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REVIEWS

Innovations in technology with applicability in healthcare

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Abstract

Background. Leadership, communities, and the individuals who produce technology all need to shift their value systems to use technology equitably and sustainably. Several examples of technology applications seek to undermine human rights, human justice, and fairness. As a result of the fact that it makes it simpler for patients to participate in the process of fulfilling their medical requirements, digital health has the ability to play a role in the innovation process that is taking place within the healthcare business. In today's world, there has been considerable growth in the number of intelligent technologies and sophisticated equipment (such as smart wireless and wearable sensors) used to monitor and treat patients' diseases rapidly. This is done by giving patients fast access to critical health indicators and conducting continual evaluations.

Aims. The purpose of this research is to describe and examine novel methods for using newly developed technology in the medical industry. This study's objective is to analyze the many ways modern technology is being incorporated into the healthcare system to serve patients better. We will primarily emphasize Artificial Intelligence (AI), Virtual Reality (VR), the use of Smart Phones, Exoskeletons, and several other types of robotic technology.

Conclusions. Several uses of artificial intelligence (AI) technology may be found within the healthcare industry. These technologies have been developed to support medical imaging and diagnostic services, combat pandemics, provide virtual patient care, increase patient engagement and adherence to treatment plans, reduce the administrative burden on healthcare professionals, and monitor patients' compliance with exercise regimens. Because of their ability to precisely assess patients' development, cutting-edge technologies such as artificial intelligence (AI) should be included in augmented reality (AR) rehabilitation systems. In addition, creating a system based on augmented reality that can be used on mobile devices may help achieve other advantages, such as remote patient recovery monitoring and the provision of real-time attention at reduced cost.

Keywords: innovations, technology, artificial intelligence, healthcare.

Introduction

There is a significant possibility that cutting-edge technology could make people healthier. However, advancements in technology may not automatically ensure fairer health results. Communities that lack resources are often left out of the conversation as technological breakthroughs alter the ways in which people, systems, and information interact with one another. In places where technology repairs have been pushed on communities, the outcomes have included abandoned equipment, computer programs that are incompatible with one another, and ineffectual regulations.

To apply technology equitably and sustainably, leadership, communities, and the people who create technology must transition their value systems (Pârvu et al., 2023). There are several instances of technical applications that work to undermine justice, fairness, and human rights. One such example is the adoption of complex medical procedures rather than more straightforward preventative measures. The development of technology and its use both need to observe ethical standards and the values of the communities in which they are used to produce equal results (Fong & Harris, 2015).

The process of digital transformation is continuing, and it has the potential to provide possibilities in the healthcare industry—but only if the appropriate infrastructure and skills are made accessible. The use of digital technology for the purpose of transforming enterprises and services is referred to as "digital transformation" in Regulation (EU) 2021/694 of the European Parliament and the Council on 29 April 2021, which established the Digital Europe Program and repealed Decision (EU) 2015/2240. The digital platforms of the Internet of Things, cloud computing, and artificial intelligence are all examples of technology contributing to digital transformation. While this is happening, the areas of society most likely to be impacted include the healthcare industry, financial services

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industry, and telecommunications industry (Stoumpos et al., 2023).

Because it makes it easier for patients to take part in having their medical needs met, digital health has the potential to play a part in the healthcare industry's innovation process. When the patient is no longer in a condition of well-being, they can recover from their bad state of health. In this particular instance, the patient is allowed to take part in the decision-making process about their medical treatment. The patient needs to do research on their own through the Internet or by utilizing digital health apps (for example, via their mobile phone) in order for them to make the most informed choice possible for their health (Iyawa et al., 2016).

The development of information technology (IT) has led to notable advancements in healthcare services, most notably in remote health monitoring (Li et al., 2019). Utilizing physical sensor networks to prevent illness and detect high-risk disease impairments (Mohammadzadeh et al., 2020) is one of the most important reasons why this technology is being developed. Today, intelligent technologies and sophisticated equipment (such as smart wireless and wearable sensors) have significantly increased for quick monitoring and management of patients' conditions. This is accomplished via prompt access and continuous evaluation of patients' vital health indicators (Gries et al., 2018; Junaid et al., 2022).

It is the right moment to make a concrete transition toward holistic technology and data-driven digital tools, which should be done while considering the short-, medium-, and long-term reaction plans. This will involve both public and private healthcare systems all over the country in promoting policy discourse, technical support, and training on specialised policy and response initiatives at the regional and national levels. It is also true that the well-tested hardware is already in place, and quite a few trials have already been carried out; nevertheless, this technology has not been put to good use, especially in developing countries, due to a lack of national will, a lack of finances, and a lack of strategic planning to reach those who need it the most (Nair, 2022).

We also want to state the importance of using new technologies in physical activities (Szabo, 2021a) for the development of coordination (Szabo et al., 2021), balance (Szabo, 2021b) and general rehabilitation (Szabo, 2022; Szabo & Neagu, 2022).

This study aims to devise and investigate original approaches to using new technology in the medical field. The purpose of this study is to investigate the ways in which contemporary technologies are being implemented into the healthcare system. We will concentrate on Artificial Intelligence (AI), Virtual Reality (VR), the use of Smart Phones, Exoskeletons, and other forms of robotic technology.

Innovations in technology

The phrases "innovation" and "innovator" have become popular buzzwords in recent years, and their usage has spread to various other industries, including the healthcare industry. To this day, however, no definition of innovation is all-encompassing and universally recognized, and other fields of study, such as economics, public health, geography, and sociology, use somewhat different ideas. Schumpeter was one of the leading economists to recognize the great significance of innovations to each economic structure, fluctuating from an individual corporate unit up to entire economies and the international economy developing new company frameworks, or entering a new business. He also included entering a new demand as an illustration of innovation. In addition to this, he portrayed innovation as the "creative destruction" that lies at the underpinning of every development produced inside a capitalist market system (Flessa & Huebner, 2021).

Barriers encountered

The theoretical scientific study in this sector is still relatively low despite the plethora of new ideas in the healthcare industry and the rising need for them. At the equal moment, there is an increased need for investigation on various health-related advancements. While early conceptual work may be discovered in the literature, most focus on particular healthcare apps such as pharmaceutical services. Innovations complementary to current outcomes and structures challenge those answers and methods, and as a result, they encounter opposition from the reputable system. The lack of widely disseminated novel ideas is not the primary challenge confronting the health industry; instead, the innovation gap is the primary challenge (Berwick, 2003). Barriers to innovation will be created because of the high expenses associated with innovation, the need to learn new methods and adapt old systems, and the fear of being displaced by new technology (radiological diagnostics). Even though the innovation seems exciting, there is no assurance that it will ever be successful and become the new standard method of solving the problem. In point of fact, many potentially successful ideas or good end up being confined to a narrow market because their creators cannot surmount the obstacles that stand in their way (Flessa & Huebner, 2021).

Components of healthcare

The following are the three primary components that make up the healthcare system: (I) Primary service providers for medical care, such as physicians, nurses, technicians, and hospital administrations (II) Services connected to medical emergencies (III) Patients who are in need of health and health-related services (III) Users of health and health-related services. Every year, there are increasing instances of security and privacy breaches in the healthcare industry; for example, in 2017, more than 300 breaches were revealed, and between 2010 and 2017, up to 37 million data were compromised (Hölbl et al., 2018). The growing use of digital technology in healthcare has led to a greater awareness of concerns around the safe storage of patient medical information, access to those records, ownership, and the medical data obtained from linked sources. It is proposed that blockchain be used to solve significant challenges currently affecting the healthcare industry, such as the safe exchange of medical information and the observance of data privacy rules (Saeed et al., 2022).

Blockchain

A blockchain is a specific kind of database controlled by a network of verified users or nodes that maintains

immutable blocks of information that can be easily shared without interference by third parties (Hölbl et al., 2018). Blockchains are used in cryptocurrencies like bitcoin and ethereum, and digital forms of the cryptocurrencies bitcoin and ethereum. Data may be kept and documented using cryptographic signatures in conjunction with consensus techniques that are included as essential components in their application. The potential to preserve data is one of the most important goals for using BCT, particularly in the healthcare sector, which is subject to the vast exchange and distribution of a substantial quantity of data (Saeed et al., 2022).

Evaluation of health innovations

It is vital to understand better how innovation by care providers, particularly by radiation centers, impacts performance to minimize the negative consequences that may be caused by introducing innovations either too rapidly or too slowly and to increase the cost efficiency of care delivery. For instance, the majority of the healthcare expenditure growth may be linked to the introduction of new technologies. Furthermore, in the radiation field, novel technologies often need substantial financial expenditures in apparatus, quality assurance, and extra staff training, although it is frequently unclear to what degree these advances will lead to improved patient results (Ramaekers, 2013). The literature does not always give a clear image of how innovations are assessed, for example, because scientists believe that the development of innovations is not ideal for stringent assessment or because innovations are continually altering. This results in the literature sometimes failing to provide a clear picture of how innovations are reviewed. It is vital to acquire a deeper insight into the anticipated advantages of a proposed novel intervention in clinical practice compared to the projected extra expenses (Jacobs et al., 2017). This is required from the standpoint of society.

Therefore, it is essential to assess innovations not just on one aspect of production but on complete performance as a whole. The research that has been done on this topic identifies this as a synthesis of efficacy and efficiency (Hovmand & Gillespie, 2010). Effectiveness in this context refers to the external criteria used in the evaluation of goods and services; from the patient's standpoint, we link this concept in our research to patient outcomes, patient safety, or patient service. The term "effectiveness" refers to the degree to which certain goods, services, or treatments are successfully compared to the money they cost (Jacobs et al., 2017).

Telemedicine

Significant advancements have been made to healthcare services as a direct result of information technology (IT) developments, especially regarding remote health monitoring. The early detection of high-risk disabilities and illness prevention are two of the most important objectives that may be accomplished via physical sensor networks (Mohammadzadeh et al., 2020). Today, there is significant growth in the use of advanced technologies and instruments (such as intelligent and wearable wireless sensors) to quickly monitor and manage patient circumstances. This is accomplished via the provision of prompt access and continuous evaluation of patients' vital health indicators (Junaid et al., 2022).

Such intelligent devices must be able to store and convey data in many different types of healthcare or medical care (for example, telemedicine) (Da Costa et al., 2018). Wearable sensors are primarily used to monitor and record patients' health issues and conditions and perform several additional functions that are directly relevant to their health. In other words, vital health indicators represent the patient's physiological condition, the activity of their organs, and the course of their sickness. Evaluating these indicators has a substantial impact on illness prevention and the diagnosis, treatment, and care of patients. These health data, if evaluated correctly and promptly, might offer a helpful reference for providing healthcare that is both efficient and of high quality. A large number of intelligent gadgets, Internet of Things (IoT) technologies, and artificial intelligence (AI)-based technologies have been devised and developed in order to increase the timeliness and continuity of the evaluation of patient health status and appropriate healthcare subsystems (Junaid et al., 2022).

The rapid expansion of technology is transforming behavioral science, bringing disruptive innovations in healthcare delivery and research. Integrating technology-based tools into healthcare has tremendous potential to drive behavioral change across health and wellness goals, from smoking cessation to chronic disease management. Indeed, a growing body of research demonstrates the acceptability, effectiveness and cost-effectiveness of behavioral intervention technologies (BITs) (Mohr et al., 2013), indicating that the adoption of technology in behavioral healthcare can improve the quality of care and minimize implementation barriers that traditional behavioural interventions face (e.g., lack of time, lack of social support, few incentives for behavioural change) (Sucala et al., 2017).

The use of health information technology (IT) in a complex adaptive health system has the potential to enhance patient care, but it also carries with it the risk of unintended effects and the emergence of new difficulties (Ash et al., 2004). One of the most pressing problems that need to be addressed is ensuring the safety of information technology used in medical settings. In order to successfully create, deploy, and maintain a secure new digital infrastructure, the scientific community is working toward a deeper understanding of the complex interactions between people, processes, the environment, and various technologies. While recent findings from the hospital context suggest that information technology in healthcare might make treatment safer, there is evidence to suggest that it can cause new safety concerns, some of which may not become apparent for a long time after the technology has been installed (Sittig et al., 2020).

Technologies used in healthcare

Technology has become an integral part of the healthcare sector, completely transforming medical practices. Cutting-edge digital technologies have improved surgery efficiency and helped maintain patient quality of life. Even people with severe medical complexities can maintain their health with the help of these technologies (Maksimović & Vujović, 2017). The involvement of artificial intelligence

(AI), machine learning, the Internet of Things (IoT) and blockchain has revolutionized the healthcare sector, and the application of these technologies is beyond the expected limits. Robotic surgery is the most promising advanced use of these technologies, which has proven more effective than conventional surgical procedures. Many apps and digital devices help healthcare professionals monitor patients' health in real-time, even without visiting them. After years of research, these digital devices are much more thoughtful and sensitive and work based on the scientist's algorithm. These devices significantly increase patients' recovery rates. The wearable devices manage the daily routines of users' lifestyles. The advancement of digital technologies is changing the conceptualization of healthcare in recent times. Digital devices mainly work in the healthcare process and procedure (Akhtar et al., 2022).

Although the technology and applications are sometimes not straightforward, many researchers have developed easy-to-use devices to enhance digital technologies related to healthcare. Therefore, digital healthcare has dramatically altered the present healthcare system, resulting in an easier way of life for patients and healthcare practitioners. Even though digital technologies are more effective in delivering healthcare services, stakeholders have raised several significant concerns about using these technologies. One of these worries is regarding the confidentiality and integrity of patient information. Online access to digital health data makes it possible to see extensive information and a patient's medical history, but this accessibility raises concerns about the patient's privacy (Akhtar et al., 2022).

Healthcare services are evolving globally in response to an explosion of readily available digital technologies. The adoption of digital technologies as a means for citizens to access health and social care is accelerating at an unprecedented pace, pushing patient-centred care towards digital health (Sherman & Grande, 2019). Many countries and organizations are paying increased attention to digital health, which has seen a surge in the publication of health policies and reports, such as the UK's Digital Strategy published in 2012, the European Union's Digital Decade and Digital Europe Programme, the World Health Organization's Draft Global Digital Health Strategy (2020-2025), China's Healthy China Plan 2030. The term "digital health" refers to the use of information and communication technologies that are easily accessible: providing patients with preventative services, treatment, and education; promoting the tracking and monitoring of diseases; and enabling consumers to participate in the provision of healthcare services. Digital health is the integration of digital technology and health information to increase the efficiency of healthcare delivery and improve patient health. Digital health technology is the adoption of digital technology in health, examples of which are seen in electronic health records, telemedicine or telehealth services, robotics and eHealth, and mobile health supported by smartphones, wearable devices, mobile apps and various monitoring devices (Yao et al., 2022).

E-health has become an integral part of the healthcare system as it addresses several challenges in medicine, including reducing errors and providing more efficient services with more accurate outcomes (Jhamb et al., 2015). In this way, the use of electronic health records, in which all information pertaining to a patient is saved, helps to avoid the wrong administration of medicine during medical treatment, as well as ensures that the patient is treated swiftly and in an environment that is both comfortable and efficient. However, for virtual healthcare to be deployed, its deployment must first undergo appropriate planning and strategy (da Fonseca et al., 2021).

User acceptability and the kinds of infrastructure, systems, and management used all have a role in determining whether or not e-health is implemented successfully in a nation. Meanwhile, four groups are vested in the outcomes: business owners and managers, medical experts, patients, and those in charge of setting health insurance and care policies (Swinkels et al., 2018). E-health plans must be carried out in an integrated fashion for the use of information technology in healthcare to be successfully implemented. This must also include the creation of rules, laws, or regulations. This is true in telehealth, m-health, or specialised categories such as electronic health records or health literacy e-learning (da Fonseca et al., 2021). Telehealth and m-health both fall under this category.

Artificial Intelligence

Many areas of healthcare could benefit from the use of artificial intelligence technology. According to a recent literature review, artificial intelligence is already being used: "in assessing the risk of disease and estimating treatment success (prior to) initiation; in attempting to manage or mitigate complications; to assist in patient care during the treatment phase or active procedures; and in research aimed at elucidating the pathology or mechanism and/or ideal treatment for a disease" (Becker, 2019). In terms of risk, others have summarized several health-related concerns: the potential for bias in the data used to train artificial intelligence algorithms, the need to protect patient privacy, potential distrust of digital tools on the part of physicians and the general public, and ensuring that healthcare personnel handle artificial intelligence in a trustworthy manner. Other concerns relate to the physical applications of artificial intelligence. For example, while robots could help care for the elderly, there are risks of reduced human-to-human contact, deception to encourage companionship with a machine, and loss of control over a person's own life. Questions have also been raised about the extent to which artificial intelligence technologies could replace clinicians and, if so, whether the opacity of decisions based on machine learning weakens the authority of clinicians, threatens patient autonomy, or jeopardises joint decision-making between doctor and patient (Bærøe, 2020).

Artificial Intelligence (AI) includes various technologies based on algorithms and advanced learning systems. Different terms are used concerning AI, such as machine learning, deep learning and conventional neural networks (Hashimoto et al., 2018). In addition, there is no universally agreed definition of AI, while it is suggested to be defined as a system capable of interpreting and learning from data to produce a specific goal (Fasterholdt et al., 2022).

Virtual Reality

Virtual Reality (VR) is seen as an information and

education tool and a patient rehabilitation tool. The term refers to a set of new technologies, including computers or mobile devices with interactive 3D graphics display boards, controllers and head-mounted displays (HMDs) embedded with position tracking tools (Chow et al., 2021). As this technology develops, it will become possible to construct virtual worlds that are more engaging and fulfilling, which will assist learning, medicine, and healthcare in overcoming the limitations that have traditionally been imposed on these fields. Virtual reality (VR) has the potential to bring about significant advancements in a variety of medical treatments. These advancements will enable healthcare practitioners to provide patients with more pleasant experiences by creating 3D virtual worlds. In addition to this, it may assist the employees working in healthcare facilities in gathering and exchanging health data via simulation systems, which can also play roles in the process of medical decision-making and distant learning. It would seem that virtual reality has the potential to play a significant role in the realization of HC's Health 4.0 goal (Liu et al., 2022).

The use of VR for therapeutic purposes has garnered the most significant interest among all its uses in the healthcare industry. Researchers have shown that using virtual reality (VR) in treatment may help patients maintain their physical and emotional health in several ways. For instance, the use of virtual reality (VR) in conjunction with cognitive behavioral treatment (CBT) or exposure therapy (ET) has been shown to be effective in treating mental diseases such as anxiety related to public speaking and driving phobias. Virtual reality (VR) sports activities have been demonstrated to enhance upper limb motor function and everyday independence in stroke survivors (Rodríguez-Hernández et al., 2021). This pertains to conditions that affect the body. In addition, virtual reality (VR) may be used as a method of pain management (PM) that does not need intrusive procedures. In addition, patients with pulmonary illness may experience an improvement in their emotions due to virtual reality, which reduces their levels of worry and tension. The encouraging information in publications that concentrate on various clinical illnesses has increased the likelihood that physicians would utilise virtual reality simulations in their research and clinical trials. Consequently, the use of virtual reality (VR) in treatment has emerged as a critically significant component of HC and Health 4.0, and VR-assisted therapy has emerged as one of the primary uses of VR (Liu et al., 2022).

Use of smartphones

The opportunity to apply smartphones to POC has resulted from their large number, rapid worldwide spread and improved imaging/diagnostic functions. Even in places with limited resources, such as a remote mountain community, a smartphone may be used as a tool that is part of a system that is small, portable, and inexpensive for real-time POC. Using smartphone networks, POC community health workers can share information about initial diagnostic tests and treatment with expert providers at a distance. Enhanced smartphone features also promote their use at POC. Smartphones offer various software applications with different functions, including managing information and time using notes, maintaining and accessing medical records, collecting referrals and information using manuals, and even monitoring the patient using collected clinical data for use at POC (Ventola, 2014). Recently, cell phones have been used as an imaging modality for illness diagnosis by employing visible light, green fluorescent protein (GFP), and near-infrared (NIR) light. This has allowed for the visualization of tissues and even individual cells. This suggests that the utilisation of cell phones at points of contact has progressed into the "deep water zone." Nevertheless, no prior work has methodically assessed the efficacy of smartphones in diagnostics through imaging techniques that have become possible through the consolidation of recently advanced hardware, such as smartphone spectrometers, or the intelligent use of groundbreaking smartphone imaging instruments (Huang et al., 2021). This is because no previous work has attempted to measure the efficacy of smartphones in diagnostics through imaging techniques that have transitioned possible.

Several systematic reviews and meta-analyses have reinforced the usefulness of mobile phones and smartphones (including wireless handheld tablets and cell phones) in various health areas. These include the application of mHealth technology in care delivery and chronic disease management with specific applications for hypertension monitoring, medication adherence support, obesity and weight loss, diabetes, substance abuse prevention, mental health and physical activity, to name a few. Apps have also been developed for self-care management of asthma, smoking cessation, maternal and neonatal care, and stress reduction using mindfulness strategies, all including biofeedback provision. Additional reviews have concentrated their attention more narrowly on mobile applications that are aimed at illnesses that the WHO has deemed to be a critical global health priority (Martínez-Pérez et al., 2013). These evaluations, for the most part, provide support for promising outcomes that may have potential health benefits for a wide variety of evidence-based therapies for mobile and smartphone applications (Hansen & Scheier, 2019).

Exoskeletons and robotic technology

Wearable exoskeletons and robots based on exoskeletons are built on a mechanical framework that theoretically matches the skeletal structure of a limb or other body component that is involved. These devices are known as exoskeletons. In recent decades and still today, they are the subject of much research, given the benefits they can bring to the end user (Tiboni et al., 2022).

Robotic rehabilitation provides repetitive, flexible and customizable exercises that complement the work of the physiotherapist, aimed at the functional recovery of patients reporting impairments or disorders resulting, for example, from stroke, brain or spinal cord injury (SCI), amyotrophic lateral sclerosis (ALS), orthopedics, surgery, or cerebral palsy (CP) (Amici et al., 2019; Sturza et al., 2023). Other significant advantages are associated with the use of robotic devices in rehabilitation. These advantages include, for example, repetitive intensive training, performing recovery at home with remote control, automatically adjusting device support according to the patient's progressive recovery, increasing patient engagement through proposed

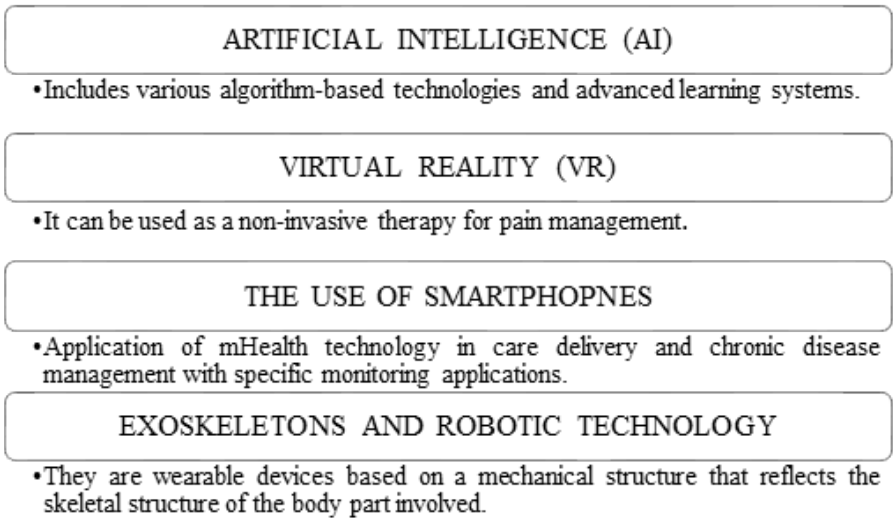

Fig. 1 – Technologies used in healthcare.

computerized activities in the form of games, monitoring progress by objectively evaluating outcomes, and reducing the over aggressiveness of the recovery process.

Kinematic structure and the kind of drive may be used to categorize different industrial exoskeletons. Soft exoskeletons lack any kinematic structure, whereas rigidly structured devices may be divided into anthropomorphic and non-anthropomorphic categories according to their kinematics. In addition, the construction may vary from devices that support the whole body to devices that aid just a single joint, which makes them theoretically customizable. Actuators may be broken down into three categories: passive, semi-active, and active. The force needed to aid the activities made by the user is released by utilizing the elasticity of the materials (such as torsion springs or pistons). However, passive exoskeletons do not include actuators or electronic elements such as transducers or controllers. Instead, they rely on the flexibility of the instruments to provide assistance. Compared to power (semi-active and active), this kind offers advantages in the form of convenience, economy, and clarity in design. These benefits are threefold. Exoskeletons function in unison with the wearer, lessening the burden, boosting the user's physical capabilities, and alleviating any ergonomic concerns associated with detaining and succeeding with instruments (Baldassarre et al., 2022). Due to these unique properties, exoskeletons work in this manner.

Conclusions

1. Artificial intelligence (AI) technologies are used for various healthcare applications. These technologies have been developed to support medical imaging and diagnostic services, fight pandemics, provide virtual patient care, increase patient engagement and adherence to treatment plans, reduce the administrative burden on healthcare professionals and monitor patients' exercise compliance.

2. Some cutting-edge technologies, such as AI, should be integrated into AR rehabilitation systems as they can accurately track patients' progress. In addition, developing an AR-based system on mobile devices could contribute to more benefits, as it can achieve remote patient recovery monitoring and provide real-time attention with lower costs. Because it can further boost user motivation, augmented reality (AR) systems would also benefit from access to additional game-based rehabilitative material geared at various groups.

3. As technology improves, it will be possible to design virtual worlds that are both more interesting and more rewarding, which will help education, medicine, and healthcare break free of the limitations traditionally imposed by these fields.

Conflict of interests

Nothing to declare.

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