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Leveraging Cloud Computing for Advanced AI-Driven Biomedical Healthcare Systems

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Abstract : The use of AI is expanding quickly in the healthcare industry, and several AI programs have been designed to address the most critical issues faced by healthcare providers today. Leaders in the health care industry must be well-versed in artificial intelligence (AI) and its potential applications in enhancing the quality, safety, and accessibility of treatment to patients in order to realize the goal of value-based medicine. This article serves as a primer on artificial intelligence (AI) technologies including machine learning, NLP, and AI voice assistants, as well as their appropriate use in the medical field. Further, it offers actionable advice to guide policymakers in crafting an AI strategy that can facilitate digital healthcare transformation. There is a lot of faith that artificial intelligence (AI) can revolutionize the healthcare industry in every way, from diagnosis to therapy. The overwhelming consensus is that AI technologies will complement and improve human efforts rather than displacing them. Healthcare workers may rely on AI for assistance with a wide range of jobs, including routine administrative work, clinical documentation, patient outreach, and more specialist areas like image analysis, medical device automation, and patient monitoring. Both direct healthcare applications and those throughout the healthcare value chain, such as drug discovery and ambient assisted living, will be explored in this chapter as some of the most significant uses of artificial intelligence in the healthcare industry today.

Keywords: Artificial Intelligence, Healthcare Applications, Machine Learning, Precision Medicine, Ambient Assisted Living, Natural Language Programming, Machine Vision.

Introduction

The promise of artificial intelligence (AI) to liberate massive data and obtain insight for supporting evidence-based clinical decision-making and delivering value-based care is driving its fast development in the healthcare sector. When it comes to the digital transformation of healthcare, it is essential for health executives to be aware of the current status of artificial intelligence technologies and the ways in which these technologies may be utilized to enhance the quality, safety, and accessibility of health services.

Artificial intelligence (AI) has already begun to impact nearly every facet of healthcare, from clinical decision support at the point of treatment to patient self-management of chronic illnesses at home to actual drug discovery. Artificial intelligence (AI) technology is promising, but it is difficult and expensive to create and use. In order for AI to be successfully implemented in the healthcare sector, a number of obstacles must first be addressed. Among these difficulties are the following:

(1) A misunderstanding of the limitations of specific artificial intelligence tools;

(2) the most important challenges that health organizations confront today cannot be properly addressed due to a lack of defined plans for integrating various forms of artificial intelligence into the present care systems;

(3) inadequate human resources for artificial intelligence (AI) development;

(4) The incompatibility of AI technologies with legacy infrastructure; and

(5) A lack of access to good and diverse medical data for training Machine Learning (ML) algorithms.

In this paper, we'll discuss solutions to these problems by first outlining the current status of artificial intelligence technologies and the ways in which they might revolutionize the healthcare system. We'll also talk

about how to choose, build, and deploy AI solutions that enhance care quality, availability, and affordability. Then, to help health professionals plan for AI integration and digital healthcare transformation, we'll provide some suggestions.

The State Of AI Technology

The term "artificial intelligence" is commonly used to describe computer programs that mimic human intellect or intelligent behavior in some way, especially in areas like learning, reasoning, and problem solving. AI, thus, is not just one thing, but rather a wide variety of computer models and algorithms that create intelligent processes and behaviors. Recent years have seen rapid development in artificial intelligence (AI), especially in the areas of machine learning (ML), natural language processing (NLP), artificial voice technology, AI assistants, and robots, thanks to the availability of huge data, fast processors, and better computational models and algorithms. Image identification, speech recognition, big data analytics, and healthcare are just a few areas where cutting-edge new solutions have been developed to address challenging real-world challenges. Next, we'll take a look at the state of artificial intelligence technology and talk about how it may be put to good use in the medical field.

Machine Learning

The majority of recent advances in artificial intelligence may be attributed to machine learning. Machine learning (ML) often refers to a system that trains a predictive model from input data patterns and then utilizes that model to predict relevant outcomes for unseen data. Machine learning algorithms, a crucial component of AI, may acquire this "learn ability" in an autonomous fashion, allowing them to learn and grow from experience without any human intervention. Many other branches of artificial intelligence rely heavily on machine learning, including natural language processing, speech recognition, and robotics. As the basis for comprehending the promise and limits of various forms of AI technology, the key ML algorithms should be familiar to health executives. Supervised learning, unsupervised learning, Reinforcement Learning (RL), and deep learning are the most widely used ML algorithms.

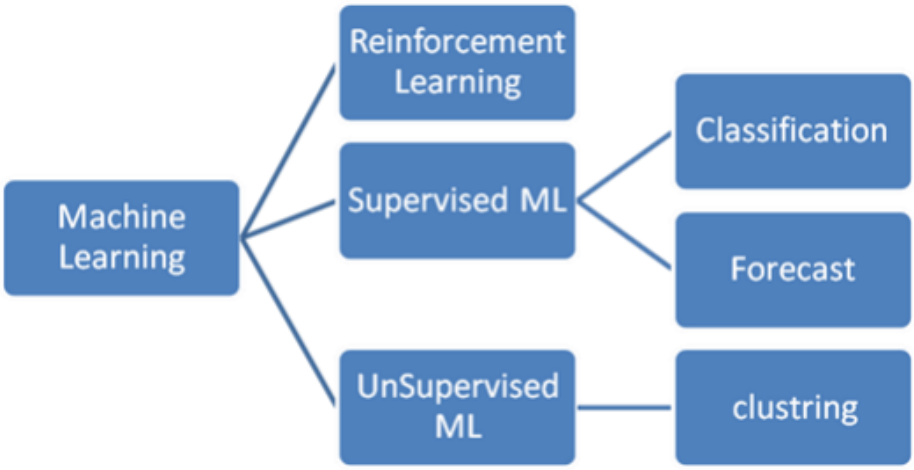

Figure Types of Machine Learning

Supervised learning takes an input data set and outputs some known, labeled outcomes; it then looks for patterns that correlate the two to anticipate the results. This strategy requires input from the user on the expected outcomes of the algorithm when applied to a specific data set. Algorithms may be trained to anticipate the outcomes of new experiments using just the data and the correctly classified answers provided. The healthcare industry has made extensive use of supervised learning, which provides data-driven clinical decision support by mapping input variables into discrete categories (such as using medical imaging to diagnose a cancer tumor, its subtypes, and the severity of each) and by performing predictive analytics within a continuous output (such as

by using Electronic Health Record [EHR] data to make predictions about the recurrences, prognosis, and mortality of a disease).

Discovering the structure of data and making predictions with only input is the goal of unsupervised learning. When the results are uncertain or when categorizing the data would be too expensive, our learning approach shines. Exploratory analyses of clustering, anomaly detection, and pattern identification in many different kinds of data are its most common applications. Unsupervised learning has found a number of applications in healthcare, including the prediction of illness risk using genetic biomarkers and the creation of patient-specific medicines informed by genomic differences. To some extent, unsupervised learning is closer to "true AI" since it can "learn" autonomously without human labeling of outcomes. However, since it lacks supervision from a person, unsupervised learning is more likely to make mistakes since it may rely on insignificant aspects of the data to form predictions. Thus, in reality, supervised and unsupervised learning are commonly employed together, with the former often employing a substantial quantity of unlabelled data for training and the latter using only a fraction of labeled data. This hybrid approach, known as semi-supervised learning, combines the best features of both types of learning algorithms.

A more independent learning method, reinforcement learning uses reinforcement and error as feedback to educate a computer agent to execute actions and interact with its surroundings. This method, in which the agent learns solely through experience and without the aid of data or labeling, is widely regarded as the pinnacle of self-learning systems, and it yields excellent results for sequential decision-making tasks or tasks with well-defined rules and outcomes, such as abstract strategy board games like Go. It has also found application in autonomous vehicles and robots. It has applications in healthcare, including the optimization of treatment plans and robotic-assisted surgery, both of which need the agent to continually interact with the environment and adapt its actions depending on the feedback from the environment.

Using a back propagation technique that may operate on several levels of abstraction, deep learning is able to uncover the complex structure in massive data sets. With the use of artificial neural networks and its many processing layers including the crucial "hidden layers" that play a major role in breaking down the problem to be analyzed supervised and unsupervised learning algorithms may be made more capable of tackling complicated real-world situations. The fields of Go, computer vision, speech recognition, natural language processing (NLP), drug development, and genomics are all examples of fields where deep learning has led to significant advances.

Machine learning has been used on a wide variety of data (including photos, sounds, videos, and text) to complete hard tasks using huge amounts of data, with results that are on par with or even better than those obtained by human specialists. Clinical intelligence that is data-driven and evidence-based has the potential to improve healthcare across the board, from initial diagnosis to follow-up care, from drug discovery to the provision of social services.

Despite its impressive results in medical imaging and large data, machine learning (ML) is not a panacea. Machine learning is less useful for jobs that need human-level reasoning or domain-specific expertise, or for scenarios that fall beyond the bounds of the ML training data set. This is because ML requires a lot of processing time and a lot of data to find simple relationships and patterns. As such, it does not provide a thorough knowledge of the phenomena under research or its underlying causal relationships. As a result, it's challenging to both explain ML results and address the specific mistakes that have been identified in ML algorithms.

Natural Language Processing

Automatic analysis and representation of human languages, often in text format, is the goal of natural language processing, which employs computer methods to achieve this goal. Many recent advancements in speech recognition, machine translation, text categorization, question answering, sentiment analysis, information extraction, and search engine performance may be attributed to the incorporation of ML techniques into NLP. Doctors' notes, test findings, lab reports, medicine orders, and discharge instructions all constitute huge amounts

of unstructured textual data in the healthcare industry. This wealth of descriptive data may be mined with natural language processing technologies to glean useful information about patients, which can then be utilized to refine diagnosis and treatment plans. Health service delivery, especially the way patients are treated, stands to benefit greatly from machine learning and natural language processing's ability to efficiently process vast volumes of visual and textual data.

Artificial Intelligence Voice Technology and Assistants

The human voice is the most common and widespread means of communication among all peoples. Voice recognition software powered by artificial intelligence is revolutionizing human-machine interaction by making health records more accessible, usable, and even archivable. The voice interface has the ability to improve the user experience by removing obstacles associated with the usage of sophisticated systems or the transmission of information via text.

The healthcare industry is just starting to use voice technology, despite its widespread usage in other sectors, in order to help with the informational difficulties that affect both healthcare providers and their patients. In an effort to streamline the clinical recording process and make EHRs more user-friendly, several EHR suppliers and health providers are using speech technology. In the consumer market, AI assistants like Alexa, Siri, Cortana, and Google Assistant have acquired the "skills" to assist with simple and everyday healthcare activities, such as notifying patients when it is time to take their prescription and setting up appointments. When it comes to answering concerns about a person's health, voice assistants powered by artificial intelligence are still in their infancy. The commercial success of text-based chatbots (such Babylon, Ada, and Buoy) suggests that they are more trustworthy than their voice-based counterparts. However, such text-based chat bots' dependability is typically achieved by limiting user input to predefined words and phrases, preventing users from taking the initiative in the debate. It is certain that more sophisticated AI voice health assistants will be produced in the near future that are capable of unrestricted language input and human-like natural dialogues thanks to the high expectations of investors and the efforts of both large and small tech businesses.

Literature Review

Sri Sunarti et al (2021), The purpose of this research was to assess the potential benefits and potential dangers of using artificial intelligence (AI) in the medical field. Three databases (Web of Science, Google Scholar, and EBSCOhost) were searched in depth to locate publications for this methodology. The use of AI to enhance medical care. The reliability of research utilizing the Joanna Briggs Institute was evaluated by two reviewers separately. The implementation will lead to enhanced patient diagnosis, prevention, and treatment as well as greater resource efficiency and equity in healthcare delivery. There is a lack of public sector adoption of AI, and issues with patient privacy and autonomy rights arise when AI is used in healthcare settings. Artificial intelligence (AI) has to be implemented to improve the efficiency of healthcare service administration and medical decision-making. We address some of the ethical problem lists encountered by AI clinical application, and the difficulty of promoting early acceptance and continued deployment in the health care system.

Fotis Kitsios et al (2023), Rapid change is occurring within the administrative and clinical processes of healthcare organizations as a result of the introduction of artificial intelligence (AI). The significance of artificial intelligence (AI) in many fields has been brought home by this change, which is notably noticeable in medical practices including preventative screening and early diagnosis. Research from the past suggests that AI might improve the standard of treatment in the medical field. Artificial intelligence (AI)-based technology has been said to enhance people's lives by making them easier, safer, and more productive. In this study, we conduct a thorough literature assessment of the academic studies that have already been conducted on the topic of artificial intelligence's use in the medical field. The review considered 132 academic papers found in scholarly databases in order to suggest a categorization scheme. The lecture discusses the positive and negative effects that AI capabilities have on patients, doctors, businesses, and the health sector as a whole. The social and ethical ramifications of AI are also discussed, with respect to the results of value-added medical services for healthcare decision-making, data privacy and security, and health monitoring skills.

Research Methodology

Disease prevention, early diagnosis, and therapeutic decision-making are all areas where the healthcare system stands to benefit greatly from the incorporation of artificial intelligence and machine learning into IoT-enabled WSNs. Better, more tailored medical treatment is possible in the future. Artificial intelligence relies heavily on machine learning. Complex algorithms and pattern recognition are applied to large volumes of sample data in order to construct the models. These models, once improved, will be able to be employed in hitherto uncharted territories. There are significant differences between the methods of supervised learning, unsupervised learning, and reinforcement learning. To meet the three different types of learners, a wide variety of strategies and techniques are employed. Recently, deep learning's rising importance in this area can be attributed to its capacity to spot tiny patterns in massive data sets. More and more people are keeping tabs on their own health data via wearables and smartphone apps. There are several potential benefits to feeding this information into an AI system. Using data analytics, researchers and medical professionals are learning more about and developing treatments for uncommon genetic diseases and undetected medical problems. In most cases, developing novel diagnostic methods for individualized treatment would be impossible without intensive data analysis. Medical professionals and support staff can utilize these algorithms to improve the accuracy, speed, and reliability of their analysis of pictures obtained by radiography, nuclear medicine procedures, magnetic resonance tomography scans, or ultrasound of various organ systems (brain, lungs, skin, fundus, etc.). AI algorithms are already improving diagnostic imaging methods in the medical field. Patients may gain independence via the use of AI-based solutions. Children may set and monitor their progress toward healthy lifestyle goals with the help of wearable technology. Individuals who have access to their own data are better able to weigh their options for treatment and do the necessary self-evaluation. In the future, AI may be able to efficiently analyze large data sets and generate new ones that generate information, as in the field of epidemiology, which investigates the causes, patterns, and population-level effects of illness. By analyzing an organism's phenotype, proteome, genome, or the genetic composition of its cells or microorganisms (microbiome), new opportunities have opened up for the early identification of illnesses. It is also less difficult to keep tabs on and control vital signs like blood pressure and blood sugar.

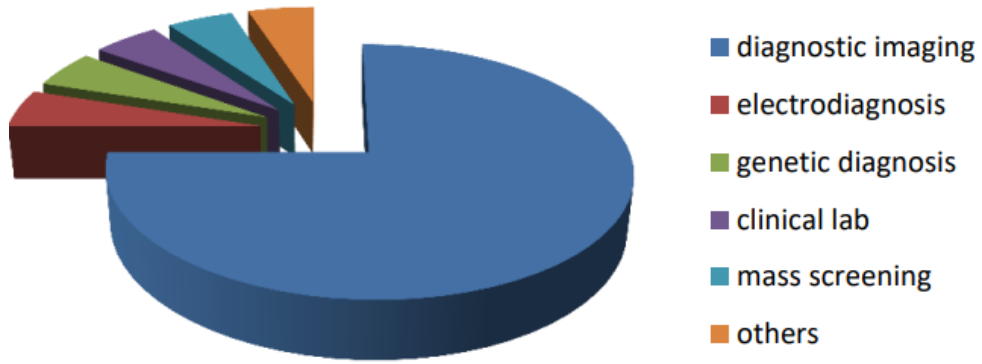

Figure Applications of AI in Health sector

Health Monitoring and Prognosis

In order to evaluate health data and flag any risks, it is predicted that artificial intelligence technology would be used more frequently in preventative medical examinations. This would greatly expedite the process of identifying high-risk individuals for specific diseases and conducting targeted diagnostic procedures. In this case, a trip to the doctor for an examination is usually your best bet. AI is very useful for screening for diseases at an early stage. In fact, it may be challenging to recognize rare diseases in their early stages due to the subtlety of their symptoms. Researchers on the European Union project I-PROGNOSIS have developed a smartphone app for diagnosing Parkinson's disease at an early stage. Data from healthy and sick study participants is presently being collected; this includes information on behaviors as simple as holding a Smartphone, making calls, and taking images, all of which are being stored in the Cloud as part of the study. The user's behavior is

analyzed with machine learning methods, and if any abnormalities are found, the user is advised to consult a medical professional. Self-management might be facilitated by learning systems that provide individualized suggestions for a patient's lifestyle changes. Wearables are predicted to play a major role in this and raise fresh worries about the interaction between humans and technology. Wearables may provide ongoing risk assessments, help set goals for a healthy way of life, and inform the creation of training plans. It would be possible to train global models with data collected locally at the end points. Recommendations for further action on various scales (including individual, regional, and global) can then be developed. The process by which several computers work together to acquire AI expertise is known as "distributed machine learning.

Chronic Illness Therapy

Many people who have what is medically deemed a chronic disease must remain on lifelong medication regimens. Medication administration and dosing may be simplified with the use of smart technology, which in turn lowers anxiety and lessens the possibility of adverse effects. Increasing insulin requirements are associated with lifestyle changes, pharmaceutical use, and medical attention for people with diabetes. Studies on "closed-loop glucose systems" are now being conducted with the end objective of creating self-sufficient systems that can perform the role of the pancreas. A smart system like this would include an algorithm that constantly polls a glucose monitor for readings and then uses those readings to control the operation of an insulin pump, allowing for dynamic adjustments to be made to the way blood sugar is managed. In addition to the stress caused by a physical sickness that drags on for a long time, the patient and his family may also have to deal with the added strain of a mental health issue that refuses to go away. Artificial intelligence has the potential to aid in the early detection of psychological problems and their subsequent treatment. The data it collects might be used by the doctor, the patient, family members, and nurses to improve the patient's condition, or at the very least, to give some measure of comfort. Changes in speech patterns may indicate the onset of depression, and MIT researchers have devised a model that uses artificial neural networks to do so. In total, 142 in-person clinical interviews were used to inform the model's development. Because of this, at least one smartphone app might be created, one that analyzes a user's text and speech for anomalous patterns and other signs of abnormal behavior.

Respite Care

The use of digital recording systems is on the rise, particularly in outpatient care centers and senior living facilities. Also, more and more nurses are showing an interest in cutting-edge scientific discoveries. It is nevertheless estimated that the combined expenditures of purchase and upkeep will be somewhat high. In contrast, human care is naturally exceedingly complex and not amenable to easy mechanization. This is because robots will never be able to fully replace humans in terms of empathy and connection. Even if the care sector of the health business is even less digital than the rest of the sector, AI has applications there as well. Voice recognition software backed by AI might, for instance, help with patient medical records. The procedure, although challenging, may be less so with some help. Recent findings in the realm of AI-powered robots intended for use in restoring motor function after neurological illnesses are also quite promising. Learning methods can be employed in conjunction with the patient's unique data to create a personalized training plan. The RECUPERA project, led by the robots Innovation Center at the German Research Center for Artificial Intelligence (DFKI), was a major advancement in the field of rehabilitation robots. Participants in the project worked with Rehaworks GmbH to develop a movable exoskeleton to aid in upper body movement as part of stroke rehabilitation therapy.

The analysis of biosignals (such as the activity of the brain and muscles or the direction of a view) in combination with environmental variables may one day be used by AI-powered robots to aid in the rehabilitation of stroke sufferers. When motor abilities are weakened, as they often are following a stroke, such systems may identify intended movements and reroute them. The patient may, for example, lose the ability to raise his right arm; the AI may analyze brain activity to determine the cause of the problem and then implement a robotics-based solution. Rehabilitating stroke patients will result in faster motor skill recovery. In order to be controlled by biosignals, rehabilitation robots display the excellent performance of learner systems because to the large amounts of data they must analyze in a short amount of time while using very little power.

Research Design

The future of healthcare might be drastically altered by AI. It is the primary ability supporting the growth of precision medicine, which is widely acknowledged as a much-required improvement in healthcare. One way that AI is used is through machine learning. It is expected that AI will ultimately become proficient in that industry as well, despite early attempts to make ideas for diagnosis and therapy being hard. Rapid progress in AI for imaging analysis means that computers may soon be analyzing the vast majority of images used in radiology and pathology. Future applications for speech and text recognition might include patient communication and the transcription of healthcare records. The biggest hurdle for AI in healthcare isn't whether or not the technologies will be advanced enough to be effective, but rather, whether or not they will be adopted into standard clinical practice. AI systems need to be validated by regulatory bodies, integrated with EHR systems, standardized enough so that comparable products perform similarly, taught to clinicians, paid for by public or private payer organizations, and improved over time. Then and only then will they be widely used. Eventually, we'll figure out how to solve these problems, but it'll take a lot more time and energy than it would take for technology to advance. Therefore, it is expected that AI will be used in clinical practice at least occasionally during the next five years, with its prevalence increasing over the next ten. More and more evidence suggests that AI systems will complement human clinicians rather than supplant them in the delivery of patient care. Long-term, it's feasible that doctors' preferences and work arrangements will be shaped by the need to utilize their distinctively human skills, such as empathy, persuasion, and the ability to see the big picture. In the near future, the only people who will be out of job in the medical industry are those who refuse to collaborate with artificial intelligence.

Conclusion

ML has the potential to become an invaluable resource for anyone working in the fields of medicine, science, and research. Every day, it seems, a new breakthrough is made in machine learning. Every advancement brings with it a unique ML application with the ability to address a real-world issue in healthcare. The medical community is keeping a close eye on the development of machine learning technologies. Machine learning concepts are being applied in the medical field to aid in lifesaving, early disease identification, better patient care, more patient engagement in the healing process, and many other areas. Using AI-driven technologies and machine learning models, multinational corporations may enhance healthcare services. The development of effective remedies for serious illnesses is accelerated by this technology, which is used by the pharmaceutical industry and other businesses. Pattern recognition, sequencing, and computer-simulated clinical trials are just some of the methods that have allowed businesses to speed up their testing and monitoring. In addition to individual behaviors, socioeconomic variables, such as household income, social networks, and educational attainment, have a significant role in determining an individual's health status. Health organizations understand that they must address the "whole individual," not just symptoms, in order to make meaningful improvements in people's health. For chronic, treatable diseases like diabetes, heart disease, and others, ML models may soon be the primary tools used to identify individuals at increased risk of acquiring these conditions.

References

[1] Jordan MI, Mitchell TM. Machine learning: trends, perspectives, and prospects. Science. 2015;349(6245):255-60.
[2] Quinlan JR. p. C4. 5: programs. for mac. hine learning; 2014. Elsevier.
[3] Wiens J, Shenoy ES. Machine learning for healthcare: on the verge of a major shift in healthcare epidemiology. Clin Infect Dis. 2018;66(1):149-53. DOI: 10.1093/cid/cix731, PMID 29020316.
[4] Yan Y. Machine learning Fundamentals. Mach Learn Chem Saf Health Fundam Appl. 2022;19-46.
[5] Musen MA, Middleton B, Greenes RA. Clinical decision-support systems. In: Shortliffe EH, Cimino JJ, editors. Biomedical informatics: computer applications in health care and biomedicine. Cham: Springer International Publishing. 2021;795-840.

[6] Adler-Milstein J, Embi PJ, Middleton B, Sarkar IN, Smith J. Crossing the health IT chasm: Considerations and policy recommendations to overcome current challenges and enable value-based care. J Am Med Inform Assoc. 2017;24(5): 1036-43. DOI: 10.1093/jamia/ocx017, PMID 28340128.

[7] Baars MJ, Henneman L, Ten Kate LP. Deficiency of knowledge of genetics and genetic tests among general practitioners, gynecologists, and pediatricians: a global problem. Genet Med. 2005;7(9):605-10. DOI: 10.1097/01.gim.0000182895.28432.c7, PMID 16301861.

[8] Bloomrosen M, Starren J, Lorenzi NM, Ash JS, Patel VL, Shortliffe EH. Anticipating and addressing the unintended consequences of health IT and policy: A report from the AMIA 2009 Health Policy Meeting. J Am Med Inform Assoc. 2011;18(1):82-90. DOI: 10.1136/jamia.2010.007567, PMID 21169620.

[9] Bright TJ, Wong A, Dhurjati R, Bristow E, Bastian L, Coeytaux RR, et al. Effect of clinical decision-support systems: a systematic review. Ann Intern Med. 2012;157(1):29-43. DOI:10.7326/0003-4819-157-1- 201207030-00450, PMID 22751758.

[10] Dixon BE, Simonaitis L, Goldberg HS, Paterno MD, Schaeffer M, Hongsermeier T, et al. A pilot study of distributed knowledge management and clinical decision support in the cloud. Artif Intell Med. 2013;59(1):45-53. DOI: 10.1016/j.artmed.2013.03.004, PMID 23545327.

[11] Dolin RH, Boxwala A, Shalaby J. A pharmacogenomics clinical decision support service based on FHIR and CDS hooks. Methods Inf Med. 2018;57(S 02):e115-23. DOI: 10.1055/s-0038-1676466, PMID 30605914.

[12] Greenes RA, Bates DW, Kawamoto K, Middleton B, Osheroff J, Shahar Y. Clinical decision support models and frameworks: Seeking to address research issues underlying implementation successes and failures. J Biomed Inform. 2018;78:134-43. DOI: 10.1016/j.jbi.2017.12.005, PMID 29246790.

[13] Kalaiselvi K, Deepika M. Machine learning for healthcare diagnostics. In: Jain, Chatterjee JM, editors. Machine learning with health care perspective: Machine learning and healthcare, V. Cham: Springer International Publishing; 2020. p. 91-105. DOI: 10.1007/978-3-030-40850-3_5.

[14] Bak B, Skrobala A, Adamska A, Malicki J. What information can we gain from performing adaptive radiotherapy of head and neck cancer patients from the past 10 years? Cancer Radiother. 2022;26(3): 502-16. DOI: 10.1016/j.canrad.2021.08.019, PMID 34772603.

[15] Ghazal TM, Hasan MK, Alshurideh MT, Alzoubi HM, Ahmad M, Akbar SS, et al. IoT for smart cities: machine learning approaches in smart healthcare—a review. Future Internet. 2021;13(8):218. DOI: 10.3390/fi13080218