



Citation Article: Yuryk O., Barabanchyk O., Malets M. Innovations in medicine: modern challenges, future definitions: A narrative review. *Futur Med [Internet]*. 2022;1(2):26-34. Available from: <https://doi.org/10.57125/FEM.2022.06.30.03>

Innovations in medicine: modern challenges, future definitions: A narrative review

Olha Yuryk ^{1*}, Olena Barabanchyk ², Milan Malets³

¹ State Institution "Institute of Traumatology and Orthopedies of the National Academy of Medical Sciences of Ukraine, Kyiv, Ukraine

² Department of Internal Medicine, Educational and Scientific Center "Institute of Biology and Medicine" of Taras Shevchenko National University of Kyiv, Kyiv, Ukraine

³Kyiv City Clinical Oncology Center

Abstract

Background The improvement of healthcare services is one of the highest priorities for all societies worldwide. Healthcare services have shown vivid changes in the last decades due to technological advances, from examining patients and diagnosis to recently developed drugs. Although there are significant efforts to improve healthcare, humanity faces many challenges.

Aim: to study the recent medical innovations in the different aspects of healthcare services. The authors also aim to investigate the various modern challenges in medicine.

Methods: PubMed, Web of Science, Scopus, Embase, SpringerLink, and the Cochrane Library were searched in order to find various articles concerning this topic. The next search strategies were used: (medical innovations) AND (artificial intelligence) AND (medical challenges). These strategies were used for searches that ended in April 2022.

Scientific novelty: Doctors used to make their own opinions in varied cases by means of limited tools. However, together with the introduction of modern technologies into the healthcare system over the previous few decades, medical practice has become increasingly dependent on technology. Medical technology is the development of instruments with the overall purpose of increasing patients' quality of life. There is much anticipation for the new tools one can create and for the outcomes they will enable, as diagnostic and treatment equipment constantly improves. Therefore, in this review, the aim is to address the tactics of the new technologies and applications in medicine.

Conclusion: Medical innovations exist in all healthcare aspects, from education and diagnosis to management. Recent technologies have demonstrated a considerable benefit in healthcare services improvement. However, a number of obstacles that both societies and individuals face are illustrated. There is a growing interest in resolving current concerns and challenges and obtaining the greatest benefits from medical breakthroughs.

Keywords: medical innovations, artificial intelligence, challenges, and healthcare.

Received: February 3, 2022

Revised: February 23, 2022

Accepted: May 17, 2022

Published: June 30, 2022

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Introduction

Innovations in medicine can be defined as any enhancements in the individual's quality of life and the overall quality of services [1]. The healthcare services Improvement is one of the highest priorities for all societies

* **Corresponding author:** Olha Yuryk: olhayuryk01@gmail.com

DOI: <https://doi.org/10.57125/FEM.2022.06.30.03>

worldwide. Healthcare services have shown vivid changes in the last decades due to recent technological advances, from examining patients and diagnosis to recently developed drugs. Recent technological innovations are also expected to keep improving the healthcare [2]. The conventional healthcare system provides medical services through an integrated approach which consists of the hospital facilities, the medical individuals, and the up-to-date equipment. Based on the country's infrastructure and individual orientation, this conventional healthcare system varies from one country to another. The recent medical technologies application may allow the general public better services, care, and flexibility [3-5]. Recent innovations allow the accessibility of information, diagnostic, and management services for the majority of people, including those in low-income countries.

Although there are significant efforts in healthcare improvement, humanity faces many challenges. These challenges are present as the recent innovations require more recently developed technologies, drugs, devices, implants, and procedures [6]. The National Audit Office Financial sustainability of the NHS reported that the cost remains the main issue in healthcare innovation. The NHS must cut costs to cover the anticipated £22 billion budget gap between patient demands and available resources [7, 8]. Due to the recent innovations, there is also an increase in the percentage of older people, usually with much comorbidity, besides; the much-rising public expectations supposing that someone needs surgery or treatment for an illness or disease. In that case, it's increasingly likely that advances in medical technology will advance the chances of a successful outcome. Medical innovations have occurred throughout history, continually advancing our ability to treat complex diseases. These include the first vaccine for smallpox in the 18th century, the development of antibiotics in the 1920s, and the world's first organ transplantation three decades later. However, the 21st century brings even more progress, with technological advances revolutionising the healthcare system. One problem with developing a product innovation is that the development time is frequently rather long. New technical and medical knowledge challenges the original invention and thus makes it necessary to adapt the product even before the innovation is marketed.

In this review the authors aim to study the recent medical innovations in the different aspects of healthcare services as well as to investigate the various modern challenges in medicine.

Research Problem

There is a significant lack in both healthcare facilities and providers. Therefore, there is rising interest in integrating new technologies in medicine. There are doubts that these medical innovations would replace physicians and make decisions. However, others suggest that these innovations have a great impact on the improvement of provided healthcare services.

Research Focus

In this review, authors focused on studying innovations in medicine and the integration of new technologies in medicine. The investigation of the roles and applications of artificial intelligence in medicine is also evaluated.

Research Questions

1. What is the current medical status?
2. What are the recent innovations in medicine?
3. What are the applications of artificial intelligence and modern technologies in the healthcare system?
4. What challenges do societies and individuals face in properly enhancing the healthcare system?

Research Aim

In this review, the authors tried to study the recent medical innovations in different medical aspects, as well as to investigate the various modern challenges in medicine.

Research Methodology

General Background

The rising demand for healthcare services has resulted in an overall medical system personnel and materials lack over time. This increased a great interest in incorporating innovative technological capabilities into medical systems in order to assist patients and clinicians in obtaining optimal and sufficient healthcare services [9]. There is evidence that AI plays a significant role in analysing medical Imaging, patients' symptoms, and investigations from electronic medical records, as well as linking these factors together to determine illness diagnosis and prognosis [10]. Despite high attempts to enhance the healthcare, humanity face numerous challenges. These difficulties exist because current advances necessitate the use of more recently created technologies, medications, equipment, implants, and procedures. Because of recent developments, there is also a growth in the percentage of elderly persons, frequently with several comorbidities. Furthermore, the public's expectations are increasing [11]. Improving patients' quality of life remains the primary purpose of recent medical innovations.

The authors aimed to evaluate different tactics for integrating new technologies in medicine and studying the challenges in modern medicine. Thus, PubMed, Web of Science, Scopus, Embase, SpringerLink, and the Cochrane Library were searched in order to find various articles that discussed this topic. The next search strategies were used: (medical innovations) AND (artificial intelligence) AND (medical challenges). These strategies for searches ended in April 2022. Some types of publications, such as proposals, letters, procedures, and opinions were excluded. The references involve articles that were chosen as they are related to the given topic.

Statistical analysis

In this review, the results of previous trials and retrospective studies that tried to determine the best applications of modern technologies in medicine and the challenges in modern medicine were gathered and compared. So, any statistical analysis methods were not used, nevertheless conclusions are made by comparing these results.

Research Results

The authors performed the title and abstract, and then a full-text screening of these articles was effectuated in order to choose the articles related to our topic. About 624 papers concerned the recently developed technologies and the applications of these technologies in medicine. Data on artificial intelligence applications, innovations in medicine, and challenges were adequately covered in 41 articles in Figure 1.

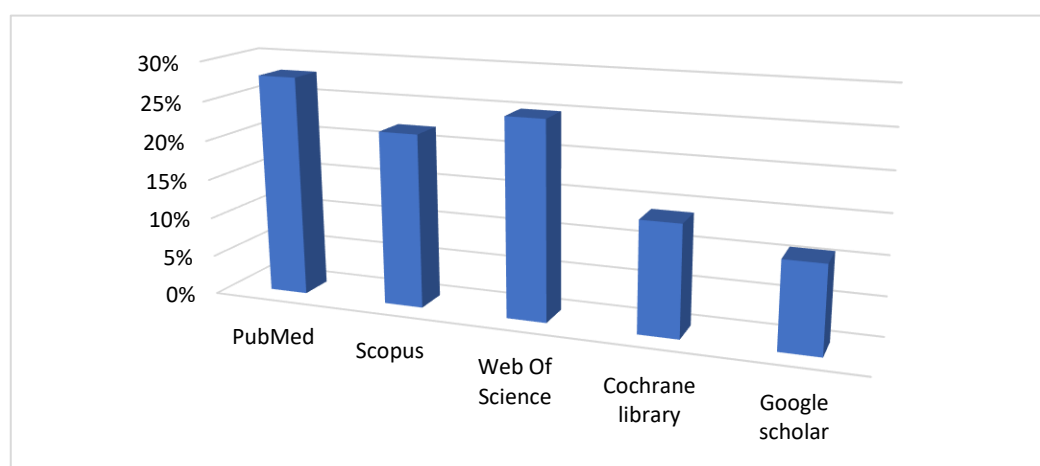


Figure 1. Showing the results of using authors' search strategy

Literature Review

In the past, doctors used to make their own decisions in various cases based on few and limited tools. However, in the last decades, with the development of modern technology implementation in the healthcare system, medical practice has become more dependent on technology utilisation [12]. The recent innovations in medicine aim not only to improve the condition of patients but also aim to increase preventive medicine by detecting symptoms and risk factors of different diseases before they are developed [11]. Medical technology is the development of instruments with the overall purpose of increasing patients' life quality. There is much anticipation for the new tools that can be created and the outcomes they could enable as diagnostic and treatment equipment constantly improves.

Innovations of diagnostic imaging techniques in medicine

Medical Imaging is a process of visualising the human body's internal organs' structure and function for clinical and therapeutic purposes, as it provides a comprehensive study of the normal and the disturbed body status in addition to treating diseases [13]. There have been intense changes in the medical imaging healthcare sciences in the last decades. Various imaging modalities showed great benefits in modern healthcare systems, such as X-ray radiography, X-ray computed tomography (CT), positron emission tomography (PET), magnetic resonance spectroscopy (MRS), magnetic resonance imaging (MRI), endoscopy, electrical source imaging (ESI), medical photography, thermography, medical optical Imaging, single-photon emission computed tomography (SPECT), digital mammography, magnetic source imaging (MSI), tactile Imaging, and ultrasonic and electrical impedance tomography (EIT) [14]. Some modalities do not produce a diagnostic image but provide the diagnostic

contribution through graphs with less accurate results than the standard imaging modalities such as electrocardiography (ECG), magnetoencephalography (MEG), and Electroencephalography (EEG). It is believed that they may be considered a form of medical Imaging but within limits.

A previous study reported that till 2010, there were about five billion investigational images had been conducted worldwide, about 3.3 billion of them were imaging that depended on ionizing radiation [15]. A previous study demonstrated that about 50% of all ionizing radiation exposure in the United States population came from various medical imaging techniques [16]. Nowadays, medical imaging modalities can diagnose almost all major medical diseases and abnormalities, including malignant, neurological, cardiovascular, surgical, and traumatic diseases but also have a crucial role in preventing, managing, and treating various abnormalities [17]. Therefore, integrating highly trained technicians who will perform the imaging technique and the experienced physician who will interpret the result is mandatory to provide the maximum benefits from these recent technologies.

Diseases medical diagnosis is considered a significant challenge in medicine. History taking and patient examination usually require a complementary modality to reach the correct diagnosis. Therefore, there is much use of the newly developed imaging techniques, which have shown great beneficial roles in helping physicians as many diseases may present with similar manifestations.

Of all mentioned modalities, a few techniques considered the newly advanced techniques in medicine, such as CT, MRI, PET scan, digital mammography, sonography, and SPECT will be described.

Computed Tomography (CT)

It is first invented in the 1969s by Hounsfield. It may also be defined as X-ray CT, which radiologists utilise to obtain clear cross-sectional images of the scanned part of the patient body. CT scanner systems have been developed over the years to enhance the obtained images (Figure 2).



Figure 2. Shows a CT scanner system that is utilised to visualise the patients' internal organs

The CT scan works by producing X-rays from different perspectives, which are finally processed by a computer to create a clear image of the diagnosed part. There are great innovations in this computed-based technology which yielded an overall improvement in the final image resolution, that in turn showed great advances in its diagnostic role [18]. The CT scan is considered an effective and reliable method for monitoring and detecting various malignancies, including bladder carcinoma, renal cell carcinoma, and cancers in different body parts [19]. Among the innovations in bone CT scan techniques are high-resolution and volumetric quantitative CT (QCT). These bone imaging modalities can investigate bone abnormalities, particularly bone malignancies and osteoporosis. Advanced CT imaging can also detect bone mineral density (BMD). CT is a safe procedure that usually does not cause harm effect. However, due to this modality's wide popularity, an increased risk of malignancy in those exposed to CT compared with control patients was demonstrated. Brain tumours and leukaemia risk were increased in children exposed to CT radiation [20]. It is well known that children are more sensitive to radiation-induced tumours than adults.

Magnetic Resonance Imaging (MRI)

MRI is one of the best non-invasive imaging modalities to visualise internal body structures and functions. It can be conducted by hardware consisting of multiple mechanical and electrical components that act together and send hydrogen ions and signals to an attached computer system in order to obtain high-resolution MR images. MRI shows a growing beneficial role in modern medical services. It is one of soft tissue's most important medical

imaging modalities [21]. Many recent MRI hardware and software improvements have occurred in the last decades. Thus, scientists are looking for new MRI applications that could improve healthcare services. Unlike other imaging modalities, MRI has no risk of ionizing radiation and its adverse effects on the body. Therefore, the whole-body MRI represents one of the most prominent applications of MRI to diagnose bone metastases. MRI can detect skeletal tumours better than bone scintigraphy because there are many protons in the tumour matrix [22]. The most frequent findings made by MRI include cranial tumours, spine disorders, multiple sclerosis, stroke, musculoskeletal abnormalities, bone diseases, and vascular occlusions.

Although MRI is a powerful diagnostic and reliable test, it may alter and damage medically implanted devices, except for some stents, heart valves, and artificial joints. Furthermore, it is very expensive and takes much time for scanning and processing compared to the alternative imaging techniques. Additionally, many patients cannot tolerate the scanning and proceeding environment of MRI [23]. In addition to the diagnostic role of MRI, there is increasing therapeutic value in minimally invasive surgeries, such as treating essential tremors by thermally ablating subthalamic nuclei using MR-guided focused ultrasound surgery [24]. More innovations in MRI modality may allow for better-provided healthcare services.

Medical Ultrasound

Although it is considered to be one of the earliest developed imaging techniques since it was first used in the 1960s, it is a reliable diagnostic tool for many diseases. It gained great popularity worldwide due to its many advantages, including that it is radiation-free and has no side effects. Besides, it is much less expensive than other imaging modalities. It is also portable and easy to use [25]. Thus, it is the preferred imaging technique in children, gynaecology, and obstetrics for monitoring pregnancy and foetal health [26]. The ultrasound utilises highly frequent sound waves, which are produced by electrical signals from the ultrasound transducer. After that, the image is created by the reflected sound waves from the internal tissues as different reflected waves yield different reflected echo degrees [27]. Radiologists and special technicians can use ultrasound to visualise the liver, kidneys, urinary bladder, heart, blood vessels, and other tissues in the body.

Among the existing innovations in the field of medical imaging techniques are the 4D imaging modalities. It is an enhanced modality that utilises a combination of 4D ultrasound, 4D CT, and 4D MRI. The best techniques for diagnosing malignancies are 4D ultrasound and 4D CT. While 4D MRI is widely utilized in heart diseases [17].

Innovations and artificial intelligence (AI) in medicine

There have been rising demands for healthcare services over time which yielded an overall shortage in medical system individuals and materials. This raised the interest in integrating the recent technological facilities in the medical systems to help patients and even physicians reach optimum and sufficient healthcare services [9]. It is well known that AI has a great role in improving all aspects of healthcare services, from diagnosis to treatment. Nowadays, there is evidence that AI has a great beneficial role in analysing medical Imaging, patients' manifestations, and investigations from electronic medical records (EMRs), in addition to correlating these parameters together to reach the diagnosis and prognosis of the disease [10]. The developed smart devices provided an opportunity for healthcare providers to use medical applications and search platforms to reach any medical information at any time with its last updates. It also helped improve telehealth, providing remote healthcare services to everyone worldwide, especially in developing countries lacking specialists [28]. We believe that this technology may also provide better healthcare services in developed countries.

Although there are fears that AI will replace human existence, AI actually improves and facilitates the overall work of physicians and all healthcare staff. In 2018, Forbes studied the best medical applications of AI and concluded that AI showed the greatest benefits in analysing images, virtual assistants, robotic-assisted surgeries, and supporting clinical decisions [29]. This is consistent with other recent reports demonstrating AI applications in medical fields (Figure 3).



Figure 3. Showing virtual reality can help current and future surgeons enhance their surgical abilities before an actual operation [30].

Discussion

Deep learning and machine learning are parts of AI that help in solving issues in imaging applications such as medical image analysis, lesion segmentation, and computer-guided diagnosis. Furthermore, AI reports are created by enhancing the quality of images, integrating image interpretation, and biomarkers analysis [31–33]. Lung cancer is one of the most serious and common thoracic cancers. There is evidence that AI has the ability to identify benign and cancerous lesions in the lungs [31]. Deep learning algorithms learn through studying the data space and giving them better problem-solving abilities. Recently, the most commonly utilised deep learning algorithms in medical Imaging are Convolutional neural networks (CNNs) [33]. However, various deep learning algorithms showed beneficial roles in different healthcare aspects.

Cancer is considered one of the most serious diseases, responsible for one in six deaths worldwide. The malignant tumour becomes more heterogeneous on disease progression with various mixed cells. Malignancies are usually managed as a whole and homogenous disease. Thus, a deep understanding of this complexity in tumours allowed us to develop efficient treatment strategies with better outcomes [34]. Nanomedicine is a newly emerged treatment that aims to deliver traditional chemotherapy medicines in vivo, yielding better results [35, 36]. Furthermore, the targeted therapy is another cancer treatment modality that targets a specific area in the tumour, such as intracellular organelles or the tumour vasculature [37]. Moreover, gene therapy depends on modifying gene expression, triggering cancer cells' apoptosis. Among the contributing innovative therapeutic techniques are pathomics and radionics [38–40]. They can aid in collecting data, developing new therapeutic techniques, predicting the treatment response, and the overall disease prognosis.

Volosovets et al. studied the current challenges in the Ukrainian healthcare system from the official statistical data from 2009–2020 [41]. They found that there are many challenges, such as a lack of physicians and the high costs of medical services. They suggested that more medical education and increasing the number of medical students may help replenish the existing deficit of medical personnel. Additionally, they suggested more changes in contributing to the new activities and technologies in the healthcare systems.

There are various medical innovations in all aspects, from education and diagnosis to management. Recent technologies have shown a significant beneficial role in improving healthcare services. However, several challenges facing both societies and individuals were demonstrated. There is a rising interest in solving the current issues and challenges in addition to getting the maximum benefits from innovations in medicine. The development, adoption, and diffusion of innovation in health care cannot be taken for granted. The vast majority of innovations—great ideas with very good intentions—will never find their way into the healthcare market, even if they have the potential to meet people's needs. Profit certainly plays a role, but using the right tools and having the knowledge of innovations are even more important. The process from the original idea to the establishment of the innovation as the new standard solution requires professional management, i.e., proper planning, thorough organisation, appropriate staffing, constant motivation, and many forms of control and synchronisation. Innovations in health care can be minor (such as a new wrapping for sterilising) or remarkable (such as a completely new paradigm of medicine and a shift in human understanding of health and disease). The existing world is the result of innovation processes of the past—and the future world will be the consequence of today's innovation processes. Whether this future brings a better quality of life, more efficient health care provision, and equity among stakeholders depends a lot on the inventions are made today, the adoption process, and current diffusion. What humanity expects in the near future is definitely an integrated and patient-centric healthcare system. Technologies such as big data, AI, IoT, and augmented & virtual reality will increasingly make their way into this field; this and other environmental variables will pave the way for reconfiguring ecosystems involving new stakeholders. Hospitals will be rethought as a function of an increasingly tangible switch from a treatment regime to one that will allow people to cope with certain pathologies (mostly chronic) directly in their own homes. All of this necessarily requires that healthcare professionals acquire new knowledge and skills and those healthcare systems worldwide make a collaborative effort, as suggested by the Covid crisis in such a way that geographical distances are shortened and inequities in the use of healthcare services are reduced.

Conclusions and Implications

1. There is a global interest in integrating new technologies in medicine.
2. Preparing the public, healthcare professionals and policy decision-makers for the future of medicine is critical.
3. The Med Tech field needs to work as a community proclaiming their new high-quality approaches and integrating them across organ sectors.
4. Newly developed technologies have a beneficial role in developing overall healthcare services.
5. Mobile medical technology is expanding with multiple diagnostic and monitoring platforms using mobile app systems, which can require new ways of approaching data analytics.
6. AI has several applications in all medical fields that have a significant impact on the current healthcare systems.

7. We are facing challenges in the development of these enhancements.
8. It is necessary to provide potential opportunities for new technologies in order to reach an improved comprehensive medical service.
9. Technology and innovations in medicine aim to globally help all patients, providing evidence for particular conditions that need to be personally considered, involving the patient's decision while treating, forecasting, and preventing disease.
10. Policymakers must integrate medical approaches into national strategies in order to improve the healthcare.

Author contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: This study does not require IRB approval as it does not involve human subjects/data.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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