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Artificial Intelligence-Based Mobile Health Solutions in the Health 4.0 Era

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ABSTRACT

In the Health 4.0 era, technological advances continue to bring major changes to the health care industry. Artificial intelligence (AI)-based Mobile Health (mHealth) solutions are an important innovation that will meet modern needs. As time goes by, modern society is increasingly dependent on health technology in everyday life, especially to manage their health conditions. The use of Mobile Health, especially via smartphone devices, has been proven to provide more personalized and affordable health services. Additionally, AI makes diagnosis and health monitoring easier. In this article, the concept of mHealth AI 4.0 is discussed, with particular emphasis on its critical role in providing responsive, proactive, and patient-focused healthcare. In the Health 4.0 era, it is hoped that we can make a positive contribution to improving the quality of health services by using this solution.

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1. INTRODUCTION

Health is essential to happiness, productivity, and personal satisfaction. It affects physical health, mental health, longevity, academic and professional success, interpersonal relationships, and relationships with others. Additionally, it reduces health care costs, drives economic growth, and improves societal well-being. Customer needs can be integrated into the entire production process by industry 4.0 through its cyber-physical systems. With the help of experts in the pharmaceutical industry, machine learning approaches can study the behavior of drugs and vaccines and develop new drugs. Big data analysis accelerates the identification of potential drugs that suit a patient's condition. The use of smart machines and supply chain management systems in the healthcare sector can help optimize the distribution of healthcare resources across the country. By integrating Industry 4.0 principles into the healthcare supply chain, we can improve coordination, efficiency and better respond to the growing demand for healthcare services[1][2].

industrial revolution 4.0 with artificial intelligence (AI) studied technologies, such as additive manufacturing, artificial intelligence, artificial vision, big data, advanced analytics, cybersecurity, developments in the Internet of Things (IoT), robotics, and virtual reality and augmented reality, and supporting technologies to assist the design and implementation of systems that can help reduce occupational health and safety risks associated with physical and mechanical work. However, the type of technology and how it is used influences it [3][4][5].

One important factor that can influence the level of innovation in organizations, regions and countries is ease of access to knowledge. Encouraging the exchange of knowledge between economic actors from various contexts and sectors will increase their level of innovation. So it shows that technological awareness, the influence of social media, and personal innovation significantly influence the function of human resources with artificial intelligence. In addition, perceived risk significantly moderates the relationship between technology awareness and human resource functions [6][7].

2. PREVIOUS RESEARCH AND LITERATURE REVIEW

Some of the research results on the role of mobile health and AI in global healthcare today are as follows.

Table 1. Results of Previous Research Review

Title	Author	Method	Results	Weaknesses and strengths
Ethics 4.0: Ethical Dilemmas in Healthcare Mediated by Social Robots [8]	Antonio Soares Nuno Piçarra, Jean Christopher Giger, Raquel Oliveira, Patricia Arriaga	GPower software was used for sample size calculation in this study.	showed that people are more likely to perceive healthcare agents who respect patient autonomy	The advantages include greater respect for patient autonomy and better moral factors. On the other hand, there are shortcomings, such as the perception of lower moral responsibility for robots and the emergence of ethical issues in treatment decisions, which show how complex the development of health technologies that take the patient's ethical perspective into account is.
Artificial Intelligence in Health Use of digital transformation and artificial intelligence strategies for pharmaceutical industry in Pakistan : Applications and challenges[9]	Khadija Shoukat Min Jian Muhammad Umar Habiba Kalsoom	The methodology used in this research involves analyzing literature and previous research to evaluate developments in digitalization of the pharmaceutical industry in the United States, European Union, and Japan, as well as analyzing the current situation in Pakistan's pharmaceutical industry	Pakistan needs to accelerate digital transformation in the pharmaceutical industry and build a more efficient service platform for pharmaceutical companies	The advantage of this journal is that it provides in-depth insights into the application of digital technology and AI in the Pakistani pharmaceutical industry. However, a drawback is the lack of direct empirical data that supports the proposed findings and recommendations [6]. In addition, this journal also does not provide information about ethical approval and data availability, which may affect the validity and generalizability of research findings
Demystifying Supervised Learning in Healthcare 4.0: A New Reality of Transforming Diagnostic Medicine[10]	Sudipta Roy, Tanushree Meena and Se-Jung Lim	Commonly used methodologies include supervised learning with various types such as classification and regression trees (CART), RF, NB, SVM, ANNs, and RNNs	The use of the SML method in the field of medical imaging can help in disease detection, target lesion segmentation, radiotherapy dose estimation, and synthetic image generation.	The advantages of using SML in the field of medical imaging include its ability to produce accurate, stable and reliable results. However, there are also some drawbacks, such as privacy issues, data security, and bias in data-based decision making
Journal of Information Security and Applications	Sudeep Tanwar, Karan Parekha,	Comparison of Blockchain-Based Methods: This article presents a	According to the performance evaluation, this article suggests a patient-	This article provides a comprehensive overview of the use of blockchain technology in health systems,

Blockchain-based electronic healthcare record system for healthcare 4 . 0 applications[11]	Richard Evans	comparison of current methods for securing electronic health systems (EHR).	based method that uses blockchain technology to improve EHR security and privacy and shows increased throughput and decreased latency. This article discusses a comparison of blockchain to ensure the security of health e-journals and the potential use of blockchain in revolutionizing the health system. Distributed ledgers, consensus, and smart contracts are cited as advantages of this technology. Overall, this article provides insight into blockchain applications that can improve EHR performance, security, and privacy.	specifically in improving the security of electronic health records (EHR). A comparison of different blockchain approaches to secure EHRs provides insight into the advantages and disadvantages of each. However, this article lacks detailed information regarding the methodology of reviewing related works and performance evaluation, limiting the reproducibility of the results. The advantage lies in the proposed patient-based approach to access control policy. However, increased methodological transparency is needed to strengthen the validity of the results.
Medical 4.0 technologies for healthcare: Features, capabilities, and applications[12]	Abid Haleem Mohd Javaid Ravi Pratap Singh, Rajiv Suman	The research method used in the journal is a literature study based on a literature review to understand Medical 4.0 technology and its application in the health sector	Health 4.0 technologies, such as m-health, IoT, and big data analytics, have revolutionized the healthcare industry by improving patient care, personalized medicine, and data analysis. Design plays an important role in the development of smart health systems, with a focus on human-centered design and patient safety. Nonetheless, the implementation of these technologies also poses challenges, such as ownership of patient data, conflicts between data and self-diagnosis, and cultural changes in the health system. However, the potential impact of technological advances in healthcare is significant, with the potential to improve patient health and the health system as a whole.	The strength of this journal is that it presents comprehensive information regarding Medical 4.0 technology and its application in the health sector. However, the weakness of this journal is the lack of emphasis on the challenges and obstacles that may be faced in implementing Medical 4.0 technology in the health sector.

Design for Health 4.0: Exploration of A New Area[13]	Bause, Melania; Khayamian Esfahani, Bahar; Forbes, Hannah; Schaefer, Dirk	The research methods used in this journal include analysis and synthesis of literature regarding Health 4.0, as well as discussion of the role of technology and design in Health 4.0.	The result of this journal is an emphasis on the importance of technology in Health 4.0, as well as the role of design in the development of smart health systems. Although there are challenges in implementing this technology, its potential impact is significant in improving the health of patients and the health system as a whole. The journal also highlights the role of technology in enabling personalized healthcare and provides an overview of the challenges and opportunities associated with Health 4.0.	The advantage of this journal is that it provides an in-depth understanding of Health 4.0 and the latest health technologies, as well as highlighting the role of design in the development of smart health systems. However, the shortcomings of this journal are the lack of emphasis on concrete solutions to overcome the challenges faced in the implementation of health technology, as well as the lack of discussion regarding the social and cultural impacts of the use of technology in health.
Artificial intelligence-powered decentralized framework for Internet of Things in Healthcare 4.0[14]	Vikram Puri Aman Kataria Vishal Sharm	This research uses experimental methods to evaluate the performance of blockchain technology in health data management.	The article discusses the use of blockchain technology in decentralized health data management. This research aims to provide transparency, security and privacy in patient health data. They perform performance evaluations in terms of time consumption, energy, transaction throughput, average latency, and gas consumption.	The weakness of the journal discussion is the lack of explanation about how to integrate artificial intelligence with smart contracts and blockchain technology in health 4.0 applications. The advantage is the in-depth discussion about evaluating the performance of blockchain technology in health data management, as well as the integration of rule-based artificial intelligence, nodes
Innovations in Internet of Medical Things, Artificial Intelligence, and Readiness of the Healthcare Sector Towards Health 4.0 Adoption[15]	Kamalakanta Muduli, Mechanical Engineering Department Papua New Guinea University of Technology, Lae, Papua New Guinea & Mechanical Engineering Department, CV Raman Global University,	The research method used in this journal is SWOT-AHP analysis to identify areas that need urgent improvement in facilitating the adoption of Health 4.0	This journal discusses innovations in the Internet of Medical Things, artificial intelligence, and the health sector's readiness for the adoption of Health 4.0 in India. Through SWOT-AHP analysis, this journal identifies areas that need urgent improvement to facilitate the adoption of Health 4.0.	The strength of this journal is that it presents a SWOT-AHP analysis that helps identify areas that need urgent improvement to facilitate the adoption of Health 4.0 in India [3]. However, the drawback is that it is not explicitly mentioned in the available information

	Odisha, India, Venkata Parsuram Kommula, University of Botswana, Botswana, Kalyan Kumar Sahoo, Arni University, India			
Application of the Industry 4.0 Technologies to Mobile Learning and Health Education Apps[16]	Nuno Mateus-Coelho, Maria Manuela Cruz-Cunha Paulo Silva Ávila	This study used a questionnaire approach to collect data from medical students and young doctors at two universities in Portugal	The results showed that mobile health applications have been well received by users and have the potential to improve health knowledge, skills and practices.	The advantage of the research method used is the use of a questionnaire which allows collecting data from a wide number of respondents, in this case medical students and young doctors. However, the disadvantage of this research method is the limitation in obtaining more in-depth or contextual information from respondents. Apart from that, the use of questionnaires can also give rise to bias or errors in filling in data by respondents
Impact of industrial revolution 4.0 on reproductive health and infertility management[17]	Sulagna Dutta Pallav Sengupta	ctDNA detection method, this research invites readers to understand the role of ctDNA in tracking tumor processes molecularly	The results show that liquid biopsy, especially ctDNA, can help complement pathological and imaging results in the diagnosis of lung cancer.	Liquid biopsy has many interesting advantages, especially when using circulating tumor DNA (ctDNA). Its non-invasive approach differentiates it from invasive tissue biopsy procedures and reduces risk and discomfort for the patient. When the sensitivity and specificity of ctDNA are low, its ability to detect mutations or molecular changes can be limited.

Based on the table above, here is a discussion of a summary of some research mobile health and AI in global health:

1. The GPower approach of measuring sample size in this study indicates that people are more likely to like healthcare providers who provide patient-centered care. The consequences include higher expectations about patient outcomes and more positive moral factors. But it must be acknowledged that there are drawbacks, such as moral relativism that is more prevalent in robots and the emergence of ethical problems in worker protests. This illustrates the intricate process of developing health technology that enhances patient perspective
2. This study employs a methodology of literature analysis and ongoing research to assess the pace of digitalization in the pharmaceutical industry in the United States, Europe, and Japan while analyzing the current state of the Pakistani pharmaceutical industry. First and foremost, this indicates that Pakistan needs to embrace digital transformation in the pharmaceutical industry and create more efficient pharmaceutical company platforms. The strengths of this journal lie in the research findings about the application of digital technology and artificial intelligence (AI) in Pakistan's pharmaceutical industry. However, the deviation includes imprecise empirical data that undermines the conclusions

and recommendations made, as well as unclear information about the purpose of the experiment and data availability, which might affect the validity and generalizability of the study.

3. A common methodology used in medical transcription is supervised learning, which employs a variety of models such as Random Forest (RF), Classification and Regression Trees (CART), Naive Bayes (NB), Support Vector Machines (SVM), Artificial Neural Networks (ANNs), and Recurrent Neural Networks (RNNs). Utilizing the Supervised Machine Learning (SML) method in healthcare can make a significant contribution to disease detection, target lesion segmentation, radiotherapy dosage estimation, and even the generation of synthetic patients. The significant improvement from SML is attributed to its ability to provide results that are accurate, stable, and interpretable, enabling more accurate diagnosis and more efficient patient care. Nevertheless, concerns about privacy, medical data security, and potential bias in data-driven decision-making must also be carefully considered in order to ensure ethical and secure implementation.
4. This article compares current methods for implementing electronic health records (EHRs) with a focus on blockchain technology. Increased throughput and decreased latency accommodate adopting patient-based methods that leverage blockchain technology to improve EHR security and privacy, as well as improved performance. The article highlights key features such as distributed ledgers, consensus, and smarts as the main benefits of blockchain technology. In summary, this article provides comprehensive information about the use of blockchain applications to improve work efficiency, security, and privacy of electronic health records, particularly in the context of the healthcare system's revolution. Despite this, there are still limitations when it comes to providing information about the methodology of job evaluation and training, which can lower reproducibility of results. This article's strengths are based on the use of a patient-centered approach for controlling access procedures; however, greater methodological transparency is required to ensure the validity of the results presented.
5. This journal uses a method of literature study based on case studies to understand Medical 4.0 technology and its applications in the health sector. Healthcare 4.0 technologies, such as IoT, m-health, and big data analysis, have revolutionized the healthcare industry by increasing patient safety, personalizing medication, and conducting data analysis. With an emphasis on human-centered design and patient-centered design, architecture retains a crucial role in the development of the intelligent health system. However, the application of this technology also creates challenges, such as the loss of patient data, conflicts between data and self-diagnosis, and changes to the dietary regimen within the healthcare system. Nonetheless, the potential impact of technological advances in health is significant, with the potential to improve the health of patients and the health system as a whole. The journal's strengths are found in its comprehensive information research on Medical 4.0 technology and its applications in the health sector. But the drawback is the potentially dangerous nature of the challenges and obstacles that are encountered when implementing Medical 4.0 technology in the healthcare sector.
6. To see Health 4.0, this journal uses literature analysis and synthesis methods. The results show that design and technology are critical to building smart health systems. The journal highlights the benefits of technology for improving the health of patients and the health system as a whole, although it acknowledges the difficulties of implementation. Understanding of the latest health and Health 4.0 technologies, as well as an emphasis on the role of design, makes her stand out. However, shortcomings include a lack of concrete solutions to address problems that arise when implementing health technologies and a lack of discussion about the social and cultural impacts of implementing technologies in health contexts.
7. Experimental methods were used in the research to evaluate how blockchain technology functions in health data management, with particular emphasis on system decentralization. The main goal is to increase the openness, security and privacy of patient health information. Time, energy, transaction throughput, average latency, and gas consumption are part of the performance evaluation. This journal has shortcomings because it does not provide an explanation of the integration of artificial intelligence with smart contracts and blockchain technology in health 4.0 applications. However, the benefit lies in the in-depth analysis of the performance evaluation of blockchain technology in health data management, which includes a discussion of the role of nodes and the integration of rule-based artificial intelligence.
8. This journal uses the SWOT-AHP analysis method to identify areas that require urgent improvement in supporting the adoption of Health 4.0. The focus is on innovation in the Internet of Medical Things,

artificial intelligence, and the readiness of the healthcare sector in India towards Health 4.0. Through SWOT-AHP analysis, the journal has been able to clearly identify areas that require urgent improvement to facilitate the adoption of Health 4.0 in India. The strength of this journal lies in the presentation of a SWOT-AHP analysis which helps in identifying critical areas of improvement. However, the drawback is that it is not explicitly mentioned in the available information.

9. This study collected data from medical students and young doctors at two universities in Portugal. The results suggest that mobile health applications have the potential to improve users' health knowledge, skills, and practices. The advantage of this research method lies in the use of questionnaires, which allows collecting data from a large number of respondents, including medical students and young doctors. However, disadvantages include limitations in obtaining more in-depth or contextual information from respondents, and the possibility of bias or errors in filling in data by respondents.
10. This study uses ctDNA detection techniques, which helps readers understand the function of ctDNA in tracking tumor processes molecularly. The results show that liquid biopsy, especially using ctDNA, can complement pathological results and images in the diagnosis of lung cancer. The advantage of liquid biopsy, especially using ctDNA, is that it is a non-invasive method which differentiates it from invasive tissue biopsy procedures. This not only lowers the danger and discomfort for the patient, but also provides important information about lung cancer diagnosis. Although the sensitivity and specificity of ctDNA may be low, its non-invasive capabilities may increase clinical value. However, it should be noted that the ability of ctDNA to detect mutations or molecular changes may be limited, so further assessment is needed for its accuracy.

3. METHODS

A literature review is a systematic investigation of academic publications and current research in a particular field. Its objective is to provide a thorough review and comprehension of the current status of knowledge regarding a specific subject. Through a critical analysis and synthesis of multiple sources, a literature review assists researchers in identifying important theories, methodologies, and discoveries associated with the selected topic. Researchers can identify gaps, inconsistencies, or limitations in the corpus of current knowledge by using this comprehensive assessment, which also helps in comprehending the historical development of the subject.

Furthermore, a literature review is essential for setting the foundation for future research projects. The context, theoretical framework, and methodological techniques that have been previously used are established, providing insightful information that helps researchers hone their study questions, formulate strong hypotheses, and create reliable methodologies. A well-conducted literature review advances study in a particular topic by drawing lessons from earlier studies. It also helps scholars formulate new theories or approaches and promotes overall progression in scholarly inquiry.

4. RESULTS AND DISCUSSION

4.1. Mobile Health

MobileHealth (mHealth) offers a practical solution to the spatial issues facing remote caregivers. With this solution, caregivers can monitor and share information remotely, overcoming geographic barriers often faced in caregiving. MobileHealth includes all technology-based platforms that improve patient care and healthcare services remotely, thereby increasing healthcare efficiency. To achieve universal health coverage, the rapid growth of mobile health increases the need to include it in continuous care systems. However, the best way to use mobileHealth technology to monitor and communicate with providers is limited on site. Connected mobile digital devices and MobileHealth apps can leverage social connections to address significant care gaps, such as asthma management. This shows how important it is to study the full scope of health to transform health care and meet the changing demands of nurses[18][19][20][21][22].

4.2. Artificial Intelligence (AI)

The overlap-based Dice similarity coefficient is one of the most commonly used quantitative metrics to measure the performance of artificial intelligence (AI)-based segmentation tools. Many large companies and corporations are reconsidering their strategic plans to incorporate artificial intelligence (AI) in order to keep pace with developments in the artificial intelligence industry and benefit from emerging artificial intelligence-based products or solutions. Although artificial intelligence (AI) is highly anticipated in medical diagnosis,

estimates of the widespread and rapid adoption of this technology are not yet entirely correct. AI can transform the medical imaging industry and improve productivity and patient outcomes. AI not only offers opportunities but also presents challenges for biomedical research and healthcare[23][24][25][26][27].

4.3. Mobile Health AI In Era Health 4.0

With the launch of Health 4.0, we are entering a new era in healthcare, where the delivery, adoption and use of new technologies is experiencing difficulties. The Fourth Industrial Revolution, or Industrial Revolution 4.0, has resulted in major changes and progress in various sectors, including the health services sector. Advanced technologies such as artificial intelligence (AI) and the Internet of Things (IoT) have changed the world. One form of AI, Federated Learning, differentiates itself by using all historical patient health data, as well as real-time information from mobile diagnostics and IoT solutions. The term "Medical 4.0" may refer to specific local applications or contexts, although it is not commonly used in the healthcare field. Medical 4.0 contributes to the development of healthcare practices by emphasizing patient-centered therapy and medicine and technological breakthroughs and advances in the medical field [12][28][29][30][31].

Mobile Health AI in the Era of Health 4.0: Connected and Smart Health Transformation:

1. Artificial Intelligence (AI) in Diagnosis and Treatment:

   Ai-Doctor can be used throughout the process, from diagnosis to providing effective treatment advice, as it can detect a variety of common retinal disorders. In the medical field, especially in early detection and diagnosis, artificial intelligence (AI) systems are developing rapidly. This opens up new opportunities for medical task processing and suggests possible clinical applications in the diagnosis and treatment of lung cancer. AI for mobile health in the Health 4.0 Era delivers more accurate medical diagnoses and more personalized care. AI can process patient health history, examination results and sensor data from mobile or wearable devices. As a result, AI can offer treatment suggestions that are more timely and tailored to individual conditions[28][29][30].
2. Use of Federated Learning:

   Assisted teaching is used when in a situation where an organization does not have a sufficient amount of data to model their business logic or cannot share data with external parties.This type of mobile health AI that uses historical data and real-time information from mobile devices and the Internet of Things (IoT) is critical to maintaining patient privacy. Federated Learning allows AI models to evolve and improve without compromising the security of patient data[31].
3. Continuous Health Monitoring:

   Using a combination of deep learning and natural language processing, continuous remote health monitoring is possible and healthcare providers can create more personalized care plans and faster interventions. Ultimately, this will result in better patient outcomes, reduced healthcare costs, and improved quality of care. Mobile Health AI enables continuous health monitoring, such as measuring vital parameters, analyzing sleep patterns, and monitoring physical activity, through integration with wearable devices and health sensors. This monitoring allows real-time monitoring of health conditions, allowing for faster intervention and disease prevention[32].

   While great progress has been made in smart and connected healthcare, more innovation is needed in research, deployment and technology to unlock new opportunities and move towards health 5.0. Despite the fact that the term “Mobile Health 5.0” may not currently be widely used or officially defined, potential characteristics of Mobile Health 5.0 can be based on previous trends and developments. Advanced technologies such as augmented reality (AR), virtual reality (VR), and more advanced wearable technologies may fall into this category. With an increase in features intended to help individuals manage their own health, a greater focus on patient and user engagement may become a feature. In the fields of diagnosis, treatment and health management, the adoption of artificial intelligence can bring progress, providing smarter and more personalized solutions. Mobile Health 5.0 may focus on stricter regulatory compliance and safeguarding patient data as concerns about data security and privacy increase[33].

4.4. Mobile Health Development

The World Health Organization (WHO) recently conducted research on e-health tools and services, including m-health. The research found that countries need support in implementing policies and strategies for e-health development; recommendations for assessing and evaluating the need for e-health services; information about best practices and trends; and advice on e-health standards and norms [38].

Health mobility (mHealth) refers to the use of mobile and wireless communications technologies to improve the delivery of health information, monitoring of medical conditions, and health services. The development of mHealth has brought major advances in terms of ease of access to health information, monitoring of medical conditions, and provision of health services through mobile applications, wearable devices, and other mobile-based solutions. This includes many things, such as health promotion, remote consultations, health condition tracking, and chronic disease management. mHealth can help people more easily obtain health care, improve the efficiency of care, and provide better support to those looking after their health.

The development of mobile communications systems, on the other hand, has seen an increase in frequency ranges—starting from 450, 850-900, and 1,800-2,100 MHz in the 1-3G era, going up to 2.6 GHz in the 4G standard. and further up to 10-40.5 GHz with 5G standards. However, concerns about the impact of electromagnetic field (EMF) exposure in the 2-5G range arise due to the lack of electromagnetic field (EMF) exposure risk data. Given the increase in frequency bands as cellular technology advances, it is critical to assess and understand the health impacts of electromagnetic exposure at higher frequencies [39].

One of the most significant innovations in the healthcare industry is the advancement of Mobile Health (mHealth), which has transformed health management and given people more access. This is the evolution of mHealth over time:

1. The Rise of Health Apps in the Mobile Era (Early 2000s)

   Health applications that appeared in the early 2000s started the era of mobile health. Although the technology at that time was not yet fully developed, this initiative resulted in an easy-to-use health-based mobile application. The emergence of health applications on mobile platforms contributes to increasing access to health information and people's awareness of their health.

   The health app ecosystem made great strides, with Apple's launch of the App Store in 2008, allowing developers to create and deploy health apps to more people. The development of the Android platform in the 2010s also helped expand the health application ecosystem and support the broader concept of Mobile Health. Health mobility, also called mHealth, refers to the use of mobile and wireless communications technologies to improve outcomes, health services, and research. MHealth is poised to play a larger role in engaging patients in self-care as smartphone ownership increases in the United States and around the world. The health apps market continues to grow exponentially, driven by advances in software and hardware in smartphones and the increasing ease of use of these devices. As a result, mHealth is becoming an increasingly cheaper and more accessible solution for the wider community.[34]
2. Personal Health and Fitness Monitoring (2010s)

   A look back at a time when personal experience became a pivotal piece of evidence on how food choices affect one's health in the early 2000s. Many people are starting to articulate fat consumption as a matter of personal satisfaction and a consumer's right to make decisions that impact the health of the general public.

   Personal health and fitness monitoring made great strides in 2010. There are now fitness monitoring apps that allow users to monitor physical activity, sleep patterns, and other health factors. Integrated health monitoring platforms such as Apple HealthKit and Google Fit enabled more comprehensive health data collection in 2014. Fitness monitors and smartwatches are becoming increasingly popular devices that can be used in conjunction with health apps, forming a comprehensive solution for monitoring a person's personal health. By allowing users to access their health data directly through their mobile devices, this innovation is creating a new trend in health and fitness services. Additionally, they encourage people to improve their lifestyles to improve their own health and fitness[35].
3. Remote Health Consultation (2010s)

   Doctors can evaluate patients remotely with telemedicine, allowing them to get the desired results. First, it allows for a more efficient and equitable distribution of limited health resources, enabling health services to reach remote areas facing shortages of doctors and other workforce. This reduces the need for long journeys and reduces the associated carbon emissions. Telemedicine also serves as a bridge connecting patients with rare diseases to specialized services. This helps some patients overcome transportation difficulties.

   The development of Mobile Health (mHealth) caused remote health services to become increasingly important in 2010. There is no longer a need to visit a doctor in person, because patients can consult with a doctor via a mobile application. To overcome geographical barriers, this increased

accessibility is essential, especially for routine consultations or emergency situations. Incorporating mHealth into the healthcare system represents a major change; digital platforms help patients, their experience, and overall healthcare delivery[36].

4. Integration of Artificial Intelligence and Big Data (2020s)

   Extensive digitization efforts have led to a massive proliferation of data in recent times. This idea is supported by the Internet of Things (IoT) and smart devices in future mobile communication systems. These advances have opened up many opportunities for the application of smart engineering in various fields, aided by future advances in cellular network systems.

   Mobile Health (mHealth) improved significantly in 2020 thanks to the incorporation of AI and big data. AI helps with more accurate medical diagnoses and treatment adjustments for healthcare applications. This technology has been shown to play an important role in the generation of intelligent and informed health data, which helps doctors make better decisions. The synergy between AI and big data marks an important step towards mHealth. It promises more personalized and advanced healthcare solutions.

5. Technology and Internet of Things (IoT) Development (2020s)

   Conventional healthcare methods have been left behind by the integration of the Internet of Things (IoT) and Artificial Intelligence (AI), especially when it comes to monitoring, predicting and preventing infectious diseases. This integration of digital technologies opens up many opportunities for more innovative healthcare solutions.

   Sensor-based Internet of Things (IoT) technologies are proving useful in healthcare interventions and offer better solutions for medical record storage, sample management, device integration, and understanding the causes of disease. Additionally, this IoT technology offers tremendous capabilities to mitigate risks in challenging situations.

   There were major advances in the Internet of Things and technology, in the 2020s, which helped build a more sophisticated health monitoring system..These technological advances demonstrate the potential of the Internet of Things to revolutionize healthcare, particularly in improving the efficiency and precision of health monitoring systems. Integrated health sensors on mobile and wearable devices enable real-time data collection to support more accurate and in-depth health monitoring[37][38].

6. Mental Health Apps (2020s)

   Health apps can serve as a useful complement to traditional services or as a first step in a stepped care model, with less intensive requirements. Mental health apps, or "apps," are a possible solution to problems such as a shortage of mental health professionals, logistical issues that hinder utilization of services, reduced costs associated with implementing Evidence-Based Medicine (EBT), and engaging individuals in care who might not otherwise seek the service[39][40].

   Mental health app developers must understand the unique needs of individuals facing mental health issues, which may differ from the needs of the general population. By understanding this, they can create mental health apps that are useful and user-friendly[41].

   2020 saw an increase in awareness of mental health. Recent mental health apps allow people to get support and monitor their mental health conditions. These apps are essential for addressing mental health issues and improving emotional well-being, and they demonstrate the growing importance of the use of technology in mental health services.

7. Personalization of Healthcare (2020s)

   The development of smart implantation opens many doors for more holistic and individual-focused healthcare. Many healthcare providers consider the Personalized Implantable Health Care Monitoring Systems (PIHMS) field to be a very large market. Even though the development of the middle class in Indonesia is increasing rapidly, the ratio of doctors in Indonesia is still low[42][43].

   The last ten years, there has been an increased focus on personalizing healthcare through the use of genetic and patient data. Health apps have begun to provide more individualized care, allowing patients to receive treatment tailored to their unique needs and characteristics. Methods like this can increase the effectiveness of health services and encourage patients to be an active part in managing their own health. A future where healthcare is more patient-centric and more accessible will be heralded by the convergence of smart implants and personalized healthcare strategies.

   The value creation transformation also began with the emergence of Industry 4.0. Data-driven services, also known as intelligent services, are increasingly important for new business models and

data exchange processes between companies. Data-driven services use data analysis techniques such as machine learning[44].

4.5 Challenges In Mobile Health 4.0

Smart and remote health systems built with blockchain technology can address efficiency and security issues. By supporting the maintenance of a single record, such as cross-border medical licenses, this technology can overcome financial challenges and issues such as cultural limitations, lack of mobile network connectivity, and electricity in rural areas. Although global eye health programs have made great progress, there are still problems with poor self-management and unequal distribution of medical resources. The rapid development of digital health and artificial intelligence brings many opportunities and challenges, including challenges caused by the technology itself. Describing the Internet of Robotic Things (IoRT) emphasizes the principles, characteristics, tools and challenges of IoRT, combining research concepts such as robotics and the Internet of Robotic Things[45][46][47][48][49].

1. Data Security and Privacy:
   Era of mobile health, sensitive health data is collected and stored on platforms, data security is the biggest issue. It is critical to ensure that patient personal data is protected from cybersecurity threats.To protect the confidentiality and integrity of health data, strict data security protocols, such as end-to-end encryption and rigorous access controls, must be implemented.
2. System Compatibility:
   The ability of different systems and platforms to communicate seamlessly with each other is a major obstacle in overcoming health system 4.0. This can disrupt data communication between health institutions. One way to facilitate communication between systems is to implement interoperability standards such as Fast Healthcare Interoperability Resources (FHIR). This improves care coordination by enabling seamless data exchange.
3. User Application:
   One of the big challenges in integrating AI-based mobile health solutions is ensuring that society adopts them widely. People must feel comfortable and confident when using health applications that rely on artificial intelligence. The healthcare sector, public acceptance and trust in AI technologies can be increased through active user participation in solution development, effective education campaigns, and user-friendly user interfaces.
4. Reliability and Validity of Artificial Intelligence:
   The main challenge in leveraging artificial intelligence for healthcare diagnosis and treatment is ensuring that the results produced by AI algorithms are correct and reliable.To increase public confidence in the reliability of AI in healthcare, cross-institutional validation processes, the use of high-quality data to train AI models, and transparency of algorithms are needed.

4.6. Mobile Health 4.0 Solution

Most people use health technology in their daily lives to manage their health conditions, which may make them more ready to adopt artificial intelligence-based solutions. For example, survey teams from the Ministry of Health and other national programs use mobile phones regularly to visit health facilities and care for patients at home. In the healthcare field, Fog/Edge computing architectures are commonly used to develop remote monitoring solutions that utilize networks of field sensors and clothing to implement responsive, protective, and preventive systems. The AI-driven ChatGPT solution changes the way water quality is monitored and analyzed in real-time. It offers a proactive approach to processing[50][51][52][53][54].

1. Data Security and Privacy:
   One important step to protect patient data is implementing strong data security protocols. Security systems should include strict privacy policies to govern data access and use, as well as end-to-end encryption to protect data in transit and at rest.
   Additionally, continuous auditing and monitoring is essential to detect potential security breaches and respond quickly to security threats.
2. System Compatibility:
   To ensure that various health systems can communicate efficiently, interoperability standards such as FHIR (Fast Healthcare Interoperability Resources) offer a uniform data format that enables seamless data exchange between various health platforms.
   It requires commitment from all healthcare providers to adopt these standards and ensure seamless integration of their systems.

3. User Application:
   Public education campaigns are an important step to increase public understanding of the benefits and safety of AI-based health applications. Providing clear, easy-to-understand information can help reduce doubt and increase trust.Solutions can be tailored to user needs and preferences by actively involving users in their development through surveys, participatory forums and beta trials.The application should have a pleasant and non-confusing user experience with an interface design that is user-friendly, intuitive and easy to understand.
4. Reliability and Validity of Artificial Intelligence:
   To train an AI model well, high-quality data is required. This is important to ensure that the data used is representative and relevant to the user population.To ensure that AI models can provide consistent and accurate results across a variety of clinical environments, cross-institutional validation is necessary. Additionally, it is important to show how the AI makes decisions to build user trust.In addition, mechanisms for regular model updates and improvements based on practical experience and changes in population data are needed.

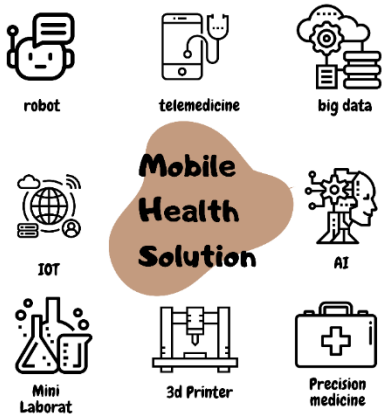

Figure 1 Mobile Health Solution

1. Robots: Many Human-Robot Interaction (HRI) researchers are investigating the potential use of robots in healthcare. Robots such as waiters, nurses, or even surgical robots increase efficiency, accuracy, and the ability to perform specific tasks in the healthcare field[55].
2. Telemedicine is considered as one of the factors that improve the management of HbA1c and can improve therapy adherence, as well as reduce medication use and diabetes complications. The use of communication technology in telemedicine enables remote healthcare services such as consultation with doctors, diagnosis, and treatment of patients through digital platforms. This allows healthcare to be available in remote or hard-to-reach places[56].
3. The utilization of big data is attracting the attention of academics in the healthcare field, as it helps patients and healthcare professionals better decision-making, diagnosis, and disease prediction. By using big data approaches and analysis, we can optimize resources, increase clinical confidence, and drive patient engagement[57][58].
4. Rapid advances in healthcare have been made possible by recent innovations in the Internet of Things (IoT). The Internet of Things (IoT) is used in a variety of healthcare activities, such as disease detection, treatment, and monitoring. As one of the leading contemporary technological innovations, IoT enables the integration of health devices and data monitoring, which allows for better health management and real-time patient monitoring.[59][60][61].
5. It is not a monolithic entity with specific attributes; it is a flexible collection of capabilities that can be used in various situations. In recent years, the use of AI in healthcare has shown great potential for improving patient care, diagnosis, and treatment outcomes. In this context, AI is used to analyze complex medical data, perform diagnosis, and forecast diseases. AI systems can also help doctors

with treatment recommendations, speed up the diagnosis process, and improve the precision of care[62][63].

6. Small and portable laboratory technology called "mini lab". It speeds up on-site diagnosis, treatment processes, and clinical decision-making.
7. 3D printing technology offers many research and development opportunities and disrupts healthcare. 3D printing can be used in healthcare to create models of organs, specialized medical devices, or even prostheses. This enables solutions that can be customized to the patient's needs[64]
8. Precision Medicine: Personalization of healthcare based on a patient's genetic, environmental, and lifestyle information enables more effective and targeted treatments, with lower side effects, and better clinical outcomes.

Mobile Health 4.0 solutions can improve overall health management by increasing accessibility, efficiency, and quality of care..AI-based Mobile Health (mHealth) solutions are critical to improving healthcare services in the Health 4.0 era. In an effort to create a connected and responsive health system, this image shows the integration of innovative technologies such as robotics, mini laboratories, 3D printing, big data, wearable devices, and telemedicine. Mini labs and wearable devices are expected to enable continuous health monitoring, while 3D printing technology is expected to help develop customized medical devices. The focus of using big data and the Internet of Things is the collection and analysis of health data to help make smart decisions. Artificial intelligence helps in diagnosis and treatment recommendations, and telemedicine enables remote consultations. Additionally, the solution includes precision medicine methods to provide care tailored to each patient's unique characteristics. Mobile Health AI solutions in the Era of Health 4.0 aim to improve the accessibility, efficiency and quality of healthcare services. It will lead the transformation towards an adaptive and leading health system through holistic integration.

5. CONCLUSION

Health 4.0 era, health technology, especially the Internet of Things (IoT) and artificial intelligence (AI), is having a positive impact on health services. In this context, mHealth enables remote care, while AI accelerates drug manufacturing, improves supply chain management, and improves response to healthcare demand. AI also enables personalized healthcare. Combined with new technologies such as Federated Learning in AI, health data management is becoming increasingly innovative. This combination brings us to a new era in healthcare where technology is bringing major breakthroughs.

The healthcare paradigm has changed due to advances in remote healthcare, greater access to information, and personal health monitoring through wearable devices and applications. Artificial intelligence (AI) and big data improved the accuracy of medical diagnosis in 2020, and Internet of Things (IoT) technology helped build advanced health monitoring systems. The emergence of mental health apps shows increased awareness of mental health issues. On the other hand, the emphasis on personalization of healthcare through the use of genetic data opens up opportunities for care that is better suited to each person's needs and more effective. MHealth continues to provide smarter, cheaper health solutions around the world, driving innovation in healthcare.

The implementation of blockchain technology, artificial intelligence, and the Internet of Robotic Things (IoRT) can overcome the major problems faced by Mobile Health 4.0. Data security, system compatibility, user adoption, and reliability of artificial intelligence are some of the key issues. To overcome this problem, strong security protocols, public education campaigns, interoperability standards such as FHIR, and application development with user-friendly interface designs are solutions. The integration of technology and the promotion of digital health is essential to address the problems of self-management, distribution of medical resources, and lack of connectivity in rural areas. Therefore, Mobile Health 4.0 offers great opportunities for innovative, technology-based solutions to improve healthcare across the world.

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