Journal of Population Therapeutics
& Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v31i3.4812

THE ROLE OF BLOCK CHAIN TECHNOLOGY IN SECURING ELECTRONIC HEALTH RECORDS: OPPORTUNITIES AND CHALLENGES

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Abstract:

Background: Medical devices encompass a diverse array of innovations aimed at patient rehabilitation, disease diagnosis, treatment, and prevention without relying on metabolic, immunological, or pharmacological means.

Objective: This review aims to explore notable advancements in medical device development, focusing on wearable technology, assistive technologies such as exoskeletons and communication software for individuals with limited mobility, medical training applications, artificial intelligence (AI) in medical imaging diagnosis, and virtual reality (VR) for pain management.

Methods: A comprehensive search of the literature was conducted to identify key developments in medical device technology. Relevant studies, articles, and reports were reviewed to provide insights into the current landscape of medical device innovation.

Results: The review highlights several significant advancements in medical device development. Wearable technologies offer continuous monitoring and feedback for patients, enabling personalized healthcare interventions. Assistive technologies, such as exoskeletons and communication software, empower individuals with disabilities to enhance their mobility and communication capabilities. Medical training applications facilitate simulation-based learning for healthcare professionals, improving clinical skills and patient outcomes. AI applications in medical imaging aid in accurate diagnosis and treatment planning, enhancing clinical decision-making processes. Virtual reality devices offer promising avenues for pain management, providing immersive experiences that distract patients from discomfort and improve overall well-being.

Conclusion: The rapid evolution of medical device technology continues to drive innovations in patient care, rehabilitation, and disease management. Future research and development efforts should focus on harnessing the potential of these advancements to improve healthcare outcomes and enhance the quality of life for patients worldwide.

Keywords: Wearable technology, assistive technology, metabolic, immunological, and pharmacological

INTRODUCTION:

Many technologies that, through methods other than metabolic, immunological, and pharmacological, can be utilized for the diagnosis, treatment, prevention of a disease, or rehabilitation of a patient are considered medical devices. They can also be used for other compatible purposes. To train medical staff to perform successful interventions with less risk and to improve daily health conditions, monitor rehabilitation processes, avoid future health complications, or even integrate human beings into society when they are disabled, continuous technological advancements have made it possible for the field of application of medical devices to be broad (Abdel-Basset et al., 2019). The digitization of health records has revolutionized healthcare delivery, enabling efficient data management, accessibility, and analysis. However, traditional electronic health record (EHR) systems are often centralized, prone to security breaches, and lack interoperability between different healthcare providers. These shortcomings pose significant challenges to data privacy, integrity, and patient-centric care. In response to these challenges, blockchain technology has gained attention for its potential to address these issues and revolutionize the healthcare industry.

Modern medical technology includes devices.

Due to their diversity, medical devices can be used in many different areas of medicine for diagnosing, preventing, treating, or rehabilitating illnesses or conditions and assisting or replacing human physiological processes. As a result, technological advancement in this area involves the creation of new devices that enable intervention in previously unimaginable or novel fields. There are many different trends in the technological advancement of medical devices worldwide, many of which come from the various biomedical engineering and medical specialties, which increasingly seek technological intervention in the health field, continuously modernizing the healthcare systems in search of efficiency and effectiveness (Coventry & Branley, 2018).

Blockchain Technology Overview: This section provides an overview of blockchain technology, including its core principles, components, and characteristics. It explains concepts such as decentralization, consensus mechanisms, cryptographic hashing, and smart contracts, which form the foundation of blockchain systems. Additionally, it discusses different types of blockchains, such as public, private, and consortium blockchains, and their suitability for healthcare application (Bonsón & Bednárová, 2019)s.

Portable or wearable devices, as its literary translation of "Wearable Devices" suggests, as well as trends in the development of assistive technologies for mobility, technologies applied to learning through simulation, artificial intelligence involved in diagnosis for medical imaging, and even the use of virtual reality for specific applications such as pain treatment are examples of cutting-edge technological development trends (Bernard et al., 2018).

Benefits and Limitations of Blockchain in Healthcare: We discuss the potential benefits of adopting blockchain technology in healthcare, such as improved data security, enhanced interoperability, reduced administrative costs, and streamlined data sharing. Additionally, we address the limitations and challenges associated with blockchain implementation, including scalability issues, regulatory concerns, and the need for standardization and consensus among stakeholders(Dai et al., 2019).

Table 1: Wearable Technology

Technology	Description	References
Wearable Devices	Gadgets worn as accessories, attached to clothing, implanted, or tattooed on the skin. Utilized for monitoring, treatment, or assistance in leading healthier lifestyles. Incorporates biosensors and network connections for real-time data collection.	(Sim, 2019), (Khezr et al., 2019), (Coventry & Branley, 2018; Liu et al., 2019), (Griggs et al., 2018)

Table 2: Assistive Technologies

Technology	Description	References
Speech Encoding System	Implantation of multielectrode array in sensorimotor cortex enabling communication for paralyzed individuals.	(Défossez et al., 2022), (Angrick et al., 2023)
Robot-Powered Exoskeletons	Assistive devices for movement assistance and enhancing capabilities.	(Pamungkas et al., 2019), (Starczyńska & Sacharuk, 2020), (Gilbert et al., 2016), (Tu et al., 2020)

Table 3: Healthcare Simulation Technology

Technology	Description	References
Laparoscopy Simulation	Reproduction of laparoscopic procedures for training and skill development.	(Li et al., 2020), (Awal et al., 2021)
Advanced Cardiovascular Simulation	Simulation software for analyzing effects of invasive medical devices on cardiovascular system.	(Schreuder et al., 2009)
Harvey Simulator	Dummy-based simulator for mimicking various heart diseases.	(Norman et al., 2012)

Table 4: Artificial Intelligence in Medical Imaging

Technology	Description	References
Deep Learning Computer Systems	Utilization of machine learning algorithms for image analysis, aiding in diagnoses.	(Jones et al., 1997), (Sengupta et al., 2007)
Virtual Reality for Pain Management	Three-dimensional computer-generated environments for pain management, cognitive behavioural therapy, and deep breathing exercises.	(Gauthier et al., 2019), (Michael et al., 2014), (Meel, 2020)

Wearable technology

To monitor, treat, or assist people in leading better lifestyles, "Wearable Devices" is a category of gadgets that can be worn as accessories, attached to clothing, implanted in the user's body, or even tattooed on the skin. This technological advancement is a result of the trend toward the usage of portable electronic devices, sometimes known as "wearable electronics," such as wrist gadgets (smartwatches) and smartphones (smartphones), for leisure activities and sports measurement.

Combining biosensors and network connections, these products have 11sv paved the way for using these medical technologies (Sim, 2019).

Biosensors can offer real-time physiological data, enabling their usage in various non-invasive assessment applications. The ability to monitor daily activities, such as physical or health-related activities, is made possible by real-time measurement and data communication. Four areas of medical application have been identified: health and health monitoring, safety, management of chronic diseases, diagnosis and treatment of diseases, and rehabilitation. Generalizing this technological trend, it can be said that specific devices have been created to track breathing and heart rate using optical biosensors on bands worn on the chest, arm, or wrist and actively communicating the data with smartphone applications (Khezr et al., 2019).

Other uses for this kind of gadget include monitoring changes in stress levels or cognitive load via the skin's galvanic response and variations in conductivity caused by microscopic measurements of sweat gland secretion. Similar to this, other devices are made to track movements using sensors typically found in smartphones, such as GPS, gyroscopes, and accelerometers, which help identify the wearer's movements. Other devices act as emergency response systems, trying to alert family members or medical personnel of the carrier's need for care. As in the case of assistive digital ecosystems for the aged, these technologies can be used or combined to create systems with one of the aims above (Coventry & Branley, 2018; Liu et al., 2019).

This entails the incorporation of biosensors through wearable technology, mobility and environment monitoring tools used in smart homes, communication and information processing tools that can be used to prevent falls, track the health of patients who have experienced a cerebrovascular accident (CVA) and are undergoing rehabilitation by collecting electrocardiography (ECG) and electromyography (EMG), and automatically contact emergency services or a medical professional (Griggs et al., 2018).

Assistive technologies

A person's autonomy and ability to function in daily life and live a healthy, fulfilling, independent, and dignified life can be maintained or improved with the use of assistive technologies. Some people are excluded and isolated because they lack this technology due to disease, a handicap, or even old age. Only one in ten persons who use assistive technology have access to them, according to the World Health Organization; since they are expensive, few people are aware of the issue, and there aren't enough educational or financial resources (Desmond et al., 2018).

Speech encoding in a paralyzed anarthria patient

With the ongoing advancement of technology, many people now have access to assistive technologies that can drastically alter their way of life. One such technology is a system that allows paralyzed persons to regain their communication capacity. A recent study looked at the effects of implanting a multielectrode array in the language-controlling region of the sensorimotor cortex in a person with anarthria, which is the loss of speech articulation due to a stroke. The components of this type of technology are schematized in Figure 1 (Défossez et al., 2022).

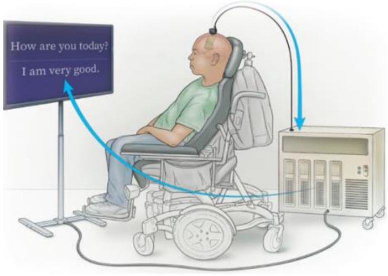

***Figure 1** shows a representative diagram of the system for speech encoding in a paralyzed anarthria patient.*

Note: This text has been modified from Neuroprosthetics for Speech Decoding in a Paralyzed Person with Anarthria.

The creation of this device allowed for the real-time decoding of sentences from the participant's cortical activity at an average rate of 15.2 words per minute with an average error rate of 25.6%, proving that the cerebral cortex is still capable of producing electrical representations of speech and language even after 16 years of paralytic anarthria (Angrick et al., 2023).

Robot-powered exoskeletons

Exoskeletons are medical devices that researchers are developing as assistive technologies to help the movement of people with disabilities. An exoskeleton is a support system worn on the body like clothing and is used to help with movement and/or enhance the human body's capabilities. While lower-extremity exoskeleton designs are the most common, efforts have also been made to design similar technology for the upper extremities. Here is some information about each type (Pamungkas et al., 2019).

Upper arts

Robotic systems for upper limb rehabilitation can be assessed from two angles: from the mechanical aspect or from the control system they employ. Nevertheless, they can all function passively, with the exoskeleton controlling the patient's arm. However, in the active mode, the exoskeleton only partially assists the patient's arm. For the past 11 years, the Massachusetts Institute of Technology (MIT) in the US has been developing a specialized exoskeleton for the physiotherapeutic care of stroke victims. This innovative project's experts have clarified that they do not intend to replace professionals with this kind of technology but rather to give them a tool to boost productivity (Starczyńska & Sacharuk, 2020).

The patient must place the lower portion of his arm and wrist inside the orthopedic device while sitting with a table in front of him during therapy supported by this technology. The arm exercise is demonstrated on a screen in front of the patient; if no movement is made, the device moves the patient's arm; if the patient starts to move independently, the gadget offers varying degrees of direction and support to encourage arm movement. The MIT gadget under development is seen in Figure 2 (Zhang et al., 2019).

***Figure 2** shows how MIT technology can deliver interactive, high-intensity physical treatment.*

Note: Converted from the MIT A robot from MIT can expedite stroke medication studies.

Lower body parts

In medical settings, the majority of lower extremity exoskeleton development focuses on giving or restoring the capacity to walk to persons who cannot do so for various reasons. According to the Centers for Disease Control and Prevention, the most prevalent mobility problem in children is cerebral palsy, which is caused by neurological damage before, during, or after birth. It is estimated that 500,000 children in the United States have cerebral palsy (Zhou et al., 2021).

Many children with the disease above have a hunched gait characterized by excessive knee flexion, which causes pain and increasing loss of function, even though more than half of them can walk independently. A robotic exoskeleton for the leg powered by tiny motors has been developed at Northern Arizona University (NAU) in the United States to offer some remedy or assistance to people suffering from this disorder. There is a hunched gait in children with cerebral palsy (Gilbert et al., 2016).

***Figure 3** illustrates a lower limb exoskeleton being used on a child patient.*

Note: This article has been modified from "NAU bioengineer's study shows wearable robotic exoskeletons improve walking for children with cerebral palsy," which can be found at this link: Northern Arizona University news and research information.

In a study at the National Institutes of Health Clinical Center in Bethesda, Maryland, children with cerebral palsy were fitted with an assistive device (an exoskeleton for the lower limbs), they took part in practice sessions, and at the end of the study, six of the seven participants displayed improvements in walking posture that were comparable to those seen in patients who had undergone invasive orthopedic surgery (Tu et al., 2020).

Healthcare simulation technology Simulation technologies, i.e., the process by which an experience is recreated in known or controlled conditions to identify new strategies to be implemented in different situations or uncontrolled, owe a significant portion of the technological advancement in the healthcare sector. Since the knowledge and abilities of people are brought into play to solve the problems that the healthcare professional may find himself facing in the course of his daily work, conducting simulations can also help provide competence, mental capacity, and the ability to give an assertive response to those who practice them. Today, simulation technology and its applications can be used in various ways, from employing computers to operating using educational tools to make a professional's experience more realistic (Yang et al., 2018).

Simulation of laparoscopy

In laparoscopic surgery, tiny incisions of less than a centimetre inject short, thin tubes, known as trocars, into the belly. Long, narrow devices are inserted through trocars to move, cut, and stitch tissue. The goal of training with laparoscopic simulators is to ensure the specialist uses the fundamental components to achieve the correct and effective execution of laparoscopic surgery. This includes knowing and mastering the steps, such as how to take the threads, how to cross them, how to tie the knots, etc., being able to repeat the action several times until the task is performed smoothly, obtaining results without errors, and demonstrating continuous Performance (Li et al., 2020).

The fundamental components of this kind of simulation include a training box with direct viewing capabilities via mirrors or video cameras. The most cutting-edge systems, however, consist of virtual reality simulators in which a laparoscopic procedure is reproduced, adding layers of reality through tactile sensation and tissue manipulation while using the instruments. This is accomplished through haptic devices, which transmit and receive the movements made by the user in the simulator. Figure 4 depicts the LAP Mentor III simulator at the Medical Simulation Centre, Royal Free Hospital, London (Awal et al., 2021).

For the clinical diagnosis of disease, advanced cardiovascular simulation

Researchers from the Rey Juan Carlos University of Madrid are developing cardiovascular simulation software as part of the CARDIOS project, which will give specialists more diagnostic precision when used with traditional tools designed for this purpose. The software can anticipate the circumstances of potential surgical intervention and analyze the effects of invasive medical devices like catheters, stents, artificial valves, or artificial heart pumps, which are essential components in treating some cardiovascular diseases or surgical interventions of this kind on the cardiovascular system. A screenshot of the CARDIOS experiment at Madrid's Rey Juan Carlos University is shown in Figure 5 (Schreuder et al., 2009).

Figure 4 *(Surgical Sciences, n.d.) shows an LAP Mentor III medical simulator at the Royal Free Hospital in London's Medical Simulation Centre.*

Note: Adapted from Surgical Science by Simbionix Simulators, https://simbionix.com/simulators/lap-mentor/, offers the most thorough surgical simulation instruction for students of all levels.

Figure 5*. Rey Juan Carlos University of Madrid's CARDIAC Project*

Note: This information has been modified from Advanced Cardiovascular Simulation for the Clinical Diagnosis of Diseases, published by Universidad Rey Juan Carlos at https://www.urjc.es/todas-las-Noticias-de-actualidad-cientifica/1442-simacion-cardiovascular-avanzada- for the clinical diagnosis of diseases.

The simulator for cardiopulmonary patients, Harvey

Harvey's simulator differs from the others in using a dummy to mimic 27 distinct heart diseases. The simulator shows various physical outcomes, such as auscultation of blood pressure, bilateral jugular venous pulses, arterial pulse and waveforms, precordial pulses, and auscultatory events in the four classical areas. These outcomes are synchronized with the vibration and change with breathing. Healthcare practitioners can practice their clinical skills in a controlled yet realistic environment using Harvey, which can simulate a range of heart ailments by adjusting blood pressure, respiration, pulse, normal heart sounds, and murmurs (Norman et al., 2012).

Artificial intelligence in the diagnosis of medical imaging

The use of computer tools to create procedures that replicate human intelligence, that is, these simulations are meant to be as accurate as possible, is known as artificial intelligence (AI). Capable of self-correction, learning, and thinking. Artificial intelligence comprises several logical algorithms that have been thoroughly evaluated and from which a computer can derive rules for making judgments in particular circumstances. Artificial intelligence applications in medicine have also been used to compare medical professionals' decisions with those produced by a computer, concluding that outcomes in specific medical fields, such as the analysis of medical images, can be comparable, transcending on a personal medical level due to the AI's lack of fatigue and stable characteristics (Jones et al., 1997).

This kind of technology is evolving to detect intricate patterns in images automatically and offer radiographic-related quantitative evaluations. It has been revealed that deep learning algorithms employing image results (current and previous) from a patient's CT scans can forecast the risk of lung cancer. This application aims to uncover findings perceptible or undetected by the human eye (Sengupta et al., 2007).

Deep learning computer systems, which are layers of machine learning, are demonstrated in Figure 6 as they have evolved.

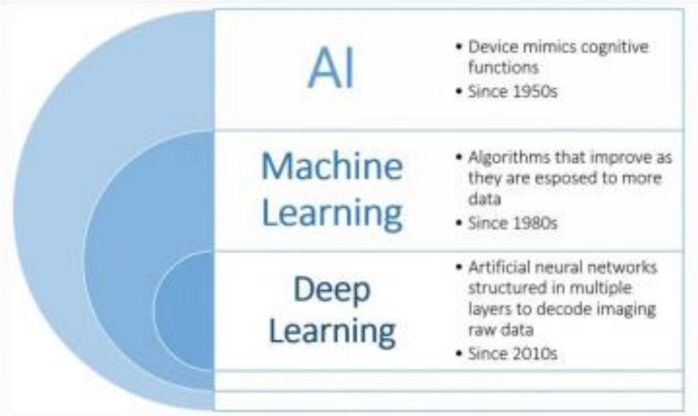

Figure 6 *Deep learning is a subset of machine learning techniques.*

Note: This article has been modified from Artificial Intelligence in Medical Imaging: Threat or Opportunity? Once more,6 leading the way in medical innovation are radiologists.

Because some AIs can distinguish between malignancy and benignity in tumours or lesions, these technologies are employed for objective second-opinion diagnoses to support the radiologist's interpretation and diagnosis of medical pictures. Studies have shown how this technology enhances diagnostic imaging by lowering observer variability and is a significant support for clinical decisions like suggestions for biopsies or thoracotomies, among other things (Norman et al., 2012).

Medical applications of virtual reality

Virtual reality for the treatment of pain. A three-dimensional computer-generated environment that can be seen through special glasses and provides a 360-degree perspective of a virtual environment is known as virtual reality. This immersive technology gives users the impression that they are in another world, among other things. We are disproving the long-held belief that the advent of this kind of technology would transform the way we live. Virtual reality has been demonstrated to be helpful in various fields, including marketing, entertainment, education, communication, and, of course, medicine (Gauthier et al., 2019).

Using virtual reality to manage chronic pain has been researched for a while. The FDA approved the marketing of a prescription virtual reality device for home use in November 2021 to help with chronic low back pain. This type of device uses the principles of cognitive behavioural therapy and other behavioural therapy techniques to reduce pain and pain interference, and it consists of a virtual reality headset and controller, as well as a "breathing amplifier." The patient's breathing towards the headset microphone to be used in deep breathing exercises. Figure 7 illustrates a virtual reality headset comparable to the one the FDA approved for use at home to treat low back pain (Michael et al., 2014).

Figure 7 *shows that the FDA has approved a home-use virtual reality system for treating chronic low back pain.*

Note: The following has been modified from Non-Drug Pain Treatment at Home

In a randomized, double-masked clinical trial with 179 patients that lasted 8.5 months in total and included a baseline evaluation period of two weeks, a virtual reality tour of eight weeks, a post-treatment assessment, and follow-up one, two, three, and six months after program completion, the FDA assessed the device's safety and efficacy. After the program, 66% of participants using the VR device reported a pain reduction of at least 30%, compared to only 41% of participants in the control group. During the trial, no significant adverse events were noticed or reported. About 20.8% of participants said they were uncomfortable wearing the headphones, and 9.7% said they felt queasy and sick (Meel, 2020).

CONCLUSIONS:

Trends in medical device development aim to bring about radical changes in daily life. These can be accomplished by using anything from simple accessories with specific health functions, like managing chronic diseases, to the use of more sophisticated devices, like reality simulators virtual environments for training healthcare professionals or treating patients, which significantly benefits both patients and professionals: it is easier for patients to diagnose, monitor, or treat themselves, and it also helps professionals diagnose and treat patients.

With the increasing dismantling of exclusion barriers for people with disabilities, more and more software and devices are being developed in the field of assistive technologies to assist patients with disabilities that limit their autonomy, such as the examples mentioned above: software to aid communication in people who have lost the ability to speak or the use of exoskeletons to help patients with physical disabilities.

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