)” [2].
- “Small electronic and mobile devices, or computers with wireless communications capability that are incorporated into gadgets, accessories, or clothes, which can be worn on the human body, or even invasive versions such as micro-chips or smart tattoos” [3]

The report published on July 8, 2024 [4] reported that globally, the value of wearable technology was USD 120.54 billion, projected to be USD 1695.46 billion by 2032. Considering the usage of wearables across different segments, healthcare wearable devices globally account for 25% of the market share. The report [5] suggested that the healthcare wearable market would be USD 61.30 in 2022. For the forecast period 2023-2030, the report predicted the market will expand at a compound annual growth rate of 14.6%. These wearables can be broadly categorized into four classes:

- Carried
- Mounted
- Intimate
- Embedded

Smartphones are classified as carry wearables since they can be carried and are close to the body. Mounted devices like smartwatches, glasses, and mounted displays are worn, and they monitor vital parameters that can be collected through the organs. Devices almost indistinguishable from the human body, like prostheses and contact lenses, are termed intimate devices. Finally, wearables embedded inside the human body are examples of embedded technologies.

This chapter delves into various aspects of wearables in healthcare. Section 2 discusses wearable architecture. Section 3 highlights energy harvesting and its management. Section 4 delves into critical elements of the data processing cycle. Section 5 illustrates various applications in the healthcare industry. Section 6 discusses the limitations and challenges of wearable technology.

ARCHITECTURE

The wearable technology is woven around the Internet of Things (IoT) ecosystem. Body sensors, Body Area Networks, Fog Computing / Edge Computing, Mist Computing, and Cloud Computing are vital components of wearable IoT (WIoT). Two prominent IoT architectures that standardize communication between various devices are 1. The oneM2M architecture model [6] and 2. The IoT World Forum architecture. Both architectures intend to ease the interoperability among heterogeneous devices, services, and applications.

Wearable Body Sensors

Wearable Body Sensors (WBS) are miniature sensors capable of data collection, computing, communication, storage, and energy management. The primary requirements while deploying WBS are [7]:

- Accurate data is collected either directly through sensors or indirectly through peripheral devices. The health parameters being monitored are vital for medication during routine and emergency patient situations. Devices must meet global standards before they are deployed for data supervision and management.
- It is imperative to process the collected data locally or remotely for necessary feedback and to activate the response system. WBSs have very limited computing power and storage capacity. The vast amount of data generated must be stored and computed at the remote end. However, communication delays can cause devices to respond too slowly when a patient's vital signs become unstable.

Fig. (**1**) illustrates the applications and categorization of the wearable sensors.

Body Area Network

In the literature, Body Area Networks are IEEE 802.15.6 compliant networks, sometimes called Body Sensor Networks, Medical Body Area Networks, and Wireless Body Area Networks. BAN refers to very short-range communication by biosensors on, near, within, and around the body. The network is connected to an Internet Gateway, ensuring continuous real-time medical data aggregation and monitoring. The deployed sensors must perform their intended operations and update the patient's live location. The typical BAN consists of sensors, processors, transceivers, and batteries. The key challenges that need to be addressed are:

CHAPTER 6

Predicting the Risk of Heart Attack Using Machine Learning Algorithms

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Abstract: This chapter uses two datasets to predict heart attacks, which provide valuable insights into the machine learning algorithms used in the prediction process. The first dataset used in this chapter is the heart attack risk prediction dataset, which has 14 attributes relevant to heart health, including demographic information of the patient, clinical features, diagnostic test results, symptoms, risk factors, and outcome variables. The second dataset used in this chapter is the heart attack dataset collected at Zheen Hospital in Erbil, Iraq, in 2019. The dataset has 1319 records of patients and nine attributes indicating the heart health status of the patients. The categorical data is normalized and represented in the dataset. This chapter aims to predict the risk of a heart attack using three machine learning algorithms. Since both datasets used in this chapter have labeled data, these algorithms should fall under the category of supervised machine learning, where the machine learns from the data provided in the training process to predict the results for the test data. Decision Tree, Random Forest, and K Nearest Neighbors (KNN) are the methods selected for this chapter based on several criteria. Incorporating several datasets permits the identification of issues related to data heterogeneity and sample size limitations and, thereby, the examination of the model's generalizability and reliability.

Keywords: Decision tree, Heart attack, K-Nearest neighbors, Random forest, Supervised machine learning.

INTRODUCTION

Machine learning plays a significant role in diagnosing various medical diseases. Predictive capabilities can impact the health care experience for professionals in early diagnoses and detection, implying prevention strategies and saving lives through early intervention [1]. Nowadays, heart disease statistics according to the American Heart Association, declared in the National Institute of Health in their

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annual report the impact of some factors like cholesterol, blood pressure, glucose measures, and lifestyle on the possibility of encountering a heart attack [2].

Therefore, this chapter focuses on solving the problem of analyzing the factors that usually trigger heart attacks. It implements supervised machine learning algorithms on two datasets to predict heart attacks through training on data about both the individuals who have experienced heart attacks and those who have not. The symptoms are taken as features to predict whether the patient is at risk of a heart attack and classify new data points. The goal of this chapter is to predict the risk of a heart attack using three machine learning algorithms. Since both datasets used in this chapter have labeled data, these algorithms should fall under the supervised machine learning category, where the machine learns from the provided data in a training process to predict the test data output. K Nearest Neighbors (KNN), Decision Tree, and Random Forest [3] are the methods selected for this chapter based on several criteria that will be explained further.

Machine Learning (ML) can play an essential role in discovering medical risk factors using data-driven methods [4 - 7]. In this chapter, the techniques of machine learning are employed to create predictive models that can effectively diagnose whether patients are having a heart attack or not. The methodology followed to complete the chapter involved gathering real datasets that contain patients' demographic information, medical health factors, and clinical test results. The data is then processed and cleaned to be in suitable formats for the machine learning models training. Moreover, feature selection and scaling techniques were applied to conclude the most relevant predictors of heart attack risk. Afterward, three predictive models, random forest, decision tree, and KNN, were trained on the prepared data to learn the relationships between the features selected and the targeted variable. The method's performance on the created test subset was measured using a variety of metrics, including Mean Square Error (MSE), accuracy, classification report, and confusion matrix. This chapter aimed to provide healthcare practitioners with a predictive model that would identify the heart attack risk for patients to enable them to take early intervention or preventive measures.

The data collection process in this chapter has some associated limitations, as the effectiveness of the ML model relies significantly on the quality and quantity of the data given to train the models. Medical data collection is challenging and raises several ethical and legal considerations, including patients' privacy and data security. Several datasets were tested in this chapter based on the data appropriateness to extract features and train models.

A good data set with only 303 records was found at a point in the data collection process. The quality of data features was excellent for the prediction process; however, the number of records in the data was small. To address this limitation in the number of records, data augmentation was used through repetition, which might exacerbate the overfitting risk. This might lead the ML model to memorize the duplicated instances rather than capturing the patterns. Furthermore, data augmentation was also needed in the second dataset collected because of the significant class imbalance that can occur in the data. Therefore, the Synthetic Minority Over-Sampling Technique (SMOTE) was employed to generate synthetic records based on the features of the minority class samples for class balancing.

MACHINE LEARNING MODELS

Decision Tree (DT) is considered a non-parametric ML algorithm that follows the method of "divide and rule," where the workspace is split into divisions. The DT algorithm uses the principles of greedy search to identify the optimal split points within a search tree. The decision tree structure is like a flowchart, in which the information gained from the dataset increasingly helps in building the tree recursively [8, 9].

The DT method can be utilized well for classification tasks, especially in the medical field, for diagnosing many diseases. Therefore, it is used due to the labeled data, which qualifies this chapter's tasks as classification. This chapter uses the decision tree to classify the labels as zeros or ones according to the given features. The root node is selected based on the highest information gain feature. It splits the tested dataset into many subsets that will be divided recurrently until no more subsets are separated by forming a termination node indicating the end of data [10]. The most important feature of this method is that it can manage the non-linearity in the data (between the features and the heart attack risk) that might sometimes be present in complex medical data. Because of the dataset division, there is no restraint in the relationship between the input variables and labels. This method also has low computational complexity, which makes it suitable for non-large datasets.

The Random Forest (RF) method is commonly employed for regression and classification problems. RF can be considered a bagging method extension that employs feature randomness for an uncorrelated forest of decision trees. The main significant difference between the RF and the decision tree method is that decision trees consider all the possible features for the node split. In contrast, the random forest only selects the subsets of those features to generate decisions. This method was used because it is highly stable. It gives the average answer given by

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CHAPTER 7

Predictive Analysis of Cardiovascular Health Through Machine Learning

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Abstract: Cardiovascular illnesses are a significant contributor to illness and death on a global scale, highlighting the importance of identifying them early and implementing preventative healthcare measures. The highest heart rate reached during physical activity, referred to as 'heartRate', is a crucial measure of an individual's cardiovascular well-being. Precisely forecasting this parameter can aid in promptly identifying individuals in danger, enabling immediate medical intervention. This study uses machine learning techniques to forecast 'heartRate' by examining various physiological and clinical characteristics. The chapter describes the utilization of Linear Regression, Random Forest, and Gradient Boosting models, with each model evaluated for its prediction accuracy. This work examines the inherent obstacles in machine learning applications in healthcare, including data imbalance and model interpretability. It offers a thorough review of the effectiveness of models used for predicting cardiovascular health indicators. This undertaking is not solely focused on forecasting a numerical value but on comprehending the complex connections among many health variables and how they collectively impact cardiovascular function. The goal is to aid in the early diagnosis of health issues and provide individualized healthcare solutions.

Keywords: Cardiovascular health, Gradient boosting regressor, Linear regression, Machine learning, Predictive analysis.

INTRODUCTION

The chapter explores the domain of predictive healthcare, explicitly examining the estimation of the maximum heart rate attainable during physical exercise, which is a crucial indicator of cardiovascular well-being. Using Machine Learning (ML) methods, the research intends to forecast the heart rate by analyzing a wide range of physiological and clinical characteristics [1, 2]. This would help in detecting potential heart-related health issues at an early stage. The main goal is to employ

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machine learning techniques to effectively estimate and predict the heart rate. This undertaking is not solely focused on forecasting a numerical value, but on comprehending the complex connections among many health variables and how they collectively impact cardiovascular function. The main objective is to develop a tool that can assist healthcare providers in proactively identifying patients with an elevated susceptibility to cardiovascular illnesses.

This chapter examines the utilization of ML methods to forecast the maximum attainable heart rate in individuals, a vital measure for evaluating cardiovascular well-being. Machine learning can play an important role in discovering medical risk factors using data-driven methods [3, 4]. The study uses three major machine learning models, Regressor of Random Forest Linear Regression [5 - 7], and Regressor of Gradient Boosting [8], to analyze physiological and clinical characteristics. The metrics of R-squared (R^2), Mean Absolute Error (MAE), and Mean Squared Error (MSE) [9 - 12] are used to assess the performance of each model on the tested dataset.

The chapter addresses obstacles such as imbalanced data, high dimensionality, and processing limitations to enhance the accuracy of the employed models. The results illustrate the considerable capacity of ML to improve the accuracy of predictions and provide valuable information for assessing cardiovascular health in the tested dataset. The goal is to aid in the early diagnosis of health issues and provide individualized healthcare solutions. This can facilitate early detection of heart disease, improving treatment outcomes. It can also optimize healthcare resource allocation by identifying high-risk individuals and advance research in applying machine learning to healthcare diagnostics.

PROBLEM DESCRIPTION

This chapter aims at leveraging Machine Learning (ML) to predict the maximum heart rate achieved (thalach) by individuals, which is a critical measure in assessing heart disease risk. By analyzing various physiological and clinical features alongside 'thalach', the chapter seeks to enable the early identification of individuals at risk for heart disease, potentially facilitating timely intervention and management.

MACHINE LEARNING LIBRARIES

The following libraries will be employed in this work [13].

- The pandas package is applied for data manipulation and ingestion.
- The Numpy package is applied for numerical operations.

- The Matplotlib.pyplot and Seaborn packages are used to visualize the data, facilitating an understanding of the distributions of various features and the target variable.
- **Sklearn** is used for its comprehensive suite of tools for machine learning, including various machine learning models that are imported for building predictive models.
- StandardScaler and MinMaxScaler are applied for feature scaling to normalize the tested dataset and improve the model training.

DATASET DESCRIPTION AND DATA PROCESSING

Dataset Description

The heart disease dataset encompasses a broad array of physiological and clinical features associated with heart disease. The dataset provides a comprehensive overview of patients' characteristics and their correlation with heart disease, with 1027 entries [14]. The features include:

- **Demographic Factors:**
  - Age: Patient's age.
  - Sex (female or male).
- **Behavioral Factors:**
  - Cp (Chest Pain Type): Serum cholesterol in mg/dl.
- **Medical History Factors:**
  - Fbs: Fasting blood sugar > 120 mg/dl (false or true).
  - Restecg: Categorizes resting electrocardiographic results into 3 types.
- **Medical Current Conditions:**
  - Trestbps (Resting Blood Pressure)
  - Chol: Serum cholesterol in mg/dl.
  - Thalach: Highest heart rate achieved.
  - Exang: Exercise-induced chest pain (yes or no).
  - Oldpeak: ST depression induced by exercise relative to rest.
  - Slope: peak exercise ST segment slope.
  - Ca: number of major vessels (0-4) colored by fluoroscopy.
  - Thal: thallium stress test results indicating probable heart disease (values 0-3).

Fig. (**1**) shows the dataset statistical information, and Fig. (**2**) presents the dataset correlation analysis.

CHAPTER 8

Machine Learning Models for Analyzing Diabetes Datasets to Predict Disease Progression and Patient Outcomes

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Abstract: Machine learning is central in analyzing numerical diabetes datasets to predict disease progression and patient outcomes. The primary objective is to develop a model that accurately forecasts the patient's future health status based on historical and current medical data. Predictive analytics is essential for early intervention and personalized patient care. The chapter focuses on the pressing healthcare challenge of diabetes, a pervasive condition characterized by significant complexity and requiring precise diagnostic measures. Recognizing the ample data available on diabetes and the severe complications associated with the disease, there is an imperative demand for enhancing the accuracy of its diagnosis. The dataset utilized in this chapter was meticulously compiled from patient records within the Iraqi healthcare system, specifically sourced from the Medical City Hospital's laboratory and the Specialized Center for Endocrinology and Diabetes at Al-Kindy Teaching Hospital. To advance the diagnosis and predictive modeling of diabetes, a comprehensive dataset was curated, drawing from a wide range of medical and laboratory analysis records. This dataset was pivotal in fostering a deeper understanding of the multifactorial nature of diabetes within Iraqi society. Support Vector Regression (SVR), Random Forest Regressor, and K-Nearest Neighbors Regressor (KNN) were applied to the tested dataset. In the experimental results, the SVR model showed the most significant improvement post-optimization, with substantial decreases in Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE), and a notable increase in R^2, indicating a substantial enhancement in both the model's accuracy and its explanatory power.

Keywords: Diabetes, K-nearest neighbors regressor, Machine learning, Random forest regressor, Support vector regression.

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INTRODUCTION

The prevalence of diabetes worldwide is a growing health concern, leading to an increased need for predictive models that can accurately forecast diabetes progression and complications based on patient data [1]. Machine learning models can be crucial in predicting such outcomes, which can be instrumental in preventive healthcare and resource optimization. However, the challenge lies in accurately modeling the progression of diabetes using clinical data, which is often heterogeneous and contains numerous potential predictors [2, 3]. The primary objective of this chapter is to process two distinct numerical datasets related to diabetes by cleaning data, which includes removing irrelevant features and handling missing values to create a robust dataset for model training.

Machine learning can be essential in discovering medical risk factors using data-driven methods [4, 5]. Three different machine learning regression models are selected to be applied to predict various diabetes-related outcomes: Support Vector Regression (SVR), Random Forest Regressor, and K-Nearest Neighbors Regressor (KNN) [6]. The model training is performed using the preprocessed dataset, and the initial performance is evaluated to establish a baseline for comparison. To assess the final models' performance on a separate test subset and generate comprehensive reports that include prediction error and original versus prediction analysis, insights are provided into each model's accuracy and precision.

The software libraries and packages involved in the execution of the machine learning project focused on diabetes dataset analysis and predictive modeling. The pandas (pd) package is used for data manipulation and analysis. It is used for reading, writing, and processing data from various file formats, as well as handling missing data. The NumPy (np) package is used for numerical computing with Python, which supports multi-dimensional arrays and provides mathematical functions to operate on array elements. The Matplotlib.pyplot (plt) is applied to the Python 2D plotting library. It includes creating static, interactive, and animated visualizations in Python. It is helpful for plotting graphs, histograms, and scatterplots.

The preprocessing and data cleaning process for completing missing values, including replacing these values encoded as np.nan using the mean, median, or most frequent value along each column, is performed based on Scikit-learn's Impute.SimpleImputer package. The standardization of the dataset for scaling features to center around zero with a standard deviation of one, essential for many machine learning algorithms, is applied using Scikit-learn's Preprocessing. StandardScaler package. Scaling each feature to a given range is performed by

Scikit-learn's Preprocessing.MinMaxScaler, which includes scaling a feature to a chosen range, often between zero and one. The last preprocessing step for encoding labels with values between 0 and n classes-1, including converting categorical text data into a model-understandable numerical format, is performed by Scikit-learn's Preprocessing.LabelEncoder.

The machine learning algorithms of the Scikit-Learn library include Scikit-learn's SVM.SVR, Scikit-learn's Ensemble.RandomForestRegressor, and Scikit-learn's Neighbors.KNeighborsRegressor. The training and evaluation of the machine learning model are performed using Scikit-learn's Model Selection. train_test_split and Scikit-learn's Metrics packages. Splitting arrays or matrices into random trains and test subsets, including splitting the dataset into training and testing sets for model validation, is a fundamental step in machine learning. The metrics for measuring model performance include mean_squared_error and mean_absolute_error, which evaluate the performance of the models.

Support Vector Regression (SVR) is applied in the context of regression problems. Random Forest Regressor and K-Nearest Neighbors Regressor (KNN) are also applied to the tested dataset. The KNN algorithm searches for 'k' nearest instances in the training dataset and averages their values to make a prediction. In the experimental results for the dataset, the SVR model shows the most significant improvement post-optimization, with substantial decreases in Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE), and a notable increase in R^2, indicating a substantial enhancement in both the model's accuracy and its explanatory power. The KNN model shows marginal improvements in MSE, RMSE, and MAE and a slight increase in R^2. The improvement is positive but not as pronounced as SVR. The Random Forest Regressor performed worse post-optimization, with increases in MSE, RMSE, and MAE and a decrease in R^2. This indicates that the optimization may not have been effective, or the model may have overfit the training data and thus performed poorly on the test set. After parameter optimization, the SVR model outperforms the other two models on the second dataset.

METHODOLOGY

Dataset and Evaluation Metrics

For the regression task, a numerical-related application and topic dataset (Diabetes Predictions) are used [7]. For implementation, the Python programming language is applied using Pandas, NumPy, Scikit-learn packages for machine learning algorithms, and Matplotlib for visualization. For the dataset preprocessing, the process includes:

CHAPTER 9

The Impact of Large Language Models on Healthcare

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Abstract: Healthcare will significantly shift, and LLMs will play a significant role in this industry. Retraining the use of medical databases or generic LLMs to finetune might help develop strategies to improve the usability of LLMs for healthcare. Additionally, multimodal LLMs feature fusion using various data sources, including tabular and visual data, which leads to even greater performance than humans. Even though there are many advantages to using LLMs, it is essential to acknowledge that the content created cannot be solely the responsibility of LLMs. To prevent any potential harm, it is crucial to thoroughly evaluate anything AI generates. Reducing the bar for LLM deployments means that there is more time to focus on improving deployment requirements. To better assist clinical decision-making, efforts should encourage incorporating LLMs in medicine, strengthen human-machine collaboration, and enhance LLM interpretability in clinical contexts. Physicians may optimize the advantages of AI while minimizing possible hazards and improving patient outcomes by utilizing LLMs as an auxiliary tool. Ultimately, the cooperation of administrators, patients, data scientists, doctors, and regulatory agencies will be necessary to integrate LLMs into healthcare effectively.

Keywords: AI, Corpus, Data, Ethical relationship, Healthcare, LLM, ML, Medical specialization, Training.

INTRODUCTION

A person's capacity to express and communicate is known as their language. It starts to form in early childhood and keeps evolving throughout their lifetime [1]. Conversely, machines must have the innate capacity to comprehend and exchange information through human language if outfitted with robust Artificial Intelligence (AI) algorithms. The objective of enabling robots to read, write, and

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converse like humans has long been a scientific problem [2]. Strictly speaking, one of the main strategies for increasing machine language intelligence is Language Modeling (LM). LM generally attempts to forecast the probability of future (or absent) tokens by modeling the generative likelihood of word sequences.

Large Language Models (LLMs) have gained immense interest in the last five years. These models have self-attention capabilities, and they can extract and understand the meaning and relationship between words and phrases in a sentence. These large-scale unsupervised models are trained on an enormous amount of data to enable them to generate coherent and contextually relevant responses. LLMs have found applications in various domains, including healthcare, entertainment, transportation, education, etc.

Large Language Models (LLMs) are set to revolutionize healthcare. They can enhance clinical decision support, automate administrative tasks, and improve patient engagement. LLMs have applications in various medical specialties, offering innovative solutions for diagnostics and patient care. However, integrating LLMs in healthcare faces challenges like data privacy, security concerns, and the need for vast training data. Collaborative efforts between healthcare professionals and data scientists are essential to realize the full potential of LLMs in healthcare. Section 1 of this chapter reviews the background of large language models.

BACKGROUND OF LLMS

Language models are probabilistic models used for various text-based natural language processing tasks. LLMs are the latest form of language models. They combine large data sets, neural networks, and transformers. This section covers the four main phases of development in LM research:

- Statistical Language Models (SLM). The prominent statistical learning methods in the 1990s generated SLMs [3]. The primary objective is to create a word prediction model based on the Markov assumption, for example, using the most recent context to anticipate the following phrase. Bigram and trigram language models are examples of SLMs. These language models extensively improve task performance in Natural Language Processing (NLP) and information retrieval [4, 5]. Nevertheless, high-order language models endure the “curse of dimensionality,” making it challenging to predict exponential transition probabilities.
- Neural Language Models (NLM). Using neural networks, such as recurrent neural networks and multi-layer perceptrons, NLMs [6] define the probability of

word sequences. A study [7] significantly contributed to this by creating and expanding the concept of learning efficient features for text input conditioned on the aggregated context information and presenting the idea of distributed representation of words. Generic neural network techniques expanded the concept of learning efficient features for text input to create a comprehensive solution for a range of NLP applications. Moreover, Word2Vec is a technique that builds a more straightforward, shallow neural network to learn distributed word representations. It was introduced and quickly gained popularity in various natural language processing applications. This research has significantly influenced the area of NLP by introducing the representation learning application of language models.

- Pre-trained Language Models (PLM). An early technique called ELMo [8] included pre-training a bidirectional long short-term memory network and optimizing it according to specific downstream tasks. This allowed for learning fixed word representations rather than context-aware word representations. These pre-trained context-aware word representations have significantly raised the bar for Natural Language Processing (NLP) tasks and are instrumental as all-purpose semantic features. This work has motivated numerous follow-up studies and established the paradigm for "pretraining and finetuning" learning. Much work on PLMs has been created after this framework, presenting distinct designs such as GPT-2 [9]. According to this paradigm, the PLM must frequently adjust to various requirements and conditions.
- Large Language Models (LLM). Researchers discover that improving model capability frequently results from scaling PLM [10]. Many experiments have trained ever-larger PLMs to investigate the performance limit. These larger PLMs behave differently from smaller PLMs and demonstrate unexpected capabilities in resolving several challenging tasks despite scaling primarily done in model size. These huge-sized PLMs, garnering more and more interest from researchers, are referred to by the academic community as "Large Language Models (LLM)." One outstanding use of LLMs is ChatGPT2, which transforms the GPT series LLMs into dialogue and offers incredible human communication capabilities. Thus, one type of Artificial Intelligence (AI) produced by training neural networks on massive amounts of textual data is Large Language Models (LLMs). Source code and other innovative human-like outputs may be made quickly by LLMs.

KEY TECHNIQUES FOR LLM

The evolution of LLMs into broad and competent learners has been a long journey. LLM's success can be attributed to various crucial strategies, as discussed below:

CHAPTER 10

Ethical and Legal Framework for AI in Healthcare

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Abstract: The adoption of new technology by a nation plays a vital role in its growth. The use of AI systems in the healthcare sector holds a stronger position with the increasing presence of advanced technology. These systems provide recognition to the processing and analysis stage, where medical data is considered, its pattern is located, and information is gathered. However, there is a high risk involved when any new form of technology is utilized in reality. In society, there is a need to understand the significance of maintaining both ethical and legal aspects when using AI systems. With transformative technology, the livelihood of an individual is impacted. In healthcare, any error in procedures and protocols can lead to disaster. The integration of these systems in medical practice requires an effective legal framework that can safeguard human health. There is a need for training and education sessions for the stakeholders to have awareness of the new technologies' complexities. This chapter will highlight the critical concerns that are required to be taken into focus to maintain privacy and algorithmic transparency. It guides the policy draft makers to consider the moral grounds to ensure accessibility. Since the level of danger is unpredictable, the AI utilization needs to have its limitations. With effective harmonized governance, the adoption of AI will navigate more opportunities and build a landscape that will be beneficial for mankind.

Keywords: AI system, Algorithm, Ethical, Healthcare, Legal framework, Privacy, Technology.

INTRODUCTION

In the field of healthcare, the utilization of AI has been the most recent change that has been introduced. Being under the domain of computer science, AI is expected to make the system more efficient and quicker. With the presence of dedicated algorithms, the aspect of problem-solving and learning has become more approachable. By recognizing the repetitive patterns, the technology is based on drawing conclusions.

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With the development in this sector, several applications have been strengthening its performance. For instance, machine learning has been used to perform various roles in this sector. Providing information about the patients from multiple platforms has resulted in the formation of structured data. This has opened the pathway for innovative ideas and the delivery of accurate information. This technology has guided doctors by providing diagnoses and treatment plans, along with estimated predictions. It is beneficial in monitoring and developing medicines. To promote preventive measures, the healthcare sector is focused on updating itself with new innovative AI applications nowadays [1].

To maintain the smooth functioning and effective monitoring of this technology, there is a requirement for an ethical and legal regulatory framework to ensure adequate involvement of AI in healthcare activities [1]. To support the efficiency and accuracy of diagnosis and treatment systems, AI has been a great guide during the COVID-19 pandemic. Post this pandemic, AI has been introduced in the service facility. Unfortunately, the concern arises about patient information confidentiality. There is a requirement to train the employees before taking assistance from any AI system. There is a need to maintain human equity and focus on preventive measures, as there might be errors while operating this system. There is a requirement of liability and responsibility when considering such situations. There is an urgency to have governance for maintaining collaborative steps that address ethical and legal considerations while using these technologies. Data security, appropriate consent, and privacy are essential elements to prevail in ethical AI. These technologies are required to be free from bias, and governance for software and algorithms should be uniformly applied. Also, they need to maintain transparency while addressing social and ethical concerns, which require a protective regulatory framework [2]. To have improved outcomes, research skills, and clinical trial results, AI must be monitored to attain a healthy impact on the environment [3].

The WHO's report has highlighted the principles and considerations that must be followed for ethical reasons. By reflecting on the challenges, this report has determined the gaps that must be addressed to maintain AI standards in the future [4]. It can be a great contributor to achieving sustainability to attain universal health coverage. Despite this, it has been a matter of concern regarding how transnational issues can be taken into consideration. Software utilization and its computing have resulted in various challenges in addressing human health support. To promote the practice of human autonomy and technology accessibility, AI needs to be regulated and monitored adequately. There is a need to invest in healthcare technology to strengthen AI usage in emerging and developed nations. To fight against misleading data, illegal usage of applications, and ineffective health applications, there is a necessity to have ethical and legal parameters to safeguard the dignity, confidentiality, and privacy of an individual as a patient [5]. There is a need to engage in adaptability and interaction with the data while providing this service. Victims of data breaches are required to have preventive mechanisms in place. Effective governance leads to ethical behavior, which results in the development of algorithms that predict and offer help in drug discovery, diagnosis, and operational efficiency. Medical decisions should be human-protective, based on the possibility of providing remedies for healthcare facilities [6]. Human intelligence combined with AI requires the effective development of algorithms and computational methods through which machines can predict accurate data, and this information can be used for achieving determined goals. Healthcare facilities can only be improved when appropriate guidelines are provided by the authorities. To support clinical performance, there is a need to reduce human errors, which requires technology that prevents unforeseeable circumstances. Ethically, there is a necessity to have qualified and trained medical manpower. The liability of prescriptions generated by AI is unclear, which requires stakeholders in this field to be obedient followers of the legislative system in the near future. AI integration in this would require stronger and narrower tasks to be fulfilled properly with effective moral standards and a legitimate approach [7].

Ethical Standards: AI Use in Healthcare

There is a need to understand that sensitivity should be among the primary goals of maintaining AI as a safety tool. Being accessible, it must be ensured that there is no invasion of privacy. Due to its inclusivity, AI is required to be examined. Being non-discriminatory would lower the risk involved. Despite contextual and emotional intelligence, it is required to be user-centric, which will lead to safer AI. AI being responsible could result in attaining sustainability. It is essential that AI ethics be based on these aspects, which would enhance user participation. By maintaining fairness in AI systems, the outcomes will be beneficial in considering societal requirements. The technology can be utilized for users' comfort by understanding their needs. By reflecting on their emotions and needs, one can understand the user's objective in preferring AI systems. Such practices enhance the vital role of prevailing ethical standards when using these systems. With responsible AI developers, the security and integrity of healthcare prevail. The AI models should only be used for authorized purposes and should prevent manipulation. With social values, the AI ecosystem would fulfill societal requirements. With technical support, its performance can be improved and result in the fulfillment of long-term goals. By incorporating ethics into technology implementation, its ecosystem would become equitable and reliable. With an awareness program, AI governance can be ethically formulated. Monitoring will guide AI in its functioning and will fulfill the user's needs. Transparency in this

CHAPTER 11

AI In Medicine and Healthcare Sector: An Analysis of Laws of Medical Negligence

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Abstract: Artificial Intelligence (AI) is rapidly transforming the healthcare landscape, offering exciting possibilities from drug discovery to improved disease diagnosis and treatment planning. Real-world examples are woven throughout the paper to illustrate the significant impact AI already has on various aspects of patient care. However, implementing AI in healthcare is not without its challenges. Ethical considerations, data privacy concerns, and potential biases in algorithms are all critical issues that demand careful attention. The paper emphasizes the importance of transparency, fairness, and trust in developing and deploying AI-powered healthcare solutions. Obtaining informed consent from patients when AI is involved in their diagnosis or treatment is a complex issue that needs to be addressed. Ensuring the reliability and safety of AI algorithms, while maintaining transparency in the development process, presents another hurdle. Mitigating bias in AI algorithms is crucial to guarantee fair and equitable treatment for all patients. Finally, protecting patient privacy while enabling data sharing for AI development presents a significant challenge. Collaboration among healthcare professionals, AI developers, and policymakers is crucial to ensure that AI is used responsibly and effectively to improve healthcare outcomes for all. Beyond the potential of AI, the paper delves into the legal and ethical considerations that arise with its use in medicine.

The first aspect to consider is the copyright and patent rights associated with AI creations, as well as the question of liability. Can AI be held liable for medical negligence? If so, who is responsible – the AI itself, its creator, or some combination? These questions become even more relevant in the context of established medical negligence jurisprudence. This paper seeks to understand how different countries are approaching AI-based medical treatments and explores the prospects for future development. It also discusses the legal and ethical implications that may arise, analyzing the advantages and disadvantages of investing in AI for healthcare. By undertaking a doctrinal research approach, the paper critically evaluates the prospects of integrating AI into the healthcare sector and analyzes the policy and legal frameworks needed to ensure responsible use. This research is particularly relevant for policymakers and legal professionals responsible for shaping AI's future in healthcare.

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INTRODUCTION

Integrating Artificial Intelligence (AI) into healthcare has revolutionized medical diagnostics, treatment planning, and patient care. AI-powered tools, such as machine learning algorithms, robotic surgery systems, and predictive analytics, have enhanced precision, efficiency, and accessibility in medicine. However, the increasing reliance on AI in clinical decision-making raises critical legal and ethical concerns, particularly regarding accountability in medical negligence cases.

Traditional medical negligence laws are based on human error and professional liability, but AI introduces complexities where responsibility may be distributed among developers, healthcare providers, and even the AI systems themselves. As AI evolves, legal frameworks must adapt to address issues such as algorithmic bias, data privacy, and liability attribution in AI-related medical errors.

Individuals have rights and liabilities inherent to their liberty within society and under the law. These rights and freedoms are granted by the law and are supported by consequences for actions that infringe upon the freedom of others. The law aims to establish equilibrium in society by regulating the exercise of rights and imposing liabilities for any harm caused to others. The principles of liability arise from the interaction between the exercise of rights and liberties on one hand and the violation of the rights of others on the other hand. Intellectual property rights, too, are based on the concept of 'Balance of Rights' between the right holder and the interests of society. Both copyrights and patent law aim to incentivize the author/inventor of a new form of creation, which will, at the end of the term of protection, fall into the public domain, thereby serving to cater to the interests of the public. The IP laws are based on the premise of affording protection against any form of infringement, and hence, these are negative rights that grant a monopoly status to the right holder. The Utilitarian and the Labor theories are justifications behind the grant of IP rights, which seek to protect the rights and interests of the creator against any alleged infringer who tries to accrue unjust enrichment from the creations of the former.

The Law of Torts encompasses various civil wrongs, including negligence, which occurs when one person breaches their duty of care towards another person. This duty of care is imposed by law and requires individuals to take measures to protect, preserve, and respect the rights of others. Negligence can include reckless and careless behavior, regardless of whether there is an intention to cause harm. Recklessness occurs when someone is unaware of another person's rights and their duty of care. On the other hand, carelessness involves a lack of diligence and consideration for the potential consequences of breaching the duty of care. If a party is found negligent and their actions result in harm or damage to another person, they can be held liable for their actions and may be required to compensate the affected party. This ensures that individuals exercise their rights and freedoms without infringing upon the rights of others.

The concept of Artificial Intelligence (AI) and its applications in medicine and healthcare are explored in this article. It examines the potential implications of AI on copyrights and patents, questioning whether AI devices and their output should be eligible for intellectual property rights. Additionally, the article delves into the concept of professional and medical negligence, specifically focusing on cases of medical negligence involving AI. It discusses the legal framework surrounding the liability of doctors and medical practitioners and the importance of informed consent in determining their liability. The article aims to analyze the intersection of AI and tort law, highlighting the potential challenges and considerations that may arise in the future.

ARTIFICIAL INTELLIGENCE IN MEDICINE AND HEALTHCARE

R. Kurzweil has defined artificial intelligence as "the science of making computers do things that require intelligence when done by humans" [1]. AI can be defined as the capability of a computer program or a computer-controlled robot to perform tasks that would typically require human intelligence [2]. The Cambridge Dictionary has defined artificial intelligence as "the study of how to produce machines that have some of the qualities that the human mind has, such as the ability to understand language, recognize pictures, solve problems, and learn from experience". [3] Prolific developments made over a few decades in the recent past seem to have transformed the definition of artificial intelligence to 'an imitating intelligent human behavior'. [4] With the emergence of a new era, it is now possible for programs to generate original and novel creative works independently, without human intervention. Artificial Intelligence systems are designed to empower computers to perform tasks that typically require human-like intelligence [5]. AI systems are equipped with algorithms that learn from the data fed into them, enabling them to generate creative works with minimal human involvement. Artificial Intelligence is a field focused on developing computer programs capable of performing tasks that would typically require human intelligence, such as language translation and speech recognition. AI can be seen as the ability of a computer program or a robot to perform tasks that would usually require human intelligence [6].

CHAPTER 12

Précision Healthcare: Advancing Patient Care Through Decision Tools, Wearables, and Ethical Considerations

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Abstract: Précision healthcare is a revolutionary approach to medicine that emphasizes individualized treatment plans based on each patient's unique needs. This abstract delves into several aspects of précision healthcare, including wearable technology, sophisticated decision-making tools, patient care paradigms, and related ethical and legal issues. Précision healthcare transforms patient care through clinical, genetic, and lifestyle data by tailoring treatment plans to optimize benefits and reduce adverse effects. Modern systems must process complex decision-making information, like Artificial Intelligence (AI) and Machine Learning (ML) algorithms, to accurately and promptly inform healthcare decisions. With the ability to continuously monitor vital signs, exercise levels, and illness biomarkers, wearables have become essential components of précision healthcare. These gadgets make it possible to gather real-time data, improving early health anomaly detection and remote patient monitoring. Nonetheless, there are important moral and legal issues with applying précision medicine. Considering problems like patient consent for data use, privacy protection, and fair access to cutting-edge technologies is essential. Regulatory frameworks must change to promote innovation in healthcare delivery and guarantee adherence to ethical norms and data protection regulations. In navigating the complex legal and ethical considerations terrain, this chapter offers a thorough overview of the multifaceted landscape of précision healthcare, highlighting its potential to revolutionize patient outcomes through tailored treatments, cutting-edge decision tools, and wearable technologies.

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INTRODUCTION

Précision healthcare, also called précision or personalized medicine, is a transformative approach to medical treatment and healthcare delivery [1]. It aims to customize healthcare decisions, practices, interventions, and products to individual subjects/patients or groups of subjects/patients, depending on their individual characteristics. These features/characteristics include genetic history/makeup, biomarkers, lifestyle, and physical environmental factors [2].

The core principle of précision healthcare is to move away from the traditional one-size-fits-all approach, which assumes that the same treatment or intervention will work similarly for everyone [3].

Instead, précision healthcare leverages advanced technologies such as genomics, big data analytics, and AI to tailor medical care according to each patient's needs [4]. This approach allows healthcare providers to predict more accurately which treatments and prevention strategies will be most effective and safe for each individual [5]. Key elements of précision healthcare include:

- Genomics and Molecular Profiling: Understanding the genetic and molecular basis of diseases to identify genetic makeup or genetic variations that can influence disease development, progression, and response toward treatment [6].
- Data Integration and Analysis: Utilizing large-scale data sets, including Electronic Health Records (EHRs), genetic data, imaging data, and patient-reported outcomes, to derive insights and make informed decisions [7].
- Targeted Therapies: Developing therapies that target specific genetic mutations or biomarkers associated with particular diseases, thereby improving treatment efficacy and minimizing side effects [8].
- Preventive and Predictive Medicine: Predicting disease risk based on genetic predispositions and other factors, enabling early intervention and personalized preventive strategies [9].
- Patient-Centered Care: This approach involves putting the patient at the center of decision-making and considering their preferences, values, and goals when developing treatment plans [10, 11].

Précision healthcare can revolutionize healthcare delivery through effective treatment, reduced adverse effects, and optimized resource allocation. However, challenges such as data privacy concerns, integration of complex data sets, and equitable access to these advanced technologies remain essential considerations in their widespread adoption. In summary, précision healthcare represents a shift in pattern toward more effective and patient-centric medical care, promising to improve outcomes and quality of life for patients across diverse populations.

PRÉCISION HEALTHCARE AND WEARABLE TECHNOLOGY

Précision healthcare leverages wearable technology to collect real-time, continuous data on an individual's health parameters. Wearable devices monitor various metrics like activity levels, heart rate, sleeping patterns, levels of oxygen, blood glucose, etc. Wearable devices include fitness trackers, smartwatches, and biosensors [12]. The integration of wearable technology into précision healthcare offers the following:

- Continuous Monitoring: Wearable devices offer healthcare professionals a real-time view and a comprehensive continuous stream of data, which is more precise than periodic check-ups [13].
- Personalized Insights: Data from wearables can be analyzed alongside other health information (like genetic data or medical history) to personalize treatment plans and interventions based on individual health patterns and needs [1].
- Early Detection and Prevention: Wearables can detect subtle changes in health metrics early, enabling early intervention and preventive measures tailored to individual risks and behaviors [14].
- Patient Empowerment: Wearable devices empower patients and give them access to self-health data, promoting self-awareness, adherence to treatment plans, and active participation in their healthcare decisions [14, 15].
- Research and Development: Aggregated data from wearables contribute to large-scale studies and research efforts, accelerating the development of new treatments, interventions, and healthcare innovations [16].

While wearable technology enhances the potential of précision healthcare, challenges such as data privacy, measurement accuracy, and integration into clinical workflows need to be addressed to fully realize its benefits in improving patient outcomes and healthcare delivery.

DECISION-MAKING TOOLS IN PRÉCISION HEALTHCARE

Decision-making in précision healthcare is supported by various tools and technologies that enhance the ability of healthcare providers to deliver personalized and effective treatments [17]. These tools leverage advanced analytics, genetic information, and patient-specific data to inform clinical decisions [18]. Here are some key decision-making tools in précision healthcare:

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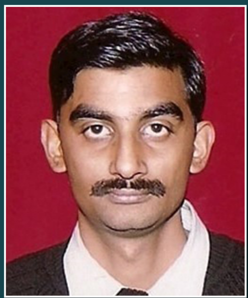

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Shobhna Jeet

Dr. Shobhna Jeet, from the School of Legal Studies at K.R. Mangalam University, is a specialist in health law, bioethics, and medico-legal regulation. Her academic expertise encompasses patient rights, data protection in healthcare, privacy laws, digital health governance, and legal concerns surrounding AI-assisted diagnosis and wearables. She has contributed to teaching, legal research, and interdisciplinary consultancy, offering deep insight into compliance, accountability, and ethical frameworks in healthcare systems. Dr. Jeet's scholarship ensures that advancements in precision healthcare align with legal safeguards and ethical standards, strengthening the human-centric, transparent, and responsible deployment of emerging clinical and digital-health technologies.