Balancing Technological Advances with User Needs: User-centered Principles for AI-Driven Smart City Healthcare Monitoring

Ali H. Hassan[1], Riza bin Sulaiman[2], Mansoor Abdulhak[3], Hasan Kahtan[4]
Institute of IR 4.0 (IIR4.0), Universiti Kebangsaan Malaysia, Bangi 43600, Malaysia[1, 2]
College of Computer and Cyber Sciences, University of Prince Mugrin, Madinah 41499, Saudi Arabia[1, 3]
Cardiff School of Technologies, Cardiff Metropolitan University, Cardiff CF5 2YB[4]

***Abstract*—In recent years, the integration of artificial intelligence (AI) technologies has greatly benefited smart city healthcare, meeting the growing demand for affordable, efficient, and real-time healthcare services. Patient monitoring is one area where artificial intelligence has shown great promise. Improved health outcomes have been made possible by the advancement of AI-based monitoring systems, which enable more personalized and continuous patient monitoring. However, to fully maximize the benefits of these systems, a user-centered approach is essential, which prioritizes patients' needs and experiences while ensuring their privacy and autonomy are respected. This study focuses on the application of user-centered design principles in the development and deployment of AI-driven monitoring systems in smart city healthcare. Addressing the challenges and opportunities of AI-driven monitoring systems, the article considers issues such as privacy and security concerns, data accuracy, and user acceptance. Finally, some possible future directions to the challenges are suggested. A user-centered approach to AI monitoring systems is recommended for healthcare providers to enhance patient experience in smart city healthcare.**

Keywords—Smart healthcare; patient monitoring; smart city; artificial intelligence; user-centered

I. INTRODUCTION

The advancement of technology in the modern era has had a significant impact on the delivery of healthcare services. With the increasing demand for affordable, efficient, and real-time healthcare, smart cities have become a hub for the integration of artificial intelligence (AI) technologies. Smart cities are urban areas that use technology to improve their residents' quality of life. A healthcare system consists of certain groups (such as patients, primary care physicians, pharmacists, and other specialists) and a variety of stages (such as medical issue screening, sickness determination, clinical therapy, and recovery) [1]. Together, all these parties contribute to the implementation of the smart healthcare ecosystem. Global healthcare practices are changing because of a shift in digital technologies. The integration of intelligent technology and healthcare systems enables easy access to healthcare data and connects resources for effective management of unpredictable health care demand [2]. Unlike traditional healthcare, smart healthcare utilizes IoT, 5G wireless technologies, cloud computing, big data and artificial intelligence [3]. These technologies are the most effective communication framework since they allow more accurate collection, recording, and analysis of patient data and direct knowledge sharing between healthcare service providers [4].

Healthcare is an important aspect of smart city development, and the incorporation of AI technologies has the potential to revolutionize healthcare service delivery in these areas. One area where AI has shown significant potential is in patient monitoring. The development of AI-driven healthcare monitoring systems has enabled continuous and personalized patient monitoring, leading to improved health outcomes. Healthcare monitoring is important in maintaining healthcare services for patients such as the elderly or those suffering from chronic diseases. It can reduce the need for medical intervention [5], will rely less on traditional physical health facilities like hospitals and long-term care centers, and will be more individualized as a result. Numerous studies have been conducted on smart healthcare to monitor patient health, for example, Parkinson's disease [6] and mental health [7] and cardiovascular disease [8]. However, to maximize the benefits of AI-driven monitoring systems in smart city healthcare, it is crucial to adopt a user-centered approach. This approach prioritizes patients' needs and experiences while ensuring their data is collected and analyzed in a manner that respects their privacy and autonomy. This is particularly important in smart cities where populations are diverse and have unique healthcare needs. Industry 5.0 and 5G telecommunication technology have made it possible to create low-cost sensing technologies for real-time monitoring and data acquisition [9]. These systems could help increase patient experience and promote health outcomes by emphasizing the needs and experiences of patients.

As the demand for healthcare services in smart cities continues to grow, the integration of user-centered AI monitoring systems has the potential to play a critical role in meeting that demand. By prioritizing the needs and experiences of patients, these systems have the potential to enhance patient experience and improve health outcomes. Therefore, this study aims to investigate the role of user-centered AI monitoring systems in enhancing patient experience in smart city healthcare. The study seeks to understand how we best can overcome the challenges associated with employing AI-driven monitoring systems in smart city healthcare, with a focus on incorporating user-centered principles into the design and implementation of these systems. The remainder of this study is organized as following: Section I summarize the background and motivation for the study. Section II gives a description of the key elements and qualities of a smart city. Section III reviews the adoption of AI in healthcare. Section IV explores AI-driven monitoring system, including remote, mobile and wearable health monitoring systems. Section V shows research studies that have adopted a user-centred approach to develop AI-based monitor systems. In Section VI, the challenges, opportunities, and potential future directions are presented. Finally, Section VII concludes the paper, summarizes the main points and suggests guidelines for areas of future work.

II. Method

This systematic review aims to synthesize the existing literature on the role of user-centered AI monitoring systems in smart city healthcare. The search strategy for this review included electronic databases such as Web of Science, PubMed, Science Direct, Google Scholar, IEEE Xplore and ACM Digital Library as well as manual searches of reference lists of relevant articles. The search terms included “AI-based monitor systems”, “smart city”, “smart health”, “user-centred design in healthcare”, “challenges and opportunities of AI monitor systems”. The inclusion criteria for this review were studies that involved the development of AI-based monitor systems and studies which adopted a user-centred approach to the development of AI monitor systems. Review studies were included to understand the past and current state of the research topic. Exclusion criteria included studies that did not use a AI-based innovations. Two reviewers independently screened titles and abstracts to assess their eligibility, and full text articles were evaluated to be included. A narrative synthesis approach was used to summarize the key findings of the included studies, identifying patterns and themes across studies. The data was analyzed to better understand the challenges, opportunities, and impact of user-centered AI monitoring systems in smart city healthcare. The Prisma model shown in Fig. 1 illustrates the complete process of article search and selection.

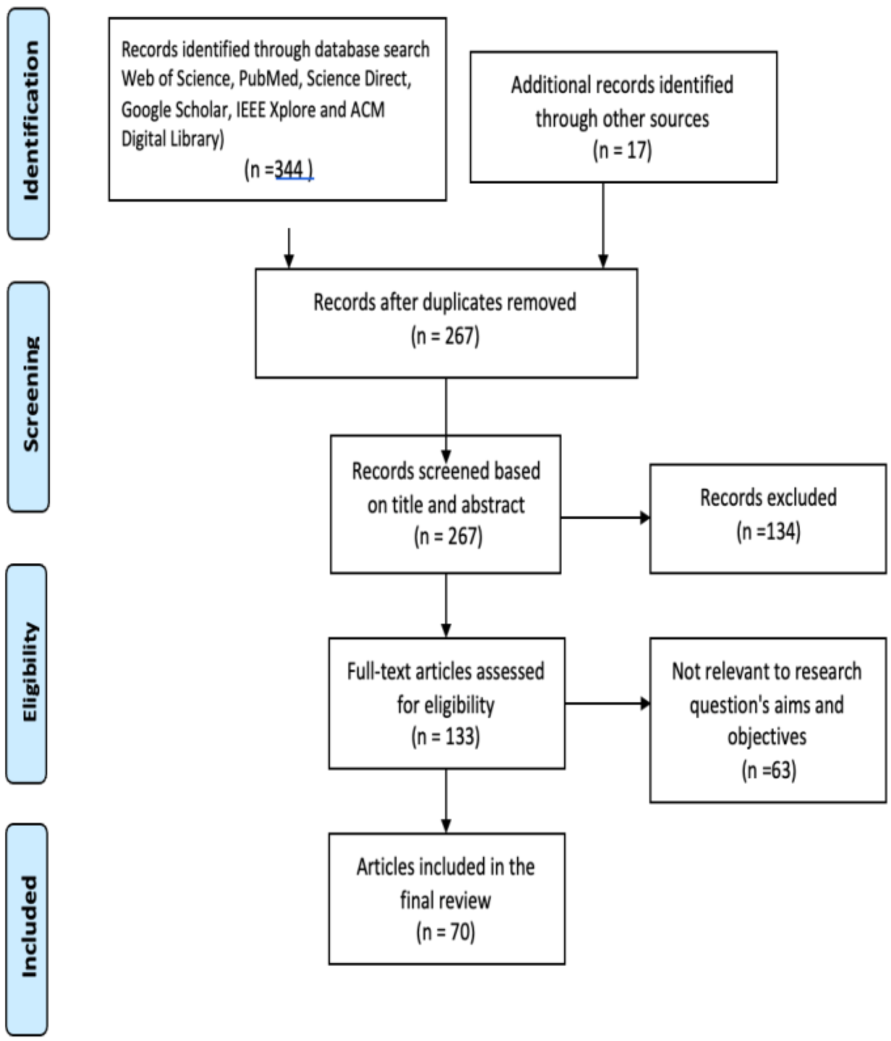

Fig. 1. Prisma model shows number of record included and excluded.

III. Literature Review

A. Smart Cities

Cities consist of various interacting entities, such as citizens, businesses, modes of transportation, communication networks, services, and utilities. The development of cities poses numerous challenges, such as waste management, lack of resources, air pollution, and health concerns [10]. Smart cities are thought to provide opportunities to solve these problems [11]. The main goal of a smart city includes connecting residents, facilitating communication, improving government performance and economic growth, promoting sustainability and improving citizens' quality of life using smart technologies [12], [13].

1) Smart cities infrastructure: A smart city's infrastructure is increasingly dependent on advanced technologies to address population growth-related issues. AI and IoT-enabled devices will improve the quality of life and maximize the efficiency of a wide range of daily services in smart cities, such as smart transport, smart energy, and smart water management [14]. Fig. 2 illustrates the infrastructure of smart cities.

a) Smart healthcare: Smart cities aim to provide smart healthcare solutions. Sensors and smart devices have significantly contributed to the availability of high-quality patient care using smart health technologies.

b) Smart education: In smart education, the focus is on and learner-driven, personalized, and adaptable learning services, interactive, collaborative, and collaboration resources and services. In addition, a smart learning environment facilitates the realization by learners of an effective, efficient, and meaningful learning experience [15].

c) Smart transportation: Smart transportation is a technological advancement in the conventional transportation system that improves public life by delivering optimized services through mobile devices, city-installed devices, or sensors built into cars. These sensors and devices enable easy parking reservations, efficient street lighting, optimal route suggestions, public transit telematics, accident prevention, and autonomous driving [16].

d) Smart buildings: In smart cities, energy efficiency is emphasized, and buildings are designed to function according to individual fulfilment, so that they are more sustainable and energy efficient; for example, the use of smart devices in smart buildings allows many tasks to be handled, including controlling climate, lighting, and many other aspects based on detection of presence [17].

e) Smart energy systems: A smart energy system is built on technological advancements with the goal of decreasing energy consumption and boosting the use of renewable resources. The primary goal of smart energy is to conserve non-renewable resources for use in emergencies [11].

f) Smart manufacturing: Smart RFID tags make it easy to trace a product from the factory to the retailer, greatly reducing time and costs. Smart packaging can also include benefits like brand protection, quality assurance, and customer customization [16].

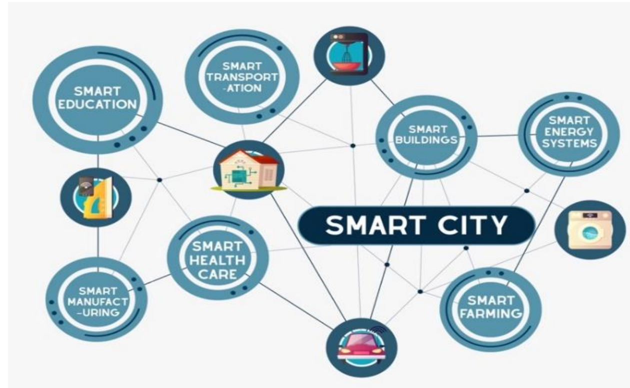

Fig. 2. Components of a smart city.

g) Smart farming: Effective agriculture production is crucial for our people to prevent a future potential food crisis. The use of IoT technology in agriculture may undoubtedly contribute to securing enough food demand and improving the overall efficiency of agricultural production processes. Significant crop information could be gathered and used for yield monitoring and the early detection of diseases that could have a major effect on crop yield and quality. Soil and nutrient monitoring would optimize agricultural production methods and result in water savings, which are valuable in some geographic areas [14].

2) Overview of smart cities characteristics: Smart cities can help to enhance city residents' standard of living while also making the city more sustainable and efficient. With the help of technology and data, smart cities can improve city infrastructure and services and solve some of the most pressing problems facing modern cities. Smart cities have several key characteristics that make them innovative and efficient as illustrated in Fig. 3.

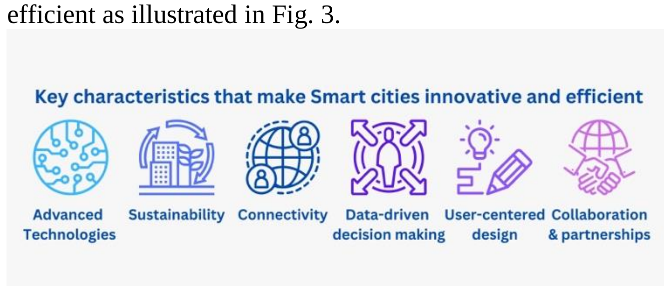

Fig. 3. Key characteristics that make smart cities innovative and efficient.

a) Advanced technologies: Smart cities infrastructure are based on innovative technologies to combat urban challenges with the help of IoT devices, artificial intelligence (AI), cloud computing, and Big Data analytics, [14], [18], [19].

b) Sustainability: Smart cities are designed to minimize their environmental impact including reducing energy consumption, encouraging the use of green spaces, and improving air and water quality [10], [20].

c) Connectivity: Smart cities are highly interconnected, with advanced communication networks connecting residents, businesses, and government agencies. This enables real-time data exchange and seamless communication [13].

d) Data-driven decision making: In smart cities, data is the driving force behind decisions and services. The data collected through advanced technologies are used to identify trends and improve services to better the quality of live for its residents [21], [22].

e) User-centered design: Smart cities are designed with citizens' needs in mind, with the goal of improving the wellbeing and welfare of their citizens [23]–[25]. Accessible and affordable transportation, green spaces, and sustainable housing are part of this approach.

f) Collaboration and partnerships: For smart cities to succeed, governments, businesses, and residents must collaborate. Collaboration, transparency and sharing of data and resources are essential to solving urban problems and creating a more efficient and sustainable city [20], [25].

Smart cities are the future of urban development, designed to address some of the most pressing issues that cities face. IoT devices, cloud computing, big data and artificial intelligence are examples of advanced technologies that enable real-time data exchange and data-driven decision making. Smart cities are also designed to reduce environmental impact, promote sustainability, improve connectivity, foster collaboration, and focus on the needs of citizens. A user-centered approach will help to ensure that the needs of citizens are considered when designing the city. Collaboration and partnerships are critical to smart city success because governments, businesses, and residents must collaborate to solve urban problems and create a more efficient and sustainable city. Transparency and resource sharing are critical to achieving this goal. By embracing these principles, cities can improve the quality of life for their citizens and ensure a sustainable future for future generations.

3) Smart city for a smart healthcare: Smart cities and smart health are two interrelated concepts that are changing the way we live and manage our health. A smart city is a framework that employ technology and data to handle the issues of waste management, traffic congestion, air pollution and energy use etc. to improve the quality of life for citizens [19], [20]. Smart health, on the other hand, refers to the use of cutting-edge technologies. The Internet of Things (IoT), artificial intelligence (AI), cloud computing, and an array of digital tools has enabled us to improve the way we manage and maintain our health [3], [19]. Combining the benefits of smart cities and smart health can help to create healthier and more sustainable environments for their citizens. Artificial intelligence and machine learning technologies are key tools utilized in smart healthcare, where it can be used to analyze large amounts of data and thus improve diagnostic and treatment precision. It can also be used to predict diseases and disease progression, allowing for earlier intervention and improved patient care [26]. Cloud computing is utilized for numerous disease diagnosis applications, allowing stakeholders to make informed medical decisions [27]. IoT devices can collect and monitor patient data in real time, improving care and reducing the need for in-person hospitalization [28], [29]. These devices can also aid in disease prevention by enabling the user to monitor their own health status, assess their situation, and receive advice and recommendations [3]. Robotic technology can be used to improve surgical precision and reduce the risk of surgical complications [30].

Smart healthcare can provide numerous benefits to both patients and healthcare professionals. Patients will benefit from reduced wait times for doctor's appointments as well as more personalized treatment and care. Furthermore, the technologies can help reduce healthcare costs while improving diagnostic and treatment precision and efficiency [31]. Although smart healthcare has many advantages, there are also challenges to overcome. Such as, privacy and security when using smart healthcare technologies. The collection and sharing of personal health information has the potential to violate privacy and security. As a result, it is critical to have adequate security measures in place to protect patient data [32], [33]. Moreover, Healthcare professionals may also require new training and skills as a result of the technologies, which can be challenging [34], [35]. Smart healthcare is an innovative approach to the healthcare sector in which technology is used to improve patient care and healthcare quality. AI, IoT, and robotics technologies can provide benefit to both patients and healthcare professionals. However, there are obstacles to overcome, such as, training requirements, and concerns about privacy and security. If appropriate safeguards are in place, smart healthcare technologies may continue to have the capability to enhance healthcare services and patient care.

B. Advancements in AI- Driven Healthcare Monitoring Systems

1) Artificial intelligence: Artificial intelligence (AI) is of growing importance as it has the potential to improve healthcare through innovative medical devices and provide more personalized healthcare. The various domains AI plays a role is illustrated in Fig. 4. The application of new mobile devices, the development of smart home technologies, and the growing acceptance of smart health have made it possible for healthcare providers to access various form of medical media, such as X-rays and voice recordings. It is now much easier to obtain and share medical data with other healthcare providers for future care [36]. Smart home technologies have assisted healthcare providers in providing high-quality, low-cost care to patients. Structured and unstructured healthcare data can be processed using artificial intelligence. Machine learning (ML), which includes neural networks, classical support vector and deep learning, are common AI techniques used in the healthcare sector [37].

Research shows that there are various healthcare domains where AI can play a critical role. For example, wearable technologies [38] and [39] allow patients to monitor their health and AI-based clinical decision support systems are continuously used to aid and improve diagnosis [31]. Chatbots have been employed to provide mental health services that could lead to early prevention and support [7]. Surgical robots and mixed reality technology can help perform more precise surgeries [30]. To increase the effectiveness of their operations and patient management, many hospitals are installing artificial intelligence technologies that allow the information to gather from electronic medical records (EMRs) [40]. The drug industry [41], [42] is another area that has benefitted from the application of AI.

Fig. 4. Application of artificial intelligence in healthcare.

2) AI-driven monitoring system in smart healthcare: AI-driven monitoring systems have attracted researchers' attention due to their significant impact on people's lives. There have been numerous research studies [33], [43], frameworks [44], [45], [46] and services [8], [36] that focus on integrating artificial intelligence for smart healthcare. Table I summarizes the development of health monitoring systems considering the healthcare context, the invention, and AI technology.

- Remote Health Monitoring Systems

Researchers in [8] used IoT and AI to remotely monitor cardiovascular patients using a device that allows for smart monitoring of human vitals such as body temperature, heart rate, oxygen levels. In [36], the authors suggest a smart home healthcare monitoring system where installed sensors and devices can meet the needs of elderly people for continuous care at home. Researchers in [47] offer a system for remote monitoring of chronically ill or older people. The system is designed to automatically identify physiological signals [48] developed a framework for hybrid real-time remote monitoring (HRRM) for chronically ill patients. Researchers in [49] developed a home health monitoring system to track the health conditions of individuals with type 2 diabetes and hypertension. The system would diagnose and monitor patients' blood pressure and diabetes status. Researchers in [50] developed a remote monitoring system for Parkinson's disease patients using a voice signal as input.

- Mobile and Wearable Health Monitoring Systems

Researchers in [44] developed a deep learning-based voice pathology detection system for remote patient monitoring. The mobile application uses parallel CNNs to extract deep-learned features. In [51], the authors suggest a mobile and automatic system to improve patient cardiovascular health management abilities using IoT and AI technologies. A mobile application system is proposed by [45] for obesity management. The application utilizes a genetic algorithm as an AI engine to predict the meals a user will need to consume to meet their calorie, macronutrient, and micronutrient goals. The author in [46] presents a wearable health monitoring device to monitor patients' activities and vitals while they are engaged in activity to support efficient and effective health monitoring. The author in [52] offer a Smart Health Monitoring System framework built using IoT and machine learning to monitor patients affected by coronary artery disease. Research by [53] focuses on developing an AI-based patient monitoring system to observe the vital signs of Covid 19 patients remotely. Another research team in [54] have developed a smart healthcare framework for the detection and monitoring of COVID-19 using smart connectivity sensors and deep learning (DL). The application collects and analyzes patient Chest X-ray images. The system will then predict the patient's status and alert the healthcare professional to take action. In [55], the author offers a smart home healthcare framework for diabetic management using AI technologies. The proposed framework included portable sensors to detect temperature, blood sugar level, and activity of diabetic patients.

Remote diagnosis and treatment are crucial in rural areas and other regions with insufficient qualified medical professionals. Numerous healthcare applications' capacity to gather patient data remotely can help to overcome workforce constraints and process the data automatically for use in patient care as needed [5]. Further, traveling for medical care is not only time- and money-consuming, but it can also be challenging for some people, such as the elderly [56]. Automating smart healthcare monitoring systems limits the risk of human error, which can put both patients and providers at risk [57]. The information obtained is the main difference between face-to-face and remote diagnosis.

AI-based monitoring systems are showing promising results and can help to transform the healthcare industry by providing a more efficient and effective way of monitoring patients' health, reducing the risk of human error, and providing more affordable treatment options. Remote health monitoring systems employ IoT and AI-based technology to remotely monitor cardiovascular, elderly, chronically ill, and Parkinson's disease patients. Mobile and wearable health monitoring systems collect real-time data on patients through use of mobile applications, wearable devices, and IoT technologies. The use of wearable devices and mobile phones has made it easier to collect data for remote diagnosis and treatment. IoT and sensor technology are also used to handle the data collected by these devices. The use of AI in healthcare monitoring has the potential to provide affordable treatment options and improve the overall health of vulnerable citizens. The future of healthcare monitoring is expected to see an increase in the adoption of wearable devices and mobile applications, making the use of AI in healthcare monitoring more prevalent in daily life.

Modern technology, including mobile and wearable devices, has made it easier to find affordable treatment options by collecting real-time data without affecting regular activities. Wearable sensors such as watches, straps and glasses as well as mobile phones are useful methods to collect data [7]. Usually, these devices are linked to a network and establish remote communication with mobile devices. Fig. 5 shows the growing trend of wearable technology and the increasing focus on collecting and analyzing personal health data to improve overall wellness. The use of cloud-based infrastructure and edge computing devices allows for real-time data processing and analysis, which can lead to more accurate and actionable insights. Wearable devices including glasses, watches, and chest straps, can be connected to edge computing devices such as smartphones or middleware servers through Wi-Fi and Bluetooth technology. These devices are used to collect and transmit data related to the wearer's health and fitness, and the data is processed and stored on cloud-based infrastructure for further analysis. Glasses can have a display that can provide the wearer with real-time information such as heart rate and other health metrics. During exercise, the chest strap may monitor the wearer's heart rate and other vital signs, while a watch may track physical activity, calories burned, and sleep patterns. With enough data obtained, it is possible and practical to provide remote diagnosis and remote therapy. IoT and sensor technology are combined to handle the data that has been obtained [56]. The use of wearable devices will grow and become more prevalent in daily life, making them potentially useful to monitor the health of vulnerable citizens [58].

TABLE I. SUMMARY OF HEALTH MONITORING SYSTEMS

Ref.	Healthcare context	Invention	AI technology
[8]	Cardiovascular patients	A device based on IoT and AI that monitor the human vitals, including oxygen levels, heart rate, and body temperature.	K-Nearest Neighbors (KNNs)
[36]	Health conditions of elderly people	A monitoring system that includes video cameras and microphones fitted in the smart home.	Interlaced derivative pattern
[47]	Chronically ill or elderly	A physiological signal monitoring Smart-Monitor system.	Deep Neural Network
[48]	Chronically ill patients	A framework for hybrid real-time remote monitoring (HRRM) for chronically ill patients.	Naïve Bayes, Support vector
[49]	Type 2 diabetes and hypertension	A Smart home health monitoring system that analyzes blood pressure and glucose levels.	Support vector K-NN, Decision tree
[50]	Parkinson's Disease	A healthcare monitoring system for PD patients using voice signal as input	Support vector Gaussian mixture model, Random forest tree
[44]	Voice disorders	A smart mobile healthcare framework that enables voice pathology detection. The system used parallel CNNs to extract deep-learned features.	Parallel convolutional neural network, AlexNet
[51]	Cardiovascular patients.	An AI-enhanced mobile system for cardiovascular health management	Convolutional Neural Network, Recurrent Neural Network
[45]	Management of Obesity	A mobile application for self-management of obesity.	Genetic Algorithm technique
[46]	General health	An IoT and AI-based wearable monitor that tracks the patient's activities and vitals	Neural network
[52]	Coronary disease	A Smart Health Monitoring System. The application includes a pulse sensor that can be placed on a fingertip to monitor early signs of heart disease.	Decision Tree Algorithm and Random, Backwoods Classifier Algorithm, Support vector machine
[53]	Covid 19	AI-Based Patient Monitoring System to observe vital signs of patients. A webpage application is used to communicate between patients and health professionals.	Deep neural network
[54]	Covid 19	A smart healthcare framework for detection and monitoring of COVID-19.	ResNet50, convolutional neural network
[55]	Diabetic patients	A framework for automated monitoring of diabetic patients using sensors and smartphones.	Naïve Bayes, Random Forest, ZeroR, Simple logistic, sequential minimal optimization

Fig. 5. Wearable device application process.

3) User-Centered Principles in AI-Driven Monitoring Systems: User-centered AI monitoring systems are health monitoring systems that are designed with the end user in mind. These systems employ artificial intelligence (AI) technology to collect, process, and analyze health-related data to improve patients' overall health and well-being. The goal of these systems is to provide personalized health monitoring and support to users without interfering with their privacy [33]. According to research, user-centered AI monitoring systems have the potential to transform the health industry by providing real-time health monitoring and support to patients [26], [59]. Using artificial intelligence technology, health-related data such as vital signs, physical activity levels, and sleep patterns can be automatically collected, analyzed, and used to detect health-related issues [8], [49].

Several studies have highlighted the importance of involving end users in the development of AI monitoring systems. Study [60] presents a comprehensive design methodology for developing mobile health (mHealth) apps for chronic pain management. The methodology focuses on incorporating user-centered design principles to improve the user experience and app adoption. The author discusses the pain management landscape, current challenges with mHealth app development, and highlights the importance of involving end-users in the design process. Also [61] provides a detailed overview of the importance of user-centered design in the development of health apps. The study emphasizes the increasing popularity of health apps and the need for designers and developers to ensure that these apps meet the needs and preferences of users. The authors discuss several key components of a user-centered design approach, such as user research, user feedback, and continuous evaluation, all of which are necessary for ensuring that health apps are effective, usable, and accessible. The authors also offer practical advice for those looking to create user-centered health apps. They emphasize the importance of taking user characteristics like age, gender, culture, and socioeconomic status into account during the design process. The authors emphasize the importance of health apps being accessible and usable for people with disabilities.

A study by [62] developed a voice monitoring system for disorder prevention using a user-centered design approach. The authors present a step-by-step process for developing a voice monitoring system that meets the needs and preferences of users, as well as a thorough overview of the importance of user-centered design in the development of healthcare technologies. The authors suggest a process for user-centered design that includes user research, prototyping, testing, and evaluation. The authors also provide a detailed discussion of the technical challenges involved in developing a voice monitoring system, such as speech recognition and data processing, as well as recommendations for overcoming these obstacles. A study led by [63] investigates dementia patients, their caregivers, and healthcare providers' physical, psychological, and social needs. The study employed a user-centered design method, which included semi structured interviews, workshops, and smart home trials. The findings of this study demonstrate how this methodology can help uncover psychosocial and contextual factors, as well as help to develop more patient-centered interventions. The authors suggest that their findings can be incorporated into clinical practice as well as public health strategy to develop patient-centered interventions. Another study by [32] outlines a user-centered strategy for creating smart home solutions that puts an emphasis on creating home automation systems that meet users' needs and expectations. The authors develop scenarios to better understand user needs and behaviors as well as to point out areas where smart home technology can benefit users in their day-to-day activities. The study found that user-centered design can produce smart home systems that are more efficient and user-friendly, and that it is essential to incorporate user feedback throughout the design process to produce solutions that satisfy their needs.

User-centered AI monitoring systems have the potential to transform the health industry by providing personalized health monitoring and support to patients without interfering with their privacy. Incorporating user-centered design principles in the development of these systems is crucial to ensure that they are effective, usable, and accessible. User-centered design methodologies have been successfully employed in various healthcare technologies, such as mobile health (mHealth) apps for chronic pain management, voice monitoring systems for disorder prevention, and smart home solutions for dementia patients. As shown in Fig. 6 these methodologies involve user research, prototyping, testing, and evaluation, which uncover psychosocial and contextual factors and help to develop more patient-centered interventions. Incorporating user feedback throughout the design process can produce solutions that satisfy user needs and preferences and are more efficient and user-friendly. Understanding the needs, preferences, and behavior of users is critical to the success of these technologies, and incorporating user feedback throughout the design process can produce solutions that satisfy user needs and preferences. As healthcare technologies continue to advance, incorporating user-centered design principles will be essential to develop patient-centered interventions that improve patient outcomes and experiences.

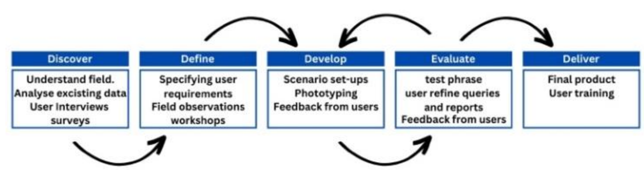

Fig. 6. Collaborative AI system build through a user-centered approach.

IV. Challenges and Opportunities of AI-Driven Monitoring Systems in Smart City Healthcare

A. Challenges

The development and deployment of user-centered AI monitoring systems in smart health is a complex process that is faced with some significant challenges. The main challenges are highlighted here including data privacy and security, data quality and availability, interoperability, clinical validity and user acceptance.

1) Data privacy and security: Health data is highly sensitive and personal information that must be protected.

Ensuring the privacy and security of health data is a major challenge in the development and deployment of user-centered AI monitoring systems [32]. AI systems have a significant and ongoing security challenge due to the complexity of the data and increasing frequency of network attacks. Security faults, for example, an area of concern since medical data, which is gathered by different types of sensors, is subject to errors. These faults can make it challenging to understand or diagnose the patient's condition. Furthermore, real-time monitoring necessitates a fast and dependable network connection, which can be difficult to achieve in rural areas and on low-power systems [33].

2) Data quality and availability: For AI monitoring systems to be effective, they must be trained on high-quality data. Health data consisting of doctors' notes, observations, results of pathology, radiology images, and signals are typically not very extensive and can be challenging to access [64], [65]. A significant challenge is ensuring that the data used to train AI systems is accurate, up-to-date and widely available.

3) Interoperability: AI monitoring systems must be able to integrate with existing health IT systems to be useful [66]. This necessitates that the systems exchange data and communicate with one another in a seamless manner. Ensure that AI monitoring systems are interoperable with existing health IT systems can be difficult, especially in environments where different systems use different data standards.

4) Clinical validity: For AI monitoring systems to be effective in clinical settings, they must be able to provide accurate and reliable information. This necessitates system validation and the accuracy and dependability of the results [64], [67]. It is crucial to ensure AI monitoring systems are clinically valid, especially in the health sector since inaccurate diagnosis and treatment can have severe consequences.

5) User acceptance: AI monitoring systems must be usable and provide transparency to end-users to be effective (Miotto et al., 2017). This includes ensuring that the systems are user-friendly and that users trust the information that they provide [60], [61]. Ensuring that AI monitoring systems are acceptable to end-users can be challenging, particularly in the context of health where users may be concerned about the reliability of the information provided.

6) Trust: The success of user-centered AI monitoring systems in smart health greatly depends on building trust with the users. Users will not accept the results of AI systems if they do not trust the system [68].

Despite of these challenges, the development and deployment of AI-based monitoring systems for smart health remains a significant area of research and development. Identifying and addressing these challenges can help develop user-centered AI monitoring systems in smart health that are effective, usable, and trustworthy, improving patient health.

B. Opportunities

AI-driven monitoring systems have made a substantial impact on people's lives, attracting the interest of researchers. Although there are several challenges in the development and deployment of AI-based monitoring systems there are also numerous advantages, such as personalized Health Monitoring, the delivery of remote diagnosis and treatment, and the collection of real-time data without interfering with regular activities. The opportunities are demonstrated in this section.

1) Personalized health monitoring: These systems use AI technologies to collect, process, and analyze health-related data, allowing for personalized health monitoring and support to the users. The automatic collection of data, such as vital signs, physical activity levels, and sleep patterns, can help detect health-related issues in real-time [8], [49], [61], [69].

2) Real-time feedback: These systems can provide real-time feedback to the user, allowing them to make informed decisions about their health. They can help identify potential health risks and provide personalized health recommendations, such as lifestyle changes or exercise regimens, to help improve overall health [3], [32], [61].

3) Non-intrusive monitoring: User-centered AI monitoring systems in smart health are designed to be non-intrusive, allowing users to monitor their health without interference with their daily activities [33].

4) Improved health outcomes: These systems can help individuals manage their health more effectively and make lifestyle changes to improve overall health outcomes. By providing real-time feedback and personalized health recommendations, these systems can help individuals make informed decisions about their health and well-being [26], [59].

5) Increased access to health services: User-centered AI monitoring systems in smart health can help increase access to health services for individuals in remote or underserved areas. By allowing for remote monitoring and analysis of health-related data, these systems can help bridge the gap in access to health services for these individuals [3], [33].

6) Increased efficiency and reduced costs: The use of AI technologies can help streamline healthcare processes and reduce costs. By automating the collection and analysis of health-related data, these systems can reduce the need for manual data entry and analysis, saving time and resources [3], [26], [70]-[72].

The current research indicates that while user-centered AI monitoring systems hold significant potential for transforming the healthcare industry, there are also certain challenges related to their development and deployment. One of the key challenges is making sure the system is user-friendly and simple to use, as many patients may be intimidated by technology [61]. Furthermore, there are privacy and security concerns associated with the collection and storage of health-related data that must be addressed for these systems to be safe and secure to use [33]. Other concerns include Clinical Validity, Data Quality and Availability and Interoperability of these systems. However, there are some great opportunities in developing and deploying user-centered AI monitoring systems in smart health. One of the main advantages of these systems is their ability to provide users with real-time feedback, allowing them to make informed health decisions [3]. Furthermore, these systems can offer personalized health recommendations, such as lifestyle changes or exercise programs [69] to assist users in improving their overall health.

V. Future Directions for User-centered AI Monitoring in Smart Health

Within this section, potential future directions will be presented regarding the challenges related to developing and implementing user-centered AI monitoring systems in the context of smart health. An overview of the challenges along with the possible future directions is illustrated in Table II.

TABLE II. Overview of Challenges and Possible Future Directions

Challenges	Examples	Potential future directions
Data Privacy and Security	Health data is highly sensitive and must be protected from security faults, such as sensor errors.	Invest in strong security measures, such as encryption, secure communication, and monitoring for breaches and unauthorized access.
Data Quality and Availability	Ensuring that data used to train AI systems is accurate, up-to-date and widely available.	Invest in data infrastructure that makes obtaining, storing, and managing health data easier.
Interoperability	AI monitoring systems must integrate with existing health IT to exchange data and communicate.	Follow common data standards and invest in tools that make integrating AI monitoring systems with existing health IT systems easier.
Clinical Validity	Ensure AI monitoring systems are clinically valid.	Invest in research and validation of AI monitoring systems to ensure they continue to provide valid and trustworthy information.
User Acceptance	AI monitoring systems must be usable and provide transparency.	Involve end-users in AI monitoring systems to ensure usability and trust. Education and training are needed to promote adoption.
Trust	Users must trust the system to accept the results of AI systems.	Develop user-friendly systems that provide accurate and reliable health-related data and are transparent in their operation.

It is critical to implement strong security measures to protect health data to address the challenge of data privacy and security. This can include employing encryption and secure communication protocols, as well as monitoring for breaches and unauthorized access on a regular basis. Furthermore, it is critical to be transparent about the use of health data and to obtain patient consent before using their data for AI training or monitoring. Data Quality and Availability are other critical factors to consider when developing high-quality AI monitoring systems. To tackle these issues, it may be necessary to invest in data infrastructure that makes obtaining, storing, and managing health data easier. Furthermore, health data sharing may be necessary to encourage the development of high-quality monitoring AI systems. As a solution to the interoperability challenge, it may be necessary to adopt common data standards and invest in tools that make integrating AI monitoring systems with existing health IT systems easier. Furthermore, it is critical to foster open communication and information sharing among different organizations to ensure that AI monitoring systems can work seamlessly with existing health IT systems. The challenge of clinical validity can be addressed by investing in the research and validation of AI monitoring systems. Additionally, ongoing monitoring and evaluation of the systems is required to ensure that they continue to provide valid and trustworthy information. User acceptance is an important factor that can determine the success of user-centered AI monitoring systems in smart health. To address this issue, we must ensure that end-users are involved in the design and development of AI monitoring systems. This can include user testing and gathering user feedback to ensure that the systems are usable and that users trust the information provided. Furthermore, education and training may be required to promote widespread adoption of AI monitoring systems. Finally, building trust with the users is a critical factor in the success of user-centered AI monitoring systems in smart health. To build trust, these systems must be user-friendly and easy to use, and provide accurate and reliable health-related data. Additionally, the systems must be transparent in their operation and provide clear explanations for the health recommendations provided to the user.

User-centered AI monitoring systems in smart health hold significant potential for transforming the healthcare industry by providing real-time health monitoring and support to patients. User-centered AI monitoring systems are designed to improve the patient experience in healthcare by using technology to collect and analyze data from patients. These systems use artificial intelligence algorithms to monitor patients and provide real-time information about their health status. However, careful consideration must be given to the design and deployment of these systems to ensure that they are user-friendly, secure, and provide accurate and reliable health-related data. By addressing these challenges, it is possible to develop user-centered AI monitoring systems in smart health that are effective, usable, and trustworthy, thereby improving patient health outcomes.

VI. Discussion and Conclusion

In recent years, smart health technologies have been gaining popularity as a means of providing high-quality patient care, including user-centered AI monitoring services. These systems hold great potential to transform the health industry by providing real-time health monitoring and support to patients. Based on the results of this research paper, there appear to be several key factors that need to be addressed when developing user-centered AI monitoring systems for smart health. These include data protection and security, data quality and availability, interoperability, clinical validity, user acceptance, and building trust among users. This is consistent with the results of previous studies that have emphasized the importance of these factors in designing effective AI healthcare monitoring systems. The current paper differs from previous studies in that it emphasizes the importance of user-centered design and involving end-users in the development process. Although previous studies have also recognized the importance of user-centered design, this paper highlights the need to involve end users in the design and development of these systems. This suggests that there may be a need for greater collaboration between developers and end-users in the development of user-centered AI monitoring systems for smart health. The research also indicates the importance of user research, user feedback, and continuous evaluation in ensuring that these systems are developed in a manner that prioritizes the needs and preferences of users. User-centered design has been shown to produce more efficient and user-friendly health monitoring systems and incorporating user feedback throughout the development process is crucial to producing solutions that meet the needs of patients and caregivers. Overall, the findings suggest that, while user-centered AI monitoring systems have significant potential for transforming healthcare, they must be designed and deployed with care to ensure that they are effective, usable, and trustworthy. By addressing the challenges identified in this study, it may be possible to develop AI monitoring systems that are better able to support patients and improve health outcomes.

Future research in this field should focus on developing and deploying artificial intelligence (AI) technologies that can collect, process, and analyze health-related data in a secure and privacy-sensitive manner. Furthermore, research should be conducted to identify ways to increase trust in these systems, such as developing user-friendly interfaces, providing clear and transparent information about how data is collected and processed, and ensuring that the data used to train these systems is diverse and representative of the population it is intended to serve. In conclusion, how we treat and monitor patients is impacted by the continually shifting number of devices in a smart city. As a result, developing smart devices often results in compatibility and security issues. Artificial intelligence and deep learning approaches can be used to improve the management and coordination of device data and network models to address this challenge and ensure smooth connectivity between smart devices.

REFERENCES

[1] S. S. Raju and R. C. Kumar, "EAI Endorsed Transactions on Smart Cities Artificial Intelligence in Smart cities and Healthcare," 2022, doi: 10.4108/eetsc.v6i3.2275.

[2] Z. Asim, "Shaping Healthcare System Under Industry 5.0: Trends and Barriers," Sudan Journal of Medical Sciences, Sep. 2022, doi: 10.18502/sjms.v17i3.12115.

[3] S. Tian, W. Yang, J. M. le Grange, P. Wang, W. Huang, and Z. Ye, "Smart healthcare: making medical care more intelligent," J Glob Health, vol. 3, no. 3, pp. 62–65, 2019, doi: 10.1016/J.GLOHJ.2019.07.001.

[4] M. Saranya, "A Survey on Health Monitoring System by using IOT," Int J Res Appl Sci Eng Technol, vol. 6, no. 3, pp. 778–782, Mar. 2018, doi: 10.22214/ijraset.2018.3124.

[5] A. A. Mohammed, M. A. Burhanuddin, M. Saad Talib, M. E. Hameed, and M. F. Ali, "A Review on IoT-Based Healthcare Monitoring Systems for Patient in Remote Environments," European Journal of Molecular & Clinical Medicine, vol. 07, no. 03, 2022.

[6] M. Raza, M. Awais, N. Singh, M. Imran, and S. Hussain, "Intelligent IoT Framework for Indoor Healthcare Monitoring of Parkinson's Disease Patient," IEEE Journal on Selected Areas in Communications, vol. 39, no. 2, pp. 593–602, Feb. 2021, doi: 10.1109/JSAC.2020.3021571.

[7] V. Mody and V. Mody, "Mental Health Monitoring System using Artificial Intelligence: A Review," in 2019 IEEE 5th International Conference for Convergence in Technology, I2CT 2019, 2019. doi: 10.1109/I2CT45611.2019.9033652.

[8] Z. Ashfaq et al., "Embedded AI-Based Digi-Healthcare," Applied Sciences (Switzerland), vol. 12, no. 1, 2022, doi: 10.3390/app12010519.

[9] M. Tabaa, F. Monteiro, H. Bensag, and A. Dandache, "Green Industrial Internet of Things from a smart industry perspectives," Energy Reports, vol. 6, pp. 430–446, Nov. 2020, doi: 10.1016/J.EGYR.2020.09.022.

[10] N. Zakaria and J. A., "Smart City Architecture: Vision and Challenges," International Journal of Advanced Computer Science and Applications, vol. 6, no. 11, 2015, doi: 10.14569/ijacsa.2015.061132.

[11] J. Galih, P. Negara, and A. W. R. Emanuel, "A Conceptual Smart City Framework for Future Industrial City in Indonesia," 2019. [Online]. Available: www.ijacsa.thesai.org.

[12] M. K. Al-Azzam and M. B. Alazzam, "Smart city and Smart-Health framework, challenges and opportunities," International Journal of Advanced Computer Science and Applications, vol. 10, no. 2, 2019, doi: 10.14569/ijacsa.2019.0100223.

[13] A. Gharaibeh et al., "Smart Cities: A Survey on Data Management, Security, and Enabling Technologies," IEEE Communications Surveys and Tutorials, vol. 19, no. 4. Institute of Electrical and Electronics Engineers Inc., pp. 2456–2501, Oct. 01, 2017. doi: 10.1109/COMST.2017.2736886.

[14] S. Nižetić, P. Šolić, D. López-de-Ipiña González-de-Artaza, and L. Patrono, "Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future," J Clean Prod, vol. 274, 2020, doi: 10.1016/j.jclepro.2020.122877.

[15] H. Singh and S. J. Miah, "Smart education literature: A theoretical analysis," Educ Inf Technol (Dordr), vol. 25, no. 4, 2020, doi: 10.1007/s10639-020-10116-4.

[16] F. Zantalis, G. Koulouras, S. Karabetsos, and D. Kandris, "A review of machine learning and IoT in smart transportation," Future Internet, vol. 11, no. 4. 2019. doi: 10.3390/FI11040094.

[17] A. I. Voda and L. D. Radu, "How can artificial intelligence respond to smart cities challenges?," in Smart Cities: Issues and Challenges Mapping Political, Social and Economic Risks and Threats, 2019. doi: 10.1016/B978-0-12-816639-0.00012-0.

[18] E. M. Ouafiq, M. Raif, A. Chehri, and R. Saadane, "Data Architecture and Big Data Analytics in Smart Cities," Procedia Comput Sci, vol. 207, pp. 4123–4131, Jan. 2022, doi: 10.1016/j.procs.2022.09.475.

[19] H. M. K. K. M. B. Herath and M. Mittal, "Adoption of artificial intelligence in smart cities: A comprehensive review," International Journal of Information Management Data Insights, vol. 2, no. 1, p. 100076, Apr. 2022, doi: 10.1016/j.jjimei.2022.100076.

[20] P. Mishra, P. Thakur, and G. Singh, "Sustainable Smart City to Society 5.0: State-of-the-Art and Research Challenges," SAIEE Africa Research Journal, vol. 113, no. 4, pp. 152–164, Dec. 2022, doi: 10.23919/SAIEE.2022.9945865.

[21] A. M. Shahat Osman and A. Elragal, "Smart Cities and Big Data Analytics: A Data-Driven Decision-Making Use Case," Smart Cities, vol. 4, no. 1, pp. 286–313, Feb. 2021, doi: 10.3390/smartcities4010018.

[22] S. E. Bibri and J. Krogstie, "The emerging data–driven Smart City and its innovative applied solutions for sustainability: the cases of London and Barcelona ," Energy Informatics, vol. 3, no. 1, p. 5, Dec. 2020, doi: 10.1186/s42162-020-00108-6.

[23] N. Gardner and L. Hespanhol, "SMLXL: Scaling the smart city, from metropolis to individual," City, Culture and Society, vol. 12, pp. 54–61, Mar. 2018, doi: 10.1016/j.ccs.2017.06.006.

[24] S. Andreani, M. Kalchschmidt, R. Pinto, and A. Sayegh, "Reframing technologically enhanced urban scenarios: A design research model towards human centered smart cities," Technol Forecast Soc Change, vol. 142, 2019, doi: 10.1016/j.techfore.2018.09.028.

[25] A. Abella, M. Ortiz-de-Urbina-Criado, and C. De-Pablos-Heredero, "A model for the analysis of data-driven innovation and value generation in smart cities' ecosystems," Cities, vol. 64, pp. 47–53, Apr. 2017, doi: 10.1016/j.cities.2017.01.011.

[26] M. Nasr, Md. M. Islam, S. Shehata, F. Karray, and Y. Quintana, "Smart Healthcare in the Age of AI: Recent Advances, Challenges, and Future Prospects," IEEE Access, vol. 9, pp. 145248–145270, 2021, doi: 10.1109/ACCESS.2021.3118960.

[27] A. Abdelaziz, A. S. Salama, and A. M. Riad, "A hybrid intelligent model for enhancing healthcare services on cloud environment," International Journal of Advanced Computer Science and Applications, vol. 9, no. 11, 2018, doi: 10.14569/IJACSA.2018.091105.

[28] T. Alam, "mHealth Communication Framework using Blockchain and IoT Technologies," no. June, 2020, doi: 10.20944/preprints202006.0180.v1.

[29] P. Valsalan, N. ul Hasan, I. Baig, and M. Zghaibeh, "Remote Healthcare Monitoring using Expert System," International Journal of Advanced Computer Science and Applications, vol. 13, no. 3, p. 2022, 2022, doi: 10.14569/IJACSA.2022.0130370.

[30] M. Bhandari, T. Zeffiro, and M. Reddiboina, "Artificial intelligence and robotic surgery: Current perspective and future directions," Current Opinion in Urology, vol. 30, no. 1. Lippincott Williams and Wilkins, pp. 48–54, Jan. 01, 2020. doi: 10.1097/MOU.0000000000000692.

[31] R. F. Mansour, A. el Amraoui, I. Nouaouri, V. G. DIaz, D. Gupta, and S. Kumar, "Artificial Intelligence and Internet of Things Enabled Disease Diagnosis Model for Smart Healthcare Systems," IEEE Access, vol. 9, 2021, doi: 10.1109/ACCESS.2021.3066365.

[32] M. J. Kim, M. E. Cho, and H. J. Jun, "Developing Design Solutions for Smart Homes Through User-Centered Scenarios," Front Psychol, vol. 11, 2020, doi: 10.3389/fpsyg.2020.00335.

[33] A. V. L. N. Sujith, G. S. Sajja, V. Mahalakshmi, S. Nuhmani, and B. Prasanalakshmi, "Systematic review of smart health monitoring using deep learning and Artificial intelligence," Neuroscience Informatics, vol. 2, no. 3, 2022, doi: 10.1016/j.neuri.2021.100028.

[34] K. Paranjape, M. Schinkel, R. N. Panday, J. Car, and P. Nanayakkara, "Introducing artificial intelligence training in medical education," JMIR Medical Education, vol. 5, no. 2. 2019. doi: 10.2196/16048.

[35] J. Grunhut, A. T. Wyatt, and O. Marques, "Educating Future Physicians in Artificial Intelligence (AI): An Integrative Review and Proposed Changes," J Med Educ Curric Dev, vol. 8, p. 238212052110368, Jan. 2021, doi: 10.1177/23821205211036836.

[36] M. S. Hossain, "Patient status monitoring for smart home healthcare," in 2016 IEEE International Conference on Multimedia and Expo Workshop, ICMEW 2016, 2016. doi: 10.1109/ICMEW.2016.7574719.

[37] A. N. Navaz, M. A. Serhani, H. T. el Kassabi, N. Al-Qirim, and H. Ismail, "Trends, Technologies, and Key Challenges in Smart and Connected Healthcare," IEEE Access, vol. 9, pp. 74044–74067, 2021, doi: 10.1109/ACCESS.2021.3079217.

[38] A. K. Tripathy, A. G. Mohapatra, S. P. Mohanty, E. Kougianos, A. M. Joshi, and G. Das, "EasyBand: A Wearable for Safety-Aware Mobility during Pandemic Outbreak," IEEE Consumer Electronics Magazine, vol. 2248, no. c, pp. 10–14, 2020, doi: 10.1109/MCE.2020.2992034.

[39] S. Sun et al., "Using smartphones and wearable devices to monitor behavioural changes during COVID-19," vol. 44, no. 0, 2020, [Online]. Available: http://arxiv.org/abs/2004.14331

[40] S. Lee and H. S. Kim, "Prospect of artificial intelligence based on electronic medical record," Journal of Lipid and Atherosclerosis, vol. 10, no. 3. Korean Society of Lipid and Atherosclerosis, pp. 282–290, Sep. 01, 2021. doi: 10.12997/JLA.2021.10.3.282.

[41] K. K. Mak and M. R. Pichika, "Artificial intelligence in drug development: present status and future prospects," Drug Discovery Today, vol. 24, no. 3. 2019. doi: 10.1016/j.drudis.2018.11.014.

[42] B. R. Beck, B. Shin, Y. Choi, S. Park, and K. Kang, "Predicting commercially available antiviral drugs that may act on the novel coronavirus (SARS-CoV-2) through a drug-target interaction deep learning model," Comput Struct Biotechnol J, vol. 18, pp. 784–790, 2020, doi: 10.1016/j.csbj.2020.03.025.

[43] R. Zhao, R. Yan, Z. Chen, K. Mao, P. Wang, and R. X. Gao, "Deep learning and its applications to machine health monitoring," Mechanical Systems and Signal Processing, vol. 115. 2019. doi: 10.1016/j.ymssp.2018.05.050.

[44] M. Alhussein and G. Muhammad, "Automatic Voice Pathology Monitoring Using Parallel Deep Models for Smart Healthcare," IEEE Access, vol. 7, 2019, doi: 10.1109/ACCESS.2019.2905597.

[45] S. M. Sefa-Yeboah, K. Osei Annor, V. J. Koomson, F. K. Saalia, M. Steiner-Asiedu, and G. A. Mills, "Development of a Mobile Application Platform for Self-Management of Obesity Using Artificial Intelligence Techniques," Int J Telemed Appl, vol. 2021, 2021, doi: 10.1155/2021/6624057.

[46] T. Malche et al., "Artificial Intelligence of Things- (AIoT-) Based Patient Activity Tracking System for Remote Patient Monitoring," J Healthc Eng, vol. 2022, 2022, doi: 10.1155/2022/8732213.

[47] P. Rajan Jeyaraj and E. R. S. Nadar, "Smart-Monitor: Patient Monitoring System for IoT-Based Healthcare System Using Deep Learning," IETE J Res, vol. 68, no. 2, 2022, doi: 10.1080/03772063.2019.1649215.

[48] M. K. Hassan, A. I. el Desouky, S. M. Elghamrawy, and A. M. Sarhan, "A Hybrid Real-time remote monitoring framework with NB-WOA algorithm for patients with chronic diseases," Future Generation Computer Systems, vol. 93, 2019, doi: 10.1016/j.future.2018.10.021.

[49] S. P. Chatrati et al., "Smart home health monitoring system for predicting type 2 diabetes and hypertension," Journal of King Saud University - Computer and Information Sciences, vol. 34, no. 3, 2022, doi: 10.1016/j.jksuci.2020.01.010.

[50] M. Alhussein, "Monitoring Parkinson's Disease in Smart Cities," IEEE Access, vol. 5, 2017, doi: 10.1109/ACCESS.2017.2748561.

[51] Z. Fu, S. Hong, R. Zhang, and S. Du, "Artificial-intelligence-enhanced mobile system for cardiovascular health management," Sensors (Switzerland), vol. 21, no. 3, 2021, doi: 10.3390/s21030773.

[52] H. Pandey and S. Prabha, "Smart Health Monitoring System using IOT and Machine Learning Techniques," in 2020 6th International Conference on Bio Signals, Images, and Instrumentation, ICBSII 2020, 2020. doi: 10.1109/ICBSII49132.2020.9167660.

[53] M. Zia Ur Rahman et al., "Real-time artificial intelligence based health monitoring, diagnosing and environmental control system for COVID-19 patients," Mathematical Biosciences and Engineering, vol. 19, no. 8, pp. 7586–7605, 2022, doi: 10.3934/mbe.2022357.

[54] N. Nasser, Q. Emad-ul-Haq, M. Imran, A. Ali, I. Razzak, and A. Al-Helali, "A smart healthcare framework for detection and monitoring of COVID-19 using IoT and cloud computing," Neural Comput Appl, Sep. 2021, doi: 10.1007/s00521-021-06396-7.

[55] A. Rghioui, J. Lloret, S. Sendra, and A. Oumnad, "A smart architecture for diabetic patient monitoring using machine learning algorithms," Healthcare (Switzerland), vol. 8, no. 3, 2020, doi: 10.3390/healthcare8030348.

[56] G. Huang, Y. Fang, X. Wang, Y. Pei, and B. Horn, "A Survey on the Status of Smart Healthcare from the Universal Village Perspective," in 4th IEEE International Conference on Universal Village 2018, UV 2018, 2019. doi: 10.1109/UV.2018.8642125.

[57] Naveen, R. K. Sharma, and A. R. Nair, "IoT-based Secure Healthcare Monitoring System," in Proceedings of 2019 3rd IEEE International Conference on Electrical, Computer and Communication Technologies, ICECCT 2019, 2019. doi: 10.1109/ICECCT.2019.8868984.

[58] B. Quispe-Lavalle, F. Sierra-Liñan, M. Cabanillas-Carbonell, and N. Wiener, "Mobile Applications for the Implementation of Health Control against Covid-19 in Educational Centers, a Systematic Review of the Literature," 2022. [Online]. Available: www.ijacsa.thesai.org

[59] B. Marent et al., "Development of an mHealth platform for HIV care: Gathering user perspectives through co-design workshops and interviews," JMIR Mhealth Uhealth, vol. 6, no. 10, 2018, doi: 10.2196/mhealth.9856.

[60] Y. Koumpouros, "User-Centric Design Methodology for mHealth Apps: The PainApp Paradigm for Chronic Pain," Technologies (Basel), vol. 10, no. 1, 2022, doi: 10.3390/technologies10010025.

[61] G. Molina-Recio, R. Molina-Luque, A. M. Jiménez-García, P. E. Ventura-Puertos, A. Hernández-Reyes, and M. Romero-Saldaña, "Proposal for the User-Centered Design Approach for Health Apps Based on Successful Experiences: Integrative Review," JMIR Mhealth Uhealth, vol. 8, no. 4, p. e14376, Apr. 2020, doi: 10.2196/14376.

[62] L. M. Kopf and J. Huh-Yoo, "A User-Centered Design Approach to Developing a Voice Monitoring System for Disorder Prevention,"

Journal of Voice, vol. 37, no. 1, pp. 48–59, Jan. 2023, doi: 10.1016/j.jvoice.2020.10.015.

[63] F. Tiersen et al., "Smart Home Sensing and Monitoring in Households With Dementia: User-Centered Design Approach," JMIR Aging, vol. 4, no. 3, p. e27047, Aug. 2021, doi: 10.2196/27047.

[64] S. S. R. Abidi and S. R. Abidi, "Intelligent health data analytics: A convergence of artificial intelligence and big data," Healthc Manage Forum, vol. 32, no. 4, pp. 178–182, 2019, doi: 10.1177/0840470419846134.

[65] R. Miotto, F. Wang, S. Wang, X. Jiang, and J. T. Dudley, "Deep learning for healthcare: Review, opportunities and challenges," Brief Bioinform, vol. 19, no. 6, pp. 1236–1246, 2017, doi: 10.1093/bib/bbx044.

[66] T. Davenport and Ravi Kalakota, "The Potential for Artificial Intelligence in Healthcare," Future Healthc J, vol. 6, no. 2, pp. 94–98, 2019.

[67] S. H. Park, J. Choi, and J. S. Byeon, "Key principles of clinical validation, device approval, and insurance coverage decisions of artificial intelligence," Korean Journal of Radiology, vol. 22, no. 3. 2021. doi: 10.3348/kjr.2021.0048.

[68] A. Hassan, M. A. A. Abdulhak, R. bin Sulaiman, and H. Kahtan, "User centric explanations: A breakthrough for explainable models," 2021 International Conference on Information Technology, ICIT 2021 - Proceedings, vol. 0, pp. 702–707, 2021, doi: 10.1109/ICIT52682.2021.9491641.

[69] M. Kim, Y. Kim, and M. Choi, "Mobile health platform based on user-centered design to promote exercise for patients with peripheral artery disease," BMC Med Inform Decis Mak, vol. 22, no. 1, p. 206, Dec. 2022, doi: 10.1186/s12911-022-01945-z.

[70] S. Saba Raoof and M. A. S. Durai, "A Comprehensive Review on Smart Health Care: Applications, Paradigms, and Challenges with Case Studies," Contrast Media Mol Imaging, vol. 2022, 2022, doi: 10.1155/2022/4822235.

[71] A. Hassan, R. Sulaiman, M. A. Abdulgabber, and H. Kahtan, "Towards User-Centric Explanations for Explainable Models: A Review," Journal of Information System and Technology Management, vol. 6, no. 22, 2021, doi: DOI: 10.35631/JISTM.622004.

[72] H. Kahtan, K. Z. Zamli, W. N. A. W. A. Fatthi, A. Abdullah, M. Abdulleteef, and N. S. Kamarulzaman, "Heart Disease Diagnosis System Using Fuzzy Logic," presented at the Proceedings of the 2018 7th International Conference on Software and Computer Applications, Kuantan, Malaysia, 2018. [Online]. Available: https://doi.org/10.1145/3185089.3185118.